LEARNING BEYOND SCHOOL

A systemic approach to promote contextualized, effective, emotional, and sustainable learning for science teachers (pre-service) in Chimoio-Mozambique.

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Dedication

In memory of my mother, Joaquina Afonso da Costa Rosário, a warrior woman, a battler, and an inspiration, who since my pregnancy played with much sacrifice the role of mother and also of "father". May God rest her soul; this woman always fought until the last moment of her life, when just in the year I finished my university degree (23rd of December, 2008), she left for another world.

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Abstract

The quality of education in Mozambique has been faced with several challenges and criticisms. This situation comes from a long time ago. In many studies, it has been revealed that the quality of education is rather low, and there is evidence that students have difficulties in reading, writing, and calculating, especially in primary education. Also, there are weak links between theory and practice in secondary education. These difficulties negatively affect the development of skills and students' profiles. In addition, this significantly delays the country's scientific, technological, and socio-economic development. The problems of education and other sectors in Mozambique could be solved by creating synergies and establishing joint approaches or actions involving all collaboration partners and as a system.

Aware of this, reforms have been carried out in the field of educational sciences to adopt innovative learning approaches through improving learning methodology and promoting contextualized learning according to the authentic needs of society. To enhance the knowledge and understanding of natural sciences and thus improve the quality of education, an interventional study was carried out based on an innovative learning theory made up of a cluster of connectivism, constructivism, and cognitivism.

Theory into practice was organized as a systemic approach based on contents found in the Mozambican curricula (teacher education and secondary schools) and integrating science-technology-society approaches. The research was devoted to analysing relevant core elements, institutional preconditions at schools and the university, and pre-service teachers' pre-conceptions about these approaches and finding out outcomes that can enrich curricula and improve the quality of education in Mozambique.

This study was designed to involve pre-service teachers of chemistry and other natural sciences (Biology and Physics) from Púnguè University working together with students of grades 8, 9, and 11 from all (seven) secondary schools existing in Chimoio. These groups would be supported by lecturers and researchers from the university, secondary school teachers, specialists, technicians from partner companies, and communities or individuals belonging to the community who together could contribute to solving a problem in a systemic approach.

Because of the Pandemic COVID-19 situation in the country, the sample had to be slightly modified and structured according to the three different stages, organised in the following way:

Stage I (preparatory): one hundred and eleven (111) chemistry's pre-service teachers from three different branches (Manica, Tete, and Sofala) of the Pedagogical University participated and applied a questionnaire. This stage took place in 2019 after the documentary study. It aimed to ascertain the pre-service teachers' preconceptions to understand their preparedness before the fieldwork.

For comparative reasons, six questions from the validated VOSTS instrument (Views on Science-Technology-Society) of Aikenhead, Ryan, and Fleming (1989), which is used widely internationally also, were incorporated into this questionnaire. The

codification of students´ views was newly adapted to four scores, namely: Realistic (R), Has Merit (HM), Naïve (N), and Neutral (Ne).

Stage II (fieldwork/practical work): Sixty-six (66) chemistry pre-service teachers from Manica and Tete participated. This stage took place in 2020 after the restructuring of the former Pedagogical University when the Manica and Tete branches were joined together to create the Púnguè University (UniPúnguè).

In this stage, three lecturers from UniPúnguè (two in organic chemistry and one in environmental chemistry) also participated in monitoring and support.

Three external people also participated: a building engineer and a pipe connection specialist (representing the water supply company/FIPAG), and the municipal councillor for education and culture (representing the municipality);

Two secondary school teachers also participated in the study (one in chemistry and one in agriculture and cattle breeding);

Stage III (Science Motivation Questionnaire): the original questionnaire questionnaires from Glynn, Taasoobshirazi, and Brickman (2009) and Sotiriou, Mordan, Murphy, and Lovatt (2017) were in English, and it was necessary to translate them into Portuguese to apply to the chemistry´s pre-service teachers (main group). For this reason, the questionnaire was translated by fifty-three (53) pre-service teachers of English courses in a pilot study before administering it to the main group.

After checking the reliability of the translation (Cronbach´s Alpha = .928), the sixty-six (66) pre-service teachers who participated in practical activities filled in the questionnaire. This questionnaire intends to assess intrinsic motivation and personal relevance; Intrinsic motivation and personal interest; Perceived Competence; Effort/Importance; Value/Usefulness, and Collaborative Work Relatedness.

The outcomes from local interventions were collected by mixed methods research involving qualitative (documentary study, participant observation, semi-structured interviews, and participatory-based research) and quantitative (questionnaires and interviews with fixed questions) methods. Data collected by quantitative methods were processed using the statistical package SPSS versions 20.0 and 25.0.

The results of the six questions taken from the VOSTS instrument show that most pre-service teachers do not present a realistic view (R), but rather a view with some legitimacy/merit (HM) in most questions (four) and with a cumulative average of about 54%, and in the case of the other two questions, the results indicated for an inappropriate view (Naïve/N) with the cumulative average of 49%.

With respect to science motivation, it was found that after practical activities, pre-service teachers have developed high levels of motivation, with the subcategory "the value/ usefulness of practical activities" scoring highest (80%) and the subcategory "collaborative work-relatedness" scoring lowest (49%).

These findings may be the result of ethnic and tribal conflicts that negatively interfere in the friendship between people, but also of the traumas caused by unpleasant and shocking memories of the use of technology in the war that lasted for about sixteen years and the repeated armed conflicts, kidnappings, and murders where science and technology have not been able to bring solutions.

This study also revealed that the pre-service teachers could not put these new approaches into practice right from the beginning, and almost none of them had heard of the systemic approach before. Additionally, in the practical activities, it was found that despite the lack of knowledge about how to design and carry out learning activities using Science-Technology-Society integration and the systemic approach, all students (100%) were satisfied.

The practical activities carried out show that applying knowledge collaboratively and by a systemic approach to solve everyday problems in communities promotes the development of skills and makes knowledge lasting, establishing contextualized, effective, and emotional learning.

In practical activities, several projects were developed, such as the production of soap based on ash as a saponification agent and other products such as lettuce, cabbage, alcohol, etc. Both the knowledge and the products resulting from these projects have been presented at national and international public events (conferences, workshops, seminars, etc.)

Further education of university students *on the job* led to several individual qualifications as bachelor's degrees (*Licenciatura*), of which five of them have already been defended with relevant monographs.

Finally, it is concluded from the findings that it will be possible to transfer this approach to other universities and schools in Mozambique and elsewhere, contributing, therefore, to help develop communities, improve learning and the profile of both students and teachers, as well as the profile of universities and schools.

Keywords: pre-service teachers, systemic approach, science-technology-society, contextualized, emotional learning.

Zusammenfassung

Die Bildungsqualität in Mosambik hat sich mit zahlreichen Herausforderungen und Kritiken auseinanderzusetzen. Diese Situation rührt aus lang vergangenen Zeiten. In zahlreichen Studien wurde herausgefunden, dass die Bildungsqualität allgemein ziemlich niedrig ist und Schüler Schwierigkeiten beim Lesen, Schreiben und Rechnen haben, speziell in der Primarstufe. Auch bestehen nur wenige schwache Verknüpfungen zwischen Theorie und Praxis im Sekundarbereich. Diese Schwierigkeiten beeinflussen negativ die Entwicklung von Fähigkeiten und Lernprofilen der Schüler. Außerdem wird die Entwicklung des Landes im Bereich von Wissenschaft, Technologie und Soziologen Ökonomie verzögert. Die Probleme im Bildungsbereich und anderen Bereichen in Mosambik könnten nur durch die Schaffung von Synergien und der Etablierung gemeinsamer Ansätze aller daran beteiligten Partner und systemisch gelöst werden.

Dessen gegenwärtig wurden im Bereich der Erziehungswissenschaft Reformen durchgeführt, bei denen innovative Lernmethoden und durch die Verbesserung der Lernmethodik und Förderung kontextualisierten Lernens nach den Bedürfnissen der Gesellschaft gefördert werden. Um Wissen und Verstehen der Naturwissenschaften zu erhöhen und dadurch die Bildungsqualität zu verbessern wurde in dieser Arbeit eine Interventionsstudie durchgeführt, die auf einer innovativen Lerntheorie im Verbund von Konnektivismus, Konstruktivismus und Kognitivismus beruht.

Die Überführung von Theorie in Praxis wurde als ein systemischer Ansatz basierend auf Inhalten mosambikanischer Curricula (Lehrerbildung und Sekundarschulen) sowie Integration von Science-Technology-Society Ansätzen organisiert. Die Forschung war darauf ausgerichtet, relevante Kernelemente, institutionelle Vorbedingungen an Schulen und Hochschulen zu analysieren sowie Präkonzepte von Lehramtsstudenten über diese Ansätze herauszufinden, und Ansätze zu finden, die Curricula anzureichern und die Bildungsqualität in Mosambik zu fördern.

Die vorliegende Untersuchung wurde gestaltet mit dem Ziel, Lehramtsstudierende der Chemie und der Naturwissenschaften (Biologie und Physik) aus der Púnguè Universität in eine Zusammenarbeit mit Schülern der Klassenstufen 8, 9 und 11 aus allen 7 Sekundarschule von Chimoio zu verwickeln. Die Arbeitsgruppen wurden von Dozenten und Forschern der Universität, von Lehrkräften an den Sekundarschulen, Spezialisten, Technikern aus Partnereinrichtungen und Behörden sowie Einzelpersonen aus der Gemeinde unterstützt, welche zusammen in einem systemischen Ansatz zur Lösung von Problemen beitragen konnten.

Wegen der Covid-19 Situation im Land musste die Auswahl der Gruppen leicht modifiziert und nach 3 unterschiedlichen Stadien strukturiert werden, die folgendermaßen organisiert waren:

Stadium I (vorbereitend): 111 Lehramtsstudenten der Chemie aus den 3 Abteilungen Manica, Tete und Sofala der pädagogischen Universität nahmen bei einer Fragebogenuntersuchung teil. Dieses Stadium fand im Jahr 2019 nach der Untersuchung der Dokumente aus dem Bildungsministerium statt. Ziel war, das

Vorwissen der Lehramtsstudenten zu erheben werden und ihre Bereitschaft vor der Feldarbeit zu verstehen.

Aus Gründen der Vergleichbarkeit mit anderen Untersuchungen wurden 6 Items aus dem validierten Instrument VOSTS (Views on Science-Technology-Society) von Aikenhead, Ryan und Fleming in den Fragebogen eingearbeitet. Das VOSTS-Instrument wird auch international weit verbreitet genutzt. Zur Kodifizierung der Ansichten der Studenten wurden 4 Einstufungen neu adaptiert, nämlich: realistisch (R), hat etwas für sich (Has Merit, HM), naiv (N) und neutral (Ne).

Stadium II (Feldarbeit, praktische Arbeit): 66 Lehramtsstudierende der Chemie aus Manica und Tete nahmen daran teil. Dieses Stadium wurde im Jahr 2020 nach der Reform der ehemaligen Pädagogischen Universität durchgeführt, als die Abteilungen Manica und Tete angeschlossen wurden, um die neue Universität Púnguè zu bilden.

Auf dieser Stufe nahmen 3 Dozenten der Universität Púnguè, davon 2 aus der Organischen Chemie und einer aus der Umweltchemie, im Bereich Monitoring und Projektunterstützung teil.

Auch drei Externe nahmen teil: ein Bauingenieur und ein Spezialist für Leitungsbau (als Repräsentant des Wasserversorgers FIPAG) sowie für die Gemeinde der Stadtrat für Bildung und Kultur. Auch nahmen zwei Sekundarschullehrer Teil, einer aus der Chemie und einer aus dem Bereich Landwirtschaft und Viehzucht.

Stadium III (Motivationsfragebogen): die Originalfragebögen von Glynn et al. (2009) und Sotiriou et al. (2017) waren in englischer Sprache, und es war daher notwendig, sie ins Portugiesische zu übersetzen, um sie in der Untersuchungsgruppe einsetzen zu können. Aus diesem Grund wurden der Fragebogen von 53 Lehramtsstudierenden der Englischkurse in einer Pilotstudie vorab übersetzt.

Nachdem die Reliabilität der Übersetzung geprüft worden war (Cronbachs $\alpha = .928$), wurde er bei den 66 Lehramtsstudierenden, die an den praktischen Aktivitäten teilnahmen, eingesetzt. Der Fragebogen zielt darauf ab, intrinsische Motivation und persönliche Relevanz zu erheben; ebenso intrinsische Motivation und persönliches Interesse; erlebte Kompetenz; Anstrengung und Bedeutung; Wert und Gebrauchswert sowie die Bedeutung der Zusammenarbeit.

Die Ergebnisse der lokalen Interventionsprojekte wurden durch einen Methodenmix aus qualitativen (Literaturanalyse, teilnehmende Beobachtung, semi-strukturierte Interviews, Aktionsforschung) und quantitativen Methoden (Fragebogen, Interviews mit geschlossenen Fragen) erhoben. Die Daten der quantitativen Methoden wurden mit dem statistischen SPSS-Programm Versionen 20.0 und 25.0 analysiert.

Die Ergebnisse der sechs Fragen aus dem VOSTS-Instrument zeigen, dass die meisten Lehramtsstudierende keine realistischen Einstellungen und Ansichten (R) aufweisen, aber insgesamt noch akzeptable Sichtweisen (HM) bei vier Fragen (54%). Bei den übrigen zwei Fragen ist die Einstellung naiv (N) mit einem Durchschnitt von 49%.

In Bezug auf Wissenschaftsmotivation wurde nach den praktischen Aktivitäten gefunden, dass Lehramtsstudierende hohe Niveaus im Bereich der Motivation entwickelt haben, wobei die Subkategorie „Wert / Nützlichkeit praktischen Aktivitäten“ den höchsten Wert (80 %) und die Subkategorie „Zusammenarbeit“ den niedrigsten Wert (49 %) aufwiesen. Der letztere Wert könnte von ethnischen Unterschieden und Traumata hervorgerufen worden sein, die von unangenehmen und schockierenden Erinnerungen über die Anwendung von Technik im Verlauf des Krieges, der 16 Jahre dauerte, herrühren. Ebenso, dass Wissenschaft und Technik nicht in der Lage waren, wiederholte bewaffnete Auseinandersetzungen, Entführungen und Mordanschläge zu unterbinden.

Die Untersuchung hat auch aufgedeckt, dass Lehramtsstudierende die neuen Ansätze nicht gleich von Anfang an in die Praxis umsetzen konnten, und nahezu keiner von ihnen hatte vorher von einem systemischen Ansatz gehört. Außerdem wurde bei den praktischen Aktivitäten gefunden, dass trotz des Mangels an Wissen, wie man Lernaktivitäten mit einem Science-Technology-Society und systemischen Ansatz entwirft und ausführt, alle Lehramtsstudierenden (100 %) zufrieden waren. Die praktischen Aktivitäten zeigen, dass gemeinsames Anwenden von Wissen in einem systemischen Ansatz zur Lösung alltäglicher Probleme in der Gemeinschaft die Entwicklung von Fähigkeiten fördert und Wissen lang andauern macht, auf diese Weise Lernaktivitäten im Kontext realisiert, erfolgreich und emotional ansprechend macht.

Im Bereich von Praxisaktivitäten wurden verschiedene Projekte entwickelt, zum Beispiel die Produktion von Seife basierend auf Asche als Verseifungsmittel, und andere Produkte wie z.B. Salat, Kohl, Alkohol. Sowohl das Wissen als auch die Produkte, die aus diesen Projekten resultierten, wurden bei Veranstaltungen im nationalen und internationalen Bereich bei Konferenzen, Workshops oder Seminaren präsentiert.

Auch die Weiterbildung der Lehramtsstudierenden selbst, sozusagen während der Tätigkeit im Projekt, führte zu verschiedenen individuellen höheren Qualifikationen (*Licenciatura*) als Studienleistung, die durch entsprechende schriftliche Arbeiten nachgewiesen werden mussten.

Aus den Ergebnissen wird schlussendlich geschlossen, dass dieser Ansatz auch auf andere Universitäten und Schulen in Mosambik übertragen werden kann. Er könnte dazu beitragen, die Gemeinden zu entwickeln, das Lernen allgemein und das Profil sowohl der Lehramtsstudenten als auch der Lehrer zu verbessern, und genauso das Profil der Universitäten und Schulen.

Chapter I - INTRODUCTION

1. Introduction

The education system in Mozambique has been considered of low quality, and at the same time, it has been the target of several criticisms for the fact that many students finish primary level still with reading, writing, and math problems. (Bonde, 2016; Castiano & Ngoenha, 2013). For some students, these difficulties extend to the secondary level and even become even more serious problems, such as:

- Lack of argumentation and reflection capacity;
- Acquisition of theoretical knowledge dissociated from practice;
- Inability to apply scientific knowledge acquired at school to solve everyday problems at home, in communities, in companies, etc.

This learning disability significantly delays the country's scientific, technological, and socio-economic development. This situation worries so-me people but it should worry all citizens, particularly scientists and academics (students, teachers, lecturers, professors, researchers, and administration) but also politicians, businessmen, and societies as a whole.

Therefore, in Mozambique, the low quality of education is aggravated by poverty, which is reflected in the lack of conditions and resources for sectors such as education, but also others such as health, agriculture, transport, etc. The application of sustainable measures for the use and sharing of the few available resources can be a viable alternative to solve a large part of these problems that negatively interfere with the quality of education and also affect all development sectors in the country.

The problems of education and other sectors can be solved by creating synergies and establishing joint approaches or actions involving the interested parties, in which they act in an active, collaborative way and as a single system.

This problem-solving model is also being applied (albeit slowly) as new learning paradigms where researchers, specialists, teachers, students, public and private

institutions form a single system to develop small projects such as improving soil fertility, seed multiplication, food production, waste collection, reduction of air pollution, tree planting, disease prevention campaigns, etc. These projects are designed based on certain community problems and school content.

The application of a systemic approach or approaches that integrate science, technology, and society in the educational sector, provides an environment that promotes greater interaction of stakeholders in the exchange of experiences and contact with the real world.

The contact with the real world facilitates students, in particular, a marked development of intellectual capacities and skills for the production of useful and applicable scientific knowledge, improving the living conditions of communities and, at the same time, improving the quality of education and his profile as a student. Therefore, to reach the levels outlined, the education system must be based on the following pillars:

- Provide the student learning that develops the ability to properly apply the theories and laws of science in practical activities of their daily life to solve society's problems, explain phenomena that occur in nature, and also improve their academic profile.
- Development of students' ability to interpret the world scientifically and to capitalize on the resources around them as tools for learning and for building solid and lasting knowledge.
- Build a society that actively participates in the construction of knowledge, developing a set of skills, attitudes, creativity, and values, which enable them to solve problems by taking responsible, moral decisions following the context and real situations.

These pillars, which one can call quality criteria for education, depend very much on the updating and reforms in the education sector, noting the technological evolution, the emergence of new theories and learning approaches, but also the fact that the challenges change with the times and these require more and more scientifically proven and sustainable solutions.

Aware of the need to improve the quality of education, the field of educational sciences has been carrying out most reforms today (Council, 1992; OECD, 2012) by adopting an innovative learning approach, improving teaching and learning methodology (NAP, 1996, 2011; Schallies, Storrer, & Welzel, 2007) to promote contextualized learning according to the real needs of the society where both teachers and students live (OECD, 2015).

Overall, the reforms undertaken are embedded in curriculum pedagogy, governance, and technology (Stewart, 2021), but specifically and pragmatically this aims to promote that curriculum changes focus on learning theories and approaches that enable the student as an independent learner to understand the nature of science, to apply scientific knowledge and develop scientific and technological tools in cognitive development, but also for the development of science and the world.

The new paradigms in education suggest that the natural sciences sector shifts from traditional "learning-by-choosing" teaching approaches or theories to the learning model where students are the centre of knowledge production or construction, such as "constructivism" (Aikenhead, 1986; Lajonquière, 1997; Taber, 2012; Villani & Pacca, 1997), and others prominent and innovative theories of learnings such as connectivism.

Therefore, more than constructing their knowledge, it is necessary that the knowledge be actively constructed, updated, contextualized, and linked to the environment in which the student lives and solving the day-to-day problems of society. Constructivism and studies on education quality have dominated the research of the last decades (Karagiorgi & Symeou, 2005).

Therefore, for more effective learning and based on the complexity of the dependent variables, the new paradigms, and educational perspectives suggest the use of not only one but multiple contemporary learning theories and approaches. For this study the following three theories were associated:

i. Cognitivism: linking concepts, real-world examples, creating and using analogies; etc., (Kelly, 2012; Rawson et al., 2018);

ii. Constructivism: by using collaborative learning/ group work, discovery learning, simulations, etc., (Taber, 2012; von Glasersfeld, 1989), as well as being knowledge producers as "already a scientist" (Hollow, 2000; Solomon, 1994a, 1994b; Tuss, 1996) and,

iii. Connectivism: by group learning or entities that connect and build the network (Downes, 2005, 2012; Goldie, 2016; Siemens, 2005).

The main wish of society, in particular, the wish of the main actors of learning activities (teachers and students) is for their country to develop a very good quality learning system (reading, writing, interpreting, problem-solving skills, etc.), but this desire depends on the established policies, the conditions created, and especially the philosophy and political will of the leaders.

Therefore, Stewart (2021) in his article on "10 best ways to reform schools", argues that to successfully fulfil the "dream" described in the previous paragraph it is necessary to include society in the creation of educational strategies and policies, on the one hand, but it should also consider it as an active part of teaching and learning activities, as well as in making decisions about what should be taught (contents)? what needs to be solved? and who knows, together with those experienced in the education sector decide how it should be taught (approaches and methodology).

The active participation of society in teaching and learning activities is done by adopting "associative" policies (i.e., a society where institutions and communities function as one and can share ideas and resources,) but also by adopting learning theories and approaches such as:

i. Integration of science-technology-society (Aikenhead, 1996; Bybee & Landes, 1999) which allows strong school-community interaction and;

ii. The systemic approach which is based on the Austrian guidelines (von Bertalanffy, 1968), is characterized by Taylor as a study in harmony, cooperation, and transdisciplinary[1] (Chiavenato, 2003; Czerniak & Johnson,

[1] Contents addressed are beyond the disciplines. Transdisciplinary learning promotes holistic and contextualized learning broking boundaries between disciplines and understanding the totality of the phenomena of human nature as well as the man himself.

2014; King et al., 2009; Schallies, 2010; von Bertalanffy, 1968), bringing together all the key stakeholders[2].

In the systemic approach, stakeholders behave as a set of interdependent elements to form a single larger set "system" with the same goal, working together as one to improve the quality of education, solve community problems, and thus develop society.

One of the effective ways of creating a system that involves communities and at the same time arousing students' interest and commitment to practical activities, as well as building a strong network, is the introduction of local content and applying approaches that allow learning to be contextualized, affective and sustainable.

Teaching contextualized makes learning more effective (Baker, Hope, & Karandjeff, 2009; Bilican, Cakiroglu, & Oztekin, 2015; Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013), and emotional (Bilican et al., 2015; Čižkova, Čtrnactova, & Nečesana, 2009) but also plays a very important role in improving the quality of education as well as in the socio-economic development of communities.

Since education is “an applied field, and learning scientists bring agendas to their work, seeking to produce specific results such as engaging students in the making of science, creating online communities for professional development" (Barab & Squire, 2004, p. 3), thus this study was conducted using the same philosophy.

The project took place in Manica province, where it involved pre-service teachers, students and teachers from secondary school, lecturers, governmental[3], non-governmental institutions[4], and strategic partners[5], which, in addition to the previous goals, they focused especially on improving the quality of learning and perception of

[2] Pre-service teachers, students at school, teachers, lecturers, schools, universities, administrations, governmental & non-governmental institutions, communities, and strategic partners.
[3] University of Púnguè, Secondary Schools, Agriculture Sector, Health Sector, Water provider (*FIPAG*), Instituto Politécnico de Manica (*ISPM* in Portuguese) and Municipality;
[4] Mozambique Fertilizer.
[5] Confederation of Economic Associations (CTA), Catholic University of Mozambique (*UCM* in Portuguese).

the nature of science as part of life and building scientific tools to solve society's problems.

The Mozambican curricula (teacher education and secondary schools) provide for the use of good everyday practices or analogies to motivate and facilitate understanding of the content but also establish the possibility of 20% of the overall time being devoted to local content, in line with the creativity of the teacher and the specific nature of each community (MINED, 2003).

This study was carried out as "school projects and community development", based on interventional research that was designed and developed by groups of students in collaborative work, linked to industry, communities, governmental and non-governmental institutions.

The projects focus on critical areas established by the Government of Mozambique, such as agriculture, malnutrition, and public health, especially during the COVID-19 pandemic period. However, all the processes were monitored by the researcher through observation, questionnaires, interviews, and voice recordings.

1.1. MOTIVATION, OBJECTIVES, AND RESEARCH QUESTIONS

1.1.1. Motivation

For many decades, it has been notorious that the majority of African countries, and in particular poor countries such as Mozambique, have been facing various problems resulting from climate change, but also hunger, poverty, disease, crime, etc., and in most cases, the solution to these problems has come from countries in America, Europe, Asia, etc., which for years have concentrated on developing the scientific and technological capacity of their countries and continents.

Mozambique is a country rich in natural resources (in the soil and subsoil) that can be used as raw material for the production of medicines, cosmetics, electricity, processing fuel for cars, feeding large transformation industries, etc., but the country's scientific and technological development is still very weak and slow, which means that most of the resources are not processed and used for the development of the country itself,

but rather exported to benefit other countries and continents that are already developed.

To make better use of available resources and to develop the country, it is necessary to have a good scientific and technological capacity, which includes establishing a good quality education system, or even education models that enable the development of skills to apply the scientific knowledge learned in school to solve concrete problems based on resources available in the community.

The natural sciences, specifically chemistry, being an experimental science, students need from the initial class in which chemistry is studied (grade 8) to realize that chemistry happens in their daily life, for instance in breathing, eating, digestion, rest, exercise, etc., but also in the development of products such as soap, toothpaste, fertilizers, grease, soft drinks, juices, beverages, etc., which are chemical products and can be produced by them, or at least they can learn and understand the principles and technologies applied.

The skills of producing food, cosmetics, or other products for everyday use always constitutes a curiosity, satisfaction, and sense of achievement for any individual who possesses it, so when this skill results from school activities, this makes learning more meaningful, emotional, robust, lasting and sustainable.

It has always been a dream to see Mozambique and Africa also as providers of solutions for part of the problems that afflict the world and not only as simple "victims waiting with much faith" that the problems are solved by others. Therefore, for the country to participate as part of solutions, it needs to adopt an active, proactive education where scientific knowledge is built collaboratively and to develop technological tools to apply for the welfare of the community.

The assumptions of application of scientific knowledge for the development of communities, the school-community link, active participation in socio-economic development, etc., are also advocated in the Mozambican education law (discussed below), which further strengthens the motivation to introduce into the curricula

approaches aimed at this application of knowledge, development of skills and improvement of the quality of education and life of citizens.

1.1.1.1. Law of Education (Law 4/83 and 6/92)

In the National Education System in Mozambique according to law 6/92 the educational process from primary up to high school is guided by the following objectives:

a) Development of capacities and personality in a harmonious, balanced and constant way, giving an integral formation in the political-ideological and moral areas, of communication of mathematics of natural and social sciences, polytechnic and labour, aesthetic-cultural and physical activities;
b) Development of creative initiative, the ability of individual study, and critical assimilation of knowledge;
c) The link between theory and practice, which is reflected in the content and method of teaching the various disciplines in the polytechnic nature of the teaching given, and the link between the school and the community;
d) Connection of study to socially useful productive work as a way of applying scientific knowledge to the production and participation in the struggle for economic and social development of the country;
e) A close link between the school and the community in which the school participates actively in the promotion of socio-economic and cultural development of the community and receives the guidance required to perform teaching and training that meet the requirements of the country's development.

Therefore, despite the law on the “national education system” establishing a strong link between the school and the community, it is worrying to note that this link does not happen in reality, and in cases where there is some link, it has been very weak, which does not allow for harmonious development and for schools to find sufficient resources for learning in the communities, and on the other hand the communities still do not benefit much from the knowledge and technologies produced in the national schools.

Many aspects established in the law aimed to build an education system with some quality, however, several studies have been done and found that the country has an education system where many students at the primary level (from 1st to 5th grade) have basic difficulties in reading, writing and counting.

Students in secondary schools reveal gaps similar to those of primary but also weak skills in applying knowledge to solve complex school problems as well as solving a problem in daily life, which makes these conclude that the quality of education in Mozambique is very low and needs various kind of research and interventions (Barreto, 2012; Bonde, 2016; Castiano & Ngoenha, 2013; Manuel & Madeira, 2016).

One of the innovations that can change the current scenario in Mozambique's education sector would be the introduction of a systemic approach to teaching and learning, a process that enhances the interaction between science, technology, and society, following the new paradigms of education in which the student is the centre of knowledge construction, actively participating in decision-making and changing behaviour and developing the student profile and the future professional.

To perceive the systemic approach is necessary to consider concepts and systems theories. A system is a set of interdependent elements to form a larger single set with the same goal. The term system is used in several disciplines, such as biology, medicine, business, physics, etc. (Churchman, 1971; Lieber, 1998). In the field of physics (in thermodynamics) the system is defined as the part of the universe that we intend to study (Peter & Jones, 2001; Peter & Paula, 2004).

The systemic approach "first of all, this term includes the idea of dealing with a group, with people who are in connection with and important from each other: A couple, a family, a clique of friends or a group of people at work can be considered as a system" (Herwig-Lempp, 1996).

The systemic approach runs on physical community systems which highlight three different types of systems, including:

- Open: a system that allows exchange with the environment, either the input or the output (raw material or finished product), suitable system for teaching-

learning process interactions and constant evolution of science-based on solving concrete problems of society;

- Closed: these are systems that do not allow the exchange with the environment. A system in which the school belongs or is embedded in the community but acts without interaction with this. This is the kind of system mostly used in Mozambican schools;
- Isolated: a system that is not part of society and there is no exchange between school and community.

According to law 6/92 (MINED, 1992), the government in the framework law allows the participation of other entities, including community, cooperatives, entrepreneurial and private in the educational process.

As set out by the government, education should opt for a systematic approach following the principles of the open system, where stakeholders (i.e. students, teachers, businesses, organizations, and society) interact in collaborative teamwork as a critical and crucial component of the commitment, quality and social justice concept of inclusion (Morgan, 2016).

The systemic principle manifested the vision of harmony in the world and wholeness in the interrelatedness of everything and is especially important in education (Broks, 2019).

1.1.1.2. Country conditions

Mozambique is a country in need of intervention in areas such as education, health, agriculture, and the environment. The research took place in the province of Manica, a province with the potential for farming and large amounts of mineral resources.

Although Manica is a potentially agrarian province, the malnutrition rates are high in contrast to the extraction of mineral resources which accelerates the erosion, soil pollution, and possible contamination of river water by mercury used in the mineral extraction process.

Manica province with an area of 62,272 km^2 has five higher education institutions, among them the University of Púnguè (the largest) has students in different areas, with an emphasis on science education and agriculture. However, despite being practical and experimental areas, most of the time they learn very theoretical content and there is a weak interaction with society and also a weak intervention in the resolution of day-to-day problems.

The teaching model (traditional) and methodologies implemented in science education in Mozambique and Manica in particular, go according to a closed systemic approach when "is displayed only what happens within an organization, regardless of the medium environment in which it is located" (Chiavenato, 2003, p. 72).

The learning process is continuous and consolidated with practice or experiences. Learning is a process that extends beyond school and to be effective it should take into account the needs of stakeholders and the environment in their surroundings.

> *"A major problem in science education is the failure of the most successful student to learn science. Too often learning is defined merely as the ability to repeat information found in the textbooks or provided by teachers such as view equates learning to remember what one reads or has been told*" (Yager, Mackinnu, & Blunck, 1992, p. 9).

As a lecturer and head of the research department, I felt that the increase of universities in the province and country as well are not directly proportional to the resolution of the problems from society at least where these are located. I notice also that the study is very encyclopedic (Ladas, 2001), where teachers are the holders and transmitters of knowledge, not leaving much room for creativity and decision-making or student participation in decision-making.

The community and the school are part of the same system and the interaction between them could bring additional gains mainly in the education sector both in quality of education as the acquisition of skills and transformation of Mozambican teaching traditional/conventional model for the new educational paradigms follow the constructivist model in which the student is the centre of education.

1.1.2. Objectives of the study

- Use connectivism and a systemic approach to promote cooperative learning, understanding abilities, and develop capacity for judgment and decide something based on information and facts;
- Promote learning in the Science-Technology-Society approach in a way to contextualized, effective, emotional, and sustainable learning;
- Prepare pre-service teachers for the internship and professionalization;
- Adopt learning beyond school in a systemic approach to improve learning and understanding of science in Mozambican curricula and the development of the communities.

1.1.3. Research questions

1) Conceptualization of a science-technology-society integration and a systemic approach for learning beyond school in Mozambique: What are the core elements? How can it be realized?
2) What are the structural and institutional preconditions to introduce these approaches to the natural science curricula at Púnguè university and secondary schools in Mozambique?
3) What are pre-service teachers´ pre-conceptions about using the science-technology-society integration and systemic approach in learning activities?
4) What are the outcomes of a local intervention that can be used to improve teaching quality and develop communities as well?

1.1.4. Hypotheses/Design-Based Research

The study takes place in a naturalistic context with intervening characteristics, where pre-service teachers understand nature by solving concrete problems of the society in their interaction with it (context issues) but also interacting with different places and institutions (universities, schools, companies, communities) that depend on the process of learning and building knowledge.

This study has characteristics of design-based research as it "focuses on understanding the messiness of real-world practice, with the context being a core part of the story and not an extraneous variable to be trivialized" (Barab & Squire, 2004, p. 4).

It was also designed to be applied in multiple theoretical perspectives (cognitivism, constructivism, and connectivism), with approaches and paradigms that contribute to the student's cognitive development and knowledge construction that promote changes in different variables.

These changes provide tangible results such as the development of prototypes, and the creation of scientific and technological tools that allow learners to produce and test theories that help them to understand how learning takes place but also allow the development of curricula and the students´ profiles.

To better clarify the variables, expectations, and possible impacts arising from the study, the table below was adapted according to the categories proposed by Collins (1992).

Category	**Design-Based Research**
Location	• Communities • Schools and • University
Variables	• Climate (establishment of a system consisting of pre-service students, university teachers, school teachers and students, public and private company employees, and people from the communities; collaborative work; finding or creating resources and conditions to develop strategic areas such as health and agriculture)
	Outputs and Outcomes: • Learning and effective application of certain contents, laws, and theories; • Development (in each of the seven schools and surrounding communities) of at least one interventional project related to the contents of the teaching programs; • Development of projects related to sensitive and strategic areas such as agriculture (assumed as the basis of development) and health; • Capitalization of community resources and development of technology for the production of food and health products; • Transfer of technology to communities;

	• Production of at least one monograph per project; • Dissemination of work in articles and scientific events; • The emergence of new projects (resulting from problems detected, profile developed, need to replicate, etc.) for a new intervention.
Focus	• Strategic areas and established priorities; • Improving the quality of education through paradigm and interventional approaches; • Capitalising on the resources available in the community as a means of learning.
Procedures	• Content learning by developing different projects; • Flexible projects depend on the students' choices and according to the needs and resources available in the communities.
Social interaction and role of participants	• Systemic approach: all stakeholders work together, interactively and collaboratively; • Communities also participate actively as the holders of indigenous knowledge, expertise, and resources; • Companies participate with knowledge and expertise, but also with resources; • Pre-service participants apply theoretical knowledge in practical activities for the good of the communities, enriching learning, developing their profile, and producing knowledge for their profession and future life.
Expected results/impacts	• Increased collaboration, communication, and interaction between students, schools, state and private institutions, and communities; • Pre-service: enrich learning, development of the scientist profile and attitudes, gain the ability and the culture of applying scientific knowledge to solve everyday problems, assume the posture of the active agent in the production of knowledge; • Lecturer: professional development and diversification of teaching methodology; • University: improvement of study plans and capitalisation of interventional approaches in the curriculum; • Capitalization of resources, material, financial and human resources among the members of the system; • To contribute to the reduction of ethnic-tribal discrimination through approximation and collaborative work among students.

Chapter II - THEORETICAL FRAMEWORK

2. Theoretical framework

Research in science education or even the teaching-learning process is in itself complex because it involves several aspects to take into account as a theory of education/learning, the nature of science, the applied teaching methodologies, the socio-economic dynamics (culture, behaviour, the habits, and customs) of the people involved, etc.

Research on the teaching-learning process is extremely sensitive, mainly to interventional research, as these deal with the educational policies and philosophies of each country, but also with humans, specifically students and teachers.

The main actors (students and teachers) in the teaching and learning activities are people with some prominence in psychic aspects, because the interaction between them and the contact or exposure with science, sometimes in an experimental way, allows them to build knowledge that sometimes exceeds the normal or acceptable limits of intelligence [6].

For Keim (2001) people differ from other animals because of the biological, psychological and social potentials that make us:

> *[…] capable of making history, of remembering the past and programming the future, of creating rules with which they judge, choose and decide in a conscious and pleasurable way, as a significant part of our planet not because of the volume they occupy, but because of their capacity to intervene and change environments. This homo should be seen in education from his humanity and should make an education that values and prioritizes this humanity having always before him the analysis of his actions in the perspective of humanization vs*

[6] Intellectual or cognitive ability is measured by the intelligence quotient (IQ) is a value obtained through tests developed in the relationship between "mental age" and "chronological age". And they are classified as: 121-130. Superdoptation; 110-120: Above-average intelligence; 90-109: Normal (or average) intelligence; 80-89: Dullness; 70-79: Borderline; 50-69: Slow Reasoning; 20-49: Reasoning far below average.

> *dehumanization without being anthropocentric in the self-eco-organizing perspective* (p. 12).

However, the learning theories applied and the motivational factors that can be intrinsic (which depends on the actors) or extrinsic (factors external to them) assume a very important role in the process of building this knowledge because after determining the policies and theories, both motivation and reason help greatly in removing barriers[7] to learning, increasing the desire and willingness to learn.

2.1. Learning theories

Learning theories are a set of methodological norms or standards to be followed that explain how a learner can best acquire, retain and recall new information according to previously defined goals that promote the construction of new knowledge.

Intrinsic (cognitive and emotional) and extrinsic (environmental) factors, as well as previous experiences, influence how understanding, or a view of the world and things is constructed or altered, and how knowledge is constructed and skills developed (Illeris, 2002; Ormrod, 2012).

Learning theories are an old concept and have been discussed since the time of Socrates (Millwood et al., 2013), the first steps toward theories of education arose from the work of Plato, also a former Greek philosopher and disciple of Socrates, when he asked the following question: “How does an individual learn something new if the subject itself is new to them?” (Fulbrook, 2019).

Later, Plato answered his “own” question by stating that knowledge is present at birth and all information learned by a person is merely a recollection of something the soul has already learned and known previously (Phillips & Soltis, 2015). This thought came to be called the "Theory of Recollection or Platonic epistemology" which was the classical learning theory.

[7] Aspects that negatively interfere with learning and obstruct the student's ability to achieve learning goals. The barriers can be psychological, environmental, emotional, cultural, or social.

Since then, several learning theorists (Fig 1) from different areas of expertise/training dedicated themselves to researching aspects related to teaching and learning, and as a result of this, different learning theories emerged, each with its principles, but all concerned with "how does the student learn?!"; this question being related to three dimensions: the content, the incentive, and the social and societal dimension, (Illeris, 2002).

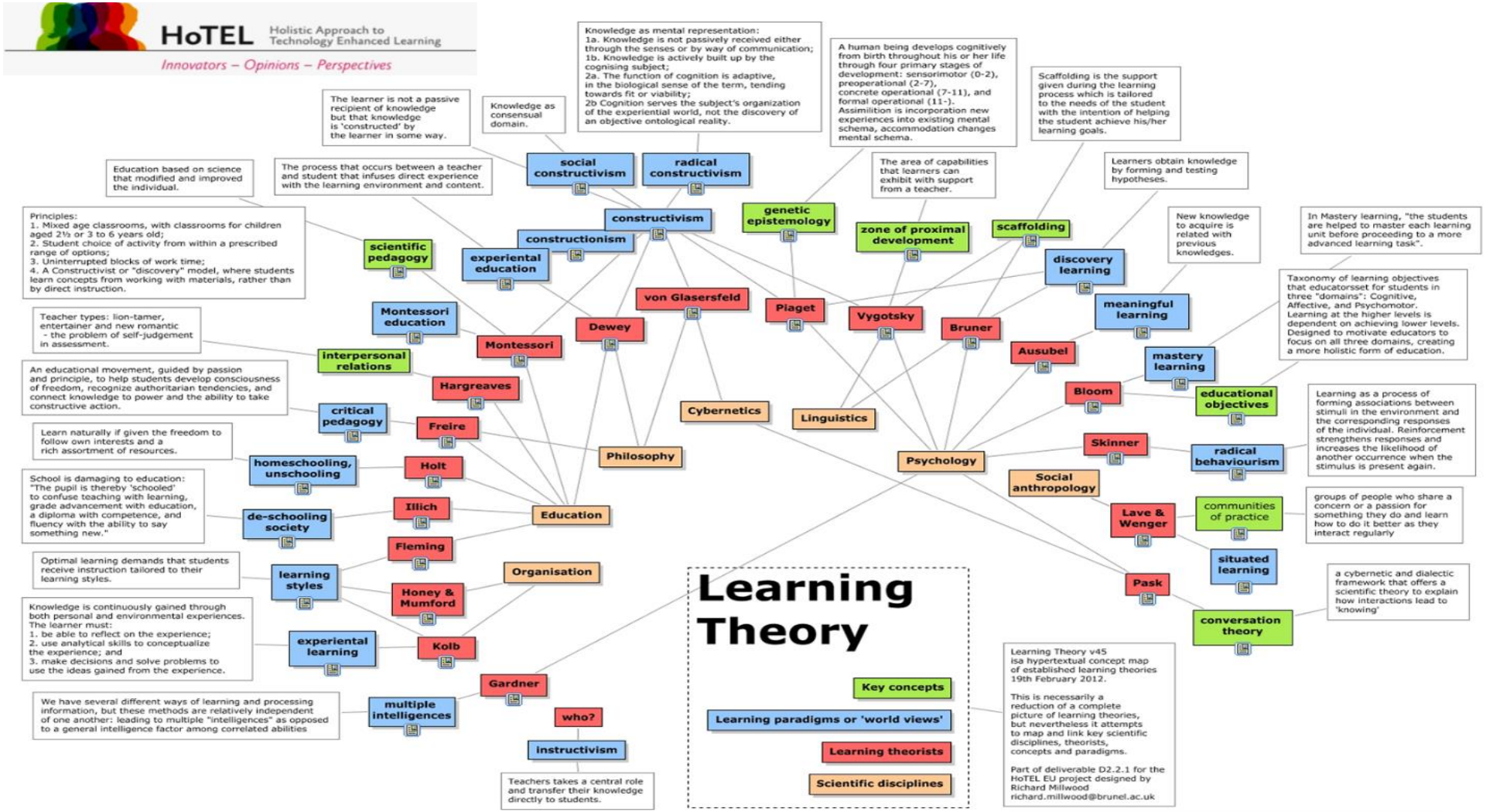


Figure 1. Learning theory and theorist (Millwood, 2013)

Currently, there are about fifteen education theories (Fulbrook, 2019), and learning schemata that have emerged from Vygotsky to Piaget and Bloom to Maslow and Bruner. Despite a large number of learning theories, some researchers summarise them in five which are: Behaviourism, Cognitivism, Humanism, Constructivism and Connectivism (WGU, 2021).

However, Humanism is practically similar to Constructivism, thus, after a deep analysis, the many learning theories end up interconverting and framing themselves into four main theories, namely Behaviourism, Cognitivism, Constructivism, and Connectivism.

To better explain the theories used in this study, a summary of the four learning theories mentioned above are presented below:

2.1.1. Behaviourism

Behaviourism is a theory of learning that focuses on an individual's observable and measurable behaviours that are repeated until they become automatic. It also deals with how an individual's external environment shapes his or her behaviour.

This theory emerged strongly in the 1910s and is most popularly associated with the work of Pavlov (using a bell as a way of alerting dogs at mealtimes), and other theorists such as James Watson, Skinner and Thorndike. Behaviourism remained a dominant theoretical perspective into the 1960s and 70s (James, 2006), in some countries, and goes up to the mid-1980s in others mainly developing countries.

“Behaviourism involves repeated actions, verbal reinforcement and incentives to take part. It is great for establishing rules, especially for behaviour management”, (Fulbrook, 2019, p. 2). Through this interaction, new associations are made and, thus, learning occurs. Learning is achieved when the stimulus provided changes with the behaviour.

For behaviourists, learning happens when the suggestion or stimulus is presented and the student reacts to them with the same type of response. This reaction of stimulus and response is repeated and becomes automatic. This change in behaviour in the face of the stimulus is what indicates that learning has occurred (Kelly, 2012).

Behaviourism is applicable as a learning theory when for example, persons:

- Aim to create measurable and observable learning outcomes among students;
- Do rote work or activities for students;
- Design repetitive practices for students;
- Provide tangible rewards and informative feedback or even bonus points (for participation or engagement) as an incentive to improve student learning performance;
- Give verbal reinforcement, using motivational words (“wonderful”, “well done”, “good job”, etc.)
- Establish rules and guide students in mastering a set of predictable skills or behaviours (Kelly, 2012; Rawson et al., 2018).

Therefore, despite many positive points from a motivational point of view, Behaviourism does not prepare students for problem-solving, freedom of thought, or creativity (Kelly, 2012). Behaviourism is a learning theory that may be more suitable for pre-school children or some early classes and not necessarily for adolescents and adults, as it is noted that it does not fit with current trends of scientific and technological development.

2.1.2. Cognitivism

Cognitivism in contrast to behaviourism is a theory of learning that focuses on the idea that students process information they receive rather than just responding to a stimulus. For this theory, learners are not a “blank slate” as with behaviourism (Fulbrook, 2019).

According to Fulbrook (2019, p. 3):

> *“Cognitive theories were developed in the early 1900s in Germany from Gestalt psychology by Wolfgang Kohler. In English, Gestalt roughly translates to the organization of something as a whole, which is viewed*

> *as more than the sum of its parts. In cognitivism theory, learning occurs when the student reorganizes information, either by finding new explanations or adapting old ones. This is viewed as a change in knowledge and is stored in the memory rather than just being viewed as a change in behaviour. Cognitive learning theories are mainly attributed to Jean Piaget".*

However, in both Behaviourism and Cognitivism there is behaviour change evidence, but there is also a big difference between them because, whereas in Behaviourism learning or behaviour change (by repetition and memorisation) is in response to stimulus in Cognitivism is in response to thinking and processing information.

In short, Cognitivism looks at the emergence of new patterns of behaviour and focuses on the thought process behind the behaviour. If someone decide to take a cognitive approach to design your material, must be sure to:

- Take into account in the learner, the characteristics that may promote or interfere with the cognitive processing of information.
- Consider and analyse which tasks are appropriate for the effective and efficient processing of information.
- Apply a variety of learning strategies that enable learners to link new information to prior knowledge (Rawson et al., 2018).

There are some examples and applications of cognitive learning theory:

- Classifying or chunking information.
- Linking concepts: associate new content with something known (spiral of contents).
- Providing structure (organizing your lecture in efficient and meaningful ways).
- Real-world examples (contextualized learning).
- Discussions (contribute to the production of knowledge).
- Problem-solving.
- Create and use analogies.
- Imagery/providing pictures.
- Mnemonics (Kelly, 2012).

Unlike behaviourists, cognitive theorists (Jean Piaget, David Ausubel, Robert Gagné) assume that “learning results in different kinds of human behaviours” (Ayalew, 2012, p. 6), which means that, each individual makes different sense of the same environment and situations, taking into account their different past experiences, cognitive processing undertaken, needs, expectation, aspirations, and motivations.

The difference between cognitive and behavioural skills can be seen (fig. 2), and the combination of these can determine the stage of learning competence below:

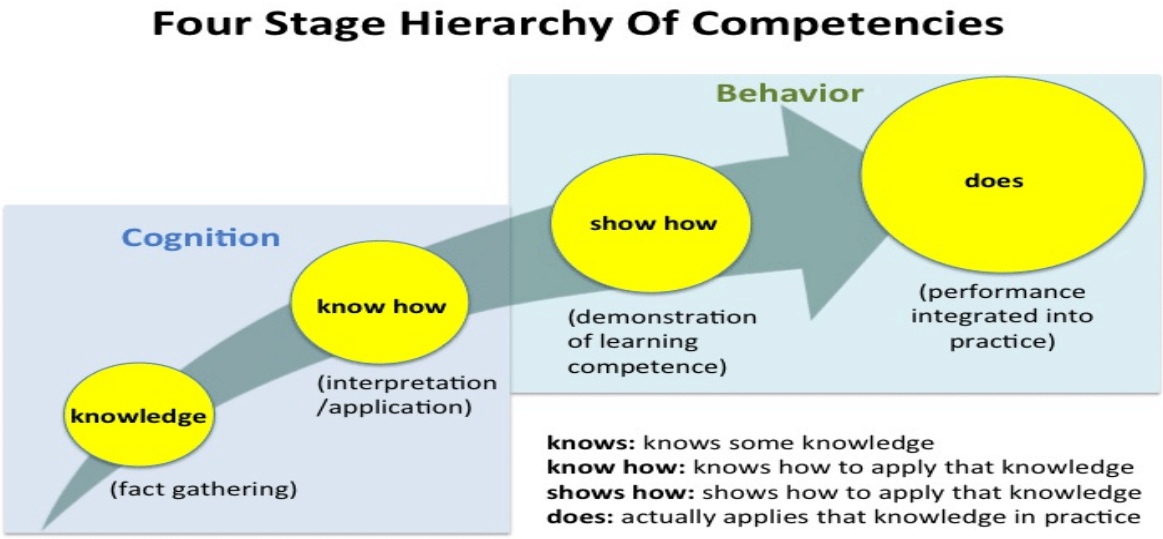


Figure 2. Four-stage hierarchy of competence
(W. Johnson, Vogel, DeCasal, Harris, & Arrighi, 2017)

2.2.3. Constructivism

Constructivism is based on the premise that we construct learning new ideas based on our prior knowledge and experiences. Learning, therefore, is unique to the individual learner (Fulbrook, 2019). Designers of this approach assume that every learner has a unique perspective, so the concept of the global ‘average’ learner is rejected (Bednar, Cunningham, Duffy, & Perry, 1992; Karagiorgi & Symeou, 2005).

“This theory empowers students to make choices about how and what they will learn results in a shift from having all learners learning the same things to allowing different learners to learn different things”, (Karagiorgi & Symeou, 2005, p. 6).

Constructivism places the learner at the centre of the learning environment and assumes that the learner isn't merely absorbing information passively but is actively involved in constructing knowledge individually (Rawson et al., 2018).

Constructivism as a theory of learning raises from Piaget´s project “genetic epistemology” or psychogenic theory (fig. 3) (Piaget, 1973, 1990, 2012), which intended to investigate how humans build knowledge from the earliest days of life and according to age group (Taber, 2012). This is the best-known constructivist conception of intelligence formation.

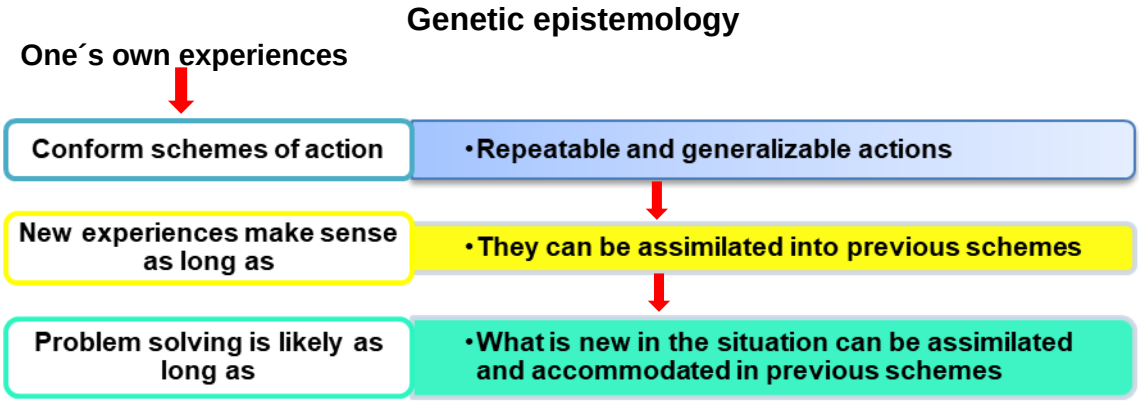


Figure 3. Schemata of the conceptualisation of Piaget's genetic epistemology. Adapted from Piaget and Garcia (1987)

It is generally assumed that knowledge is constructed by the individual himself in interaction with the environment. Vygotsky and the other Russian theorists emphasize the role of socio-cultural factors in the formation of behavioural structures (Coutinho & Moreira, 1991, p. 23), which means that society and culture (external factors) influence to a great extent the way of thinking and being (prior knowledge) and the interaction between these and the individual (actively) is what builds knowledge (new knowledge).

Constructivism is the last decade’s dominant theory that has roots in philosophy, psychology, and cybernetics and attempts to describe how people know the world (von Glasersfeld, 1989). Given the constructivist theory, knowledge is being actively constructed by the individual, and knowing is an adaptive process, which organizes the individual’s experiential world (Mayer, 1992; Taber, 2012).

Therefore, students are not considered to be knowledge producers responding to the stimulus, as in behaviourist theory, but rather as "already a scientist" (Hollow, 2000;

Solomon, 1994a, 1994b; Tuss, 1996), that actively builds knowledge while at the same time striving to make sense of the world based on experiences, goals, curiosities, and personal beliefs (Cole, 1992).

There are, according to Kelly (2012) some examples and applications of cognitive learning theory:

- Case studies.
- Research projects.
- Research-based learning.
- Brainstorming.
- Collaborative learning/ group work.
- Discovery learning.
- Simulations.

Aspects of constructivism such as "learner-centered learning", "experiential learning" and the fact that the student constructs knowledge individually and actively serve as great motivational factors in the learning process and an excellent methodology and principle for discovering the real world, producing theories, laws of science, medicines and other proposals for solving global problems and creating a new world.

2.2.4. Connectivism

Connectivism is a new generation learning theory and comes from the integration of principles explored by chaos, network, and complexity, and self-organization theories. Simon argues that learning is a process that occurs within nebulous environments of shifting core elements – not entirely under the control of the individual (Siemens, 2005, p. 5).

For Goldie (2016, p. 4) this “is one of the most prominent of the network learning theories that have been developed for e-learning environments”, a systemic approach in the learning process as well as for sharing and transfer of knowledge.

The term “connectivism” was first “coined” by George Siemens in 2004 “to describe learning networks” and share it with Stephen Downes (Downes, 2005, p. 4), and later on in 2005 Siemens published an online article entitled “Connectivism: A learning

theory for the digital age" ideas which have been developed by contributions from Downes (2005, 2006, 2008, 2012).

In a way, Siemens and Downes' connectivism works just like Bertalanffy's systemic approach since for Siemens, learning happens in a group of people or entities that constitute the network, and in the book of Siemens (2005), Downes proposes the definition of a network as follows:

> *"A network can simply be defined as connections between entities. Computer networks, power grids, and social networks all function on the simple principle that people, groups, systems, nodes, and entities can be connected to create an integrated whole. Alterations within the network have ripple effects on the whole*", (Siemens, 2005, p. 5).

In proposing connectivism as a learning theory, Siemens also drew on Karen Stephenson's statement which reads as follows:

> *"Experience has long been considered the best teacher of knowledge. Since we cannot experience everything, other people's experiences, and hence other people, become the surrogate for knowledge. 'I store my knowledge in my friends' is an axiom for collecting knowledge through collecting people "* (Siemens, 2005, p. 4).

For Downes (2012, p. 9) "Connectivism is the thesis that knowledge is distributed across a network of connections, and therefore that learning consists of the ability to construct and traverse those networks". Furthermore, Downes argues that:

> "*Knowledge is literally the set of connections between entities. In humans, this knowledge consists of connections between neurons. In societies, this knowledge consists of connections between humans and their artifacts. What a network knows is not found in the content of its entities, nor in the content of messages sent from one to the other, but rather can only be found through recognition of patterns emergent in the network of connections and interactions. Therefore, learning is the*

> *creation and removal of connections between the entities, or the adjustment of the strengths of those connections* (p. 9).

In the case of learning communities, it is very important to create conditions so that the networks formed can learn, adapt to the environment and situations and avoid stagnation, destruction, or network 'death'. Learning communities are defined as "the clustering of similar areas of interest that allows for interaction, sharing, dialoguing and thinking together (fig. 4)" (Siemens, 2005), and the participation results in conversations between learners and other members of the community including more knowledgeable others (Goldie, 2016).

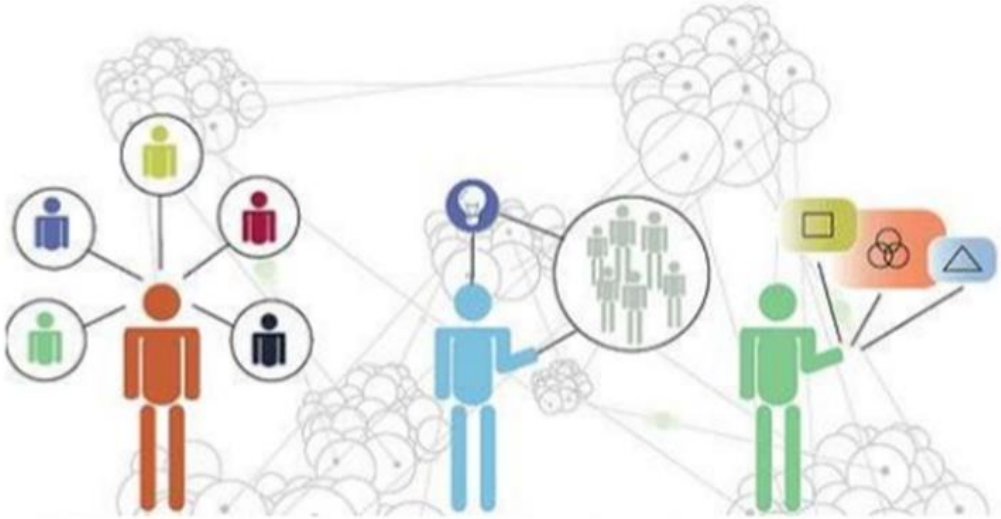


Figure 4. Connectivism Learning Theory from George Siemens and Stephen Downes. Adapted from (Austen et al., 2014)

2.2.4.1. Principles of connectivism

Connectivism as a learning theory is guided by the following principles:

- Learning and knowledge rest on different points of view and a diversity of opinions.
- Learning is a process of connecting specialized nodes or information sources.
- Learning may reside in non-human appliances.
- The capacity to know more is more critical than what is currently known.
- Nurturing and maintaining connections is very important and needed to facilitate continual learning.
- The ability to see, identify and perceive connections between fields, ideas, and concepts is an essential competence.

- Currency (accurate, up-to-date knowledge) is the intent of all connectivist learning activities.
- Decision-making is itself a learning process.

Further, in connectivism, choosing what to learn and the meaning of the information received is viewed through the lens of changing reality. For, while there is a right answer to a given situation now, tomorrow it may be wrong due to changes in the information climate, which affect the decision (Goldie, 2016; Siemens, 2005).

This fact increasingly elucidates the idea that knowledge is not something static but something that must be constantly updated by various sources and it is for this reason that it needs to be produced based on various sources of information and connections, different points of view, opinions, experiences, and real facts.

2.2.4.2. Difference between connectivism and other theories of learning

A central tenet of most learning theories is that learning occurs within a person. Even social constructivist views, which hold that learning is a socially enacted process, promote the principality of the individual (and their physical presence - i.e., brain-based) in learning. They also fail to describe how learning occurs within organizations (Siemens, 2005, p. 3).

However, connectivism presents a different approach from all other learning theories, as these theories address learning that occurs outside of people (i.e., learning that is stored and manipulated by technology, knowledge stored in a prototype, or storing your knowledge in another person, etc.).

For this study, was used a set of three learning theories: (i) Cognitivism (connecting concepts, real-world examples, discussions, problem-solving, creating and using analogies); (ii) Constructivism (inquiry projects, inquiry-based learning, collaborative learning/group work, discovery learning, simulations); and (iii) Connectivism (diversity of opinions, connecting expert nodes and information sources, learning residing in non-human devices, nurturing and maintaining connections, seeing links between fields, ideas, and concepts, up-to-date knowledge, decision making).

The implementation of the mix of the above three theories was done through two different approaches, (i) integration Science-Technology-Society and (ii) Systemic approach, establishing a contextualized teaching model to make learning effective, emotional, and sustainable.

2.3. Science, Technology and Society

The interaction between science, technology, and society is a relationship that has been going on for centuries. Scientific and technological development has as its main objective the socio-economic development of populations, solving concrete problems that affect them, such as hunger, poverty, and crime.

On the other hand, science and technology have been used for actions that are harmful to this same community, such as global warming resulting from the massive release of greenhouse gases, the development and use of nuclear and chemical weapons, the development of viruses, and indiscriminate contamination of the population, development of missiles of mass destruction, etc." The idea that the development of science and technology also had the potential to destroy society became evident in the years just following World War II" (DeBoer, 2000, p. 584).

Interest and debate on integration between Science, Technology, and Society, such as revolutions in science and technology, public concerns about the environment and resources, and general reform of the curriculum have contributed to a new educational theme, science-technology-society (STS) (Bybee, 1986; Roy, 1985; Rubba, 1987), and this, in turn, gave rise to an international movement.

> "*The STS movement has grown as a result of a general feeling of disappointment from the outcomes of the curriculum reform of the 1960s. It is important to realize that many of the basic ideas and goals of the 1960s have been adopted by STS reformers. These include student growth in the processes of science, the nature of science, the concepts of science, and attitudes toward science. Among the main differences between the STS programs and the curricula of the 1960s is the STS*

> *focus on the applications and use of knowledge, their relevance to the life of the individual and society, and the central role of the teacher in curriculum development*" (Yager & Tamir, 1993, p. 637).

The meaning of STS is too broad and encompasses several feelings and scientific areas. Although there has been an STS movement for some decades, "STS as a term was coined by John Ziman an STS movement´ supporter" (Yager, 1993, p. 145).

For Ziman (1980), the meaning of STS is too broad going by different names, such as Social Studies in Science; Science of Science; Social Responsibility in Science; Science in a Social Context; Social Relations of Science and Technology; etc, and also encompasses several feelings, fancy, pain or fancy as well as different scientific areas History/Philosophy/Sociology/Technology; etc. Further, Ziman proposed to call it cryptically STS; which is the abbreviation for Science, Technology and Society.

The polysemy above shows with certainty that, there is a view that science of any period is not divorced from its social and cultural context, but there are still few empirical studies of the real existing correlations (Merton, 1938).

Somehow the STS movement is concerned with aspects related to the social world of students in the teaching and learning process, specifically in the way they construct, resist or change concepts. Therefore, students' social worlds were seen to influence the way students make sense out of their natural world.

> "*Science, Technology and Society STS is an interdisciplinary*[8] *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*" (Mansour, 2009, p. 2).

[8] The combination of two or more academic disciplines/subjects or field into one activity (e.g., a research project).

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.

The National Science Teachers Association (NSTA, 1990) defines science-technology-society (STS) as teaching and learning science in the context of human experiences.

The STS content in a science education curriculum is comprised of interaction between science and technology, or between science and society; and any one or combination of the following:

- A technological artifact, process, or expertise
- The interactions between technology and society
- A societal issue related to science or technology
- Social science content that sheds light on a societal issue related to science and technology
- A philosophical, historical, or social issue within the scientific or technological community (Aikenhead, 1994, p. 51).

. In 1982 the National Science Teachers Association (NSTA) established STS as the central goal of science education and also states that the goal of science education during the 1980s is:

> "*To develop scientifically literate individuals who understand how science, technology, and society influence one another and, who are able to use their knowledge in their everyday decision-making. The scientifically literate person has a substantial knowledge base of facts, concepts, conceptual networks, and process skills which enable the individual to continue and learn logically. This individual both appreciates the value of science and technology in society and understands their limitations*" (NSTA, 1982, p. 1).

In Mozambique, the term STS is still somehow new. Normally this approach has been applied without in-depth knowledge of the norms, philosophies, and principles of this, but as schools are inserted into communities, and in turn, this community has been part of the political structure of the school called "school council" on one hand.

On another hand, the precarious conditions of life of the majority of populations demand that there be greater interaction between schools and communities, but the need for the application of technology for scientific, social, cultural, and economic development is also growing.

The importance of Science-Technology-Society (STS) integration in contemporary education and the difference between this approach with traditional approaches can be understood through the characteristics of each of these in the following table.

Table 1. Some characteristics of STS and Traditional instruction approaches

STS*	Traditional
• Student-centered	• Teacher centered
• Individualized and personalized, recognizing student diversity	• Group instruction geared for the average student
• Uses a variety of resources	• Directed by the textbook
• Cooperative work on problems and issues	• Some group work, primarily in the laboratory
• Students are considered active contributors to instruction	• Students are seen as recipients of instruction
• Teachers build on student experiences, assuming that students learn best from their own experiences	• Teachers do not build on students' experiences, assuming that students learn more efficiently by being presented with organized easy to grasp information
• Teachers plan their teaching around problems and current issues	• Teachers plan their teaching from prescribed curriculum guides and textbooks

*As utilized in the Iowa Chautauqua Program and as defined by the NSTA (Yager & Tamir, 1993)

2.4. Systemic approach

The concept of systemic approach had its origins between the 40s and 60s through ideas orally published by the Austrian von Bertalanffy (1968). It began in 1940 when he created the concept of the "general systems theory", an initiative and ideas that were even published in his book "General system theory: foundations, development, applications".

In that book, a system was defined as a set of entities with relations between them. The system is also defined as the bounded region in space-time, in which the parts are associated in functional relationships (Heragu, 1998).

The system can be opened, closed, and isolated. An “open system” presents relations of exchange with the environment, through inputs and outputs, this kind of system exchanges matter and energy regularly with the environment.

A "closed system" exchanges only energy and does not exchange matter with the environment around it, and finally, an isolated system, exchanges neither energy nor matter with the universe, it is an ideal and imaginary system, or it does not exist in the real world.

Bertalanffy's ideologies advocated an exchange system or open system in a more general way and deepened aspects that lead to a system with a holistic view (von Bertalanffy, 1968). In case of a lack of establishment of an interdependent relationship, it is considered to be a closed system.

To elucidate the importance of the system, Bertalanffy recounted the following expression:

> “*Technology has been led to think not in terms of single machines but in those of "systems." A steam engine, automobile, or radio receiver was within the competence of the engineer trained in the respective specialty. But when it comes to ballistic missiles or space vehicles, they have to be assembled from components originating in heterogeneous technologies, mechanical, electronic, chemical, etc.”* (von Bertalanffy, 1968, p. 4).

In the natural sciences, one can consider a system to be the set of subjects or areas of knowledge that dynamically exchange scientific and pedagogical knowledge (interdisciplinary), thus providing the tools for the interpretation of natural phenomena in a joint and integrated way and not in a fractional, fragmented or isolated way (Frodeman, 2010; Mansilla & Lenoir, 2010).

In the science education sector specifically the natural sciences present a very high level of complexity (Baimyrzaeva, 2018; Harrison & Mannion, 1996; McMullin, 1984) since this complexity derives from the natural science’s goals namely:

- understand the natural world (pure research).

- explain the events of the natural world (analysis of facts).
- research to solve a particular problem (applied research).
- solve identified problems (intervention work/technology).

The complexity of natural science assigns increased responsibilities to science-makers, where they need to have a knowledge domain for interpreting and evaluating the world critically. Therefore, in short, to become a critical consumer of scientific knowledge, science education requires a triumvirate of knowledge and understanding of:

- scientific content.
- a scientific approach to apply.
- science as a social knowledge/issue - that is the social practices or challenge of the community.

Such an understanding of the items above mentioned is also needed because it solves and will keep solving the political and moral dilemmas of the twenty-first century.

2.4.1. Definitions of a systemic approach

The system and a systemic approach have been defined in different ways and by different authors over time as can be seen in the following table.

Table 2. Definitions (summary) of System and Systemic Approach

Definition	Authors
A system is a set of interdependent elements to form a larger single set with the same goal.	(Churchman, 1971)
The system is the part of the universe that we intend to study	(Peter & Jones, 2001; Peter & Paula, 2004)
Systemic approach: the idea of dealing with a group, with people who are in connection with and important to each other: group of people at work, can be considered as a system	(Herwig-Lempp, 1996)
A systemic approach advocates a study in harmony, cooperation and transdisciplinary	(Chiavenato, 2003; Czerniak & Johnson, 2014; King et al., 2009; Schallies, 2010)
Systemic Approach: a group of people/institutions with the same goal, working together in cooperation or collaboration, affecting the entire body or system as a whole changing or transforming their environments	

2.4.2. Objectives of using the systemic approach of teaching and learning Chemistry (SATLC)

The systemic approach in the teaching and learning process is applied following the following objectives:

1. Growing the ability of students on thinking systemically: so that the student will be able to see globally any subject without missing its parts.
2. Growing the ability to see the relationships between things more than things themselves.
3. Increasing the effectiveness of teaching and learning chemistry.
4. Making chemistry subjects attractive to students instead of being repulsive to them.
5. Growing the ability for analysis and synthesis to reach creativity that is the most important output of a successful educational system.
6. Creating a new generation that can work positively with the environmental system around them.
7. Growing the ability for the use of the systemic approach in acting with any problem to put the creative solutions for it (Fahmy & Lagowski, 1999, p. 2).

2.4.3. Importance of a systemic approach for education

This approach plays a very important role in the education system today, and this importance is revealed in the following facts:

1. Framework for planning, decision-making control, and problem-solving.
2. Throws light on the dynamic nature of management.
3. Provides a unified focus to institutional efforts.
4. Helps to look at institutions as a whole and not as parts.
5. Helps the manager to identify the critical subsystems and their interaction with each other.
6. Helps in improving institutions.
7. Helps in bringing efficiency to school administration and management.
8. Helps in systematic educational planning.
9. Maximum utilization of resources.
10. Helps in improving the examination and evaluation system.

11. Maintaining, controlling, and improving the guidance services.
12. Designing, controlling, and improving the non-formal and adult education system.
13. In improving the quality of education.
14. In improving (in and pre-service) teacher training programs (Gupta & Gupta, 2013).

Both the objectives and the importance of this approach in the teaching and learning process, bring the philosophy of greater commitment, responsibility, and engagement of each individual or institution as part of a system.

In the education sector, the systemic approach plays an affective role, since education starts at home and the results of the teaching and learning process (formal education) serve as pillars for the development of a society, where the school prepares its students with the best possible quality and in turn, these students apply their knowledge in companies and institutions that carry out their activities in this same society.

The development of science and technology, climate change, the challenge of trade, politics, etc., carries with it challenges that by their nature need a multi-sector intervention and/or different specialists, thus implementing a systemic approach.

According to (von Bertalanffy, 1968, p. 4)

> *Politicians frequently ask for application of the systems approach to pressing problems such as air and water pollution, traffic congestion, urban blight, juvenile delinquency and organized crime, city planning etc., designating this a "revolutionary new concept*.

The concept of the systemic approach arises from the assumptions of the general system theory that systems cannot be fully understood only by separate and exclusive analysis of each of their component/ core elements, but rather by understanding the reciprocal interdependence of all core elements and the need for their integration, cooperation, and collaboration.

Manning (1967) quoted by von Bertalanffy (1968), writes the systems approach to his political platform saying that: "an interrelationship exists between all elements and constituents of society. The essential factors in public problems, issues, policies, and programs must always be considered and evaluated as the interdependent components of a total system ".

In this study, the student is the main author in the construction of the know-how and, thus interacts with the community, the environment, governmental and non-governmental institutions, establishing a system for teaching, learning and resolving day-to-day problems.

In a systemic approach, the holistic entity is valued and given greater priority, but even so, subparts or core elements are not neglected on the one hand. On the other hand, the profile (skills, capabilities, training area, or contribution) is selected based on the objectives, needs, and challenges of the mission/activities/program. However, the main principles of the systemic approach are:

a) **Holism:** A change in any part or core element of a system affects the whole system (Boulding, 1985; Litterer, 1973; von Bertalanffy, 1968).
b) **Specialization:** A whole system can be divided into granular (smaller and easier to understand) core elements, so that the specialized role of each core element is appreciated, mainly for the distribution and assignment of specific tasks and responsibilities, which makes the system more productive (Thakur, 2012).
c) **Non-summational:** Every core element (subsystem/partial system) is of importance to the whole. It is therefore essential to understand the actions of each core element to get a holistic perspective (Boulding, 1985; Litterer, 1973).
d) **Grouping/interdisciplinarity/transdisciplinarity:** The creation of a group of people with different skills and specializations is very important for a system, but this diversity must be controlled to avoid a vacuum, frustrations, or even failure. To avoid this, it is essential to group according to a scientific area (e.g., people from social sciences/natural sciences), specialization, or even related disciplines and sub-disciplines.

e) **Circular and multiform causality, non-linearity**: A causal link is non-linear, but a non-linear or more refined explanation model is required to prevent many parts of the system from being affected at different times (Jokela, Karlsudd, & Östlund, 2012; Shazer, 1994).

f) **Emergent properties:** This is an important concept of a systemic approach. It means that the group of interrelated entities (core element) has properties as a group that are not present in any individual component. This is the holistic view of a system (Jackson, Hitchins, & Eisner, 2010).

A systemic approach that involves individuals, companies, and institutions interacting with each other and life in the same community, presupposes that teaching is contextualized. Therefore, it creates opportunities for stakeholders to contribute to improving the quality of learning and, at the same time, help to solve other problems that affect them. In this way, the systemic approach plays an important role in improving incomes, improving living conditions, and above all, contributing to improving their quality of life.

Table 3. Resources for Evidence-Based Practice. Systematic Reviews Other Reappraised Evidence

Country	Topic	Authors	Summary
Kenya, Tanzania, and Uganda	Developing a systemic approach to teacher education in sub-Saharan Africa:	(Hardman, Ackers, Abrishamian, & O'Sullivan, 2011)	While many countries in Eastern and Southern Africa are on track for meeting the Education for All targets, there is a growing recognition of the need to improve the quality of basic education and that a focus on pedagogy and its training implications needs to be at the heart of this commitment. By drawing on three East African countries, Kenya, Tanzania, and Uganda, which are at different stages of development with regard to the reforming of teacher education, this paper explores the challenges and the lessons learned from each of the countries with regard to the development and strengthening of pre and in-service training. The tension between quality, breadth, and cost-effectiveness is explored together with a broader discussion of key principles to be taken into account when enhancing teacher education in the region as a whole.
Ukraine	Systemic approach and mathematical modelling in physical education and sports	(Lopatiev et al., 2017)	Mathematical modelling, alongside physical and live experiments, is one of the main means for obtaining new knowledge in different spheres of natural sciences. Its importance will grow further but not replace physical and live experiments, because experience always is the base of any research. In physical education, the objects of mathematical modelling include the age dynamic of the cardio-vascular system's functional state and children's and adolescents' motor fitness; modes of physical exercises' fulfilment and their influence on the efficiency of motor functioning; motor training of adolescents and children. For receiving models, the following can be used: full factorial experiment of 2k type (models of training impacts), logistic function (determination of training process and motor abilities' growth periods), and discriminant function (pedagogic control over fitness level). Conclusions: at the present stage of science development modelling is one of the most efficient and promising tools for studying complex phenomena and processes. All methods of scientific research are based on the idea of modelling: theoretical (with the help of different abstract models); experimental, based on subjective models. A modelling method is an effective tool for studying the laws of adolescents' and children's motor training and working out of the program for it.
The U.S.A and other developed countries(Britain,	Reforming Education: The Emerging	(Jacobson & Berne, 1993)	This book, the 14th yearbook of the American Education Finance Association (AEFA), provides a review and appraisal of the "educational perestroika" that has occurred over the past decade, both in the United States and in other developed countries. Rather than assessing the outcomes of a decade of educational reform, it examines the present and future of educational reform. Part 1 contains seven chapters that explore reform initiatives

Canada, and Germany)	Systemic Approach		in the United States, while the second part is comprised of four chapters that examine reform initiatives abroad. Part 3 considers the future of school reform. Following the preface, the chapters include: (1) "School Reform in the United States: Putting It into Context" (Susan H. Fuhrman, Richard F. Elmore, and Diane Massell); (2) "Cooperative Performance Incentives in Education" (Craig E. Richards, Daniel Fishbein, and Paula Melville); (3) "'Professionalizing' Teaching by Expanding Teachers' Roles" (Betty Malen); (4) "Decentralization and Community Control" (G. Alfred Hess, Jr.); (5) "Negotiating Reform: Preliminary Findings" (Julia E. Koppich and Charles Taylor Kerchner); (6) "Educational Choice: Competing Models and Meanings" (Bruce S. Cooper); (7) "Cost Analysis as a Tool for Education Reform" (David H. Monk and Jennifer A. King); (8) "International School Reform: Political Considerations" (Frances C. Fowler, William L. Boyd, and David N. Plank); (9) "Pursuit of School Quality in England and Wales" (Peter Ribbins and Hywel Thomas); (10) "Benevolence in Canadian Public Schools" (Daniel J. Brown); (11) "Educational Transformations in a 'United' Germany" (Wolfgang Mitter and Manfred Weiss); and (12) "School Reform and the 'New World Order'" (James W. Guthrie). A subject and author index are included. The appendix contains a list of the AEFA Board of Directors, 1993-94. (LMI) The final section of the book considers the future of school reform in light of the changing realities of the 90′s, concluding with a look at rapidly changing national economies, the increasing politicization of education policy, and the likely consequences of these changes on schools and educators.
Egypt	Attractive Educational Strategies in Teaching and Learning Chemistry (Awad, 2017)	Awad, 2017)	The main objective of this article is to find attractive and appropriate educational strategies and methodologies that could be used in teaching and learning chemistry to attract new generations to appreciate studying the most important discipline in science; chemistry. Chemistry is considered the central backbone of science since its concepts and theories can explain all scientific phenomena. Since science is the core of human sustainability, therefore improvement of chemical education would result in the improvement of social sustainability. Attractive educational strategies in teaching and learning chemistry can be achieved by using attractive and interactive appropriate methodologies such as Systemic Approach (SATLC), E-learning, M-learning, and any other tools in which modern technologies are integrated. *[African Journal of Chemical Education—AJCE 7(3), Special Issue, October 2017].*

Singapore	Understanding the Sustainability of a Teaching Innovation for Problem Solving: A Systems Approach	(Kin et al., 2019)	This chapter investigates which key factors contributed to or impeded the sustainability of a Mathematics Problem Solving teaching innovation that was implemented in four schools in Singapore. Recognizing that the sustainability of teaching innovations involves several interconnected components, we adopt a systems approach for this investigation. The research aim of this chapter is to develop a theoretical model that helps identify facilitators and impediments to the sustainability of this teaching innovation. Such identification is a first step to understanding systemic problems that plagued those schools in which this teaching innovation failed to sustain.
India	The Systems Approach in Education	(Gupta & Gupta, 2013)	Views of socialization, goals of education, regulations, practices, and activities within the community, school, and classroom, outcomes assessments, and personal/family values and beliefs interrelate in the total educational system. Unfortunately, the various elements of the system are not always consistent with each other. This dissipates the energy available to help children learn. Lining up the elements in a planned intervention, conceptualized from a systems perspective will increase the likelihood that the community will be focused on educating each child. If the elements are working together then, perhaps the Nigerian proverb that it takes a whole village to educate a child would be a reasonable hope.

2.5. Motivation

Motivation is one of the fundamental aspects of the process of acquiring knowledge because, by itself, it involves other factors such as attention to content or activities, the will to learn, knowing how to do, dedication to activities and tasks, collaboration in the process of acquiring and building knowledge, etc.

Contemporary paradigms and research interests in human motivation have their origin in three distinct sources, namely: psychotherapy, psychometrics, and learning theory (Birney & Teevan, 1962). However, there is divergence not only in the areas described but also in the study objectives and methodologies applied by the researchers involved.

I. **Psychotherapy:** focuses on the relief of the client's discomforts. Freud saw these discomforts as aspects resulting from a game of dynamic balance of psychic (motivational) forces, and the psychotherapist himself was the instrument of measurement of these forces. In psychometry, no importance was given to individual differences, because the study was directed case by case and the motivational system could be applied based on the perception of the afflictions of each individual.

II. **Psychometrics:** focuses on the development of psychological aptitude and performance tests. These tests were aimed at the classification and/or selection of individuals, based on a fundamental assumption, that of equality in dedication to tasks. Interest in aptitude tests led to the development of motivation tests in two areas, psychotherapy and psychometrics, and did not develop entirely independently.

III. **Learning theory:** was based on the study of learning problems which led to the invocation of motivational variables. Through the psychology of learning and laboratory research, it was noted that interests in the educational area exert some influence on motivational variables (Birney & Teevan, 1962; Todorov & Moreira, 2005)**.** Experimental studies have focused on the role of motivational variables in memory, learning, etc. (Hull, 1943).

For Stirling (2014), "motivation is a topic of interest to researchers in a variety of fields including psychology, human development, education, sociology, and business".

So far, the term motivation does not find consensus in its definition, as it can take on different categories according to the reality of the facts but also factors that human motivation. Therefore, the term "motivation" is used in different contexts, assuming different meanings and as a result of cultural constructions and interactions with the environment (Pintrich, 2003; Skinner, 1953; Todorov & Moreira, 2005).

The diversification of the area of interest, object, and objectives is considered a major difficulty in the psychology of motivation (Kleinginna & Kleinginna, 1981). So, different authors have chosen to classify the definition of motivation. So, Kleinginna & Kleinginna points to four categories, subdivided as follows:

(i) two categories of definitions emphasized internal mechanisms (phenomenological and physiological);
(ii) three emphasized functional processes (energizing, directing, and vector);
(iii) two restricted the scope of motivation (temporal-restrictive and process-restrictive); and
(iv) two emphasized the comprehensive nature of motivation (broad/balanced and all-inclusive) (Kleinginna & Kleinginna, 1981).

In general, the first five categories above refer to internal aspects involving biochemical factors (physiological and hormonal) and the remaining four refer to factors external to the individual (environment, social and cultural aspects). So, despite the separation into categories, they are interdependent.

In “A Theory of Human Motivation” Maslow subdivides motivation into three different categories, namely: (i) basic needs involving physiological needs and safety needs; (ii) psychological needs that involve, belonging & love needs and esteem needs and; (iii) self-fulfilment needs that involve self-actualization

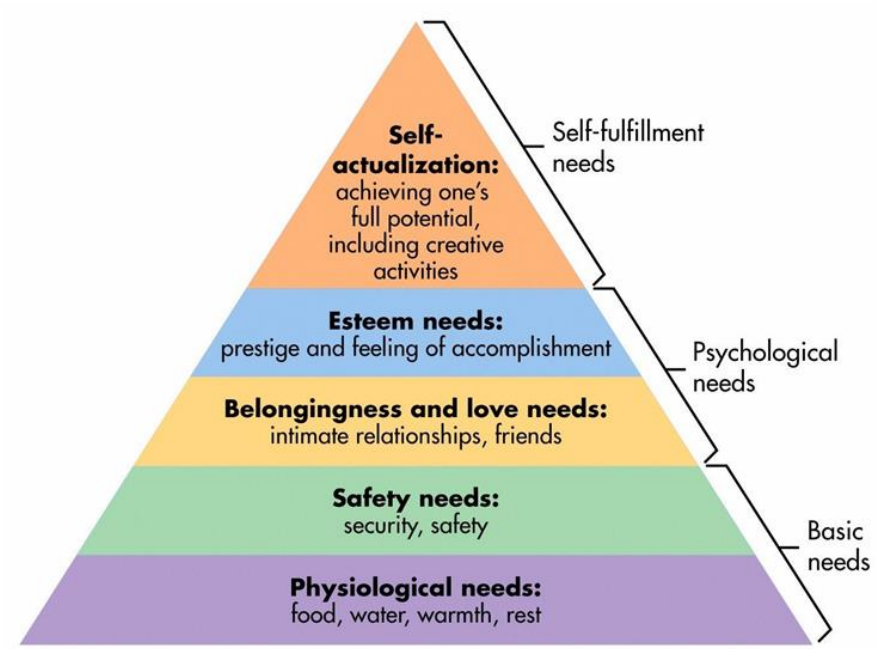


Figure 5. Maslow´s hierarchy of needs.
(McLeod, 2020, p. 1)

Motivation involves needs, feelings, and ability where one influences the other. Therefore, Maslow's categories are explained as follows:

1. **Physiological needs** - these are biological requirements for human survival, e.g., air, food, drink, shelter, clothing, warmth, sex, and sleep. If these needs are not satisfied the human body cannot function optimally. Maslow considered physiological needs the most important as all the other needs become secondary until these needs are met.
2. **Safety needs** - protection from elements, security, order, law, stability, freedom from fear.
3. **Belongingness and love needs** - after physiological and safety needs have been fulfiled, the third level of human needs is social and involves feelings of belongingness. The need for interpersonal relationships motivates behaviour
4. Examples include friendship, intimacy, trust, acceptance, receiving and giving affection, and love. Affiliating, being part of a group (family, friends, work).
5. **Esteem needs** - which Maslow classified into two categories: (i) esteem for oneself (dignity, achievement, mastery, independence) and (ii) the desire for reputation or respect from others (e.g., status, prestige). Maslow indicated that the need for

respect or reputation is most important for children and adolescents and precedes real self-esteem or dignity.

6. **Self-actualization needs** - realizing personal potential, self-fulfilment, seeking personal growth, and peak experiences. A desire “to become everything one is capable of becoming” (Maslow & Frager, 1987, p. 64).

In these categories, it is possible to notice that there are aspects that depend exclusively on the individual (internal aspects), and those that depend on the society/environment in which the individual lives (external aspects).

For McLeod (2020) this five-stage model of motivation of “A Theory of Human Motivation” from Maslow can be divided into two different categories (i) deficiency needs and (i) growth needs. For him, the first four levels (Physiological needs, Safety needs, Belongingness & love needs, and Esteem needs) are often referred to as deficiency needs (D-needs), and the top-level (Self-actualization needs) is known as growth or being needs (B-needs).

Furthermore, McLeod (2020, p. 2) argues that:

> “*Deficiency needs arise due to deprivation and are said to motivate people when they are unmet. Also, the motivation to fulfil such needs will become stronger the longer the duration they are denied. For example, the longer a person goes without food, the morehungry they will become”.*

Maslow´s hierarchy of needs is considered effective for classroom studies (Stirling, 2014) and he calls for attention to the control of external factors, from teacher to environment, which must be controlled and interfere in the performance/motivational variants of each individual. For motivation in education, he argued that a humanistic educational approach would develop people who are:

> “*Stronger, healthier, and would take their own lives into their hands to a greater extent. With increased personal responsibility for one’s personal life, and with a rational set of values to guide one’s choosing, people*

> *would begin to actively change the society in which they lived*" (Maslow, 1971, p. 195).

"Maslow's hierarchy of needs and a person's desires to satisfy them can be considered intrinsic. He held that these needs were universal to humans, but that they could manifest in myriad ways based on environmental conditions and an individual's culture and history" (Stirling, 2014, p. 5).

To connect the effects of the environment on motivation, Maslow distinguished behaviour theory, and motivation theory, arguing that "behaviour is determined by several classes of determinants, of which motivation is one and environmental forces are another" (Maslow, 1971, p. 11).

Contrary to Maslow's scientific view, several studies on motivation in academia do not theoretically distinguish between behaviour and motivation in precisely the way that Maslow proposed; instead, they look at cognitive and social constructs, sometimes in addition to needs and affective factors, when developing theories and designing research on motivation and motivated behaviour (Pintrich, 2003, p. 670).

For a better understanding of the terminology "motivation", some authors resort to factors that affect or interfere with motivational aspects, namely Self-Determination Theory (SDT) which has been developed to try to integrate both internal (the intrinsic) and external (extrinsic) factors in human motivation, thus incorporating both the intrapsychological and social-cultural aspects (Deci & Ryan, 1985; Stirling, 2014).

The Self Determination Theory as meta-theory, SDT encompasses five mini-theories: Cognitive Evaluation Theory (CET), Organismic Integration Theory (OIT), Causality Orientations Theory (COT), Basic Psychological Needs Theory (BPNT), and Goal Contents Theory (GCT) (Deci, Koestner, & Ryan, 1999; Ryan & Deci, 2000b).

- CET addresses the topic of the impact of social contexts on intrinsic motivation. Competence and autonomy are considered crucial aspects of intrinsic motivation in this theory.

- OIT primarily considers extrinsic motivation and proposes a continuum of internalization through which an individual may develop autonomy concerning extrinsic conditions.
- COT is concerned with individual orientations toward environments, identifying three primary types. They are the autonomy orientation, the control orientation, and the impersonal/a motivated orientation.
- BPNT proposes the three basic needs outlined above (autonomy, competence, and relatedness) and argues that environments that support these needs promote psychological well-being.
- GCT also addresses intrinsic and extrinsic motivation. The theory contrasts goals with intrinsic value, such as those related to community and personal growth, with goals that are extrinsically oriented, such as those related to wealth and fame. The theory argues that goals that support the three basic needs of autonomy, relatedness, and competency will support psychological well-being, while extrinsically oriented goals will negatively impact well-being.

Therefore, the relationship between the theory of hierarchy of Maslow and SDT from Deci & Ryan clarifies the existence of motivation as a phenomenon that depends on several other factors and that can be divided into internal factors which constitute intrinsic motivation, external factors which constitute extrinsic motivation and the relationship between the factors, context, and environment.

To better understand the nuances and concepts of motivation, many definitions and concepts are listed below, most of them taken from the paper of Todorov and Moreira (2005) about “the Concept of Motivation in Psychology”.

2.5.1. Definitions and concepts of motivation

- “A motive is a need or desire coupled to achieve an appropriate goal” (Krench & Crutchfield, 1959, p. 272).
- “A search for the determinants (all determinants) of human and animal activity” (Young, 1961, p. 24).
- “The basic property of motives is the energization of behaviour” (Kimble & Garmezy, 1963, p. 405).
- “Motivation is a behavioural energizer”. (Lewis, 1963; Todorov & Moreira, 2005)

- “Psychology tends to limit the word motivation ... to factors involved in energy processes and to include other factors in determining behaviour” (Cofer, 1979, p. 2).
- The real meaning and application of the word "motive" guide us to a definition that should be associated with the following three components: the behaviour of an individual; the related internal biological condition (intrinsic); and the related external circumstance (extrinsic) (Ray, 1964).
- “One can speak of a theory of motivation and mean a coherent conception of the contemporary determinants of the direction, vigour, and persistence of action” (J. W. Atkinson, 1964, p. 274).
- “Motivation: the general term describing behaviour regulated by need and instinct concerning goals” (Deese, 1964, p. 404).
- “Motivation is a term like learning in the sense that it has been used in numerous ways, with varying degrees of precision. We will not concern ourselves with its exact meaning, mainly because it has not been used precisely in this context (Logan & Wagner, 1965, p. 91).
- Motive can be understood as something that incites the organism to action or that sustains or gives direction to action when the organism "activates" itself or is activated. (R. L. Atkinson & Hilgard, 2009; Hilgard, 1953)
- “Motivation is seen as a kind of internal force that emerges, regulates, and sustains all our most important actions. However, it is clear that motivation is an internal experience that cannot be studied directly”. (Vernon, 1973, p. 11)
- “Motivation, like many other concepts in psychology, is not easily delimited"... One can gauge whether an individual is motivated or not based on observation of specific behaviours manifested or based on specific events we observe taking place. (Ferguson, 1976).
- “The question of motivation is the question 'why?' formulated in the context of behaviour. Such questions can be asked indefinitely and we limit the scope of our answers to what we have delineated, with some precision, as the discipline of psychology” (Evans, 1976, p. 23).

- “The study of motivation is the investigation of the influences on the activation, strength, and direction of behaviour” (Arkes & Garske, 1982, p. 3).
- “Changes in the significance of stimuli are the basic concern of the study of motivation” (Catania, 2006, p. 61).
- “For every action that a person or animal performs, we ask: “Why did he or she do that”. When we ask this question, we are asking about the motivation of that person or animal […]. Questions about motivation, then, are questions about the causes of a specific action” (Mook, 1987, p. 3).
- “Whenever we feel a desire or need for something, we are in a state of motivation. Motivation is an internal feeling, an impulse that someone has to do something (Rogers, Ludington, & Graham, 1997, p. 2).
- “[…] motivation is the set of biological and psychological mechanisms that make it possible to trigger action, orientation (towards a goal or, on the contrary, away from it) and finally intensity and persistence: the more motivated a person is, the more persistent and greater the activity”.(Lieury & Fenouillet, 2000, p. 9)

- “In the operational approach, motivation is the set of relations between stimulation or deprivation operations and the observed changes in behaviour that take place after these operations” (Penna, 2001, p. 19).
- “[…] intrinsic motivation occurs when three "psychological states” are present: experienced *meaningfulness* of the work, experienced *responsibility for outcomes* of the work, and *knowledge of actual* results of the work”. (K. Thomas, 2000, p. 116)
- “Motivation has been understood sometimes as a psychological factor, or set of factors, and sometimes as a process. There is a consensus among authors as to the dynamics of these psychological factors, or processes, in any human activity. They lead to a choice, instigate, cause the initiation of goal-directed behaviour [...]” (Bzuneck & Boruchovitch, 2009, p. 9).
- Motivation is a very determining and important behavioural factor that guides students, teachers, and managers at all levels of education towards the development of capacity and skills (Elliot & Covington, 2001; Pintrich & Schunk, 1996).

As can be seen, the concept of motivation is associated with factors that influence and actions that are performed, which made it so that at the beginning of the century, the challenge was to discover factors and or activities that create motivation in people.

Today, the concern changes direction, becoming focused on the discovery and adoption of "organizational resources capable of not stifling the motivational forces inherent in people themselves” (Bergamini, 2008, p. 23), because it became clear that each person already carries within them, in some way, their energies and motivations which in turn may or may not need some stimulant.

> “[…] *there is no little genie of motivation that transforms each of us into a zealous worker or condemns us to be the worst of the lazy. In reality, demotivation is neither a fault of a generation nor a personal quality, because it is linked to specific situations*” (Bergamini, 2008, p. 27).

In general, motivation can be defined as a phenomenon/energy influenced by psycho-socio-cultural and environmental factors observed by the behaviour (determination and engagement) reflected in learning and improving the quality of the achievable results.

Internal factors (e.g., state of mind, pride, courage, interest, importance, gains, etc.) and external factors (value, rewards, awards or promotions, praise, punishment, criticism, etc.) can positively or negatively affect motivation. Below is the motivational variation influenced by needs.

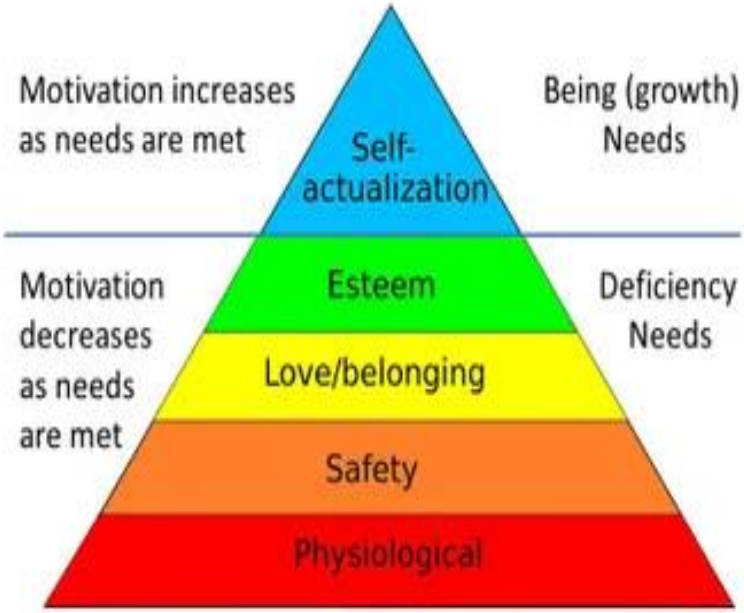


Figure 6. How needs influence motivation.
(McLeod, 2020, p. 2)

Since the individual already has some motivation (internal) but there are also external factors that can motivate him/her, motivation can be distinguished into intrinsic (internal) and extrinsic (external):

Intrinsic motivation has been defined as performing behaviours out of interest, pleasure, and enjoyment (Deci & Ryan; Vallerand & Ratelle, 2002). It is the natural intuition that guides us to act on free will, an inner force, from the core, the soul, and the heart. When forces are extremely connected to feelings, the need to overcome, win, and accomplish (tasks, dreams, etc.) is sometimes able to unexpectedly break barriers.

Intrinsic motivation acts as "the spontaneous/exothermic reaction" and has as its activating energy the emotional connection/reason, freedom, passion, self-spiration, curiosity, enjoyment, autonomy, belonging, learning, avoid guilt, which releases energy and that can be noticed by the will, commitment, and love with which one performs the activities and most of the times this energy has been contagious to other people around.

Extrinsic motivation in turn is defined as rewed-driven behaviour. This rewed can be tangible (such as money or grades) or intangible (such as social status, fame, promotion). It is action dependent on a stimulus, something unnatural.

Extrinsic motivation acts as a "forced/endothermic reaction" that needs energies and catalysts (stimulus) that can be a pleasure, social status, fear of punishment, promotion, pay rises, bonus, benefit, prizes, winnings, perks, etc.

Intrinsic motivation is influenced by rewards or extrinsic motivation (DeCharms, 1968; Deci, Koestner, & Ryan, 2001). Often the initial (intrinsic) motivation can be maintained, overshadowed, or enhanced by the maintenance, decrease or increase respectively of rewards or extrinsic motivation.

In his study on intrinsic motivation, Deci (1975) goes further by stating that:

> "*If a person's feelings of competence and self-determination are enhanced, his intrinsic motivation will increase. But if the feelings of competence and self-determination one word missing? diminished, his intrinsic motivation will decrease, […] We are suggesting that some rewards or feedback will increase intrinsic motivation through this process and others will decrease it […]*". (p. 41)

Therefore, the relationship has not always been linear, as in some cases difficulties, challenges, turmoil, etc., for some people increase motivation, while for others it decreases motivation.

However, these situations suggest that the conjugation and calibration of both motivating factors (intrinsic and extrinsic) are extremely important for the success of an activity, and in turn, this act presents a standardized behaviour trend that results in improved relationships, academic performance, career success, self-determination and feelings of competence (Fig. 7), but these results may vary with each individual and specific situations.

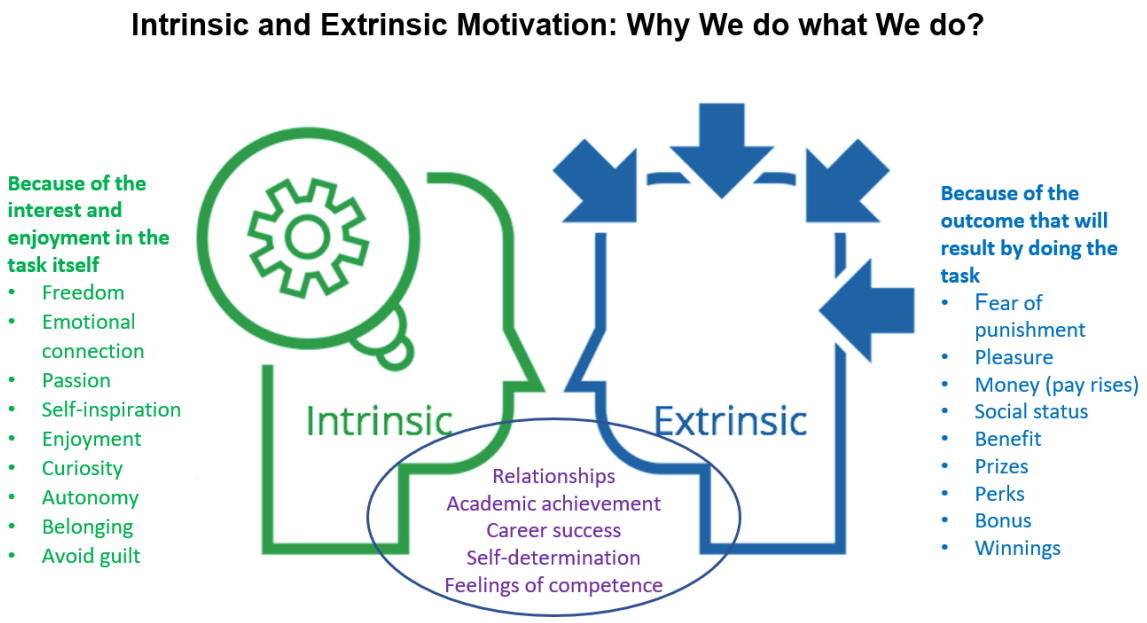


Figure 7. A combination of intrinsic and extrinsic motivation.
Adapted from (Sophan, 2020)

2.6. Contextualized learning

Contextualized learning is based on the constructivism learning approach, where students can construct their ideas and solve problems according to their own experience and day-by-day situation through adaptation and organization to the new environment (Bilican et al., 2015).

The contextualized study could address the situation currently found in the education sector where many students have a difficulty in understanding academic concepts commonly taught (that is, using an abstract, lecture method) but they desperately need to understand the concepts as they report to the workplace and to the larger society where they live and work (CORD, 2016).

Many of the contents taught in Mozambican schools may be related to the day-to-day situations of students, teachers and society in general. The contextualized conception of teaching and learning helps teachers to relate the content of the subject with the reality or situations of the real world, thus facilitating the student's understanding. (Berns & Erickson, 2001).

Contextualized learning automatically involves people, agents, companies, and institutions that develop their activities in communities. Thus, students and teachers are part of these communities and together face many problems such as crime, unemployment, hunger, malnutrition, drought, floods, erosion, lack of water, energy problems, poor health services, etc.

This situation is increasingly evident in poor countries like Mozambique, therefore, a contextualized study would be to introduce local content into the learning process, so that when studying, students, with the support of teachers, would produce knowledge applicable to solving their problems, in this way making learning enjoyable, motivating, exciting, effective and affective.

2.7. Effective learning

To reach the definition of effective learning, we must first understand what d "effective teaching" means. Effective teaching is a process that leads to improving student achievement using outcomes that matter to their future success (Coe, Aloisi, Higgins, & Major, 2014).

Effective teaching is active and practical education that can provide real learning, factual, and therefore stable or permanent understanding. Contextualized teaching can very easily create effective and lasting learning that differs from the memorization process in which knowledge can easily be provisional, temporary, or even transient.

For Watkins, Carnell, Lodge, Wagner, and Whalley (2002) to define effective learning they started defining the term learning as an activity of construction, handled with (or in the context of) others, driven by the learner's agency.

And effective learning as all of these at their best, plus the monitoring and review of whether approaches and strategies are proving effective for the particular goals and context.

Even so, is not easy to define effective teaching or learning. Perhaps that's why Watkins et al. (2002) argued that "the term effective only makes sense when context

and goals are specified”. My context is to teach science pre-service teachers using a systemic approach. In this process, they explored their day-by-day experience to improve the learning process.

From all this, we define effective learning as a process of learning which leads to improving student understanding of content in context by applying innovative and appropriate strategies where the outcomes are used for day-by-day living and future life.

According to, the OECD (2014, p. 2), for PISA 2012:

> “*Skills empower people to meet the challenges of everyday life, related to making decisions; solving problems; dealing with unexpected events, such as job loss and family break-up. Beyond better outcomes for the individual, skills also provide the vital glue for resilient communities and well-functioning societies, by strengthening inclusiveness, tolerance, trust, ethics, responsibility, environmental awareness, collaboration, and effective democratic processes*”.

An effective democratic participation process creates self-inclusion, interest, and willingness to do and do better. A learning process that establishes the development of an interest in learning has been effective and when this learning has to do with own problems or needs, the learning becomes emotional and sustainable.

2.8. Emotional learning

Emotional learning is the outcome of emotional intelligence. Emotional intelligence is defined as the cognitive ability to identify, assess, and control one’s own emotions, the emotions of others, and that of groups (Goleman, 1995).

The term “emotional intelligence” was suggested by Payne (1985) in his study about “emotion: developing emotional intelligence”. However, before this, the term "emotional intelligence" was used by Leuner (1966) in his book “emotional intelligence and emancipation. A psychodynamic study of women".

After the first two publications, first, by Leuner (1966) and later on by Payne (1985), other researchers appeared such as Greenspan who presented a model of emotional intelligence, followed by other researchers such as Salovey & Mayer in “Emotional intelligence*”,* and Goleman in "Emotional Intelligence: Why? it can matter more than IQ” (Goleman, 1995; Greenspan, 1989; Salovey & Mayer, 1989).

Goleman (1998)´s model focuses on EI as a wide array of competencies and skills that drive leadership performance, and consists of five areas:

1. Self-awareness – knowing one’s emotions, strengths, and weaknesses, drives values, and goals and recognizes their impact on others while using gut feelings to guide decisions.
2. Self-regulation – managing or redirecting one’s disruptive emotions and impulses and adapting to changing circumstances.
3. Social skill – managing other’s emotions to move people in the desired direction
4. Empathy – recognizing, understanding, and considering other people’s feelings, especially when making decisions.
5. Motivation – motivating oneself and being driven to achieve for the sake of achievement.

Goleman (2007), believes that individuals are born with a general emotional intelligence that determines their potential for learning emotional competencies. In 1995 the field of social and emotional learning (SEL) was just beginning to evolve. The term emotional is strongly linked with the term social that’s why many studies (Cohen, 2006; Feinstein, 2015; Jones & Bouffard, 2012) bring them together.

In short, Pellitteri and Smith (2007) present powerful evidence of the links between SEL and academic learning and also offers schools scientific evidence of these links, schools scientific evidence, and pragmatic examples of how SEL programs can enhance students’ success in school and life.

In this paper, the social concept has been replaced by contextualized and effective, to better analyse the influence that each situation can create on each other and the outcome of their combination to improve science learning.

Emotional learning is motivating not only for the generation that learns but also for other generations, namely; (a) adults (ascendants) who may feel proud of their descendants as vectors of community and society development; (b) younger ones (descendants) who may have the anxiety of being part of the group that brings solutions to their day-to-day problems, taking as an example the contribution of their parents or ascendants in general.

Chapter III – COUNTRY´S BACKGROUND

3. Mozambique Background

This chapter describes the historical context in which the country lived until the establishment of the National Education System and its current reforms. It also describes the political and socio-economic characteristics of Mozambique, with emphasis on aspects related to the organization of the national education system, such as the discussion of the laws supporting education, curricula, normative documents, languages spoken and different school levels established.

An overview of the aspects mentioned above may, on the one hand, highlight the scientific support for the introduction of the systemic approach in schools in the country, but on the other hand, clarify some aspects that serve as strengths or political motivations that allow the research in Mozambique.

The study may create some changes in the daily life of students, schools, universities, partners, and communities, so it is essential to contextualize the real situation of the country, the way of life, and aspects linked to education and society involved.

3.1. Historical background

Mozambique is one of Portugal's former colonies and was part of the provinces of Portuguese East Africa, which means that it was considered one of Portugal's provinces in Africa. The former province and current country (Mozambique) acquired its current geographical shape in May 1891, shortly after the signing of the Great Britain Treaty (GBT).

The GBT legalized the sharing of areas of influence in Africa and also served to legitimize European colonial nations, an occupation that, in the case of Mozambique, was in the 16th century, when Portugal began to occupy the east coast of Africa. (Albuquerque, 1899; Hedges, Rocha, Medeiros, Liesegang, & Chilundo, 1993)

The history of Mozambique in the colonial era is subdivided into two parts, the first of short duration (which lasted from 1498 to 1590), which was characterized by the

discovery of the territory by the Portuguese navigator Vasco da Gama in 1498, and the subsequent conquest until 1590.

This was considered a fertile phase for the events and great for the results reaped and was dubbed the "golden age of the province [...]" (Albuquerque, 1899, p. 35). The second phase, the longest which lasted from 1590 to 1975, was characterized by slavery, and the construction of infrastructures.

Mozambique lived under colonial domination, oppression, and slavery for approximately four hundred and seventy-seven (477) years, and at this time the education system followed the Portuguese policies and philosophy, and in turn, established education for the Portuguese and some privileged Mozambicans whom they called "assimilated" and education for disadvantaged Mozambicans whom they called "indigenous".

The "indigenous" identity was attributed to individuals of low civilization and considered to be in a savage state, who were not recognized as having any rights, including the right to good education (Gasperini, 1989), whereas the entity of "assimilated" was attributed to black or mixed-race Mozambicans who had overcome the condition of being indigenous, of being "uncivilized", making them Portuguese citizens, like the Portuguese settlers (Mindoso, 2017).

The discrimination of educational privileges according to the level of “civilization” ends with the end of colonial domination. The colonial period in Mozambique ended in 1975 with the proclamation on June 25 of total and complete independence, as the result of a war that lasted about 10 years and was known as the “armed struggle for national liberation” driven by the different movements that at the time they decided to join together and form a single movement that came to be called “*Frente de Libertação Nacional de Moçambique*” (FRELIMO).

Once independent, the government of Mozambique adopted a socialist regime and established a strategy to transform Mozambican society by adopting activities covering areas such as education, "training of the new man", health and housing. It was in the socialist spirit that law 4/83, which regulates the National Education System, was

created (MINED, 1983). After about nine years of application of law 4/83, it was readjusted, giving rise to law 6/92, which is still in use so far (MINED, 1992).

3.1.2. National System of Education

In Mozambique, the education process is coordinated by what is called the National Education System and is defined as the process organized by each society to transmit to new generations its experiences, knowledge and cultural values, developing the capacities and aptitudes of the individual, to ensure the reproduction of its ideology and its economic and social institutions (MINED, 1983).

The document reveals that in traditional society, education was dedicated to the transition of knowledge and production techniques accumulated by the elders in productive practice as well as the instruction and transmission of political, moral, and social values giving an idealistic vision of the world and the phenomena of nature.

This practice was lost with colonial domination, which imposed an education that aimed to reproduce the exploitation of man to man, colonial oppression, division of society according to skin colour, tribe, level of civilization, and other forms of discrimination.

To safeguard a good education for the oppressor class, they developed parallel education systems, one for the children of the dominant class and another for the dominated class who were called indigenous people.

The Mozambican people expressed nonconformity with slavery and the model of education imposed by the (Portuguese) colonizer, hence they organized the armed struggle for national liberation as the highest form of expression of this nonconformity and denial of slavery, oppression, exploitation, and the negative consequences of these that affected, above all, the process of education, thus creating a new society free of any form of domination.

Soon after independence, Mozambican society committed itself to the construction of socialism, which in its ideology has education as a fundamental right of each citizen and serves as a central instrument for the training and improvement of technical and

scientific capabilities of workers, but more than anything, education in Mozambique should contain content, structure, and methods that lead to the formation of the "*new man",* which means forming a Mozambican man with a patriotic conscience, scientifically qualified, professionally and technically trained and culturally liberated.

Based on the context in which the country found itself after independence, the National Education System outlined three major objectives which are:

- The eradication of illiteracy.
- The introduction of compulsory education.
- The training of staff for the needs of economic and social development and scientific, technological, and cultural research.

After the establishment of the three main objectives, a popular debate was held throughout the country to collect contributions on the models and aspects of education that the country would adopt.

From the popular debate, several contributions were collected (ideas and suggestions) and a synthesis was elaborated with general lines of the National Education System and then submitted to the popular assembly for appreciation and debate.

The consensus reached in the debate was transformed into a law that began to regulate the National Education System in Mozambique, and this law is called the National Education System Law or simply Law 4/83, because it was approved in April 1983.

3.1.2.1. First Law of the national education system 4/83

The educational activity in Mozambique is supported by laws, curriculum plans, and teaching programs in general. The educational process followed the details of the colonial regime, a regime that ended with the independence of the country in 1975.

After independence, there was a need to train and prepare the Mozambican people to ensure the country's development in various sectors.

The first Mozambican law of education comes after the colonial period and eight years after independence when the National Education System was established to regulate the teaching and learning process in Mozambique, controlled by the Mozambican government through the Ministry of Education and Culture.

The first law on education emerged in 1983, Law 4/83, which approves the National Education System and defines the fundamental principles in its application.

3.1.2.2. Law of the national education system 6/92 readjustment

The law of the National Education System, better known as Law 4/83, was readjusted in 1992 and had as its assumptions the adequacy to social and economic conditions concretely in pedagogical aspects and organizational models.

In 1992, the country had already abandoned the ideologies of the socialist regime to a capitalist one, a change that may have contributed to a large extent to altering some policies outlined in the initial law.

The readjustment of Law 4/83 did not affect the ideology of interaction or school-community connection, nor the didactic-pedagogical aspects. These were kept as originally written. However, there has been a small change in the position of articles and paragraphs, for example changing article 2 to 3, from point c) to d), etc.

The maintenance of aspects linked to school-community interaction in the NSE law supports studies and actions aimed at establishing increasingly interactive, collaborative, and partnership-based education systems where the community feels the presence of the school as an epicentre to solve their problems and the school feels part of society and these, together with the various institutions, form an interdependent and open system that will boost the teaching and learning process and develop the community.

3.1.2.3. Legislation and support documents for the education sector in Mozambique

The documents that regulate the teaching and learning process in Mozambique in general and secondary education in a specific way are:

- First Law of the national education system 4/83 (MINED, 1983)
- Law of the national education system 6/92 readjustments (MINED, 1992).
- Economic Plan for Education;
- The national policy of education and strategies.
- Secondary Education Curriculum Plan (MINED, 2003).
- Strategic Plan for Education (MINED, 2012; MINEDH, 2020) and;
- Learning Programs of Secondary Schools of grades 8, 9, and 11 (MINED, 2010a, 2010b, 2010c).

To enrich the documentary study, some articles were also evaluated, which deal with the education sector in Mozambique. The material collected guided us to get core elements/contents and design the way that a systemic approach can be realized in Mozambican's secondary schools' curricula.

3.1.2.4. Other documents supporting the teaching-learning process in Mozambique

From the set of other documents, the Curricular Plan for General Secondary Education, drawn up in 2007, stands out, which proclaims the improvement of the quality of education as one of the main objectives of the reform, following the Strategic Plan for Education II for 2005 to 2009.

This plan considers the transformation of the General Secondary Education curriculum to be a priority, from a curriculum that simply prepares students for higher education to become a curriculum that focuses on the ability to live as well as get a job, (PCESG, 2007, P. 4)

Life skills can be acquired in a variety of ways, but having experience or connection between theory and practice may be preponderant in acquiring these. The weak link between theory and practice is widely cited as a negative finding of the General Secondary Education Strategy and studies of the Ministry of Higher Education, Science and Technology.

The link between theory and practice can happen in a more effective way (Grenchik, O'Connor, & Postelli, 1999), which is through the link between the school and the community where it is inserted (Rubba & Harkness, 1991; Yager, 1993).

The link between the school and the community allows the community to participate in the management of this and the school, in turn, participates in the development of communities proposing or solving real problems, where the experiences acquired in this action serve as incentives for the retention of knowledge, reproduction and consequently improving the quality of teaching and sustainable development of communities.

The education system in Mozambique is divided after primary education into two different specifications:

i. in general education in which it prepares students for higher schools
ii. technical-vocational education that prepares the student for employment

The socio-economic context of the country, namely high levels of poverty and low levels of production, and the lack of employment, causes more demand from students, and know-how dominates the objectives of the education sector.

3.2. Mozambican socio-economic context

Mozambique is in the south-eastern strip of the African continent and the surface of its territory is 799,380 km^2, between parallels 10/27 'and 26/52' latitude and between the meridians 30/12 'and 40/51' east longitude. To the north it borders Tanzania; to the west with Malawi, Zambia, Zimbabwe, and Swaziland; and to the south with South Africa all six countries, all six English-speaking countries.

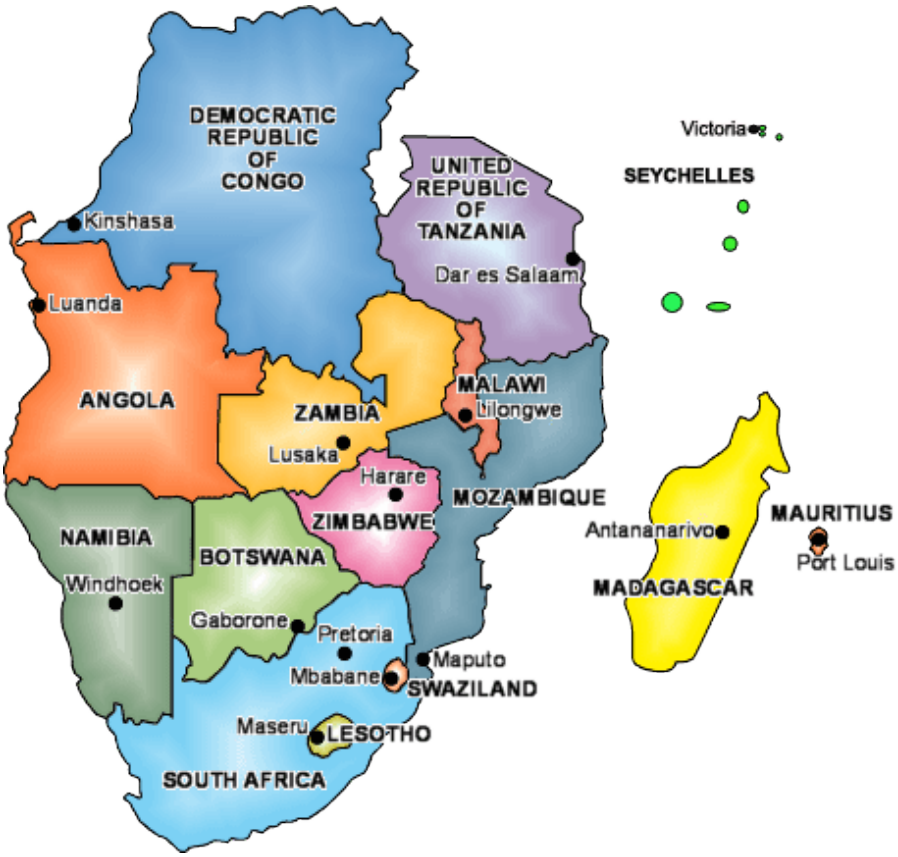


Figure 8. Map of Mozambique and the southern part of Africa.
(Santos, 2014)

The only official language of Mozambique is Portuguese, which is spoken mostly as a second language by about 50.4% of the population. Common native languages include Makhuwa (26,3%), and the remaining percentages are divided into Sena, Swahili, Changana, and others that total close to twenty official mother tongues. The country's population of around 28.861.863 is composed overwhelmingly of Bantu people (INE, 2012, 2017).

The entire eastern strip, which is bordered by the Indian Ocean for a length of 2,470 km, has vital significance for both Mozambique and inland neighbouring countries that are only connected to the ocean through Mozambican ports.

The country is divided into eleven (11) politically provinces and three different regions:

- North - Niassa, Cabo Delgado and Nampula;
- Central - Zambezia, Tete, Manica and Sofala;
- South - Inhambane, Gaza, Maputo and Maputo City.

Mozambique is on a slow growth path which has worsened since 2015, influenced by the crisis caused by the hidden debts discovered in 2016. In 2019, “macroeconomic conditions were improving, but the economic performance reverted to the pre-crisis levels. Real gross domestic product (GDP) growth is estimated at 3.3% in 2018, down from 3.7% in 2017 and 3.8% in 2016 (WBM, 2019).

At the beginning of 2020, Mozambique’s economy was expected to gradually recover in 2021, but substantial downside risks remain due to cyclones, uncertainty development of the COVID-19 (coronavirus) pandemic, terrorism in Cabo Delgado, which forced the “abandonment” of the French company Total that exploited the Rovuma gas, etc.

Therefore, “while the economy registered its first contraction in 2020 in nearly three decades, growth was expected to rebound over the medium-term, reaching about 4% by 2022” (WBM, 2021). However, this projection was made without taking into account the latest events (suspension of Total's activities) in Rovuma´s natural gas project.

The probable return of the French company Total to the Rovuma natural gas project for exploration and partial processing (liquefaction) and the implementation of the Exxon Mobil investment, which up to now has been postponed for the third consecutive year, could ease the financial pressure experienced by the country, aggravated by the rising external debt (Fig. 9).

Although a large part of the profits from the sale of gas is mortgaged by clandestinely contracted debts, the full operation of the Rovuma gas project could contribute to indirect taxes and direct investments in sectors such as education, health, infrastructure, etc.

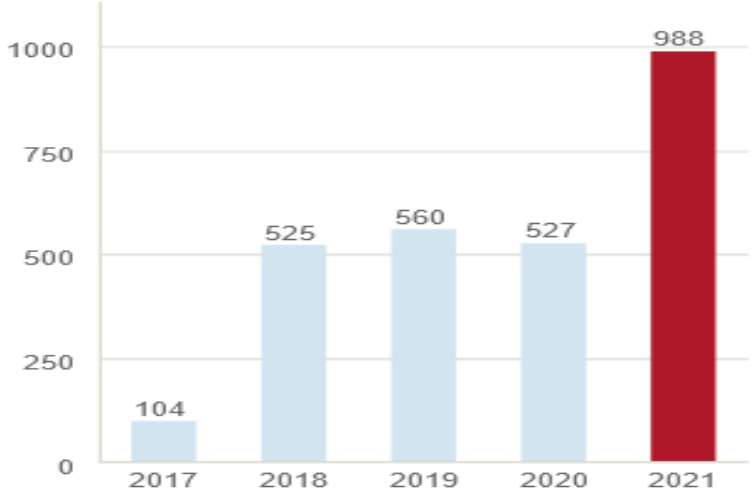


Figure 9. Lending Mozambique: commitments by fiscal year (in millions of dollars)[9]. (WBM, 2021)

Out of the constraints listed above, the country was also severely devastated by four cyclones, namely: Idai, Kenneth, Chalane, and Eloisa, the first being the most intense. The passage of cyclones significantly affected the country and in particular Sofala and Manica province (the province where the survey takes place).

Note that the project has been suspended since Total withdrew all of Afungis´ staff[10] and left the country at the end of March after violent attacks on the 24th of the same month in Palma, which culminated in the death and murder of several national citizens, with greater emphasis on decapitation of twelve foreign nationals who worked for the project.

Mozambique is one of the ten poorest countries in the world, in turn, according to the last census, 66.6% of the global population lives in rural areas, facing problems such as crime, unemployment, hunger, illiteracy, health, poor use of technology, etc. (INE, 2017).

The problems mentioned above increased the vulnerability of the population with the passage of the cyclone, which left enormous challenges, such as the destruction of

[9] Amounts include the International Bank for Reconstruction and Development (IBRD) and the International Development Association (IDA) commitments

[10] Workers at the camp located in the district of Afungi in the province of Cabo-Delegado in northern Mozambique.

homes, government and private infrastructure, loss of property, and even the death of many people.

In general, Mozambique presents a socio-political and economic development framework according to the figure below:

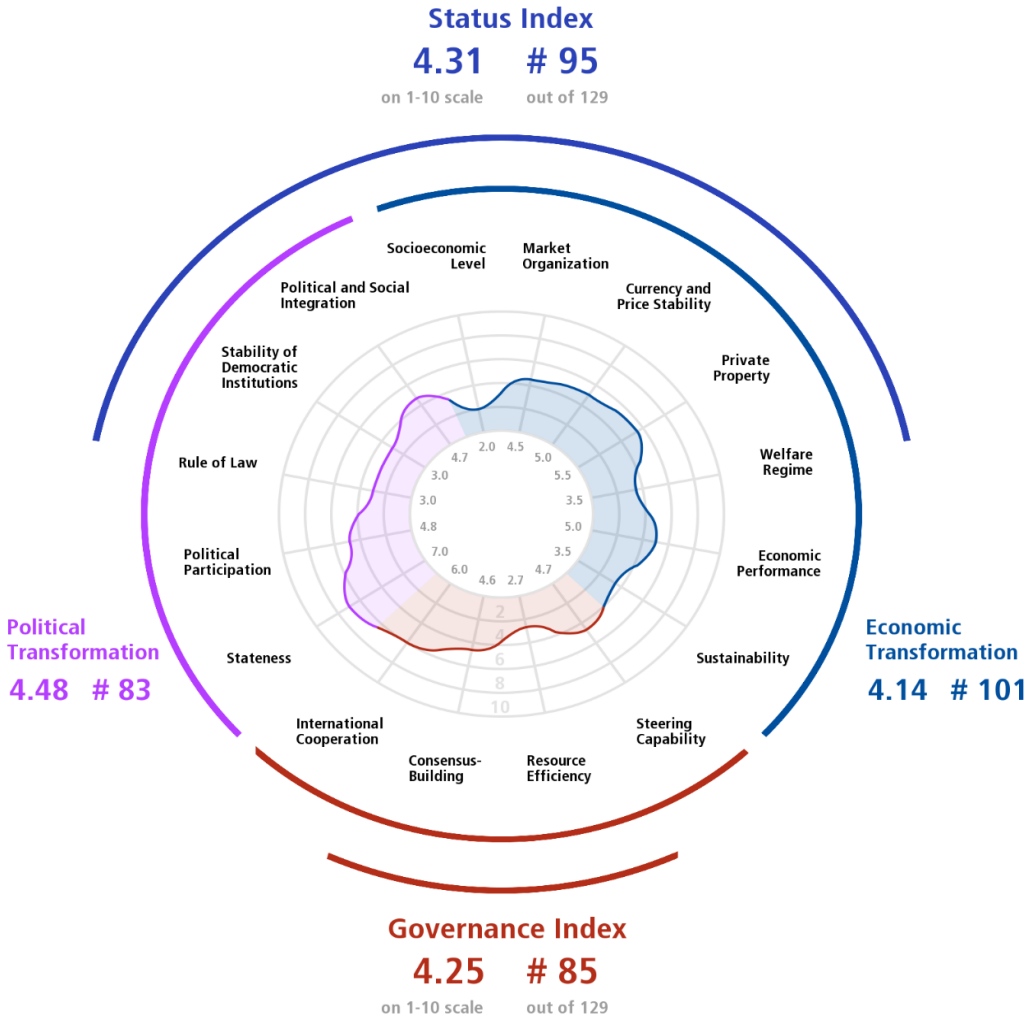
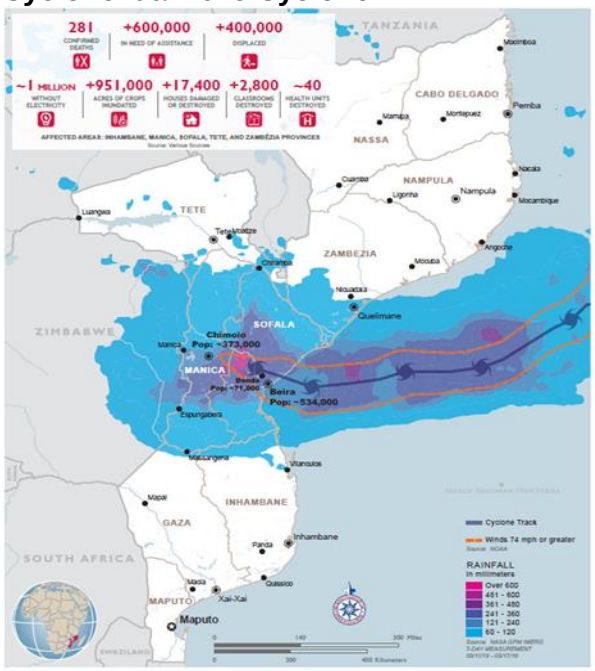


Figure 10. A framework of socio-economic development in Mozambique. (WBM, 2019).

It should be noted that the above scenario has certainly undergone some changes due to the damage caused by cyclones: Dineo on 15 of February 2017, Idai between 14 and 16 of March 2019, Kenneth from 25 to 27 of April, Chalane on 30 of December 2020, Eloise on 23 of January 2021, and Guambe on 12 of February 2021, which generally left several families displaced, destroyed infrastructure, especially schools and hospitals.

The situation of the war in Cabo Delgado and attacks by the self-proclaimed Renamo "Military Junta", which also displaces Mozambican families, and destroys infrastructures, also contribute to the downward change in the socio-economic scenario of the country, mainly in the provinces of Cabo Delgado, Sofala, and Manica.

Cyclone Idai 2019 Cyclone



Chalane 2020

Cyclone Eloise 2021

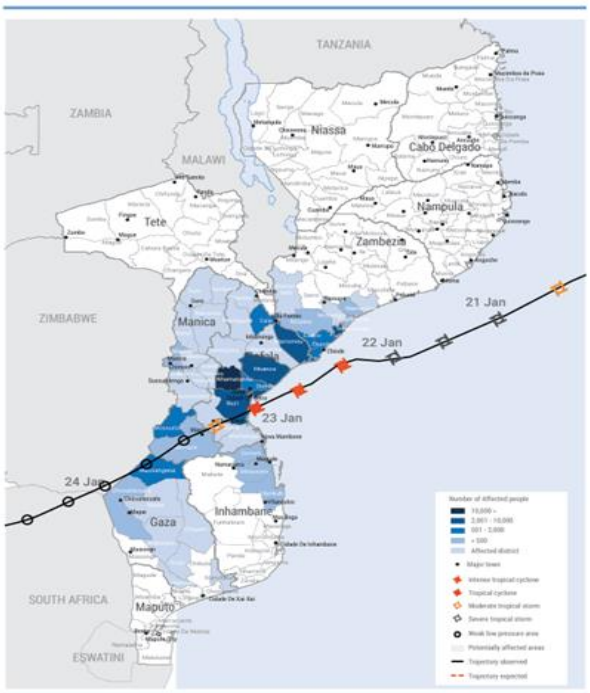


Figure 11. Cyclones that affected the Manica province.
(Notícias, 2020; OCHA, 2021; USAID, 2019)

3.2.1. Manica province

Manica province is situated in central Mozambique and covers an area of 61,661 km² and a total population of 1,911,237 according to the results of the latest Population Census 2017 (INE, 2019). The province is made up of twelve (12) districts (Bárue, Chimoio, Gondola, Guro, Macate, Machaze, Macossa, Manica, Mossurize, Sussundenga, Tambara, Vanduzi).

Five villages in part of these districts became municipalities in 2013, namely (i) Catandica- district of Báruè (ii) Chimoio- district of Chimoio, (iii) Gondola-district of Gondola, (iv) Sussundenga-district of Sussundenga, and (v) Vanduzi-district of Vanduzi.

Geographically the province has the following boundaries:

- North - Zambezi River and Luenha River which separate it from the province of Tete,
- South - Save River which separates it from the province of Inhambane and Gaza,
- West - border with the Republic of Zimbabwe
- East - Sofala province

The climatic conditions are characterized by very high rainfall and fertile soils, characteristics that contribute positively to the practice of agriculture and make the province one of the potential producers of food, animal husbandry, and the growing need for improved road access conditions, transportation, and processing of agricultural products to increase shelf life, which boosts nutrition and commercial activity for agricultural sustainability.

The province has a tropical climate (hot and temperate) with two distinct seasons: a rainy season from September to March, and a dry season from April to August. Because of its altitude and relief, Manica has relatively high rainfall.

The topography of Manica is characterized by mountains, plateaus and plains. The mountains are mainly located in the far west, with generally higher altitudes of over 1,000 m near the border with Zimbabwe (MINED, 2021).

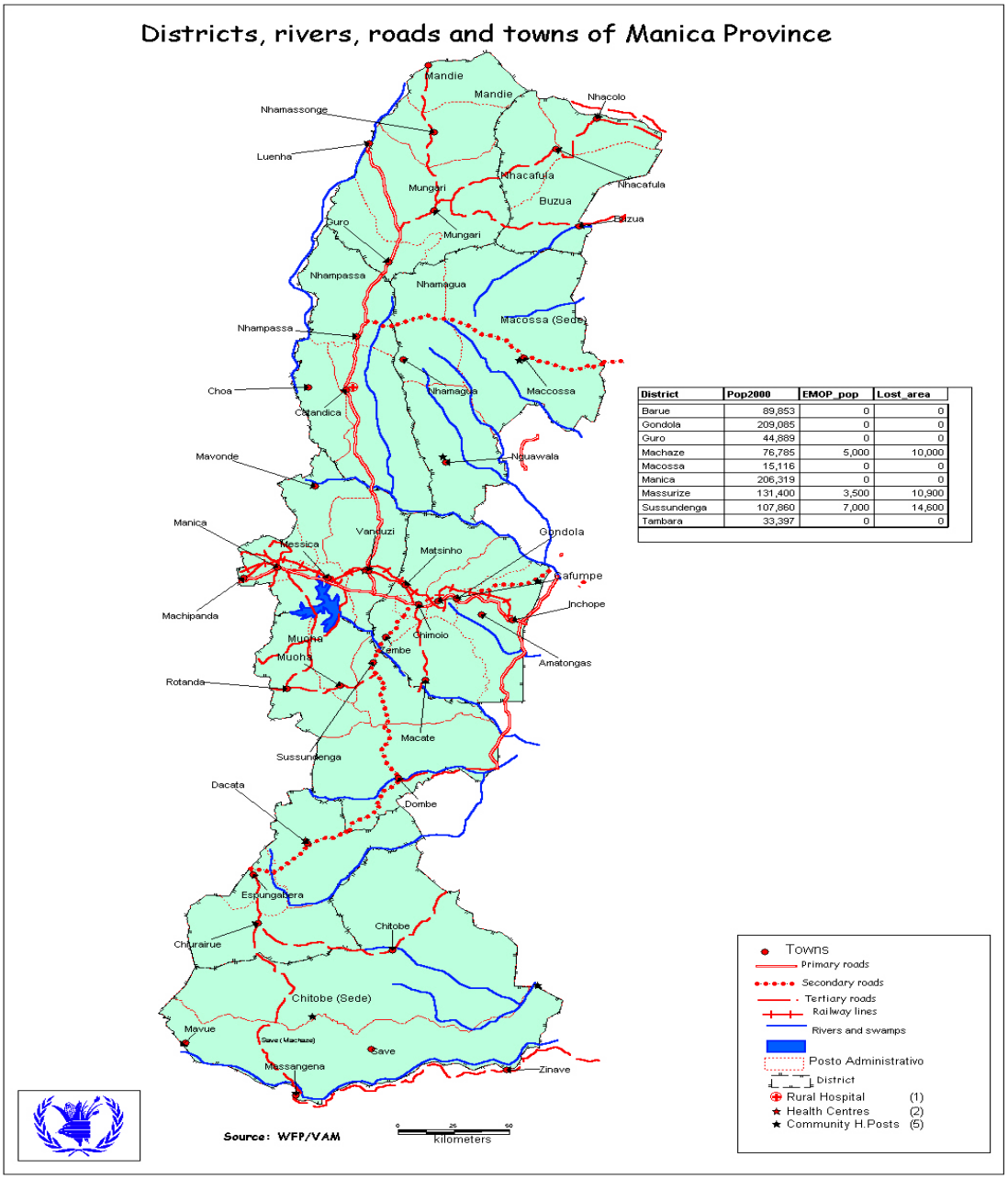
Manica has an extensive hydrographic network (rivers, reservoirs, lakes, etc.), that feeds the various fields of agricultural production, animal breeding, fishing activities, and water supply to the population and is also used for the construction of dams that guarantee the production of electricity, etc., where the Zambezi, Save, Búzi, Gorongosa, and Púnguè rivers stand out.

Manica is rich in natural resources, particularly minerals, forests, and wildlife. Therefore, the greatest potential of the province is in the agricultural sector, in the production of corn, sorghum, beans, tobacco, cotton, soybeans, and sunflower but also in the fruit and horticulture with greater emphasis on the production of bananas, tomatoes, oranges, tangerines, lychees, etc.

The agricultural activity contributes largely to family income and also boosts significantly the commercial activity of the province. In addition to food production, fishing activity, and timber exploitation, also contribute with a great impact on the economy of the province.

Chimoio is the main city of Manica and is where the greatest flow of commercial activity, banking institutions, the provincial headquarters of some NGOs, the headquarters of the Universities, and the highest concentration of schools can be found.

The province has a slow development in terms of urban growth (quality infrastructures), quality of access roads (many dirt roads), considerably low nutritional development index, and weak use of technology to boost the development of communities, among other challenges.



District	Pop2000	EMOP_pop	Lost_area
Barue	89,853	0	0
Gondola	209,085	0	0
Guro	44,889	0	0
Machaze	76,785	5,000	10,000
Macossa	15,116	0	0
Manica	206,319	0	0
Massurize	131,400	3,500	10,900
Sussundenga	107,860	7,000	14,600
Tambara	33,397	0	0

Figure 12. Map of districts, rivers, roads, and towns of Manica province. (WFP, 2000)

3.2.1.1. Chimoio´s Background

Chimoio City with an area of 170.25 Km^2, is located in the centre of Manica Province along the railway line and National Road No.6, in the region with the best agro-climatic conditions and the most densely populated in the province.

The population agglomeration (17% of the province's population) makes it the third most densely populated city in the country after the cities of Matola and Beira. The

population density awakens the need to increase food through increased production and productivity, sanitation, health care, school construction, and road accessibility, amongst other basic and complementary needs.

The city of Chimoio has similar characteristics to the province (fig.13), from relief, climate and temperatures, so it has been one of the largest centres of food production, especially vegetables.

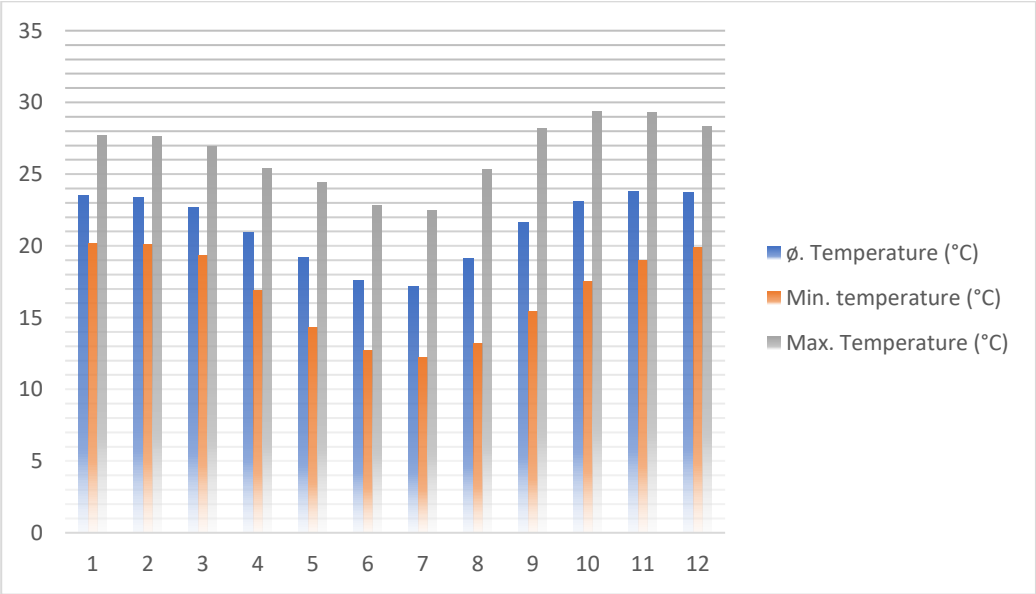


Figure 13. Chimoio´s annual temperature and precipitation rates.
Temperature data source: Climate-Data.org (2019)

3.3. Challenges

The city of Chimoio presents some challenges in all socio-economic sectors.

- In the education sector: there is a need to reduce the illiteracy rate and ensure gender equity and generally improve the quality of education.
- In the agriculture sector: there is a need to apply technology and artificial intelligence to increase production and productivity, but also to process products and reduce post-harvest losses;
- Accessibility and sanitation of the environment: rubbish in the streets, holes in the roads, stopped works, unpaved roads, and impassable stretches (Jequete, 2018).

Chapter IV – METHODOLOGY

4. Methodology

This chapter describes the methodology used to answer as accurately and reliably as possible the research questions and objectives that were intended to be achieved in this study. Therefore, the chapter also describes in detail the criteria and/or motivations behind the methods and techniques chosen to carry out the research and assess outcomes from the practical activities.

4.1. Research Design

The complete script of research is known as research design, which in turn can be defined as being "the arrangement of conditions for collection and analysis of data in a manner that aims to match relevance to the research purpose with economy in procedure”(Selltiz, 1962, p. 50).

It constitutes the essence of research design the "decisions concerning: what, where, when, how much, by what means concerning an inquiry or a research study” (Kothari, 2004, p. 31). Therefore, the research design is a general schematization of research and highlights key aspects of good research, namely: the problems, the paths to be used to collect the data to be analysed, the methods and techniques for this data collection and its subsequent analysis, the personnel involved, the place and the financial aspects.

In a more explicitly way, (Kothari, 2004) argues that design decisions happen to be in respect of these ten different items:

(i) What is the study about?
(ii) Why is the study being made?
(iii) Where will the study be carried out?
(iv) What type of data is required?
(v) Where can the required data be found?
(vi) What periods “of time” will the study include?
(vii) What will be the sample design?

(viii) What techniques of data collection will be used?

(ix) How will the data be analysed?

(x) In what style will the report be prepared?

The research design can be guided by the research question, objectives, and real local conditions (finance and background), and the previously mentioned can guide us to better methodology and great results.

This study was guided by the scheme below:

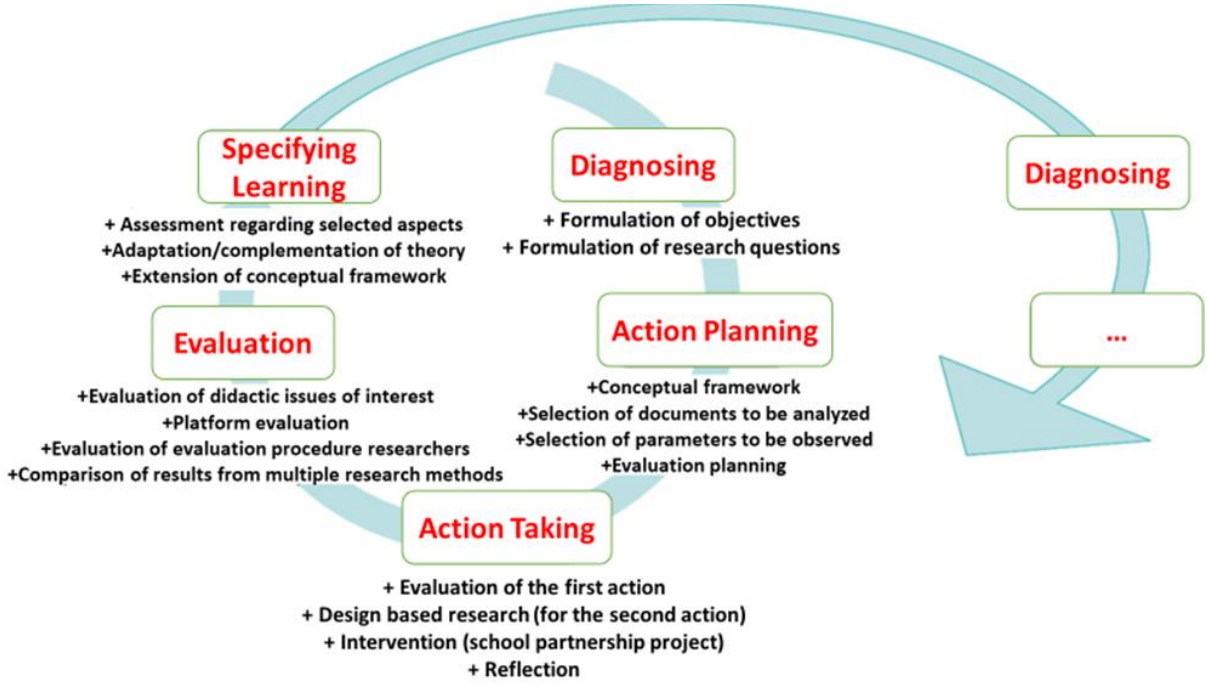


Figure 14. Methodological framework.
Adapted from (Figl, Derntl, & Motschnig-Pitrik, 2019)

4.1.2. Sample

The study was scheduled to be implemented in all seven secondary schools in Chimoio, in parallel to the university and the communities, but due to the outbreak of the COVID-19 pandemic, it only took place in one of them which is the Secondary School of Soalpo in parallel at the University and Communities.

In secondary schools, subjects are framed in two areas of learning (natural sciences and social sciences). Our intervention (all participants) was in the natural sciences,

which includes the subjects of chemistry, biology, and physics, which are learned separately.

Due to the need for an interdisciplinary and transdisciplinary approach to some field activities, there was a need to establish a system that would encompass lecturers and teachers from the three areas.

The study was designed to involve pre-service teachers and secondary school students (grade 8, 9, and 11), who would be supported by lecturers and researchers from the university, also by secondary school teachers, specialists, technicians from partner companies as well as by communities, or individuals belonging to the community who together could contribute to solving problems by a systemic approach.

The criterion for choosing the secondary schools is that they are the training places for the pre-service teachers of the university according to an existing agreement between the university and the Ministry of Education.

Secondary schools encompass students from grades 8 to 12, but according to the existing agreement, pre-service teachers can only teach in grades 8, 9, and 11, because these are grades without examinations and it was based on this agreement that the three classes indicated in the paragraph above had been chosen for taking part in this study.

Therefore, because of Pandemic COVID-19 as explained above, the project had the sample had to be slightly modified and structured according to the three different stages, organised in the following way:

1. Stage-I (preparatory): one hundred and eleven (111) chemistry’s pre-service teachers from three different branches (Manica, Tete, and Sofala) of the Pedagogical University (before being split) participated in activities and filled out a questionnaire.

   This stage took place in 2019 after an initial literature review and aimed to assess the pre-service teachers' preconceptions in order to understand their preparedness before the fieldwork.

- For comparative reasons, six questions from the validated VOSTS instrument (Views on Science-Technology-Society) of Aikenhead et al. (1989), which is used widely internationally also, were incorporated into this questionnaire.
- This stage was preceded by a pilot study (pilot study-I) to obtain information on how the questions were perceived, organize them better, and predict the average time needed to fulfil the questionnaire before it was administered to the 111 pre-service teachers. Twenty-five (25) students from the 2nd year of chemistry course from the Pedagogical University, branch of Manica participated in pilot study-I.

2. Stage II (fieldwork/practical work): Sixty-six (66) chemistry pre-service teachers from Manica and Tete participated. This stage took place in 2020 after the restructuring of the former Pedagogical University when the Manica and Tete branches were joined together to create the Púnguè University (UniPúnguè).

- In this stage, three lecturers from UniPúnguè (two in organic chemistry and one in environmental chemistry) also participated in monitoring the practical work at school and university and also gives support sometimes.
- Three external people also participated: a building engineer and a pipe connection specialist (representing the water supply company/FIPAG), and the municipal councillor for education and culture (representing the municipality).
- Two secondary school teachers also participated in the study (one in chemistry and one in agriculture and cattle breeding[11]).
- For the implementation of practical activities, several other entities and specialists in education, soils, agriculture, physics, biology, etc. were contacted to make their contributions. These groups came to be considered indirect participants in the projects.

3. Stage-III (Science Motivation Questionnaire/SMQ): fifty-three (53) pre-service teachers of English courses translated it into Portuguese in a pilot study (pilot study-II), before administering it to the chemistry pre-service teachers (main group).

[11] Subject taught in secondary education. Introduced in the 2010s to strengthen the food production and entrepreneurship policy

- After checking the reliability of the translation, the “Science Motivation Questionnaire” was administered to the sixty-six (66) pre-service teachers who participated in practical activities. The following table summarises the direct participants in the research.

Table 4. The general framework of personnel involved

	Directly Involved	***Total***
Secondary Schools Classes	1 secondary school 1 of grade 9	1 Soalpo secondary school
Secondary School Teachers		2 teachers
Pilot Study-I	Students from the 2nd year (chemistry´ course)	25 students
Pre-Service Teachers of Chemistry 2019 Total	25 Tete´s branch 58 Chimoio´s branch 28 Beira´s branch	111 pre-service teachers
Pilot Study-II	Pre-service teachers of English courses	53 pre-service teachers
Pre-Service Teachers of Chemistry (Main Group) 2020		66 pre-service teachers
Lecturers From Púnguè University		3 lecturers
Partners		3 partners

The research focused on the students and the chemistry programme, however, in case of a need for interdisciplinarity knowledge, students from other courses could be involved according to the specific knowledge, experience or skills needed.

Soalpo secondary school was used as a pilot school with the intervention and project implementation of three pre-service teachers and a grade 9 class. Of the pre-service teachers, two chose to intervene in the agricultural sector and one in the energy sector with the following projects:

- Urine-based fertilizer production: analysis of the efficiency of urine-based fertilizer vs. inorganic fertilizer (NPK[12]).
- Production of fertilizers based on food waste (Xima[13])

[12] Inorganic fertilizer consisting of Nitrogen (N), Phosphorus (P) and Potassium (K)
[13] Cooked food, made from flour obtained by grinding corn kernels (*Zea mays L.)*

- Biogas Production from Food Waste (Xima)

The last two were combined/complementary projects, so, they used the same biodigester, one student producing biogas and the other producing compost (fertilizer).

4.1.2.1. Sample characteristics in the questionnaire about pre-service teachers' preconceptions

Table 5. Characteristic of the sample of pre-service teachers who answered the questionnaire-I

gender * branch

		Branch			
		Tete´s Branch	Chimoio´s Branch	Beira´s Branch	Total
what is your gender?	Male	19	48	22	89
	Female	6	10	6	22
Total		25	58	28	111

4.2. Criteria for selecting an approach

In general, the research methods are divided into quantitative and qualitative or the combination of the two methods. Therefore, to choose the most appropriate method for the research, it is necessary to use some criteria.

For R. B. Johnson, Onwuegbuzie, and Turner (2007, p. 21), for deciding on the kind of approach, three aspects should be considered, namely: "(I) the research problem; (II) the researcher's personal experiences and (III) the public/s for whom the report will be written."

For greater consistency in decision-making on the research methods used, a table was created containing the research questions and objectives in a sequence. So my experience in guiding research activities and target audience (to be researched and readers) was also considered.

Table 6. The methodological sequence of the research

Steps	Research question	Objectives	Methodology
1st	Conceptualization of a science-technology-society integration and a systemic approach for learning beyond school in Mozambique: What are the core elements? How can it be realized?	Find core elements to introduce the systemic approach in the Mozambican learning process	**Documentary** study -School programs -education laws **Triangulation**
2nd	What are the structural and institutional preconditions to introducing a systemic approach to science teaching and learning at Púnguè University and secondary schools in Mozambique?	To know the physical, structural and organizational preconditions for the accomplishment of research-action and implementation of the systemic approach in schools in Mozambique	**Participant observation methods** -Púnguè University -Soalpo secondary school
3rd	What are pre-service teachers´ pre-conceptions about using the science-technology-society integration and systemic approach in learning activities	To gather information from the pre-service teachers about pre-conceptions that they have about university–community interactions	**Questionnaire** -Pre-service from three different branches
4th	What are the outcomes of a local intervention that can be used to improve teaching quality and develop communities as well?	Get outcomes from students at school after implementation of a systemic approach in learning activities	**Participatory-based research** -Project works

In this study, it was necessary to combine quantitative and qualitative methods to produce credible and reliable results due to the complexity of the research as it aims to introduce a new approach to the teaching and learning process in Mozambique, something that implies changing and controlling the different variables of the system.

A. Hunter quoted by R. B. Johnson et al. (2007) pointed out that “the research methods are not limited only in quantitative and qualitative, there are other methods such as qualitative participant observation, qualitative in-depth interviewing, etc.”

The mixture or combination of research methods has different names and interpretations according to different methodological movements or paradigms. From the different nomenclatures for methodologies involving two or more methods.

The methodological paradigms can be highlighted the multiple operationalism (Boring, 1953; Campbell & Fiske, 1959), triangulation coined by Webb et al. (1966), ethnographic residual analysis (Fry, Chantavanich, & Chantavanich, 1981), blended research (R. M. Thomas, 2003), multimethod research (Brewer, Cooper, Hunter, Hunter, & Brewer, 2006; Mishel, 1991; Morse, 2006), multiple methods (Darbyshire, MacDougall, & Schiller, 2005), integrative research (R. B. Johnson & Onwuegbuzie, 2004; Ward et al., 2017), complementary methods, mixed research (R. B. Johnson & Onwuegbuzie, 2004; Rooks & Ford, 2016) mixed-method (Maxwell, 2009)

Regardless of the term or paradigms listed above, all of these converge in the use of more than one research method. This application of research methods can be done, for example by (a) integration, (b) complementarity (which implies a dominant method among them), (c) junction (data are collected and analysed separately), (d) triangulation or blending of the methods and/or data (can be collected with same or different instruments) where one method or data is used to improve the understanding of another.

In general, researchers combine research methods to obtain results with greater reliability and credibility. However, among the paradigms listed, the closest approach to our vision is the term mixed methods.

The term mixed methods is in turn defined in different ways according to the different researchers. A comprehensive work by R. B. Johnson et al. (2007) entitled “Toward a Definition of Mixed Methods Research”, seeks to bring a comprehensive and realistic definition of the term.

The article cited above lists nineteen different definitions of different methodologies, of which the following stand out in this study:

> *“Mixed methods means the combination of different qualitative and quantitative methods of data collection and data analysis in one empirical*

> *research project. This combination can serve for two different purposes: it can help to discover and to handle threats for validity arising from the use of qualitative or quantitative research by applying methods from the alternative methodological tradition and can thus ensure good scientific practice by enhancing the validity of methods and research findings. Or it can be used to gain a fuller picture and deeper understanding of the investigated phenomenon by relating complementary findings to each other which result from the use of methods from the different methodological traditions of qualitative and quantitative research*", Kelle and Erzberger (2000) quoted in R. B. Johnson et al. (2007, p. 120)

Most definitions converge on the use of quantitative and qualitative methods and these authors mostly do not clarify how to use them. So, to find an appropriate concept for my study, I support the following definition:

> "*I consider mixed methods to be inquiring into a question using different data sources and design elements in such a way as to bring different perspectives to bear in the inquiry and therefore support triangulation of the findings. In this regard, using different methods to examine different questions in the same overall study is not mixed methods*". Patton (1990) quoted in R. B. Johnson et al. (2007, p. 120)

Patton (1990) takes one more step toward meeting my objectives and methodology, bringing the percipient to the use of triangulation, which first clarifies that triangulation is not a research method as such, which diverges from the thought of Webb et al. (1966), who suggested the use of the term in the field of research and adopted it as a research method.

Triangulation is a research technique used in the discussion and interpretation of data collected by different instruments to ensure greater reliability of the results. Therefore, with this input, the most appropriate concept of mixed research is from R. B. Johnson et al. (2007, p. 129) which defines as:

> "*a method, it focuses on collecting, analysing, and mixing both quantitative and qualitative data in a single study or series of studies. Its central premise is that the use of quantitative and qualitative approaches, in combination, provides a better understanding of research problems than either approach alone"*

Finally, based on the concepts mentioned, with special attention to the definition that comes from R. B. Johnson et al. (2007), I decided to adopt the concept of mixed-method research instead of the other two concepts that are also widely used, which are the mixed-method or mixed research.

In this study, "mixed-method research" is defined as an approach used by combining different methods such as quantitative, qualitative, and other methods or techniques, for data collection, analysis, and interpretation by triangulation to obtain results with good explanation and reliability.

4.3. Qualitative methods

Qualitative methods/research as "a systematic, subjective approach used to describe life experiences and give them meaning" (Keele, 2010, p. 44), was used to process data gathered by (a) the documentary study, i.e., the study of the educational programs and policies of the country, (b) the observation of structural conditions and human resources capable of conducting the study, (c) the observation of the performance of both pre-service and school students on school project works.

These methods focus on discovering and understanding the experiences, perspectives, behaviours, and thoughts of the participant, and also provide us with a depth understanding of concepts or phenomena by using alternative strategies of inquiry such as narrative, phenomenology, grounded theory, and case studies (J.W. Creswell, 2009; J.W. Creswell & Creswell, 2018; Hiatt, 1986).

> "*Qualitative research is a situated activity that locates the observer in the world. It consists of a set of interpretive, material practices that make the world visible. These practices transform the world. They turn the world*

> *into a series of representations, including field notes, interviews, conversations, photographs, recordings, and memos to the self. At this level, qualitative research involves an interpretive, naturalistic approach to the world. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them*" (Denzin & Lincoln, 2005, p. 3).

The qualitative method can be subdivided into different types of qualitative research: phenomenology, ethnography, narrative inquiry, case study research, grounded theory, and historical research (R. B. Johnson et al., 2007).

The study of research methods must take into account the type of research question, the way of approach, and the way that the ideas are constructed from the data obtained to facilitate interpretation and reach the most accurate conclusion possible. In this way, J. W. Creswell (2014, p. 32) defines qualitative methods as:

> "*An approach for exploring and understanding the meaning individuals or groups ascribe to a social or human problem. The process of research involves emerging questions and procedures, data typically collected in the participant's setting, data analysis inductively building from particulars to general themes, and the researcher making interpretations of the meaning of the data. The final written report has a flexible structure. Those who engage in this form of inquiry support a way of looking at research that honours an inductive style, a focus on individual meaning, and the importance of rendering the complexity of a situation*".

The qualitative method was important to answer the first two research questions namely: "Q1- Conceptualization of a systemic approach for learning beyond school in Mozambique: what are the core elements? How can it be realized?", and "Q2-What are the structural and institutional preconditions to introduce a systemic approach for science teaching and learning at Púnguè university and secondary schools in Mozambique?"

The sets of data obtained was evaluated with the help of a literature review and later they were triangulated, taking into account the various factors that would facilitate or hinder or even make impossible the implementation of the systemic approach in the Mozambican curriculum. Triangulating the datasets was very important to find realistic cofactors for designing subsequent research activities.

The qualitative method was also used for the third question “Q3- What are pre-service teachers´ pre-conceptions about using the science-technology-society integration and systemic approach in learning activities?”

These methods proved to be important to collect and analyse data on pre-service teachers' preconceptions in content related to the use of science-technology-society integration and the systemic approach in learning activities.

The diversification of data collection techniques and information sources led to greater accuracy of the information collected previously, which somehow helped to reduce subjectivity in the findings.

4.4. Quantitative methods

Quantitative researchers attempt to operate under the assumption of objectivity (R. B. Johnson & Christensen, 2014), maximizing the replicability, and generalizability of findings as well as are typically interested in prediction (Harwell, 2011; R. B. Johnson et al., 2007).

The quantitative method deals with the precise measurement of the data, quantification of these, tests the hypotheses, and provides an overview of the facts so that it needs to go through a validation process in order to reduce the interference of the authors in the interpretation of the data and ensure the highest possible reliability of the results.

The quantitative method was important in the study to understand the preconception of pre-service teachers about a systemic approach and get results from students at school about practical work or systemic approach in the learning process.

> "*Quantitative research is an approach for testing objective theories by examining the relationship among variables. These variables, in turn, can be measured, typically on instruments, so that numbered data can be analysed using statistical procedures. The final written report has a set structure consisting of introduction, literature, theory, methods, results, and discussion. Like qualitative researchers, those who engage in this form of inquiry have assumptions about testing theories deductively, building in protections against bias, controlling for alternative explanations, and being able to generalize and replicate the findings",* (J. W. Creswell, 2014, p. 32).

Practically the quantitative method was used to answer the last two questions raised in the study, namely: "Q3- What are pre-service teachers´ pre-conceptions about using these approaches in learning activities and about university–community interactions?" And "Q4- What are the outcomes of a local intervention project designed to improve teaching and learning in university - community interactions?"

It is noteworthy that the two questions also required the application of qualitative methods, to obtain the results with the greatest possible objectivity, therefore, in this study, qualitative and quantitative methods were used in a mixed way.

Table 7. Table of quantitative and qualitative methods

	Qualitative Research Method	**Quantitative Research Method**
When to use it	▪ When an in-depth understanding of a specific issue is required ▪ To understand behaviours, perceptions, and priorities of the affected community ▪ To explain the information provided through quantitative data ▪ To emphasize a holistic approach (processes and outcomes) ▪ When the assessor only knows roughly in advance what he/she is looking for Recommended during earlier phases of assessments	▪ To get a broad comprehensive understanding of the situation ▪ To get socio-demographic characteristics of the population ▪ To compare relations and correlations between different issues ▪ When accurate and precise data is required ▪ To produce evidence about the type and size of problems When the assessor knows clearly in advance what he/she is looking for Recommended during the latter phases of assessment
Objectives and main features	▪ To explore, and understand phenomena ▪ Provides an in-depth understanding of specific issues ▪ Detailed and complete information, contextualization, interpretation, and description ▪ Perspectives, opinions, and explanations of affected populations toward events, beliefs, or practices	▪ To seek precise measurement, quantify, confirm hypotheses ▪ Provides a general overview ▪ Provides demographic characteristics ▪ Objective and reliable ▪ Apt for generalization ▪ Objectively verifiable ▪ Prediction, causal explanation
Data format	▪ Data can be observed but not measured ▪ Mainly textual (words, pictures, audio, video), but also categorical	▪ Data that can be counted or measured. Involves amount, measurement, or anything of quantity ▪ Mainly numerical and categorical values
Answers the questions	Answers questions arising during the discussion ▪ How? ▪ Why? ▪ What do I need to look for in more detail? Questions are generally open-ended	Answers a controlled sequence of questions with predetermined possible answers ▪ What? ▪ How many? Questions are closed
Perspective	▪ Looks at the whole context from within ▪ Searches for patterns ▪ Lends itself to community participation. Seeks depth of perspective through ongoing analysis (e.g., Waves of data)	▪ Looks at specific aspects from the outside

Methods	▪ Individual interviews ▪ Key informant interviews ▪ Semi-structured interviews ▪ Focus group discussions ▪ Observation	▪ Quick counting estimates ▪ Sampling surveys ▪ Population movement tracking ▪ Registration ▪ Structured interviews
Sampling	▪ Non-random (purposive)	▪ Random
Study design and instruments	▪ Flexible, the assessor is the primary instrument for data collection and analysis.	▪ Fixed, standards control the assessor's bias.
Questionnaire tool type	▪ Checklist with open questions and flexible sequence	▪ A predetermined questionnaire with sequence and structure
Analysis	▪ Use inductive reasoning ▪ Involves a systematic and iterative process of searching, categorizing, and integrating data ▪ Describes the meaning of research findings from the perspective of the research participants ▪ Involves developing generalizations from a limited number of specific observations or experiences ▪ Analysis is descriptive	▪ Uses deductive methods ▪ Descriptive statistics ▪ Inferential statistics

(ACAPS, 2012, p. 12)

4.5. Mixed method research

The mixed-method research provides greater tools for discussion, analysis, and reflection, thus strengthening research results (Greene, 2008; Newman, Ridenour, Newman, & DeMarco, 2003; Rooks & Ford, 2016). Bouchard (1976, p. 268) argues that convergence of findings stemming from two or more methods "enhances our beliefs that the results are valid and not a methodological artifact". In addition, the mixing of research methods reduces the interferences of the investigator. Interferences need to be avoided because they can bias or negatively influence the results.

This approach also helps in clarifying the points of view of interviewees, for instance, providing more evidence that allows the reflection, crossing, or triangulation of data set from different methods and techniques applied in ways to find out the common points of view and to reflect on the divergent points and reach the most appropriate point of view to get a better conclusion.

For a better understanding of the aspects behind the arguments which claim that, mixed-method research ensures a better quality of the data set, but also that they guarantee deeper analyses, ensuring better results, we present below a summary table of research methods:

Table 8. Summary table of methods

	Qualitative research	**Quantitative research**	**Mixed research**
Scientific method	Inductive or “bottom-up” Inductive reasoning used to synthesize data The researcher generates new hypotheses and grounded theories from data collected during fieldwork, Can also develop theory	Deductive or “top-down” Deductive reasoning used to synthesize data The researcher tests hypotheses and theories with data	Deductive and inductive The researcher can test hypotheses and theories with data and from the data generate new hypotheses and theories as well

View of human behaviour	Behaviour is fluid, dynamic, situational, social, contextual, and personal	Behaviour is regular and predictable	Behaviour is somewhat predictable and it depends on context, real personal and social conditions, and the background of people involved as well
Most common research objectives	Description, exploration, and discovery Meaning of things	Description, explanation, and prediction Cause and effect relationships	Multiple objectives and a deep understanding
Focus	Wide-angle and "deep-angle" lens, examining the breadth and depth of phenomena to learn more about them	Narrow-angle lens, testing specific hypotheses	Multilens, complex and broad
Nature of observation	Multiple realities that are continually changing with individual interpretation Study behaviour in natural environments Study the context in which behaviour occurs	A single reality that can be measured and generalized Attempt to study, behaviour under controlled conditions	Study behaviour in more than one context or condition
Nature of reality	Subjective, personal, and socially constructed	Objective (different observers agree on what is observed)	Common-sense realism and pragmatic view of the world (i.e., what works is what is "real" or true)
Form of data collected	Collect qualitative data (e.g., in-depth interviews, participant observation, documentary study, field notes, and open-ended questions) The researcher is the primary data collection instrument	Collect quantitative data on precise measurement using structured and validates data collection instruments (e.g. closed-ended questions, rating scales, behavioural responses)	Multiple and differentiated
Nature of data	Words, speeches, images, categories	Variables	A mixture of variables, words, speeches, and images
Data analysis	Search for patterns, themes, and holistic features	Identify statistical relationships and descriptive frequencies	Qualitative and qualitative
Results	Particularistic findings	Generalized findings	Corroborated findings may generalize

	Representation of insider (i.e., “emic”) viewpoint. Present multiple perspectives		
Form of a final report	Narrative report with contextual description and direct quotations from research participants	Statistical report (e. g. with correlations, comparisons of means, standard deviation, effect size, and report of the statistical significance of findings)	Eclectic and pragmatic

Adapted from (Keele, 2010)

To get greater reliability from the results, the mixed-method research was applied in different phases according to research questions, objectives, the activity schedule, and the methodological sequence of the research.

The literature used for this study was diversified between books, e-books, other articles, and online documents. Therefore, from the online literary resources used, the following sources stand out: Eric, Research gate, Taylor & Francis Online, Annual review, Elsevier, and Apa PsycNet.

4.5.1. Documentary study

To introduce any methodology or approaches in education systems that may influence the quality of teaching or change the normal routine of the teaching and learning process it is necessary to study the curricula and educational policies that regulate the educational process.

The documentary study aimed to identify the structural and organizational core elements that should facilitate the introduction of a systemic approach in the Mozambican education system and the way that it can be realized to promote learning beyond the school and in turn, help in transforming learning into effective (Watkins et al., 2002).

The documents also helped to define the templates and identify their structural and institutional preconditions at Púnguè University and all seven secondary schools for introducing a systemic approach.

For this purpose, the Laws of the National Education System and the strategic plans were analysed and discussed, as these are the main documents that regulate the teaching activity in the country.

But was also analysed and discussed the learning programs of grades 8, 9, and 11 of secondary education to identify contents that can be taught by applying the science-technology-society integration and a systemic approach. However, it was also necessary to check the methodological guidelines to understand the philosophy of curricula designers.

To better frame our intervention, more in-depth research was needed. To this end, previous studies in the area of education were used, as well as the curriculum of the Pedagogical University, which was the largest teacher training institution in Mozambique (before being divided into five different universities).

The analysis was done by me and also by students (pre-service teachers). Twenty-five students, organized in groups of five each, participated in the parallel verification. The students who participated in the parallel verification were all from Tete´s branch.

The reason for their choice was because it is the branch with the most students in internship since in other branches, students face some bureaucratic barriers such as (a) the lack of flexibility in dealing with schools, (b) lack of consideration of the heads of the academic area and (c) failures in some subjects that according to the regulations, can only intern students who have passed to the fourth years with all previous subjects approved.

4.5.2. Participant observation methods

The participant observation method was used at two different stages, (i) before the intervention in schools and (ii) during the intervention, both in schools, communities, and universities.

The first moment of observation aimed to know the physical preconditions for conducting action research and implementing the systemic approach in secondary schools in Mozambique.

The second stage of observation was the longest one that aimed to monitor the activities in the field of research (schools, communities, and universities) to assess the functionality of the systemic approach in the Mozambican curricula.

At this stage, the learning processes resulting from practical activities carried out in schools, universities, and communities were observed through a systemic approach, where several research projects were developed in collaboration and partnership with governmental and non-governmental organizations, to teach and explain various school contents and, at the same time, resolve concrete issues related to the quality of education and community problems.

All moments of interactions were observed directly and some of them were recorded (by video and pictures). This model of "not recording every moment" was used because often when people realize they are being filmed, they change their behaviour, which can skew the search result (Xu, Aranda, Widjaja, & Clarke, 2018).

Video recordings play a very important role in exploring the complexity of the learning process (Calandra & Rich, 2014), reducing ambiguity in research and capturing behavioural aspects and skills that cannot be collected by other data collection instruments. But, in the application of video recordings, attention must be paid to issues related to research ethics and laws related to image capture (Derry et al., 2010; Simons & Usher, 2012).

Therefore, the Mozambican law on audio-visual matters establishes that there is consent between the parties before the capture and use of images. In this study, videos and pictures were used to capture behavioural information (those impossible to collect by other instruments used) to enrich the information in the triangulation of results, but also to serve as evidence of field activities.

4.5.3. Questionnaire

A questionnaire is simply a tool for collecting and recording information about a particular issue of interest. Questionnaires are a very convenient way of collecting useful comparable data from a large number of individuals. However, questionnaires can only produce valid and meaningful results if the questions are clear and precise and if they are asked consistently across all respondents (Fox, Mathers, & Hunn, 2000).

According to CRIT (2016, p. 1)[14], questionnaires are commonly used:

- to collect factual information to classify people and their circumstances
- to gather straightforward information relating to people's behaviours
- to look at the basic attitudes/opinions of a group of people relating to a particular issue
- to measure the satisfaction of customers with a product or service
- to collect 'baseline' information which can then be tracked over time to examine changes.

For this research, two questionnaires have been used at different times:

Questionnaire-I: was applied to pre-service teachers before activities to collect information about their teaching experience, to glean from them the previous knowledge about methodologies that would be used in the work, overall, to get the information about the pre-service view on Science-Technology-Society integration and systemic approach.

After this step, and also after having participated in the collection of information about the infrastructural conditions at universities, schools, and living conditions of the communities, in addition to providing information on the normative bases of education in Mozambique, a plan of practical activities was drawn up and implemented in secondary education, university, and communities.

[14] The Council's Research and Intelligence Team

The activity plan was based on participatory-based research as a methodological approach and was executed as a project and was established and called "*school project and community development*".

The activities from the "school project" were monitored using participatory-based research and participant observation, and finally, the questionnaire was applied to assess the intrinsic and extrinsic motivation.

Questionnaire-II: The Science Motivation Questionnaire (SMQ), designed by Glynn et al. (2009) and Sotiriou et al. (2017) was applied to pre-service teachers after activities at school, university, and communities, to assess their motivational level and collect the results about which motivational aspects had a positive and which had a negative influence on the activities.

Note: The Science Motivation Questionnaire had been planned to be administered to the students from secondary schools and the pre-service teachers after the activities. However, with the outbreak of the COVID-19 pandemic and the lockdown in schools the activity had to be suspended initially.

The reopening of school activities took place months later, but with a few restrictions, one of which was the suspension of the pre-service training course, which took place in secondary schools.

With the interdiction of the internship in secondary schools, the activities took place in collaborative work and interaction between university and community in some cases and others in interaction with some companies and institutions.

For this reason, the questionnaire to assess motivation was applied only to students from the university (pre-service teachers) of the provinces of Manica (headquarters of the Púnguè university) and Tete (Branch of the Púnguè University).

4.5.3.1. Data of questionnaire-I: to pre-service teachers before activities

The draft of this questionnaire has twenty-two (22) items, that nineteen (19) are closed-ended and three (3) open questions. The original version was in the English language

and later on translated into Portuguese to fit the mother and official tongue of the people involved.

The translation processes were made in four different steps:

i. translated by me using my English and Portuguese background and getting some support from electronic software´ Deepl[15] and Linguee;
ii. translated by two seniors' lectures from Pedagogical University with Ph.D. degrees and more than twenty-seven (27) years of experience as a lecturer in high schools, one from the English department and another from the chemistry Department;
iii. translate by the official translator company;
iv. comparison of all four translated questionnaires to get common words and sentences.

In comparing the translated questionnaires there was some slight discrepancy regarding the treatment modes which makes a lot of difference in Portuguese for example the personal pronoun "you" which in English serves for second person singular and second plural it takes different names in Portuguese as "*tu*" or "*você*" for singular and "*vocês*" for plural. Pronouns are used according to some grammatical rules, i.e., modes of treatment, and should be taken into consideration, for instance, sometimes can be used "*tu*" but sometimes must not.

From the twenty-two items come in the questionnaire, six of them (from 15 to 20) were taken from Views on Science-Technology-Society (VOSTS), one hundred and fourteen (114) multiple-choice questions from Aikenhead et al. (1989).

Questions 15, 16,17, and 20 were transcribed from VOSTS, and on questions eighteen, and nineteen the name of the country "Canada" was replaced by "Mozambique", as the research took place in Mozambique and the questions were asked taking into account the view of Mozambican students on how science and

[15] A neural machine translation service launched in August 2017 and owned by Cologne-based DeepL SE. This translation system was first developed within Linguee and released as a DeepL entity

technology are applied in Mozambique for the country's development. The 6 questions taken from the VOSTS instrument are listed below:

Table 9. Questions taken from the VOSTS instrument

No.	*VOSTS* Numbers	Question
Q15	**40412**	Science and technology offer a great deal of help in resolving such social problems as poverty, crime, and unemployment.
Q16	**40221**	Science and technology can help people make some moral decisions (that is, one group of people deciding how to act towards another group of people).
Q17	**40231**	Science and technology can NOT help people make legal decisions; for example, deciding if a person is guilty or not guilty in a court of law.
Q18	**40511**	The more Mozambique's science and technology develop, the wealthier Mozambique will become.
Q19	**40531**	More technology will improve the standard of living for Mozambicans.
Q20	**40711**	Science and technology influence our everyday thinking because science and technology give us new words and ideas.

4.5.3.2. Pilot Study

A pilot study is an experimental, exploratory, test, preliminary, trial, or try-out investigation applied in research to assess the feasibility of methods and procedures (In, 2017; Thabane et al., 2010).

The original questionnaire was in English and translated into Portuguese as explained above. Translated questionnaires can easily become vitiated or lose some meaning. Questions with different meanings may lead to different perceptions and therefore less consistent or even decontextualized answers.

To reduce inconsistency in data collection instruments, several researchers resort to pilot studies, but in addition, other researchers point out other reasons that motivate the elaboration of these studies.

Thabane et al. (2010, p. 2) point out four different "macro-reasons", which means, reasons grouped into four different categories, namely; (a) process, (b) resources, (c)

management, and (d) scientific reasons. The reasons given by Thabane et al. (2010), have very broad meanings, that is why, to better understand the reasons that led to the application of a pilot study in this research, the fifteen (15) reasons mentioned by van Teijlingen, Rennie, Hundley, and Graham (2001, p. 2) were listed below:

i. Developing and testing the adequacy of research instruments
ii. Assessing the feasibility of a (full-scale) study/survey
iii. Designing a research protocol
iv. Assessing whether the research protocol is realistic and workable
v. Establishing whether the sampling frame and technique are effective
vi. Assessing the likely success of proposed recruitment approaches
vii. Identifying logistical problems which might occur using proposed methods
viii. Estimating variability in outcomes to help to determine sample size
ix. Collecting preliminary data
x. Determining what resources (finance, staff) are needed for a planned study
xi. Assessing the proposed data analysis techniques to uncover potential problems
xii. Developing a research question and research plan
xiii. Training a researcher in as many elements of the research process as possible
xiv. Convincing funding bodies that the research team is competent and knowledgeable
xv. Convincing funding bodies that the main study is feasible and worth funding
xvi. Convincing other stakeholders that the main study is worth supporting.

For the reasons mentioned above, the ones that fit best in this study are i-vii, xii, and xiii. Therefore, the pilot study was carried out specifically to verify the existence or not of differences between both (English and Portuguese) versions, but also to verify the existence or not of ambiguities, to find consensus in both the grammar and the meaning of the sentences, to correct them and improve the instrument, thus reducing misunderstandings and ensuring consistency in the questionnaire.

The pilot study also served to assess the average response time to the questionnaire, and other aspects such as the form of the question scale, the applicability or not of questions, and vocabulary (if appropriate or not), to get an idea of trends in answers that could match the final results in some cases.

4.5.3.2.1. Characteristics of the sample of the pilot study

The pilot study “small scale version [s], or trial run [s], done in preparation for the major study” (Polit, Beck, & Hungler, 2001, p. 467), hence after translation. However, 25 students “small scale” from chemistry (2nd level) participated in the pilot study.

According to the Púnguè University curriculum, these students have an academic background close to the main group, as they have a great part of the same curricular subjects, for example, (i) basic English, (ii) Portuguese language, but also other specific subjects in the chemistry course and especially physical chemistry-I which deals about the system in thermodynamics.

Table 10. Characteristic of the sample of the pilot study-I

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	18	72.0	72.0	72.0
	Female	7	28.0	28.0	100.0
	Total	25	100.0	100.0	

4.5.3.2.2. Report of the pilot study-I

Reporting pilot studies is severely important in scientific research but, according to Prescott and Soeken (1989, p. 1) finding reveals that “despite the importance of pilot studies to the success of well-conducted research, other researchers suggest that pilot studies are under-discussed, underused and underreported”. It means that many are authors who do not see the details of the pilot study as a piece of potential information or experience to follow (aspects of success) or to overcome (aspects of failure).

There are also some researches that have been done in science education that used the pilot study as a preparatory phase before researching the main group, but they also do not present an exhaustive repot of the pilot study (Al-Rahmi & Othman, 2013; Lee, Brown, Luft, & Roehrig, 2007).

According to van Teijlingen et al. (2001, p. 5) “when pilot studies are mentioned in more detail in academic papers and reports, researchers regularly comment that they" had learned from the pilot study "and made the necessary changes, without offering the

reader details about what exactly was learned", its fits the statement that full reports of pilot studies are rare in the research literature (Muoio, Wolcott, & Seigel, 1995).

In this study, an integral report of the entire pilot study process is presented due to the importance of this information for other researchers that need to use the same instrument or similar methods, and according to Mason and Zuercher (1995) quoted in van Teijlingen et al. (2001, p. 5)

> *"Some of these processes and outcomes from both successful and failed pilot studies might be very useful to others embarking on projects using similar methods and instruments. This is particularly important because pilot studies can be "time-consuming, frustrating, and fraught with unanticipated problems, but it is better to deal with them before investing a great deal of time, money, and effort in the full study*".

Thus, the data from the pilot study of the questionnaire-I, brought up profound findings and the need for improvement or in some cases the need for some adaptation of the questionnaire to the reality of the target group, in the following aspects:

a) Grammar improvement in some points for example singular to plural expressions, consideration of gender issues in questions 4; 14, and 22;

Table 11. Grammar improvement

Questions	Original (English)	The pilot study (Portuguese)	Last version (Portuguese)
Q4	If **No**, so how long have you been teaching? If **Yes,** skip to question **7**	[…] *sim, salte para a questão 7*	▪ add of terms „*por favor*", that means, **please**. […] *sim,* ***por favor*** *salte para a questão 7*
Q14	In Mozambique, teaching and learning at school are based on the interaction among School-Community - Institutions of the state and NGOs.	[…] *a Escolas-Comunidades - Instituições do Estado e ONGs*.	▪ Changing the term *"a"* (singular) to *"as"* (plural). […] ***as*** *Escolas-Comunidades - Instituições do Estado e ONGs.*

Q22	If there is a need for […] content proposal to be taught and the school solves […].	[…] *conteúdo a ser* *ensinada* *e a escola resolve […].*	▪ Changing the word "*ensinada"* to "***ensinado"*** […] *conteúdo a ser* ***ensinado*** *e a escola resolve […].*

These little grammatical changes often distort the true meaning of the word which can influence the perception of the whole sentence and somehow lead us to wrong answers or contrary to the true point of view of the respondents.

The Portuguese language has many rules and knowledge of this brings many advantages in writing, interpreting, and explaining texts, not only in academia but in different fields and communities. There are also rules applicable to different social backgrounds, ages, and proximity/intimacy.

According to Jovana (2018), there are many advantages to understanding the rules of Portuguese. Your way of speaking will not only be prettier and more elegant, but much more professional. Inspiring the trust of the people around, you will be simpler, and selling your fish/make lobbies a less challenging task.

Therefore, it was necessary to carefully check all three (3) different translations and to suit the target group according to the specificity of this. The following question was taken from the VOSTS instrument which is the result of research carried out over six years for the validation process and categorization of responses from grade-12 students (Aikenhead, 1988).

Therefore, although a long and high-quality work was done to establish the instrument in the Mozambican reality, it was necessary to combine the last three options in a single question, as we can see below.

b) Combining the last three options into one. The questions were taken from the VOSTS instrument. This change was made in the three last options of questions number 15, 16, 17, 18, 19, and 20.

Table 12. Combination of the last three options of VOSTS answers

Questions	Original (English)	The Pilot Study (Portuguese)	Last version (Portuguese)
Q15 (i.e.)	[…] (Please read from **A** to **I,** and then choose one option only) Last 3 options: G. I don't understand; H. I don't know enough about this subject to make a choice, I. None of these choices fits my basic viewpoint**.**	*[…] (queira por favor, ler de **A à I**, e depois seleccione apenas uma opção)* ***Last three options (splitted):*** ***G.*** *Não compreendo.* ***H.*** *Não sei o suficiente sobre este assunto para fazer uma escolha.* ***I.*** *Nenhuma destas escolhas corresponde ao meu ponto de vista básico.*	*[…] (queira por favor, ler de **A à G,** e depois seleccione apenas uma opção)* ***Last three options (agglutinated):*** ***G.*** *i.Não compreendo.* *ii. Não sei o suficiente sobre este assunto para fazer uma escolha.* *iii.Nenhuma destas escolhas corresponde ao meu ponto de vista básico.*

The changes made on these four questions were because in Mozambique the subject related to science-technology and society is very new and very little spoken, so it is normal for people to say that they do not understand and therefore do not choose any choice or even reveal lack of mastery of the matter, i.e., it does not make much difference separating or joining the last three (3) options. These options were also grouped in some other studies by other researchers (Adiputra, Mudzakir, & Widhiyanti, 2019; Madeira, 2016; Tedman & Keeves, 2001);

b) Changing or increasing options from answers of numbers 2, 3, 4, 5, 6, and 13 to cover the various points of view and specificity;

Table 13. Changing or increase of options from some answers

Questions	Original (English)	The pilot study (Portuguese)	Last version (English)
Q2.	Grade of your internship? 8ª____ 9ª____ 11ª____	*Classe em que estagia?* *8ª____* *9ª____* *11ª____*	Grade of your internship? 8ª____ 9ª____ 11ª____ None____ ▪ **added one more option**
Q3.	Is this your first-time teaching? Yes___ No____	*É a primeira vez que leciona?* *Sim____* *Não____*	Is this your first-time teaching? Yes___ No____ I´m not teaching_____ ▪ **added one more option**
Q4.	If **yes,** skip to question seven (**7)** 0-2 years____; 2-5 years____; More than 5 years_	*Se a opção anterior tenha sido **Sim**, por favor salte para a questão 7* *0-2 Anos____;* *2-5 Anos____;* *Mais de 5 anos____,*	If **yes** skip to question **7** 0-2 years____; 2-5 years____; More than 5 years____ None of this choice____ ▪ **added one more option**
Q6.	Which area? 1. Natural Science__ 2. Social Science__ 3. Others_____	*Que área leccionou?* *1. Ciências Naturais__;* *2. Ciências Sociais___;* *3. Outras___*	Which area? 1. Natural Science____; 2. Social Science___; 3. Others_____ 4. None of these choices___ ▪ **added one more option**
Q13.	What kind of system best fits our education system? 1. Open system ___, 2. Closed system __, 3. Isolated system__	*Que tipo de sistema encaixa-se melhor ao nosso sistema educacional?* *1. Sistema aberto: __* *2. Sistema fechado: __* *3. Sistema isolado: __*	What kind of system best fits our education system? 1. Open system ___, 2. Closed system ___, 3. Isolated system ___, 4. I don't know enough about this subject to make a choice___, ▪ **added one more option**

Increasing or diversifying response options also increases the chances of responses so, that while there is some favourable option, there is one that is not only favourable but which in turn has the highest accuracy of student choice. In this way, the probability of obtaining more accurate answers was increased.

c) Question mode change from open to closed-ended (number five)

Table 14. changing questions from open to closed.

Questions	Original (English)	The pilot study (Portuguese)	Last version (English)
Q5.	Which grade? ___	*Que classe leccionou*?__	Which grade? grade 1-5____ grade 6-7___ grade 8-10 ____ None of this choice_____

Organizing the answers into scales (classes) helps in data analysis using statistical packages such as SPSS; but also, findings from the pilot study reveal that in all cases about 61% of students left open-ended questions unanswered (see tables below), so it was decided to put in multiple choice with all possible options, including options for those who did not teach.

Table 15. Open-ended question 1

Q8. If YES, what does it mean (way of doing and goal) for learning and teaching in your point of view?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	said something	11	44.0	44.0	44.0
	No answer	14	56.0	56.0	100.0
	Total	25	100.0	100.0	

Table 16. Open-ended question 2

Q11. If Yes: What is the difference between them in your point of view?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	said something	8	32.0	32.0	32.0
	no answer	17	**68.0**	68.0	100.0
	Total	25	100.0	100.0	

Table 17. Open-ended question 3

Q13. Why? Justify/Argument

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	said something	10	40.0	40.0	40.0
	no answer	15	**60.0**	60.0	100.0
	Total	25	100.0	100.0	

In general, the result from these three open-ended questions gave us the idea to start thinking about an in-depth interview, to reap the true point of view from pre-service

students about the systemic approach but also the motivations of not filling out the questionnaire in open-end questions.

d) Restructuring of question 10 by placing it separately to avoid ambiguity in the responses. So, from one question, four split questions arise, as explained in the table below:

Table 18. Restructuring of question 10

Questions	Original English	The pilot study (Portuguese)	Last version (English)
Q9	1. Do you remember about different kinds of systems, such as Open, closed, and Isolated? Open system: Yes____, No____, Closed system: Yes____, No____, Isolated system: Yes____, No____,	*Você se lembra de diferentes tipos de sistemas, como aberto, fechado e isolado?* *Sistema aberto: Sim____, Não____* *Sistema fechado: Sim ____, Não ___* *Sistema isolado: Sim____, Não____*	1. Do you remember about systems? Yes____, No____, 2. Do you remember about the Open system? Yes____, No____, 3. Do you remember about the Closed system? Yes____, No____, 4. Do you remember about the Isolated system? Yes____, No____,

In the pilot study, students revealed that was quite confusing in answering as was written. Hence, they suggested separating them into different options since, in the introduction, I proposed to choose only one option from each.

Dividing the question into four different new questions helped to improve the perception of the students' points of view, but also allowed the creation of a database to analyse the reliability and correlation between them.

In general, the changes helped to obtain an improved questionnaire in terms of perception of the questions, placement of options that adjust to reality, and ease of interpretation of results from the statistical program used (SPSS) and triangulation.

4.5.3.3. Categorization of the Questionnaire-I

The assessment instrument called views on science-technology society (VOSTS) from Aikenhead et al. (1989) presents items/questions that according to Aikenhead and Ryan (1992) are divided into four (4) major areas namely: (a) definition; (b) external sociology of science; (c) internal sociology of science; and (d) epistemology.

In my dissertation, the four scientific areas above are called categories. The VOSTS questionnaire has a total of four categories that are subdivided into nine-under categories as follows:

Table 19. Categories of the VOSTS questionnaire

Ord	Categories	Under categories
1	Definition	1. science and technology
2	External sociology of science	2. influence of society on science/technology; 3. future category; 4. influence of science/technology on society; 5. influence of school science on society;
3	Internal sociology of science	6. characteristics of scientists; 7. the social construction of scientific knowledge; 8. the social construction of technology;
4	Epistemology	9. nature of scientific knowledge

This study used questions related to the “external sociology of science” under categories number four, which talks about the influence of science/technology on society to find out the student’s point of view on the importance of technology and the interaction between school and community in the process of knowledge production.

During the intervention phase at schools, the pre-service teachers worked by applying science and technology in a system where they participated in science-technology-society integration and systemic approach through interaction between them, governmental and non-governmental institutions, partners, and society, which dictated the need to obtain data on the level of information and how prepared the pre-service teachers were about the methodologies and approaches used.

The VOSTS items are nominal qualitative variables, and according to Aikenhead and Ryan (1992, p. 480)

> "*The domain of the possible responses to VOSTS items derives not from a theoretical or researcher-based viewpoint (as does the domain of the distractors in a multiple-choice item, for example) but empirically from the domain of student viewpoints. Student responses to VOSTS are qualitative data-student response patterns. As will be discussed later, this shift in emphasis has implications when the issue of the instrument's validity is addressed".*

Data were processed based on item response theory. This theory "provides information on the relationship between sets of items, for example, how a student will likely respond to item X, given the student's response to items Y and Z" (Aikenhead & Ryan, 1992, p. 488).

Therefore, for statistical aspects of questionnaires, three different ways can be used namely: (1) simple frequency calculation to gauge the answer percentage of each option (2) applying the Likert scale "agree, dislike, etc" or "like, dislike, etc." or (3) apply categorized scales.

To better understand the point of view of teachers in training on the VOSTS items, in this study, the third alternative was that of categorization, also based on the specificity and sensitivity of the content of the questions.

The proposal for categorization and use of scales that can be calculated mathematically was raised by Aikenhead and Ryan (1992), after a survey in which they used the "Likert scale" to understand students' views on science-technology and society using the instrument they developed, the "VOSTS instruments", where they found about 80% ambiguity in students' answers, which means that the position of the students was not clear when the "like or dislike" scale was applied to the VOSTS options.

According to Aikenhead (1988, p. 615), the "Likert-type responses offer only a guess at student beliefs, and the chances of an evaluator guessing accurately are very remote". These findings are supported by the assumptions and intentions of the "Likert scale" as it was developed aiming to be a comparative, quantitative measure of social

attitude (Likert, 1932) while the VOST items deal with cognition and not necessarily attitude (Aikenhead, 1988).

Additionally, the application of the Likert scale "requires a large number of monotone items" (Shaw & Wright, 1967, p. 24), and differently from the Likert scale, “VOSTS items address a complex world, not a monotone attitude object. Therefore, one might have predicted the inadequacy of Likert-type scales for monitoring student beliefs about STS topics” (Aikenhead, 1988, p. 617), however, these are the reasons why we decided to score, and then perform the statistical analysis using SPSS versions 25.0. and 20.0.

For the application of statistical inferences from the VOSTS questionnaire such as test-retest comparisons and hypothesis testing using inferential statistical procedures, Rubba and Harkness (1996), developed a scoring procedure that allows such comparisons.

In a deep bibliographic review several different authors and categories applied to the same questionnaire or questions taken from VOSTS as the table below:

Table 20. Different categories of VOSTS questions according to different authors

Nr	Number of Categories	Categories	Proponent	Country
3	3	• Naïve • Has Merit • Realistic	(Rubba & Harkness, 1996) (Bradford, Rubba, & Harkness, 1995) (Öztürk-Akar & Doğan, 2013) (Zorlu, Baykara, & Zorlu, 2013)	U.S.A. U.S.A. Turkey Turkey
1		• Naïve • Plausible • Appropriate	(Vazquez-Alonso, 1999)	Spain
1		• Naïve • Plausible • Acceptable	(Vazquez-Alonso, Manassero-Mas, & cevedo-Diaz, 2006)	Spain
2		• Realistic • Acceptable • Inadequate	(Silva & Marcondes, 2013) (Canavarro, 2000)	Brazil Portugal
1		• Realistic • Plausible • Simplistic	(Miranda, 2008)	Brazil
1	4	• Naïve • Beginning to get past naïve ideas • Shows awareness of STS ideas	(Adiputra et al., 2019)	Australia

		• Sophisticated		
1		• Realistic • Has Merit • Naïve • Uncategorized	(Adiputra et al., 2019)	Indonesia
1		• Passive (P); • Naïve (N), • Has Merit (HM) • Realistic (R).	(Madeira, 2016)	Mozambique

From the literature review, a consensus was found on the names and meanings of some categories used, and the decision on which categories to adopt for this study was based on the nature of applied research questions, objectives, and context in which the study took place as criteria.

The study was conducted in Mozambique and had students from secondary schools and the former Pedagogical University (actually split into five different new Universities). The study “Mozambican university students' conceptions about the relationship between science-technology-society” by Madeira (2016) was held in the same country and in the same educational institution that included students of the natural sciences and in particular the students of the chemistry course.

For the study, it was decided to use the three codes developed by Bradford et al. (1995), and used by various authors such as Schoneweg and Rubba (1993) in the U.S.A, Öztürk-Akar and Doğan (2013) in Turkey, Adiputra et al. (2019) in Indonesia, Madeira (2016) in Mozambique, etc.

The study of Madeira stands out for having been carried out in the same country, using some aspects of similarity in terms of culture, academic and linguistic profile. The codes “Realistic (R), Has merit (HM) e Naïve (N)” according to Rubba and Harkness (1996) mean:

Realistic (R) = the choice expresses an appropriate view.

Has Merit (HM) = while not realistic, the choice expresses some legitimate points.

Naïve (N) = the choice expresses a view that is inappropriate or not legitimate.

The same meaning was adopted by Madeira (2016); Öztürk-Akar and Doğan (2013); Vazquez-Alonso (1999), so realistic is the one that expresses an appropriate view of the nature of science or technology. Similarly, a "has merit" option is the one that, while

not being completely appropriate, expresses a view that has a certain part that is appropriate to the nature of science or technology.

On the other hand, the 'naïve' view is seen as the one that expresses a view that is not relevant or appropriate to the nature of science or technology. The last three options from VOSTS we classified as “Neutral” and used the abbreviation (Ne) as a way to differentiate from Naïve as its abbreviation is “N”.

The reason why the term "Neutral" was chosen instead of "Passive" used by Madeira (2016) it´s because, passive means accepting or allowing what happens or what others do or choose, without active response/choice or resistance (online dictionary), while neutral means, not supporting or helping either side in a conflict, disagreement, etc. neutral can also mean; impartial, without favouritism, open-minded, non-partisan, non-discriminatory, disinterested, indifferent, removed.

Neutral can also mean that he judges impartially, that he is impartial (judging without passion). The figure below helps to define and understand the concept of neutral.

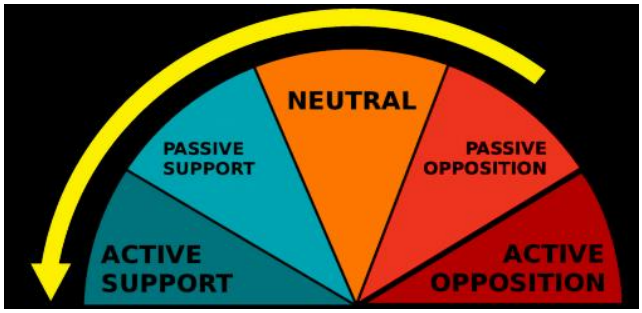


Figure 15. Example of application of “neutral” term.
(Tanner, 2021)

4.5.3.3.1. Steps for scoring questions from VOSTS

After the application of the questionnaire, descriptive statistics were done to understand the meaning of the students' choice in terms of the percentage of each answer, but this statistic does not give insight into the level of mastery of science-technology and society, so I opted for categorization and scoring:

(i) Adopted 4 categories:

Table 21. The four categories adopted

Nr	Categories	Meaning
1	Realistic (R)	The choice expresses an appropriate view.
2	Has Merit (HM)	While not realistic, the choice expresses some legitimate points.
3	Naïve (N)	The choice expresses a view that is inappropriate or not legitimate.
4	Neutral (Ne)	Not supporting or helping either side in a conflict, impartial, without favouritism, disinterested or indifferent.

(ii) Scoring VOSTS items

To score all six VOSTS items, it was necessary to start with a literature review in order to understand the procedures followed by other researchers. From the literature, it was difficult to find the scores for the six questions used in this study. For that, an e-mail with the questionnaire was sent to four Professors and one Ph.D. Student, all from Mozambique.

According to the time established, there was a response only from two Professors. A similar or even more aggravating case of weak collaboration in categorization happened in the Miranda (2008)´ study, which initially counted two hundred and fifty (250) participants (Professors/researchers) and had the response of forty (40) of them reporting unavailability to collaborate in the research and only twenty-two teachers/researchers who returned the email with the questionnaire already categorized.

The weak collaboration must probably be related to factors such as the lack of knowledge of the VOSTS instrument; lack of mastery of the categorization process, poor understanding of the activity, and lack of time to devote to a detailed assessment of the questionnaire, or even hesitation.

Thus, to a triangulation, judgment, and a more assertive score, a bibliographical review was carried out and the proposals were listed, including mine and the proposal of the supervisor, who is an STS specialist with an excellent command of the area. The table below shows the proposals listed for the final clearance.

Table 22. Last stage for the final categorization.

Questions	Authors	Realistic	Has merit	Naïve
Q15	STS Expert	**D**	**ABC**	**EF**
	Author	A**C**	BD	EF
	(Madeira, 2016)	**D**	**CEF**	**ABG**
	Prof. Dr. 2	**ABCF**	**D**	**E**
	(Cunha, 2008)	**A**		
Q16	STS Expert	**D**	**AB**	**CEF**
	Author	B	AD	CEF
	Prof Dr. 2	AF	BD	CDE
	(Cunha, 2008)	**A**		
Q17	STS Expert	**C**	**D**	**AB**
	Author	B	A	CD
	Prof. Dr. 2	CD		AB
Q18	STS Expert	**D**	**AB**	**CEF**
	Author	D	ABC	EF
	(Madeira, 2016)	F	ACE	BD
	Prof. Dr. 2	B	CD	AEF
Q19	STS Expert	**E**	**BCD**	**AF**
		D	BCE	F
	Author	**E** and F	AC	BD
	(Cunha, 2008)	**AC**		
	(Canavarro, 2000)	**E**		
	(Silva & Marcondes, 2013)			
Q20	STS Expert	**E**	**BC**	**ADF**
	Author	D	BCE	**AF**

(iii) Last decision

As the table above illustrates, finding consensus on VOSTS item scores and reaching a final decision is not easy. The same conclusion was reached by some other researchers such as Cunha (2008); Madeira (2016); Silva and Marcondes (2013) in their studies.

In this research study, some points bolded are common between two or more researchers, and others are discrepant. These discrepancies are common in studies of this nature and were found in some other studies such as Madeira (2016) in which the scoring was done by six different experts (five from Mozambique and one from Germany), and even so, to reach the final score had to choose the most chosen options mainly in the case of a realistic option.

The discrepancy was also found in Miranda's (2008) work on the categorization of the VOSTS questions in which 22 Professors participated, so to overcome the discrepancy, and reach the final decision both Miranda and Madeira used frequency (mode), i.e. the most voted option.

The method used to establish scales to monitor students' beliefs about STS topics is similar to that used by other researchers (Cunha, 2008; Madeira, 2016; Rubba & Harkness, 1996; Silva & Marcondes, 2013; Tedman & Keeves, 2001) However, among these, Tedman and Keeves used a scale of numerical variables instead of nominal.

In this study, the procedure for the final decision on the score was a little different from the others regarding the number of people and specialists involved, as well as the steps are taken to make the last decision. So, there are two different ways to make the final decision, which are:

i. Scaling of experts or participants and scaling the items based on literature review for judgment and final decision (Rubba & Harkness, 1996).
ii. Scaling of experts or participants, scaling of the items based on literature review, and finally, the researcher's judgment based on statistical analysis (Tedman & Keeves, 2001).

Similar to the studies above, in this study, the first two stages were also used, however, the sample consisted of only four people (among experts and professors), a number considered statistically insignificant and according to Miranda (2008, p. 60) “to opt for statistical analysis, there must be a minimum of six options, and the option that reaches more than 80% of the choices is voted”.

Therefore, for this reason, in this study, the final decision was taken after an in-depth discussion with the academic expert (Michael Schallies), which differs from, for example, the Tedman and Keeves (2001) study, which had the participation of seven experts and chose to calibrate the scales statistically where it obtained the Crombach Alpha value of 0.94.

However, the final decision as announced above came from the debate with academic experts in STS and with some experience in working with the VOSTS instrument but

based on the proposals sent and options taken from literature, one of which had twenty-two experts.

In the debate to make the final decision, the following aspects were determinant:

- The experience of the expert and my participation in modules related to STS in two years of my master's degree;
- The attentive reading of the questions *vs*. options of answers i. positive way and ii. negative way and the attention that should be paid to the arguments presented before the answers (e.g., in the following table);
- Contextualized evaluation of each answer. This is a very fundamental step that can guarantee a more precise choice than the simple option statistically elected.

Table 23. Example of ways (negative and positive) to answer some VOSTS questions

Questions	Options	Positive/negative way
40711 Science and technology influence our everyday thinking because science and technology give us new words and ideas.	A. Yes, because […] B. Yes, because […]	Positive way
	Science and technology are the most powerful influences on our everyday lives, not because of words and ideas: D. but because […] E. but because […] F. No, because […]	Negative way

After prolonged debate based on all of the aforementioned aspects, a consensus was reached to adopt this study with the following categories and scoring:

Table 24. Categories and scores adopted

	Categories				
Questions	**Realistic (R)**	**Has Merit (HM)**	**Naïve (N)**	**Neutral (Ne)**	
Q15. (40412)	D	ABC	EF	GHI	**Scores**
Q16. (40221)	D	AB	C E F	GHI	
Q17. (40231)	C	D	AB	EFG	
Q18. (40511)	D	AB	CEF	GHI	
Q19. (40531)	E	BCD	AF	GHI	
Q20. (40711)	E	BC	ADF	GHI	

4.5.3.4. Observation data

4.5.3.4.1. Observation before the intervention at schools

The observation was carried out in the city's seven secondary schools but also at the Púnguè University, to assess the physical and infrastructure conditions for the implementation of projects and activities related to Science-Technology-Society integration and systemic approach.

The city's seven schools are located in different areas and most of them have similar names to the neighborhood where they are located. In 2018, when the research activities started, the schools were composed according to the table below.

No.	Name of secondary schools	Students	Teachers	Students (S1)	Teachers (S1)	Students (S2)	Teachers (S2)	Men (S1)	Women (S1)	Men (S2)	Women (S2)
01	**Samora Machel** (S1 & S2)	5989	181	1506	26	4483	155	788	718	2386	2097
02	**Soalpo** (S1 & S2)	3893	61	3893	61	0	0	2153	1740	0	0
03	**Eduardo Mondlane**	4208	62	4208	62	0	0	2105	2103	0	0
04	**Vila Nova** (S1 & S2)	5253	110	2402	28	2851	82	1171	1231	1533	1318
05	**Sete de Abril** (S1 & S2)	6145	119	3224	38	2921	81	1632	1592	1518	1403
06	**Paulo Samuel Kankomba** (S1)	2843	38	2843	38	0	0	1573	1270	0	0
07	**Fepom secondary school** (S1)	2805	26	2805	26	0	0	1542	1263	0	0

Table 25. Statistical data of secondary schools (S1[16] and S2[17]) of Chimoio in 2018

All the schools have a fenced courtyard containing classrooms, an administrative block, a canteen, space for physical exercise, and sports, a place reserved for creative activities, where different projects can be implemented and various products can be produced or created.

However, the agro-ecological conditions of the city encourage most of the time the occupation of the "empty" space for the practice of agricultural activity as shown in the figure below.

[16] Secondary schools of the first learning cycle (from grade 8 to 10)
[17] Secondary schools of the second cycle of learning (grade 11 & 12)

Figure 16. Vila Nova-Chimoio Secondary School
A- Classroom and fence separating it from the vegetable garden. B- Area reserved for creative activities, especially agriculture (vegetable garden).

It was also found that the largest secondary school in the city (Samora Moisés Machel secondary school) despite having similar characteristics, the provincial government established the school as a place for the development of sports and recreational practices and bets on the installation of sports infrastructures (fig 17) and has been the venue for various sports and recreational activities at city, provincial and national events.

This infrastructural configuration reveals that from a political, administrative, and perhaps even organizational point of view, there is no specific space reserved for activities such as agriculture and some small projects/products, because the priority is to make better use of the existing space to develop projects related to sports, recreation, health, well-being, etc.

Despite this priority, the school has some empty spaces that could be fenced/protected and prepared to receive other kinds of projects with a greater focus on agriculture which has been established as the basis for the development of the country.

Figure 17. The infrastructure of the Samora Moises Machel secondary school. Chimoio
A- Administration building and classrooms; B- Pavilion (covered) for sports; C- Open space for sports.

4.5.4 Participatory-based research

Participatory-based research comes from community-based participatory research (CBPR) that rises in the health field and is defined as:

> *"A collaborative approach to research equitably involves all partners in the research process and recognizes the unique strengths that each brings. CBPR begins with a research topic of importance to the community with the aim of combining knowledge and action for social change to improve community health and eliminate health disparities",* (Minkler & Wallerstein, 2003, p. 4).

There are other terms such as participatory research, participatory action research, etc. Participatory research is defined "as systematic inquiry, with the collaboration of those affected by the issue being studied, for purposes of education and taking action or effecting change" (Green et al., 2003, p. 419).

This definition does not differ much from participatory-based research, as though introducing a new term (system/ systemic approach) which proposes a collaborative, or cooperative work between people and partners from a certain community.

"Participatory research attempts to present people as researchers themselves in pursuit of answers to the questions of their daily struggle and survival" (Tandon, 1988, p. 7).

In the case of my dissertation research activities, I participated in all phases of the research, collecting information and data to design the actions of the following stages. The initial stages of the research (documentary study and observation before the intervention) were very important for the design of the intervention scenario in schools and communities.

For Gaventa (1988, p. 19), participatory research attempts to:

> "*Break down the distinction between the researchers and the researched, the subjects and objects of knowledge production by the participation of the people-for-themselves in the process of gaining and creating knowledge. In the process, research is seen not only as a process of creating knowledge, but simultaneously, as education and development of consciousness, and mobilization for action*".

The above aspects were duly explored in this study, as everyone involved (students, partners, and myself) participated in the study as researchers but also as research objects, thus building knowledge through practical work, exchange of experiences, and production of prototypes, production of monographs, as well as production of scientific articles.

Participants developed an awareness of the need to unite academia and state and private institutions for the development of communities and applied scientific capacity, creativity, and innovation such as the application of indigenous knowledge (IK[18]) and artificial intelligence (AI[19]) for the well-being of communities, countries, and the world.

The goal of participatory research is "[…] to enable the oppressed groups and classes to acquire sufficient creative and transforming leverage as expressed in specific projects, acts and struggles […]", (Fals-Borda & Rahman, 1991).

Participatory Action Research is defined by Wallerstein, Duran, Oetzel, and Minkler (2003, p. 1) as:

> "*a systematic investigation, with the collaboration of those affected by the issue being studied, for the purposes of education and taking action or effecting social change, PAR is not a research method but an approach to research partnerships and applications. It has roots in popular education in Third World nations of Asia and Africa, and has been applied in the US, Canada and elsewhere in disciplines including social psychology, anthropology, and adult education*".

The main goal for using this approach in this research was to create a system (fig. 18) through a project that encompassed all the cooperation partners, where each one had its role and responsibilities for common well-being.

[18] Term used to refer to the knowledge coming from communities
[19] Term used to refer to the application of technologies

The partners worked collaboratively and cooperatively, affecting social change, improving learning and understanding of science, improving teaching methodology, and at the same time solving some of the communities' problems.

The PBR approach was applied in almost all phases of the research, so until now projects resulting from these studies are being developed and also publish monographs, articles, prototypes, products, etc.

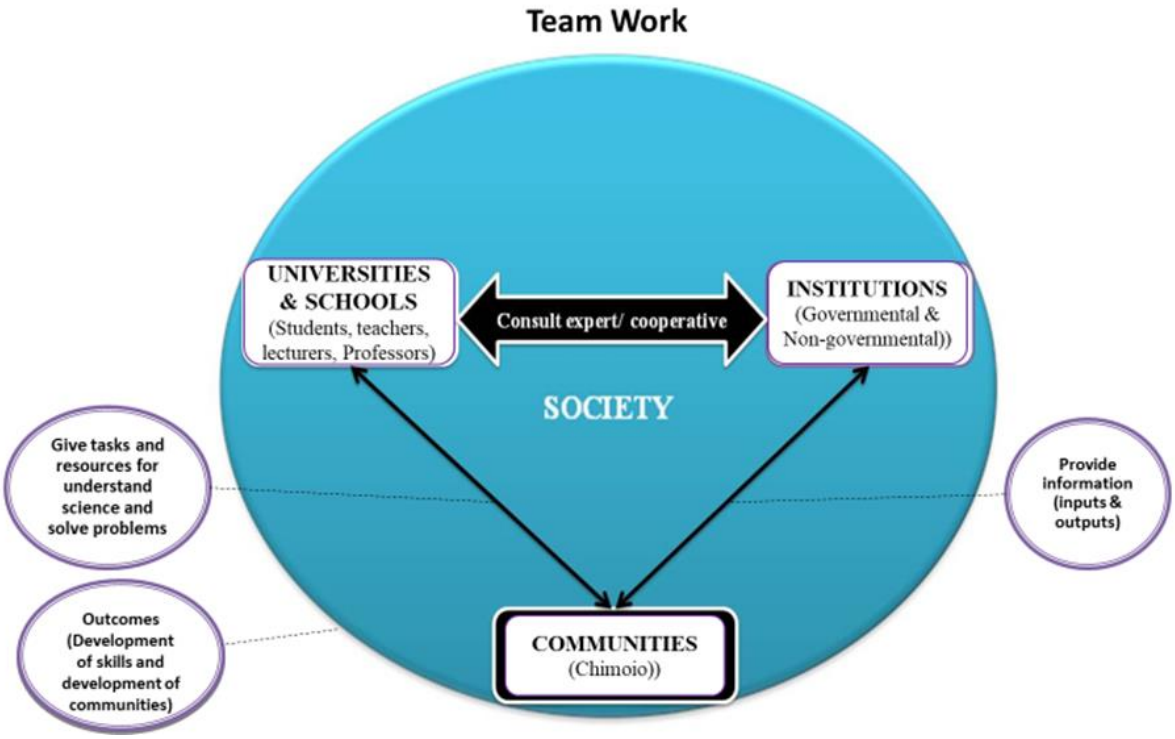


Figure 18. The framework of our system

4.5.4.1. Observation during the intervention

4.5.4.1.1. Intervention at school

After studying the normative documents of the education sector in Mozambique to find core elements for the implementation of teaching in science-technology-society integration and systemic approach in schools in Chimoio, contact was established with some partner institutions, namely the Provincial Directorates of Education and Health, the Municipality, FIPAG, Mozambique Fertilizer and the Confederation of Economic Associations (CTA), which decided to join the project.

After identifying the core elements (documentary and infrastructural pre-conditions for beginning the intervention in schools) by me and the pre-service teachers, and also with the confirmation of the partner institutions to be part of the project, three initial projects were implemented in the Secondary School of Soalpo.

These projects started in December 2019 and ended between the end of March and the beginning of April, something that coincided with the beginning of the first lockdown in the country that was decreed for the first of April 2020.

The objective of the initial projects was to study the feasibility of implementing the study to the main group to carry out scientific experiments (practical activities) and turn this project into a technology transfer tool between schools, universities, companies, and surrounding communities.

The projects initially implemented were related to the areas of agriculture, environment, and energy, and the first dealt with the use of urine to produce fertilizer for lettuce planting, the second was also related to the production of fertilizer but using food waste, and the third was for the production of biogas based on food waste.

For the first project, urine was collected (in the community), which was then treated and analysed in the laboratory, following the recommended procedures for its application to the soil (in the UniPúnguè laboratory), followed by soil preparation, planting, irrigation, and control (in the Soalpo Secondary School). The pictures below show part of this process.

Figure 19. The first project implemented at school (production of compost based on human urine). A-Urine collected in 500ml bottles; B-Urine deposited in a 10L container for decomposition reactions (by microorganisms) and urine transformation into fertilizers; C-Beds prepared for sowing lettuce; D- Beds with lettuce already sown.

The other two projects were dedicated to the development of a biodigester at the school with the support and monitoring of a FIPAG engineer and technicians and the town councillor for education, culture, science, and technology.

The biodigester was installed in the same school and remained there for about three months, which is the recommended period for the decomposition of organic material and its transformation into fertilizer.

The stages of building a biodigester based on easily accessible materials are shown in the diagram below and the stages are organized according to their hierarchy (from 1st to the 5th). The cited materials, specifications, and use of each one, but also the

process of transforming food waste into fertilizers are described right after the diagram below.

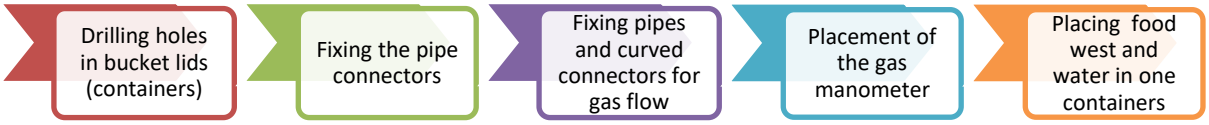


Figure 20. Diagram of biodigester construction with easily accessible material.

- **Specifications of the biodigester**

The biodigester was built using two plastic buckets (containers), one being a container for fermentation reactions and transformation of food waste into fertilizer and another to contain the gases produced. The connectors were also made of plastic and fixed with the help of Polyvinyl Chloride (PVC) lines and glue, to prevent gas leakage but also to prevent atmospheric air from entering and negatively interfering with the reactions.

In the construction of the biodigester, holes were drilled in the lids of the buckets, and connectors were placed for all the parts used for the flow of the gas produced. In this system (biodigester), pressure gauges are coupled to measure the amount of gas produced.

After the biodigester is built, the food waste is placed up to a maximum of 75% of the container's capacity and mixed with water. After mixing, the containers are sealed and left for about three months for fermentation.

Figure 21. Biodigester built on easily accessible material.
A- Drilling holes in container lids and placing pipe connectors, B- Placement of gas flow pipes, curves, and the manometer to measure the amount of gas. C- built biodigester.

The initial phase of observations presented successful results (according to the information above), so we moved on to the next stage of the same phase, which consisted of attending classes taught in the classroom.

Attendance at classes aimed to assess the learning process and the interaction between pre-service teachers, students, and teachers from secondary school, but also to verify the way they approach the content.

In addition, observation of classroom learning activities was used to assess issues or aspects related to content understanding, the learning environment, and the real conditions and characteristics of classrooms. These observed aspects served as bases for design projects and field activities that were carried out in the subsequent phase involving the previously identified partners (the system).

This phase was quite challenging and short-lived, as it took place between December 2019 and April 2020. In March 2020, the COVID-19 pandemic forced a lockdown and from then on, the country began to have several restrictions that made it impossible to continuity of classes and projects as planned.

In lockdown due to the COVID-19 pandemic, schools felt compelled to teach using digital sources (WhatsApp, Facebook, *Telescola*, Google classroom, etc.), and rearrangements of the school calendar.

This situation made the Mozambican government decide to automatically pass students from classes without examinations (primary schools, and grades 6, 8, 9, and 11), and completely suspend learning activities for this group in 2020, and only conditionally authorize teaching activities for classes with the examination (grades 5,7,10 and 12).

With the above scenario, universities could no longer send their pre-service students for internships, something that prevailed at least until mid-2022. For this reason, the implementation of teaching projects in science-technology-society integration and a systemic approach in secondary schools in Chimoio and Mozambique could not be implemented as initially designed. Therefore, it was decided to carry out practical activities at the university and in the communities and explore possible partnerships.

4.5.4.1.2. Intervention in the University and community

During the lockdown period, there was a need to readjust the school calendar and the model of the internship. So, during this time, the internships started to be carried out at UniPúnguè through simulated classes presented to colleagues (face-to-face and virtual), which meant that all other projects were also implemented in the same way at the University in the communities where pre-service teachers live.

The pre-service teachers, organized in groups of five to six people, had the freedom and autonomy to design and implement innovation and technology transfer projects based on the contents of the learning programs (from the University and secondary schools) and with the support or interaction with communities and companies.

The projects had to have a scientific character but also with some impact on improving the quality[20] of life of the communities. Therefore, the ideas and challenges raised by the students were appreciated by the main researcher, and all received comments and contributions to improving the prototypes and elaboration of the initial drafts of each activity/project.

The drafts produced could be discussed among students, but some were also taken for discussion at the course, faculty, and even higher level (university) depending on the complexity of each project. Therefore, for some projects, the discussion was held with some experienced people from the communities and focal points of some partner institutions, where you could receive better technical-scientific advice.

Following these steps, many projects were designed and implemented as practical and collaborative activities, most notably:

- Production of urine-based fertilizer for home gardening;
- Application of composting technique (mixture of rubbish and discarded food) in home gardening;

[20] Reuse of waste to develop useful products for communities, at the same time reducing contamination and environmental pollution, as well as reducing the spread of microorganisms that develop in dumps and constitute a public health problem.

- Production of bar soap based on ashes as an agent of saponification and discarded oil;
- Production of soap in powder based on ashes as a saponification agent, and purified/washed discarded oil;
- Production of grease based on peanut shells;
- Production of home-made wax;
- Use of moringa seed (*Moringa oleifera**)*** in well water purification process;
- Application of corn cobs mixed with eucalyptus leaves to combat pests, etc.

Findings, impacts, and results of all designed and implemented projects are presented and discussed in the next chapter.

4.5.5. Questionnaire-II: Science Motivation Questionnaire (SMQ)

After the practical activities, the students involved were administered the SMQ containing forty-two (42) questions taken from the original questionnaire "Science Motivation Questionnaire" which contains questions in six different categories for assessing (i) Intrinsic motivation and personal relevance; (ii) Intrinsic motivation and personal interest; (iii) Perceived Competence; (iv) Effort/Importance; (v) Value/Usefulness and, (vi) Collaborative Work Relatedness.

The original questionnaire is already validated and it was in English. Therefore, the questionnaire was applied in Mozambique where the target group is Portuguese speakers, so it was necessary to translate it from English into Portuguese.

In the translation process, some sentences may suffer some changes, therefore, in order to have good reliability of the translation, a pilot study was carried out, applying the questionnaire in two languages to students of the English course who are speakers of both languages.

The methodology used was to make the questionnaire available for students to read and answer if they agreed or disagreed with the meaning of the original and translated sentence. In case of disagreement, there was a blank space for the students to put their opinions, thus making the translation more perceptible and more similar to the original text.

4.5.5.1. Characteristics of the sample from the pilot study-II, and criteria for choosing participants

Table 26. Characteristics of the sample from the pilot study-II

Gender?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	33	62.3	62.3	62.3
	Female	20	37.7	37.7	100.0
	Total	53	100.0	100.0	

Table 27. Response from participants about the academic level

Your level

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	3rd	29	54.7	54.7	54.7
	4th	24	45.3	45.3	100.0
	Total	53	100.0	100.0	

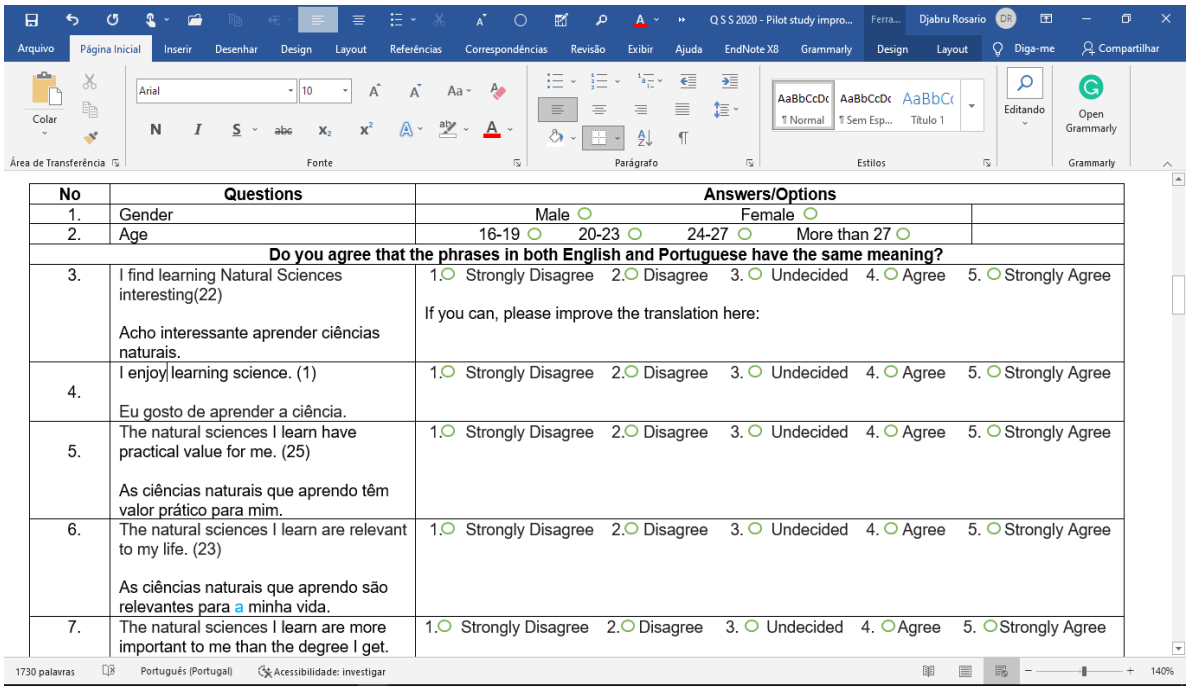
The choice of the 3rd and 4th-year classes was based on convenience sampling, as the degree courses in general and in particular, the degree course in the English language at Mozambican universities lasts four years. Therefore, these two groups of students represent the highest levels of training which means they are the ones with the highest language skills.

However, there was a need to use brainstorming and gather as many suggestions as possible, especially on words with multiple meanings, and in cases of written opinions, all students from the two highest levels participated.

The data from the pilot study were thoroughly analysed to identify possible divergences and significant changes to improve the final questionnaire that was subsequently applied to the main group of the research, which are the students (pre-service teachers) of the chemistry course.

4.5.5.2. Report of the pilot study-II

The pilot study questionnaire was designed using a structure that facilitates compression (placing the original and translated question one above the other) and collection of contributions as well as data processing.



No	Questions	Answers/Options
1.	Gender	Male ○ Female ○
2.	Age	16-19 ○ 20-23 ○ 24-27 ○ More than 27 ○
	Do you agree that the phrases in both English and Portuguese have the same meaning?	
3.	I find learning Natural Sciences interesting(22) Acho interessante aprender ciências naturais.	1.○ Strongly Disagree 2.○ Disagree 3. ○ Undecided 4. ○ Agree 5. ○ Strongly Agree If you can, please improve the translation here:
4.	I enjoy learning science. (1) Eu gosto de aprender a ciência.	1.○ Strongly Disagree 2.○ Disagree 3. ○ Undecided 4. ○ Agree 5. ○ Strongly Agree
5.	The natural sciences I learn have practical value for me. (25) As ciências naturais que aprendo têm valor prático para mim.	1.○ Strongly Disagree 2.○ Disagree 3. ○ Undecided 4. ○ Agree 5. ○ Strongly Agree
6.	The natural sciences I learn are relevant to my life. (23) As ciências naturais que aprendo são relevantes para a minha vida.	1.○ Strongly Disagree 2.○ Disagree 3. ○ Undecided 4. ○ Agree 5. ○ Strongly Agree
7.	The natural sciences I learn are more important to me than the degree I get.	1.○ Strongly Disagree 2.○ Disagree 3. ○ Undecided 4. ○ Agree 5. ○ Strongly Agree

Figure 22. Structure of the questionnaire-2 used for the pilot study-II.

After completing and contributing to the questionnaire with forty-two (42) questions, it was necessary to make small changes in eleven (11) of them, which are the following questions: 6, 8, 11, 12, 13, 14, 24, 39, 40, 42, and 43:

- Placement of articles - numbers 6, 8, 14, 24, 39, 40 and 42;
- Verbal conjugation - numbers 11, 12, 13 and 43

Table 28. Table of connector placement

Nr	Changes (bolded)
Q6	The natural sciences I learn are relevant to my life. *As ciências naturais que aprendo são relevantes para **a** minha vida.*
Q8	The science/chemistry I learn relates to my personal goals/dreams. *A ciência/química que aprendo se relaciona com **os** meus objetivos / sonhos.*
Q4	Do you use to participate in our practical activities? *Você costuma participar **das** nossas atividades práticas?*
Q24	I am satisfied with my performance at practical tasks. (11) *Estou satisfeito com **o** meu desempenho em tarefas práticas.*
Q39	I felt like I could trust my colleagues. (40) *Eu senti que realmente podia confiar **nos** meus colegas.*
Q40	I would like to have a chance to interact with my colleagues more often. *Gostaria de ter a chance de interagir com **os** meus colegas com mais frequência*
Q42	I don't feel like I could trust my colleagues. (R) *Não sinto que poderia realmente confiar **nos** meus colegas.*

The Portuguese language has many rules, for example, the verb "*confiar*" (trust in English), can be used to say *"confio em si/confio a si"* depending on the circumstances,

which in some cases may or may not change the meaning of the word. In this case, the adjustments consisted of reformulating the sentences so that they followed greater linguistic rigour.

Table 29. The verb conjugation adjustment

Nr	Changes (bolded)
Q11	I think about how I will use the science I learn. ***Tenho pensado sobre*** *como usarei a ciência que aprendo*
Q12	I think about how learning science can help me get a good job. ***Tenho pensado sobre*** *como aprender ciências pode me ajudar a conseguir um bom emprego*
Q13	I think about how the science I learn will be helpful to me. ***Tenho pensado sobre*** *como é que a ciência que aprendo será útil para mim*
Q43	My colleagues and I could likely become friends if we interacted a lot. *É provável que meus colegas e eu possamos nos tornar amigos se* ***interagíssemos*** *muito.*

The change in these four questions was in the verbal conjugation mode to facilitate the understanding of the sentence.

In general, the translated sentences had mostly the same meaning as the original English sentences, but in some cases, there was a need to improve them by following the linguistic rules and giving a little more aesthetic to the questions.

However, despite one or other additions or changes, the results reveal that most students agreed that most of the translated questions had the same meaning and were perceived in the same way as the original (in English). For this, the Cronbach's Alpha test was performed.

4.5.5.3. Validation

The initial work on the correlation between questions in the same instrument was done by Spearman and Brown when they suggested the formula called split-half (Brown, 1910; Spearman, 1910), and the study of the reliability of data collection instruments began with Kuder and Richardson in 1937, through a collection of reliability measurement formulas that was renamed KR20 (Kuder & Richardson, 1937). “Later on a simplified form of KR20 formula was given by them, known to be Kuder Richardson formula 21 or KR 21” (Sarmah & Hazarika, 2012, p. 512).

The results arising from the different formulas created at the time led to the stratification of reliability into three different types, which are:

- The reliability of stability is the coefficient that assesses the consistency with which a measure is perpetuated over time.
- Equivalence reliability assesses the consistency with which different forms of a test or instrument measure the same latent construct.
- Internal consistency reliability assesses the consistency with which a given set of measurement items estimates a given constructor latent dimension. (Krathwohl, 1998; Maroco & Marques, 2006).

Most studies use internal consistency reliability, which according to the formula KR21 is done by determining how all items on a test related to the total test (Kuder & Richardson, 1937). The Kuder-Richardson formula for measuring the internal reliability of data collection instruments was built on the scale proposed by Likert (1932) and is based on the assumption that all the items of the test are equal or nearly equal difficulty and intercorrelations.

In this study, internal consistency reliability was measured using the SPSS statistical package and Crombach's formula. The α coefficient of Cronbach's formula was initially named Kuder-Richardson Alpha and soon after was renamed Cronbach's Alpha by his work in 1951 (Cronbach, 1951).

The designation "alpha" meaning first, was intended to reflect the author's (Cronbach's) conviction that the formula he proposed is simply the first to be made of a set of calculations needed to assess the properties of a scale beyond reliability (Cronbach & Shavelson, 2004).

Table 30. Reliability recommendation criteria were estimated by Cronbach's α synthesized by Maroco and Garcia-Marques adapted from Peterson (1994).

Author	Conditions	α considered acceptable
(Davis, 1964, p. 24)	Forecast for individuals	above 0.75
	Forecast for groups of 25-50 people	above 0.5
(Kaplan & Saccuzzo, 1989, p. 106)	Fundamental research	0.7-0.8
	Applied research	0.95
(Murphy & Davidshofer, 1988, p. 89)	Unacceptable reliability	<0.6
	Low reliability	0.7
	Moderate to high reliability	0.8-0.9
	High reliability	>0.9
(Nunnally & Nunnaly, 1978, pp. 245-246)	Preliminary research	0.7
	Fundamental research	0.8

(Maroco & Marques, 2006)

The questionnaire administered in the pilot study-II contained forty-five questions, three of which were for the collection of demographic data (gender, age, and academic level), and the other forty-two questions were translated from English (original) to Portuguese. Therefore, the translation consistency assessment was applied to only forty-two questions, and the results are presented in the table below.

Table 31. Reliability of the Questionnaire II (SMQ)

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.926	.928	42

Cronbach's Alpha values show high reliability based on all the established reliability criteria and present values very close to 1 (Cronbach, 1951). The results of the pilot study, which are shown in the table above, show that the initial translation had good consistency, but even so, some improvements were made to provide greater reliability.

The translation was done with very good precision since the new sentences (in Portuguese) kept the sense of the original sentences (in English), which guarantees that there is no interference from the researchers in the results and that the version of the motivation questionnaire in Portuguese produced by us, can be used by other researchers without the need for another validation process.

4.5.6. Interviews

The interviews are a qualitative research method that seeks to describe the meanings of central themes in the life world of the subjects. The main task in interviewing is to understand the meaning of what the interviewees say (Kvale, 1994).

To complement and enrich the information gathered from the questionnaires, the action research (fieldwork), documentary studies, and observation, a total of twelve pre-service teachers who participated in the internship and research were interviewed. The students involved in the interview participated voluntarily and were subdivided into six women and six men.

The interviews were based on fourteen structured questions, and responses were recorded using notepads and a voice recorder. The interviews were organized into mixed questions (open and closed) for allowing the students to express themselves openly and to give their opinions about their prejudices and conceptions about the science-community interaction in the teaching-learning process.

The interview was also very important to collect information about the activities carried out, more concretely about the positive and negative aspects, more than anything the mixed questions served to collect information about the most outstanding aspects and about aspects that should be improved.

The interview data also served for triangulation of results that led us to consistent conclusions about the data gathered during the activities of this study.

4.5.6.1. Interviews questions

<u>Interview guidelines are applied to students after activities and questionnaires (English version).</u>

Gender Male◯, Female ◯

1. What aspects motivated you to do/choose natural sciences /chemistry (personal ◯, family ◯, historical◯, socio-cultural◯ environmental ◯,
employment opportunities ◯ other reasons◯? If others. Say which ones?

_____

_____

2. Have you ever heard about Science Technology and Society (STS) before our activities? Yes◯, No◯.
If yes, where and under what circumstances[21]?

_____

_____

3. Have you ever heard about a systemic approach in the teaching-learning process, before the activities? Yes◯, No◯.
If yes, where and under what circumstances?

_____

_____

4. Have you ever heard of collaborative or interdisciplinary work in the teaching-learning process before the activities? Yes◯, No ◯.
If yes, where and under what circumstances?

_____

_____

5. Have you ever heard of a School-University and Business partnership in the teaching-learning process before the activities? Yes◯, No◯.
If yes, where and under what circumstances?

_____

_____

6. During the activities on STS and the systemic approach in which you were involved, did you learn something relevant to society and your personal life? Yes ◯, No◯, Neither yes nor no◯,
If yes, give concrete examples:

_____

_____

7. At the end of all activities, something changed in your life about its conception (importance of science in the world and the relationship between Science, Technology, and Society)? Yes◯, No◯
If yes, it is possible to compare before and after the activities.

_____

_____

8. After the practical work is done, how do you rate the development of your skills? Improved◯, Not improved◯.

_____

_____

9. What do you think would make your classmates feel competent as university students of chemistry If they could solve a problem (hunger, poverty, disease, etc.) in their community◯? or if they could produce rockets or atomic bomb formulas, etc. in the laboratory◯?

_____

_____

10. And in your case, which of the two options? If you could solve problems for yourself and your community◯? If you could produce rockets or atomic bomb formula, etc. in the laboratory and be internationally known◯?

[21] Adapted from Madeira (2016)

_____
_____

11. Do you trust your colleagues? very much ◯ slightly ◯ a little bit ◯ no, I do not trust them◯.
If not, why? _____

12. Did you feel comfortable working with your colleagues or would you have preferred to work alone?

- If you felt comfortable with your colleagues, tell us how. very comfortable◯ slightly comfortable◯ not very comfortable◯
- If you prefer to work alone, tell us why.

_____
_____

13. Are you personally happy with the work you have done in the Systemic Approach[22]? Yes◯, No◯. Not so much◯.

14. Make general comments about your involvement in the activities

_____
_____
_____
_____
_____

The End

4.5.7. Data from the interviews

The questions cover different subjects, some related to the motivation to attend natural sciences/chemistry, others related to the approaches/methodologies used in the practical activities, but also include questions to gauge satisfaction, acquired competence, and the degree of rapport/affinity between colleagues. In general, the questions have an exploratory character, which brings added value to the triangulation of results.

The questions all had options of choice (yes or no), or categories, but still contained space for additional comments as illustrated above. The results of the interview are presented and discussed in the next chapter separately and in triangulation with other data gathered by other data collection instruments used in this study.

[22] Adapted from Madeira (2016)

Chapter V- FINDINGS AND DISCUSSION

5. Findings and Discussion

In this chapter, I bring the findings from all research questions and data sets from different methods applied in this study. For the discussions and to better understand the trend of the responses, it was also necessary to compare the results of other studies and obtain some arguments or support for a good triangulation of the collected data.

As described in the previous chapter, all documents that regulate the education sector in Mozambique have been revised so that the existence or not of the core elements can be assessed. From the documents consulted, I highlight the laws of education and the curricula.

Also, to gather information on pre-conditions and core elements were observed infrastructure and administrative conditions of schools and universities before introducing science-technology-society integration and a systemic approach.

The pre-service teachers acted as part of the system established in this study. They carried out various activities, starting with the research phase on the contents of the learning programs and ending with carrying out activities in the form of school projects and community development. After the random activities, questionnaires were applied and part of them was subjected to interviews. Findings from practical activities are discussed in the following pages of this chapter.

5.1. Core elements

In this research, core elements are defined as legal, structural, material, and moral conditions that allow the proper implementation of the systemic approach in the teaching and learning of natural science. Are also considered core elements of the weaknesses evidenced in several areas of service delivery that I call by knowledge

and opportunity available in society, which can be minimized or solved through school intervention in partnership with governmental and non-governmental institutions.

To implement the research, it was necessary to have authorization from the entities responsible for the education sector, as well as the reception and availability of the working group (pre-service teachers, students, and teachers from secondary schools, lecturers, and partners), all these constitute core elements in this research.

A system is a set of interdependent elements to form a larger single set with the same goal. In this research, the interaction between components of the system aims to improve the teaching quality while at the same time solving the real social problems and development of the communities where the schools are located.

According to the definition of “a system” and objectives mentioned in the previous paragraph, a “systemic approach” would be a set of interdependent elements with responsibilities and specific tasks but complementary, working together in an interdisciplinary, collaborative, and cooperative way to form a larger single set with the same goal.

For this research to take place, central components and elements were needed. So, the following points were established as central elements of this research:

- Authorization from de education administration
- Normative documents that regulate the education sector and lecturing activity in the community and the country in general;
- Basic infrastructures (secondary schools, government, and private institutions);
- The community where the research will be carried out (properly delimited);
- Public services (education, health, energy, transport, communications, and sanitation).

The lack of one of the elements may compromise or even ban the application of the systemic approach based on its characteristics and conditions of implementation. In turn, a full or deficient operation of the core elements may weaken or fortify, respectively, the intervention of the school in solving the problems according to the needs of the community.

5.1. 1. Discussion of data set from the documentary study

5.1.1.1. First and second law

The law of the National Education System addresses, among several items, the general principles and goals of the education sector, which are presented in chapter I, wherein article three, paragraphs d) and e) respectively highlight aspects related to creativity and the critical thinking in the teaching-learning process and the conciliation between theory and practice through a teaching-learning process based on the link between the school and the community.

In the period under analysis, Mozambique lived under a socialist regime, which may have influenced the school to be called upon to effectively contribute to the development of the community.

The school-community connection is again dealt with more prominently in the last paragraph (f) of the same article (no. 3) and in more detail, it says:

A close link between the school and the community, in which the school acts as a centre for fostering the socio-economic and cultural development of the community and receives from it the necessary guidance for the realization of education and training that responds to the demands of the development of the socialist regime in the country (MINED, 1983).

The former regime (1975 -1986) of President Samora Machel's mandate was socialist and prioritized popular power, mass democratic and social organizations, and power was extended to all Mozambican citizens by assigning them the same duty and responsibilities to participate in the materialization of the school-community link as a way of acquiring knowledge and developing communities.

The school-community linkage becomes the core element *sine qua non* for the implementation of the systemic approach since this happens in an interactive environment (school-community and technology), collaborative (interdisciplinary), and cooperative (school and different state and private institutions inserted in the community).

From the two laws (4/84 & 6/92) that support the Mozambican education system, there´s a core element for introducing a systemic approach differently, for instance, students involved (chemistry, biology, physics, mathematics, and agriculture) are moderated by lectures, and supposed to work in an interdisciplinary way and interacting with the institutions and organizations to solve the real problems of society that they detect.

5.1.1.2. Learning Programs of Secondary Schools of grades 8, 9, and 11.

Having verified the prerequisites for learning beyond the school for the insertion of a systemic approach through the school-community interaction in the laws and other normative documents of the National Education System of Mozambique, the results of a study of the education programs are presented below.

The choice of these grades was due to the internship criteria in Mozambique, which only cover classes without exams, which are classes where trainees will do the internship and can introduce the systemic approach according to the programmed contents and the material environmental conditions available.

Table 32. Contents of grades (8th, 9th, and 11th), and possible projects to be applied based on STS integration and Systemic approach

8th-grade contents			
Thematic unit	**Contents**	**Topics**	**Proposed activities (Systemic approach)**
1ª	Introduction to Chemistry	**Importance of Chemistry in Society** • Hygiene and safety rules and standards during chemical experiments. • Demonstration experiments on the transformations of substances	• Visit institutions and industries of plastic production, flour production, a plastics factory, hospitals (laboratories, medicine warehouses, etc.)
2ª	Substances and mixtures		
3ª	Structure of matter and chemical reactions		
4ª	Water	**Occurrence of water in nature;** • Physical properties and importance of water; • Water quality (drinking, brackish, mineral: cold and hot);	• Provide water to the community (piped water/water hole);

		• Sources and ways of supplying water for human consumption; • Pollution: water-polluting agents (Chemicals and microorganisms); • Treatment and conservation of water; • Diseases caused by contaminated water; • Water cycle and its importance. **Oxygen:** • Composition of the air and its importance as raw material, Air pollution; • Ozone (O3): Physical properties of Ozone. Formation, destruction, and importance of the ozone layer **Combustion:** • Fuels renewable and non-renewable resources. Mechanisms for the replacement of renewable fuels. • Flame and its structure, Fires: prevention and combat;	• Construct a water filtration system (in schools/communities with non-potable water) • Participation in the process of water treatment and conservation and awareness/awareness campaigns (rational consumption of water, hygiene, and health) • Production of plants and tree plantations surrounding "polluting" industries, open fields in deserted streets and backyards; • Projects of energy production by solar and wind sources; • Promotion of safe habits of use of fuels and prevention of fire; • Simulation campaigns

9th-grade contents

Thematic unit	Contents	Topics	Activities (Systemic approach)
1a	Atomic structure and periodic table		
2a	Chemical bonding		
3a	Principal classes of inorganic compounds		

4ª	Chlorine and the elements of group VII	**Chlorine as a representative:** • Applications and their importance in everyday life • Experience in obtaining laboratory Chlorine	• Participation in the awareness campaign and distribution of Chlorine (Health Authorities, Partners, Leaders, and community); • Visit the water provider (Fundo de Investimento e Património de Abastecimento/FIPAG)
5ª	Sulfur and the elements of group VI		
6ª	Nitrogen and the elements of group V, Mineral Fertilizers	**Fertilizers:** • Main mineral fertilizers: Nitrogen, Phosphate, and Potassium • Soil and plant effects • Soil pollution: prevention, causes, and effects • Natural fertilizers: production and advantages of their production	• Project of selective disposal of garbage (Organic and inorganic); • Composting; • Potting of vegetables in schools based on fertilizers; • Support communities in the process of producing natural fertilizers.

Contents of grade 11

Thematic unit			
1ª	Fundamental Concepts		
2ª	Atomic Structure		
3ª	Periodic table		
4ª	Chemical Bonding	**Metal connection** • Characteristics of the metallic connection • Properties of metallic bonded substances	• Visits to institutions (*Metalúrgica de Chimoio*, Factory of plates IBR); • Practical classes of welding in industries and workshops of the city;

		• Phenomena of forging, fatigue, welding, and metal seizures based on the metal structure • Important metals of the Mozambican industry (Al, Fe, Zn, Au, Ag, Cu), occurrence, obtaining, applications; • Major metallurgical industries in Mozambique • Metal alloys and their applications	• Promotion of lectures (civil engineers, masons, schools, and communities)
5ª	Principal classes of Inorganic Compounds		
6ª	Solutions		
7ª	Thermochemistry	• Energy value of food and energy needs according to the activities carried out	• Integrated agriculture, health, and nutrition project

The lessons learned in the systemic approach can be through interventions from different areas of knowledge, different disciplines of natural sciences and mathematics, institutions, cooperation partners, or as suggested by the teaching program from grade eleven for the development and development of projects and individual or group implementation strategies. (PESG 11th grade, 2010, page 4)

Most of the selected contents are by the teaching programs treated by "generating topics", which according to the General Secondary Education Programme

> "*These topics are called generators because, whatever the nature of their understanding, such as the action they bring about, it contains in them the possibility of unfolding in others that provoke new tasks that must be fulfiled, for example, from the theme "Water" taught in the 8th class can generate related sub-themes such as sanitation, agriculture, energy production, communication routes, among others. Generating themes can also emerge from the survey of the main problems of the community"*. (MINED, 2010a, p. 8)

These arguments serve as hard evidence of the existence of preconditions for conducting the research using the systemic approach in the Mozambican education sector.

Despite the proposals made, it will be up to each of the schools to decide on the type of project to implement, obeying some criterion that will be duly justified in the work. The role of the school in the choice of the project to implement can guarantee the good ethics of research and greater engagement of this which in turn may contribute to improvement in the quality of teaching and research results.

5.1.2. Structural and environmental core elements

The conditions of infrastructure and the model of the administrative organization of schools, as well as the management model of the education sector, establish environmental conditions (working environment and proper location) in schools, which facilitate the creation of a learning system that involves schools, communities, universities, and partners.

For the research in the city schools, permission had to be obtained from the Provincial Directorate of Education and this required a presentation and discussion of the project in 2016 with those responsible for the teaching and learning process in the province before my dissertation project was approved as Ph. D. candidate at PH-Heidelberg. This document (found in the appendices) was attached to the "expose" for the evaluation process of the application as a Ph. D. student in Germany.

The document issued by the Provincial Administration of education allowed the investigations to be carried out in schools, but beforehand there was a presentation of the projects to the school community (managers, teachers, students, etc.). After this presentation, work teams were created, having as criteria of volunteerism, willingness, and good faith.

5.1.3. Motivational aspects for the workgroup

The set of learning theories (cognitivism, constructivism, and connectivism) applied in this study, as well as the STS and systemic approach already constitutes some motivation, as it involves a group of individuals and entities that work collectively and in cooperation to achieve the same objective, which is to solve problems that affect them.

In the case of pre-service teachers, more than being actively involved in the projects, the motivation came from the fact that they took decisions on the contents and methodologies used to solve the problems they identified and experienced daily.

But also, the anxiety and expectation that were created to obtain project results with the highest possible quality and that would be useful for them in particular and for society in general. Furthermore, the thrill of solving concrete problems and learning from them is another motivating and affective factor.

5.1.4. Secondary schools in the city of Chimoio

The city of Chimoio has seven secondary schools and all of them have students from grades 8 to 12 and teach all the subjects of the two social classes and teach all subjects in both social and natural science areas. The existence of these areas facilitates the implementation of interdisciplinary learning as one of the characteristics of the systemic approach.

Since Mozambique is one of the ten (10) poorest countries in the world (Ventura, 2021), the level of poverty affects the sector of education. The Ministry of Education is the one that receives more funds from the state budget compared to other ministries, but the amount is spent mainly for the payment of expenses (salaries and benefits) and very little goes to investments such as the construction of classrooms and purchase of material and equipment for learning and development of science and technology.

The poor investment makes the education sector one of the ones that face the most difficulties, such as the lack of libraries, computer equipment, laboratories or laboratory equipment, computers, printers, photocopiers, etc., factors that generate problems in services general, such as water supply, sewerage, electricity, cleaning, among other basic problems.

Some of these problems that affect the school also affect the community where each school is located. However, most schools are located in areas with great agricultural potential and watersheds that can serve as strong points of school intervention in solving the problems that harm them and society.

5.1.5. Governmental and Non-Governmental Institutions

Governmental institutions operate in full but some with greater capacity to provide their services and others not so much. The government institutions are open to a public-private partnership, a policy of *doing business* that the government of Mozambique has ratified as a way to boost the socio-economic development of the country.

In particular, some partnerships have guided the relationship between public and private institutions in the area of social responsibility and/or in cases of direct support for development or specific programs that affect schools such as HIV / AIDS, retention of girls at school, school lunch.

In Mozambique, the interaction between schools and public/private institutions is slightly weak and of the few existing interactions, the most frequent have been those in which NGOs intervene in supporting programs or direct projects of a social nature, such as the strategy for the retention and protection of girls, prevention against malaria, HIV-AIDS, construction of latrines.

The examples above show that the few existing interventions or interactions are more of a social or administrative nature and not of an academic-scientific nature (for example, study of contents, teaching methodologies, etc.), which would help to improve the quality of teaching and establish learning effectively.

This weak interaction between schools and institutions constitutes strong premises for the implementation of a systemic approach in Mozambican curricula and would help a lot in the unification of the population and sectors, boosting the establishment of strong partnerships for technical-scientific development but also the development of communities.

5.1.6. Knowledge and opportunity available in society

Existing knowledge in communities should be capitalized on and used to stimulate the development of communities and transform them into areas. Therefore, this transformation involves providing basic services such as:

a) Kindergartens, schools, and public libraries;
b) Water supply;
c) Water and sewage treatment plant;
d) Health centres and public hospitals;
e) Street cleaning and basic sanitation;
f) Garbage collection;
g) The illumination of cities;
h) The paving of the streets.

Most of the services mentioned above are working but with tremendous difficulties to highlight

a) most schools do not have libraries and students are traveling long distances to use the Provincial Library located in the city centre.

For point b), the entity responsible for providing the service is the *"Fundo de Investimento e Património do Abastecimento de Água (FIPAG)"* which means Fund for Investment and Assets of Water Supply, it expanded its supply network in a campaign that began in 2011, but many areas and schools in the city continue still without a water supply system.

The lack of piped water from FIPAG means that areas and schools that do not benefit from these services are supplied by water holes made by the government, cooperation partners, or government-non-governmental partnerships.

So, to guarantee the water potability and prevention of digestive diseases, dermatitis, and other diseases that may originate from the use of inappropriate water, it needs to be submitted through the treatment process before being used. The lack of clean water is a challenge and constitutes one of the core elements of this study.

According to point c), Chimoio does not have a sewage treatment plant, and the sewage system comes from colonial times and covers less than 10% of the city and is situated practically in the centre of the city and does not include any area around this.

Points (e) and (f) are associated with c), because they converge in the fact that they are services linked to hygiene and public health. From the list of services provided these are the most problematic. The city of Chimoio was once the cleanest in the country more than 10 years ago, but today it competes for the dirtiest city in the country, perhaps it is even the dirtiest city in the country.

The garbage collection is in charge of the Municipal Council and this only collects garbage in the centre of the city (Neighbourhoods I and II) and a few around the city leaving the remaining neighbourhoods for individual management where people find two options (i) to lie down the trash in the yard, or (ii) to lie down in the street in front of your house.

The inability or negligence in rubbish collection and cleaning of the city may find motivated by the conditions of the access roads (bumpy and badly eroded roads) that have been a consequence of the lack of pavement and proper maintenance.

These and other problematic aspects served as central elements for the present investigation and served as opportunities for different interventions aiming at minimizing or solving the problem in this case particular a systemic approach was introduced in the teaching and learning process to improve learning and solve the community problem.

For point g) despite the process of expansion of the electric grid in the country and the city, some zones and schools do not benefit from the electric current of the public network. The lack of energy in the community leads to the practice of criminality (murder, rape, robbery, etc.) and in schools, conditions the teaching and management activities, thus reducing the number of people to benefit from education services and negatively influencing those who already benefit.

5.2. Discussion of data from observation in the pre-intervention stage

Samora Machel secondary school is the best structured of the seven existing schools and, therefore, constituted as the school available to host sports activities such as local, provincial, or national sports championships. Its infrastructure does not allow to

host projects such as agriculture (no space enough) but can allow many other projects that can be designed from the Curriculum.

The rest six schools can allow all other projects that we think are possible to be made from the contents of the curriculum from Secondary school from grade 8 to 12.

For learning natural science, a multi-level intervention is required that interferes with cognitive and affective aspects of the student by modifying his way of understanding, interpreting, and doing things, in a process in which he acquires new knowledge, experience, skills, awareness, and ultimately the attainment of wisdom.

5.2.1. Modality of implementation of a systemic approach

The results of analysis of the contents listed in the curricula, the facilities contained in the laws of the education sector but also the findings resulting from observations of the structural conditions of schools, guided us to establish a science-technology-society integration and a systemic approach through school projects and community development, which is characterized by establishing a learning model focused on contextualized content and contributing to the resolution of specific problems in community life that is where the student lives.

These projects carried out as practical activities involved universities, schools, governmental and non-governmental institutions, as well as university lecturers, school teachers, pre-service teachers, and students from grades 8 to 12, but also the partners constituting a system, working together in partnership and collaboratively.

5.3. Results and discussion about data set from questionnaire-I

This questionnaire was applied to the pre-service teachers to get deep information about their background and preconception about the systemic approach and methodology required for this approach.

The questionnaire has 22 questions that from 1 and 2 are demographic, from 3 to 6 for gathering information about teaching experience data, 7, 14-21 are questions about

Science-Technology-Society taken from different sources, and finally, questions 8 to 12 and 22 are for gathering information about the systemic approach.

5.3.1. Demographic data

It was necessary to have the information on the composition of the class concerning gender because many times gender exerts some influence on the results of the research that can be positive or negative about some other variable.

Several studies show that some attitudes and behaviours may vary according to gender. (Dalton & Ortegren, 2011; Zimmer-Gembeck & Helfand, 2008) for example, Dalton and Ortegren (2011, p. 1) state that “In prior studies that find gender differences, females consistently report more ethical responses than males”.

Gender issues are important in the research, although many researchers do not indicate concrete reasons, for instance, Dalton and Ortegren (2011, p. 1) state that “ [...] it is uncertain whether gender differences in ethical decision-making exist because women are more ethical or perhaps because women are more prone to social desirability response bias.

Therefore, despite these uncertainties, it is indisputable that the social role of women is different from the role of men and that, in many societies, women are all like the mirror of this one, and must act and behave with a great descent.

The above statements make us believe that the role of women is decisive and has a great influence on the way we think, see the world, act, belief, and behave. However, in this study, the findings below show a low correlation between gender and it is believed that this difference may be larger and more significant as the sample increases.

Table 33. Correlation between belief and gender

Correlations

		Q1. what is your gender?
Q15. Do You believe that Science and technology interaction offers a great deal of help in resolving such social problems as such as poverty, crime, sickness, and unemployment?	Pearson Correlation	.262**
	Sig. (2-tailed)	.005
	N	111

**. Correlation is significant at the 0.01 level (2-tailed).

The gender data presented below can be used not only to assess the views of students who may be influenced by gender type but also to assess the attendance of males and females in natural science classes and chemistry courses in a specific way.

Table 34. Pre-service teachers´ response regarding gender

Q1. What is your gender?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	89	80.2	80.2	80.2
	Female	22	19.8	19.8	100.0
	Total	111	100.0	100.0	

The findings resulting from the data presented above show that the classes are mostly made up of men (80%) compared to women (19.8%) who are generally the minority. This composition has been similar quite a bit to all the natural science classes in Mozambique.

In the pilot study carried out, an equal trend was found, but a similar trend was also found in the Madeira (2016)´ study carried out in Mozambique, where the number of women was below 25%. Furthermore, research on gender in the global research landscape reveals that some 28% of women around the world, for whatever reason, choose to enroll in social sciences rather than natural sciences (Elsevier, 2015).

The factors behind this trend are various and debatable (Burkam, Lee, & Smerdon, 1997), but this study, were highlighted two aspects, (i) historical aspects: "historically, science has always been seen as an activity carried out by men" (Leta, 2003, p. 1), and (ii) socio-cultural aspects (stereotypes and prejudices): “We agree that the record of science, until recently, is in its social aspect tarnished by gender-based exclusion”

We agree further that, “baseless paradigms" in medicine and the behavioural sciences have been pretexts for subordinating women (Schiebinger, 2000, p. 2).

According to da Cunha et al. (2014), some stereotypes still prevail in society, which should be widely worked on and discussed in all sectors of society, especially regarding the inclusion of women in certain areas of knowledge. It is the role of the family and the school to work on these stereotypes in order to promote a cultural balance between men and women, establishing an equal relationship between them.

Stereotypes and prejudices include the role of women in the home, family, and society. Gender stereotypes and prejudices vary according to the historical moment of each society, culture, tradition, habits, and customs (Parga, Sousa, & Costa, 2001).

In underdeveloped countries, women have an increased family role concerning housework such as cleaning, cooking, caring for siblings, tending the garden, and/or working in the fields to support their parents.

Activities above keep women busy and make it difficult for them to commit and dedicate themselves to the natural sciences learning model (experience, calculations, group studies, etc.), so they find a better fit in social sciences learning models (reading, memorisation, individual study, etc.), because wherever she is and whatever she is doing she can still read and memorise some content and individually learn something.

The participation of women in natural sciences has been increasing since the 1970s, 1980s, and 1990s in countries in Latin America, Asia, and Western Europe (Harding & McGregor, 1996), so this growth is not significant in African countries (Leta, 2003).

Lately, there are several organizations such as UNESCO, the Women's Forum, Human Rights League implemented programs for the emancipation of women in various areas of society, to reduce gender inequality, but this will take time and, for the time being, the number of women in the natural sciences is around 28%, according to the trend of studies and the report in the figure below, which shows the relationship between gender in the global research landscape.

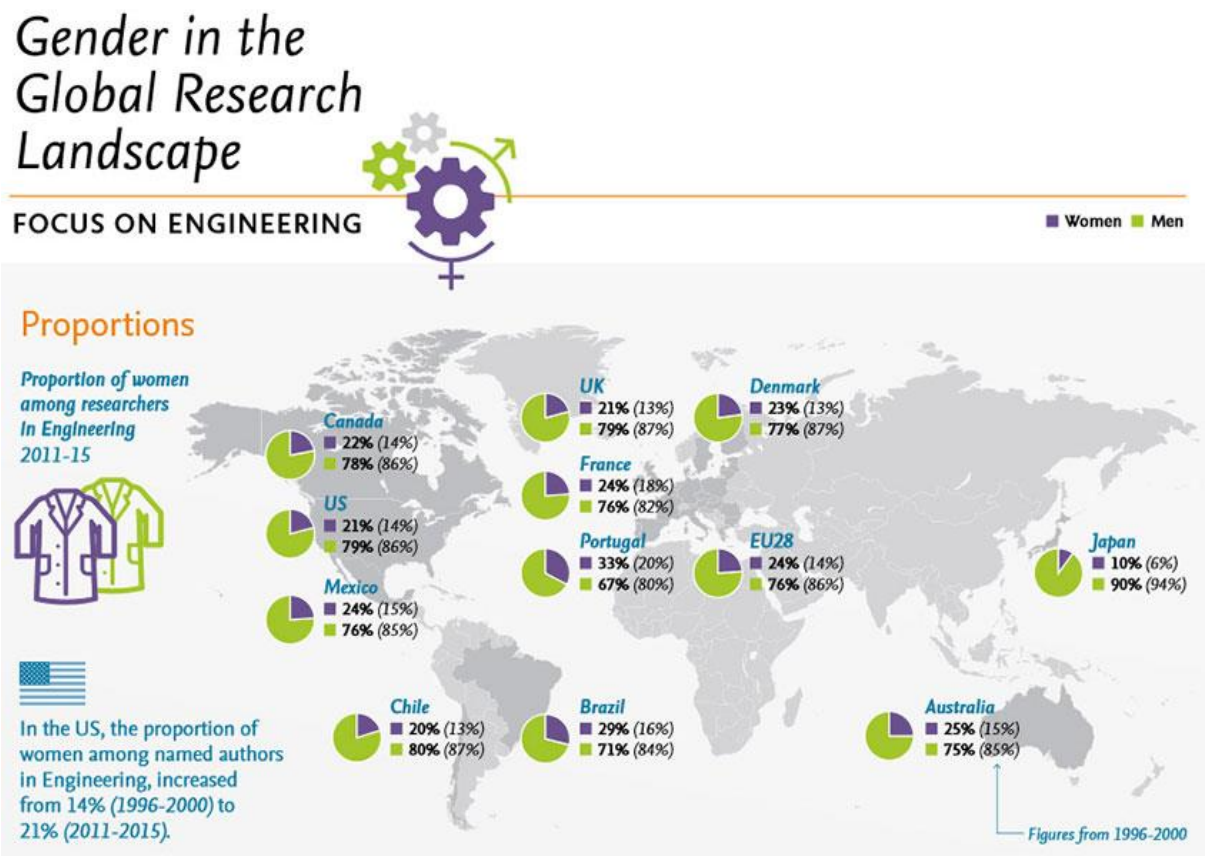


Figure 23. Gender in the global research landscape (focus on engineering) (Elsevier, 2017)

The above scenario is slightly different from the educational science scenario if it encompasses all subareas, for example, those who are trained to teach subjects in (i) natural sciences, mathematics and technology, (ii) social, psychological, and (iii) language teaching areas. But if we separate the sub-areas, we can see that women are still underrepresented in science, mathematics, and technology, both in schools and in the workplace (Acker & Oatley, 1993; Alexakos & Antoine, 2003).

Table 35. Pre-service teachers´ response regarding classes of the internship

Q2. Grade of your internship?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Grade 8	16	14.4	14.4	14.4
	Grade 9	13	11.7	11.7	26.1
	Grade 11	6	5.4	5.4	31.5
	None	76	68.5	68.5	100.0
	Total	111	100.0	100.0	

As for the internship classes, the result is not surprising, since, on the one hand, the classes authorized for internships are grades 8, 9, and 11 because they are grades without examinations, and on the other hand, a higher percentage of students did not do the internship for reasons that have also been revealed, which have to do with the University of Púnguè's curriculum, which forbids internships for students who have not passed all the subjects in their third year.

There are more pre-service teachers having their internship in grade 8 than in other for three reasons:

i. Schools: in general, in Mozambican schools there are more classes in grade 8 compared to grade 9 and, in turn, there are more classes in grade 9 than in grade 11;
ii. From grade 8 to 10, all students take courses that cover natural science and social science subjects, but from grade 11 onwards they have to choose between natural and social science;
iii. The contents of grade 8 are less complex than those of the other grades. the more complex the levels, the more complex their contents, so it is more comfortable for pre-service teachers to teach less complex content as a way to get experience, and then face more complex content than vice versa.

The split into two distinct areas which start in grade 11, sometimes it makes it necessary to bring together students from two or more classes of grade 10 to create a single grade 11 natural sciences class. This situation means that there are fewer classes in which natural science is taught in grade 11 than in grades 8 or 9, with that, grade 11 classes receive fewer students compared to others.

5.3.2. Teaching experience

In teaching experience, the aim was to get information from pre-service teachers about their teaching practice and their interaction with the real world (community and students), which we believe could be of added value in terms of mastering different teaching approaches in general and some insight linked to the systemic approach in the teaching and learning process in Mozambique.

The connection with the real world can provide some mastery by the students as this interaction may be affective and even interfere with their daily lives. Research conducted in Mexico revealed that the teacher candidates reported lasting effects of this experience on their teaching as well as their personal lives (He, Lundgren, & Pynes, 2017).

From the moment the experience becomes effective, it influences the interpretation of the interactions between science-technology and society and also the school and everyday life relationships of both students and teachers (contextualized teaching) and the use of teaching approaches according to the context and lived experiences. The results are in the tables below:

Table 36. Pre-service teachers´ responses regarding their teaching experience

Q3. Is this your first-time teaching?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	39	35.1	35.1	35.1
	No	13	11.7	11.7	46.8
	I´m not teaching	59	53.2	53.2	100.0
	Total	111	100.0	100.0	

The above table indicates that the majority (53.2%) did not teach and of the 46.8% who had experience in teaching, most of them (35.1 %) were teaching for the first time in their lives. The figures are close to that of the previous table about the class they taught. Regarding the class they were teaching in the internship, cumulatively 31.5% responded they were teaching in grade 8 (14.4%), in grade 9 (11.7%), and grade 11 (5.4%).

Comparing the numbers of pre-service teachers who were teaching for the first time (35.1%) and who taught in grades 8, 9, and 11 (31.5%), there is a small difference of (3.6%), which may hypothetically be the case that they are teaching either in high school classes not listed in the options (grade 10 and 11) or elementary school (grade 1 to 7), or even in some other activity like art, dance, etc.

To assess with some consistency how experienced they are in teaching, but specifically the time each one has to teach, the following questions were asked.

Table 37. Students' responses regarding their period of experience as a teacher

Q4. Is this your first-time teaching?

If no, so how long have you been teaching? If yes skip to the Q 7

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0-2 Years	10	9.0	9.0	9.0
	2-5 Years	1	.9	.9	9.9
	More than 5 Years	5	4.5	4.5	14.4
	None of these choices	95	85.6	85.6	100.0
	Total	111	100.0	100.0	

According to the data in the table above, we can conclude that they have very little teaching experience, as only 4.5% have more than five years of experience. In Mozambique, it is necessary to have a minimum of five years of experience to be promoted in the career of a civil servant or to assume a position of leadership. But also, to join the majority of public or private companies.

Therefore, even in cases where the "five years of experience" does not explicitly appear in the requirements, they have been important and bring some comparative advantage to those without as much work experience.

In some countries, five years are used as a minimum time for acquiring experience or competence, so we will not go to the criteria but to the practice that has become generalized and normalised in the country, and on the other hand, the criterion for teaching in secondary education is to have a degree or bachelor's degree or 12 + 1 years of training.

The pre-service teachers who participated in the study were not yet graduates (four years of study) and certainly do not hold a bachelor's certificate (3 years course) and much less than twelve plus one “12 + 1” (one year of training) because these two last courses for teaching education were extinct about seven years ago. This shows that most or almost all of them do not have any teaching experience, especially in secondary education.

Even so, to understand in a little more depth the teaching experience of pre-service teachers in other initial classes, either as permanent or part-time teachers and outside the regular internship, the following question was asked:

Table 38. Pre-service teachers´ response regarding the class they taught

Q5. Which grade did you teach?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Grade 1-5	3	2.7	2.7	2.7
	Grade 8-10	5	4.5	4.5	7.2
	None of these choices	103	92.8	92.8	100.0
	Total	111	100.0	100.0	

The results in the previous table reveal that part of those with more experience (2.7%) have already taught in elementary school and others also little (4.5%) have taught in high school. Even so, the total number of those with some experience is much smaller (7.2%), which leads us to conclude that the vast majority of pre-service involved had no experience in teaching.

This finding is somehow worrying and negatively influences their view on the science-technology relationship and society in general and, in particular, on the application of a systemic approach in the learning process.

Although the results show that the number of trainees with experience is insignificant, at the time the questions were prepared, it was aware that the areas of training and experience can influence the perception of the real world, especially in the relationship between science and technology, that is, natural science students are more connected to the technological world than social science students.

With these arguments, it was necessary to create a question that would allow collecting this information and the results are presented below:

Table 39. Pre-service teachers´ response regarding the teaching area

Q6. Which area did you teach?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Natural Science	9	8.1	8.1	8.1
	Others	3	2.7	2.7	10.8
	None of these choices	99	89.2	89.2	100.0
	Total	111	100.0	100.0	

The findings show that, from the group of pre-service teachers who taught, most of them taught subjects related to the natural sciences. These results are encouraging,

but unfortunately, as in the previous question, their percentage is too small to have any significant influence on the student's view of the role of technology in society or on the systemic approach in the teaching and learning process arising from their teaching experience in the area of scientific knowledge.

5.3.3. Pre-knowledge about a systemic approach

"System" is a content taught in the chemistry-physics subject, in the second year at university, which most students are supposed to have some notion of. The systemic approach in education is a slightly new approach or a 21st-century approach (Fahmy & Lagowski, 1999).

This approach has been applied in African countries as an emerging approach in countries such as Kenya, Tanzania, and Uganda (Hardman et al., 2011), so there was a need to design questions about the approach and others that aim to gather information about the basics of what the system is or how it works.

Table 40. Pre-service teachers´ response regarding the Science-Technology-Society approach in the learning process

Q7. Have you ever heard about integrated teaching where university/school and community have to interact?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	55	49.5	49.5	49.5
	No	24	21.6	21.6	71.2
	I do not remember/ I'm not sure	32	28.8	28.8	100.0
	Total	111	100.0	100.0	

The results show that just over half (50.4%) of the pre-service teachers didn´t hear about integrated teaching where university/school interact with the community. There's some interaction and normally it has been done through conference, seminar, and speeches mainly when the university or school need to transmit some information or project or activities that take place or involve the community.

On the other hand, its means that there are few interactions between university/school and it can also contribute at a low level to experiences or references in teaching using approaches that require some knowledge sharing or collaborative work or even school-

community partnership work.

Integrate teaching is a powerful tool in a systematic approach so that the content to be taught can stem from the needs and concerns of society and in turn society together with schools, universities and partners form a single system responsible for addressing these concerns.

Integrate teaching is one of the ways of implementing the systemic approach, but to get specific information about pre-service teacher's biases toward the systemic approach see the question and table below:

Table 41. Pre-service teachers´ response regarding a systemic approach in the learning process

Q8. Have you ever heard about a systemic approach in the teaching and learning process?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	53	47.7	47.7	47.7
	No	28	25.2	25.2	73.0
	I do not remember/ I'm not sure	30	27.0	27.0	100.0
	Total	111	100.0	100.0	

The findings in this question are slightly similar to those in (Q7), which shows that more than half of the students would never have heard of the systemic approach in their lives.

Based on the assumption that the systemic approach may have different concepts and perceptions, it was decided to obtain more information about the system to later use it to assess and better understand the level of information that students have regarding issues related to the systemic approach.

This information will also be analysed together with those related to the systemic approach in the educational system (questions asked later). The results are in the following table:

Table 42. Pre-service teachers´ response regarding the notion of a system

Q9. Do you remember about the systems?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	63	56.8	56.8	56.8
	No	48	43.2	43.2	100.0
	Total	111	100.0	100.0	

The contents related to the system are taught in the second year of the chemistry course and the pre-service teachers who answered the questionnaire were in the fourth year. In the beginning, everyone was expected to remember this, but only 56.8% said they remembered the subject and the rest did not. These results are probably because there was no prior contextualization or explanation of what it was really about.

The initial strategy was to obtain information spontaneously about preconceptions about the systemic approach and several characteristics of these to have as a starting point for the next intervention (school project), so I deepen the questions by talking about types of systems, which are (i) open, (2) closed and (iii) isolated and the results are tabulated below:

Table 43. Pre-service teachers´ response regarding the kind of system (open system)

Q10. Do you remember about the open system?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	62	55.9	55.9	55.9
	No	49	44.1	44.1	100.0
	Total	111	100.0	100.0	

About the open system, the percentage of those who remember does not differ so much from those who remember the system, however, when I appreciate the results of a closed and isolated system in the tables below, I notice that the lack of knowledge increases, with 56.8% not remembering the closed system and 61.3% not remembering the isolated system as shown in the following tables:

Table 44. Pre-service teachers´ response regarding the kind of system (closed system)

Q11. Do you remember about the closed system?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	48	43.2	43.2	43.2
	No	63	56.8	56.8	100.0
	Total	111	100.0	100.0	

Table 45. Pre-service teachers´ response regarding the type of system (isolated system)

Q12. Do you remember about the Isolated system?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	43	38.7	38.7	38.7
	No	68	61.3	61.3	100.0
	Total	111	100.0	100.0	

The results of questions 8 to 12 show that over 51.32% of pre-service teachers have no idea about a systemic approach, and the above result influences the answer about the evaluation of the type of system that best fits the teaching model in Mozambique, as illustrated in the table below:

Table 46. Pre-service teachers´ response regarding the kind of system that best fits the Mozambican educational system

Q13. What kind of system best fits our education system?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Open System	49	44.1	44.1	44.1
	Closed System	3	2.7	2.7	46.8
	Isolated System	3	2.7	2.7	49.5
	I don’t know enough about this subject to make a choice	56	50.5	50.5	100.0
	Total	111	100.0	100.0	

The trends in the table above follow the results of the previous questions where the majority revealed not having enough mastery of the subject to make some decision/choice and of those who had some choice the majority indicated the open system.

However, we cannot assume the results as conclusive; since at least the term "system" has its characteristics, is a content taught in the second year of the chemistry course and all the pre-service teachers passed through the second year.

To further explore students' knowledge about the subject system, open questions were elaborated in the pilot study and the results indicated that only about 38.7% of the teacher-trainees participating in the survey answered a few things.

Even though, most of those who wrote something couldn't answer correctly according to the concept, which means that the percentage of people who somehow demonstrate

that they have an idea, actually not even 30 % of them know what are their treats when referring to the system.

In a general way in the first phase, it can be assumed that the pre-service teachers have little knowledge about the systemic approach in the teaching and learning process, but also in aspects linked to the system, because this last one is a taught content but even so only the minority has shown to possess some knowledge, we opted to apply the deep interview to triangulate the results and to reach the definitive conclusion.

5.3.4. Interaction/partnership among School-Community-Governmental institutions and NGOs

One way of implementing a systemic approach at school is by partnership and interaction between schools and the community, so the question was asked to students in order to get their point of view.

Table 47. Pre-service teachers´ response regarding partnerships among schools, community, government institutions, and NGOs

Q14. In Mozambique, teaching and learning at school are based on the interaction among School-Community-Governmental Institutions and NGOs

		Frequency	Percent	Valid Percent
Valid	I Strongly Agree	31	27.9	27.9
	I Agree	53	47.7	47.7
	I Disagree	7	6.3	6.3
	I Strongly Disagree	3	2.7	2.7
	I don´t understand; I don´t know enough about this topic to make a choice; None of these choices fit my viewpoint	17	15.3	15.3
	Total	111	100.0	100.0

The findings reveal that almost half of them (around 47.7%) agree and almost half (27.9%) strongly agree that learning takes place in interaction among School-Community - governmental institutions and NGOs. These results encourage us to introduce this approach at school since it is a practice that has been happening and both schools and community institutions (Governmental and NGOs) are familiar with the process and this will not imply big changes in their procedures or routine.

Therefore, the introduction of a new approach needs previous preparation and training of the staff directly involved and we were interested to get information about the

interaction between science-technology and society. To obtain this information were used items from the VOSTS instrument.

5.3.5. Views on Science-Technology-Society (VOSTS) Items

The first question from VOSTS is about the pre-service teachers' belief about the role of technology in solving the everyday problems of the population.

Table 48. Pre-service teachers' responses regarding their beliefs in the power of science and technology to solve society's problems.

Q15. 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 G, and then choose one.)

		Frequency	Percent	Valid Percent
Valid	A. Science and technology can certainly help to resolve these problems. The problems could use new ideas from science and new inventions from technology.	30	27.0	**27.0**
	B. Science and technology can help resolve some social problems but not others.	19	17.1	17.1
	C. Science and technology solve many social problems, but science and technology also **cause** many of these problems.	15	13.5	13.5
	D. It's not a question of science and technology helping, but rather it's a question of people using science and technology wisely.	17	15.3	15.3
	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.	17	15.3	15.3
	F. Science and technology only make social problems worse, It's the price we pay for advances in science and technology.	4	3.6	3.6
	G. I don´t understand; I don´t know enough about this topic to make a choice; None of these choices fit my viewpoint	9	8.1	8.1
	Total	111	100.	100.

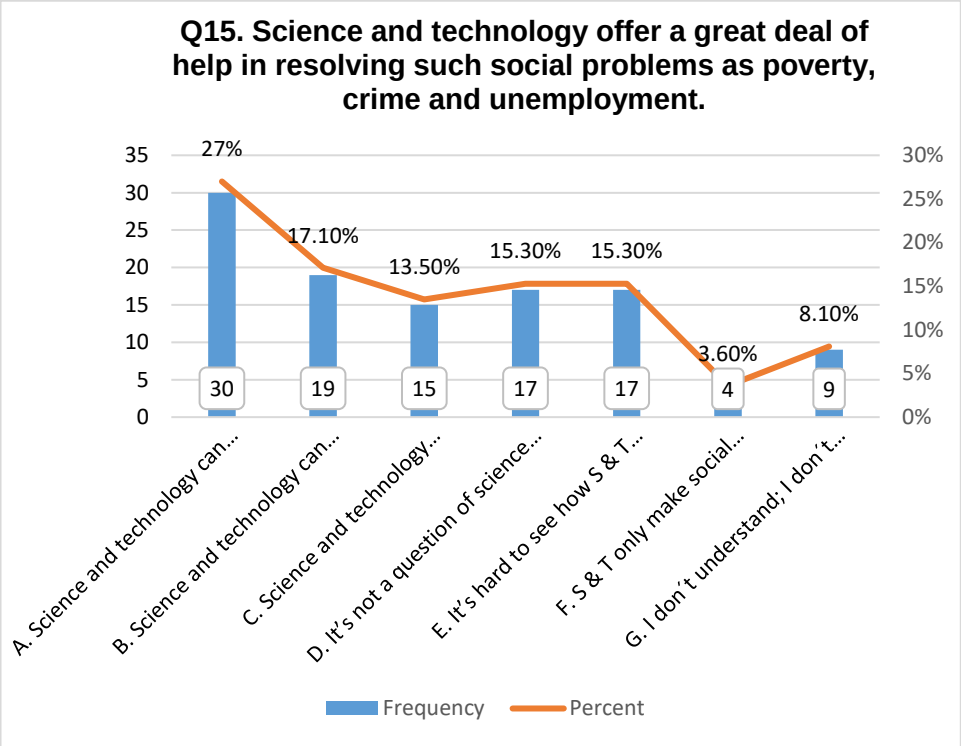


Figure 24. Pre-service teachers' responses regarding their beliefs in the power of science and technology to solve society's problems.

According to the results above, option A was the option most chosen (27%) by the pre-service teachers, followed by option B with 17.1%, and in the third position are options D and E, both with 15.3%.

This result coincides with those of studies by Madeira (2016) both in the choice of A as the point of view of the majority of students and in the approximation in percentage which in this case was 26.4%, which shows that there is a convergent understanding of the role of science and technology.

The two studies were conducted in the same country and the convergence may help explain the outcome of the influence of technology on society. I believe that technological advances vary from country to country, and beliefs are also obviously influenced by the impact of technology on each society, thus there are countries/societies where technology brings positive impacts and others not so much, and in some cases, it has brought disastrous impacts.

To assess the students' knowledge about how well they are informed and what is their view regarding the influence of science and technology on society, the response

options were categorized into four levels of knowledge which are, Realistic (R), Has Merit (HM), Naïve (N) and Neutral (Ne), discussed and defined in the methodology chapter. The data for question fifteen organized into categories are in the table below:

Table 49. Pre-service teachers' responses regarding their beliefs in the power of science and technology to solve society's problems (categorised question).

Q15. Science and technology offer a great deal of help in resolving such social problems as poverty, crime, and unemployment.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	R	17	15.3	15.3	15.3
	HM	64	57.7	57.7	73.0
	N	21	18.9	18.9	91.9
	Ne	9	8.1	8.1	100.0
	Total	111	100.0	100.0	

The findings above show that most pre-service teachers (57.7%) have a legitimate thought (Has Merit/HM) regarding the role of the interaction between science and technology to solve some problems in society such as poverty, crime, diseases, unemployment, etc., and others with some tendency contrary to the first, indicating an inadequate "naive (N)" vision as the second most chosen option, with 18.9%.

Similar findings to the trend of our pre-service teachers' choices were found in research conducted in Indonesia by Adiputra et al. (2019) in "the views of pre-service chemistry teachers (PCT)" about the nature of science and technology concluded that many PCT was in Has Merit view and few of them were in Naïve view.

In the research carried out by Madeira (2016) in Mozambique, whose questionnaire was applied to students of natural sciences (Chemistry, Physics, Biology, and Agriculture), also containing the same question (40412) taken from the VOSTS questionnaire, it was found that around 66.05% had a vision has merit (HM).

In summary, it can be deduced that the pre-service chemistry teachers recognised the role of science and technology and believe that these can solve several problems they face daily, but there are also some doubts about the real role of technology, which

makes them indicate an inappropriate view (Naïve/N) as the second-highest scoring option.

The reason for this view may be that there is a disconnection between 'real' science and the science presented in schools. This can easily be proved by the daily experiences of many students that highlight this difference and also by the inability to apply science learning in schools to solve everyday problems. “In addition, there are differences in what younger primary and older higher school students believe about the role of science in society and the work of scientists” (VSG, 2019, p. 1).

However, in Mozambique, in addition to the disconnect mentioned in the previous paragraph, other particular cases influenced the results, such as (i) a slow level of development of the country; (ii) the high unemployment rates, where some of them are caused by technology, in the replacement of man by machine; (iii) the high level of criminality in which technology has not helped to clarify cases; and (iv) the lack of knowledge about the role of technology.

Table 50. Pre-service teachers´ responses regarding whether science and technology can help make a moral decision

Q16. Science and technology can help people make some moral decisions (that is, one group of people deciding how to act towards another group of people).

Your position, basically: (Please read from A to G, and then choose one.)
Science and technology can help you make some moral decisions:

		Frequency	Percent	Valid Percent
Valid	A by making you more informed about people and the world around you. This background information can help you cope with the moral aspects of life.	41	36.9	36.9
	B. because science includes areas like psychology which study the human mind and emotions.	21	18.9	18.9
	C. because science includes areas like psychology which study the human mind and emotions.	10	9.0	9.0
	Science and technology **cannot** help you make a moral decision:			
	D. because science and technology have nothing to do with moral decisions. Science and technology only discover, explain and invent things. What people do with the results is not the scientist’s concern.	18	16.2	16.2

	E. because moral decisions are made solely on the basis of an individual's values and beliefs.	5	4.5	4.5
	F. because if moral decisions are based on scientific information, the decisions often lead to racism, by assuming that one group of people is better than another group.	1	.9	.9
	G. I don´t understand; I don´t know enough about this topic to make a choice; None of these choices fit my viewpoint	15	13.5	13.5
	Total	111	100.0	100.0

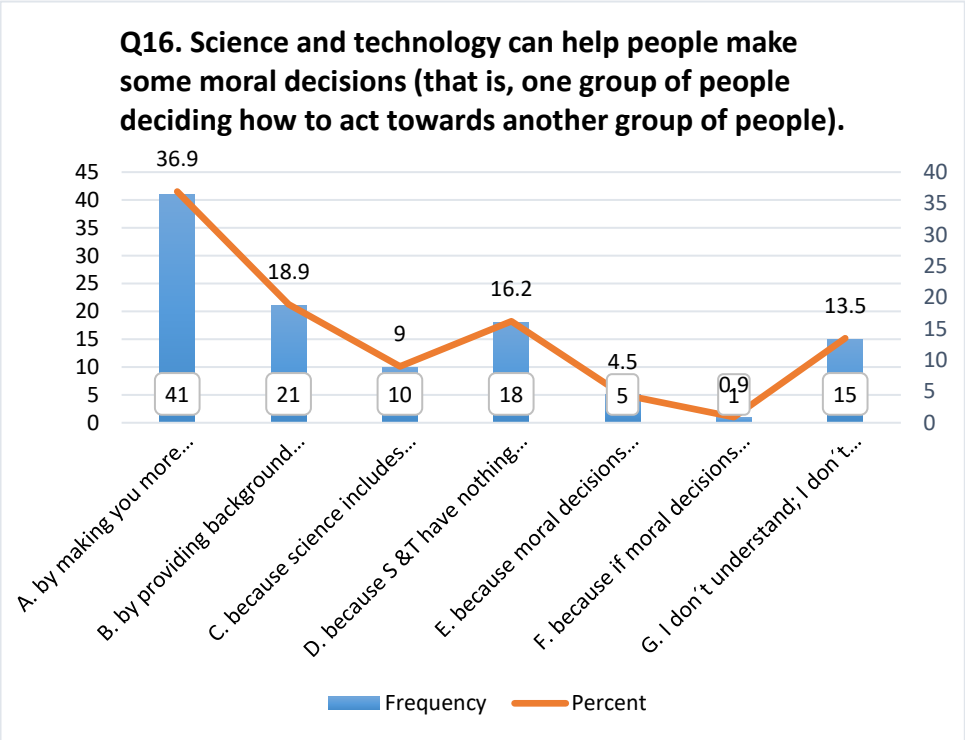


Figure 25. Pre-service teachers´ responses regarding whether science and technology can help make a moral decision

From the data in the previous table, it can be seen that option A, with approximately 37%, has the highest score, followed by option B, with approximately 19%. Option F, with 0.9%, received the lowest score from the students' point of view.

"Students believe scientists can provide important expertise when society and individuals make decisions. They also believe that the science involved in this decision-making needs to be used wisely" (VSG, 2019). This statement can be seen in our findings in the table above which clearly show that there is still a "dichotomy" in the application of science in the world that on the one hand science is used in an irresponsible way causing diseases, wars, deaths, etc. and on the other hand it is used

to help socio-economic development.

Although some people believe that scientific knowledge is capable of implying a moral responsibility for moral decisions and truth (Olivé, 2003), however, several others believe that the truth declared by science does not always influence the nature of ethics, and in some cases, the situation is exactly the opposite: meaning that on several occasions, ethics with all its weights and propositions, influences the very nature of truth (Cruz & Cornelli, 2016).

Ethics issues can be seen in terms of the responsible impact of the results achieved but also in the preservation of information ("*ética contractual*") of the research. Therefore the 'secret' component of the results, especially when science is used for harmful purposes, creates a communication barrier between scientists and society and vice versa.

These questions suggest that there must be a great deal of care and responsibility from scientists in their scientific and technological inventions, and that's why I agree with Aikenhead, Fleming, and Ryan (1987) in view that "scientists are and should be concerned with the results (both beneficial and harmful) of their work and should communicate such results to the public, […] and the public should seek out such communication from scientists".

The constraints both in the communication between scientists and society and the contradictions between the role of science for society, technical-scientific ethics, and the reality that is lived, suggest greater participation of the various sectors of society in the choice and separation between good and evil, and decision-making of important aspects for the improvement of quality of life and well-being as a result of the application of scientific knowledge with morality, responsibility, and sustainability.

For a better understanding of the students' tendencies the answers were categorized according to the criteria in the following table:

Table 51. Pre-service teachers´ responses regarding whether science and technology can help make a moral decision (categorised question).

Q16. Science and technology can help people make some moral decisions (that is, one group of people deciding how to act towards another group of people).

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	R	18	16.2	16.2	16.2
	HM	62	55.9	55.9	72.1
	N	16	14.4	14.4	86.5
	Ne	15	13.5	13.5	100.0
	Total	111	100.0	100.0	

However, although the findings show a favourable score (56%) for the legitimate view (HM), there is a slight balance in the other 3 categories, which is certainly a result of the 'dichotomy' of the use and application of science, where in some cases it is used to build a healthy society and in other cases for immoral actions and destruction within society

Table 52. Pre-service teachers´ responses regarding how science and technology can NOT help people make legal decisions.

Q17. Science and technology can NOT help people make legal decisions; for example, deciding if a person is guilty or not guilty in a court of law.

Your position, basically: (Please read from A to E, and then choose one.)

Science and technology can NOT help:

		Frequency	Percent	Valid Percent
Valid	A because they have nothing to do with legal decisions, since legal decisions are based on moral values and beliefs.	29	26.1	26.1
	B. because it's wrong to base legal decisions on technology such as the lie detector.	19	17.1	17.1
	Science and technology CAN help in a number of cases:			
	C. by developing ways to gather evidence and by testifying about the physical facts of a case.	23	20.7	20.7
	D. by studying human behaviour and explaining the human circumstances of a case.	16	14.4	14.4
	E. I don´t understand; I don´t know enough about this topic to make a choice; None of these choices fit my viewpoint	24	21.6	21.6
	Total	111	100.0	100.0

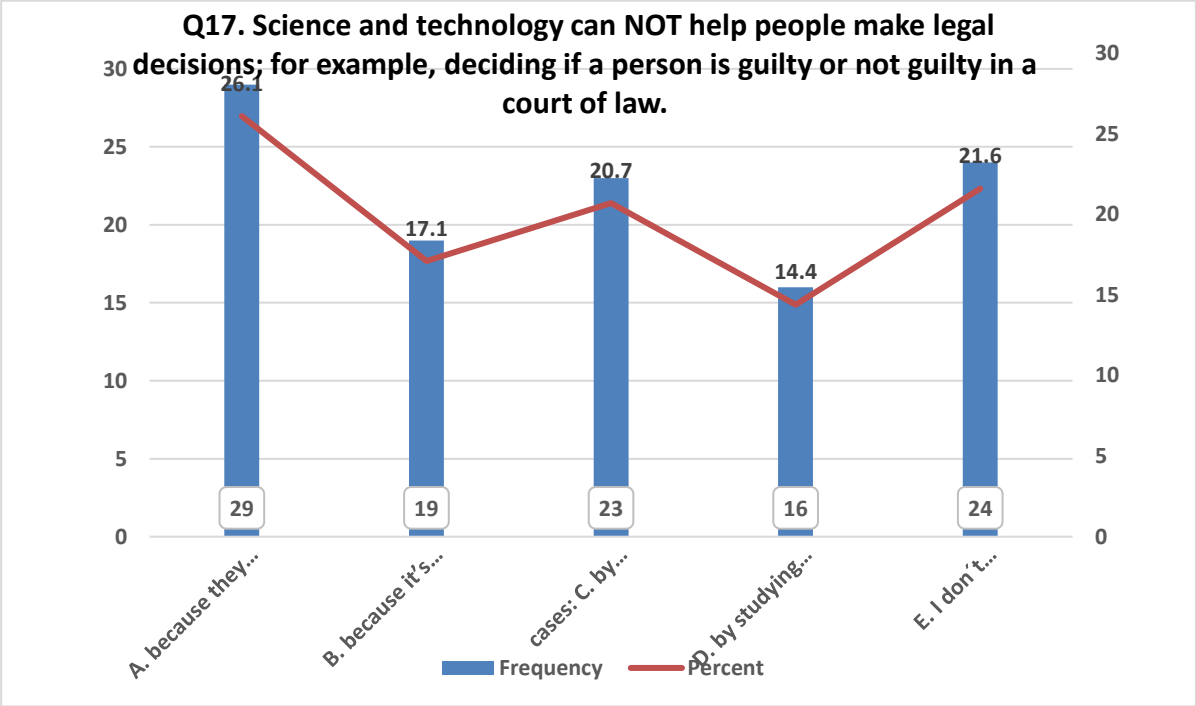


Figure 26. Pre-service teachers´ responses regarding science and technology cannot help.

On the importance or value that science and technology can provide, there is a great balance mainly between options A; C, and E; with A scoring the highest (26.1%) followed by E (21.6%) and C (20.7%).

The balance can be related to concepts such as morals, values, beliefs, etc., and on the other hand, it has to do with how science is applied in the country and in the world to solve concrete problems and satisfaction.

Moral aspects are more linked to social values, for example, what society establishes and cultivates as moral actions, which means that it can vary from society to society on the other hand the “moral” have more social acceptance than values, which makes people judge and are judged more by morals than by their value.

Between morality and the value that science and technology bring to society, there is another concept, which is 'belief' and is defined as “the convictions that we generally hold to be true, usually without actual proof or evidence and are assumptions that we make about ourselves, other in the world and how we expect things to be” (Stokeld, 2018, p. 1).

For about five hundred years Mozambique experienced slavery and colonial

oppression which culminated with the proclamation of independence in 1975. Later on, the country entered a civil war that initially lasted about sixteen (16) years, culminating with a ceasefire and a general peace agreement in October 1922.

Since then, the country has never known effective peace, as until today there are political-military conflicts mainly in the central part of the country and war in Cabo-Delgado (North of the country), which leads the country to the need to invest in technology for the defense of the homeland and security of the population, a task very far from being achieved.

The marks of slavery, wars, and conflicts in the country negatively influence the appreciation of the value of science and the use of technology for the well-being of this society, because even the advances in the field of mining (coal, gas, precious stones, heavy harnesses, etc.) and the mini agricultural mechanization provide some increase in the gross domestic product (GDP) which unfortunately is not equally distributed in all provinces (MISAU & EQUINET, 2010), but also promote socio-political and economic instability, which negatively interferes with the wellbeing and socio-economic development of these communities (Castel-Branco, 2003).

The mineral resources and the application of technologies in this sector contrary to the welfare bring more discomfort and problems such as pollution, land conflict, wars, destruction of infrastructure (hospitals, schools, houses, etc.), and deaths, among other evils for the population, especially those of surrounding areas.

To better understand the pre-service teachers' view concerning the value of technology, the options were categorised in the following table.

Table 53. Pre-service teachers´ responses regarding what science and technology cannot help (categorised question)

Q17. Science and technology can NOT help people make legal decisions; for example, deciding if a person is guilty or not guilty in a court of law.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	R	23	20.7	20.7	20.7
	HM	16	14.4	14.4	35.1
	N	48	43.2	43.2	78.4
	Ne	24	21.6	21.6	100.0
	Total	111	100.0	100.0	

The findings clearly show that there is a "disillusionment" with the way science and technology are used in societies since about 43% of the students reveal an inadequate (N) view on the role of science and technology in the well-being and development of society, followed by about 22% who presented a neutral view on this category.

This view is associated not only with the history of the country characterized by slavery, wars, and constant conflicts that affected them psychologically and built a traumatized society (Gasperini, 1989) but also by the low level of use of science and technological development both in schools and in various sectors (health, agriculture, security, etc.), which characterizes underdeveloped countries such as Mozambique.

Table 54. Pre-service teachers´ responses regarding whether science and technology would increase Mozambique`s wealth.

Q18. The more Mozambique's science and technology develop, the wealthier Mozambique will become.

Your position, basically: (Please read from A to G, and then choose one.)

Science and technology will increase Canada's wealth:

		Frequency	Percent	Valid Percent
Valid	A. because science and technology bring greater efficiency, productivity, and progress.	33	29.7	29.7
	B. because more ST would make Mozambique less dependent on other countries. We could produce things for ourselves.	32	28.8	28.8
	C. because Mozambique could sell new ideas and technology to other countries for profit.	8	7.2	7.2
	D. It depends on which science and technologies we invest in. Some outcomes are risky. There may be other ways besides science and technology that create wealth for Mozambique.	18	16.2	16.2
	E. Science and technology **decrease** Mozambican's wealth because it costs a great deal of money to develop science and technology.	3	2.7	2.7
	F. Science and Technology **will not bring** any change to Mozambique.	5	4.5	4.5
	G. I don´t understand; I don´t know enough about this topic to make a choice; None of these choices fit my viewpoint	12	10.8	10.8
	Total	111	100.0	100.0

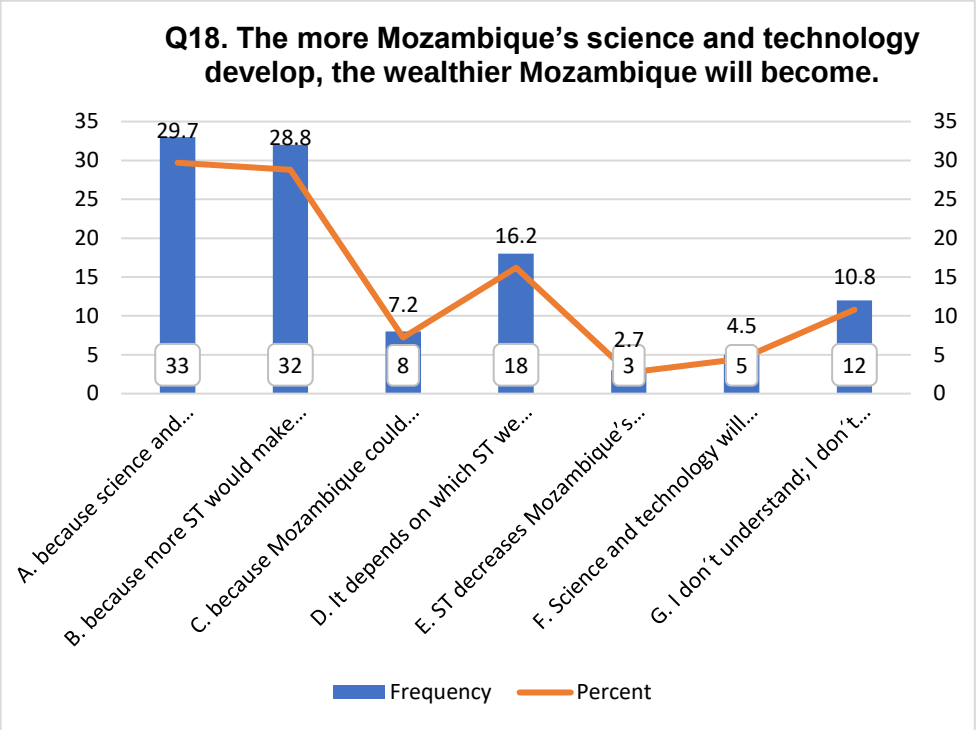


Figure 27. Pre-service teachers´ responses regarding whether science and technology would increase Mozambique`s wealth.

Regarding the effect of science and technology on the wealth in the country, there is a balance between alternatives "A" and "B" with higher scores. Low scores were for alternatives "E" and "F" with 2.7% and 4.5% respectively.

The results show that students have an optimistic view of the importance of science and technology for the country's wealth, as they recognize that scientific and technological development can bring greater efficiency, productivity, and progress to the country, in addition to making Mozambique less dependent on other countries.

Science and technology provide the development of products with national and international standards but also accelerate innovation in various fields and above all the creation of wealth, entrepreneurial and innovative strategies for the social and economic development of the country and the world (Hitt, Ireland, Camp, & Sexton, 2001).

In companies and factories, technology can positively influence the reduction of manufacturing costs and product costs for customers, also helping to increase production and productivity, increase the quality of the final product, and allowing the creation of more flexible and accessible business models, which is reflected in the

maximization of raw material, increase in company profits, improvement in employees' incomes, and creation of wealth for them and their families but also for the country.

The table below shows, in a summarised and categorized way, the students' views:

Table 55. Pre-service teachers´ responses regarding whether science and technology would increase Mozambique`s wealth (categorised question).

Q18. The more Mozambique's science and technology develop, the wealthier Mozambique will become.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	R	18	16.2	16.2	16.2
	HM	65	58.6	58.6	74.8
	N	16	14.4	14.4	89.2
	Ne	12	10.8	10.8	100.0
	Total	111	100.0	100.0	

According to the categorized results, it is assumed that the optimism of the students reveals a view with some merit (HM) with the highest score (approximately 59%) and followed by a realistic view with 16.2% which reveals that science and technology are indeed important for the country's wealth.

However, the realistic option indicates that to get rich or not, depends heavily on the kind of technologies that we invest in, as science and technology can be used to destroy the country, as is the case of wars like what is happening in Ukraine with the Russian invasion, in Cabo Delegado-Mozambique with the invasion of the insurgents.

The results also suggest that despite policies, external support, and the application of science and technology in the health sector, it still faces some challenges in terms of benefits and coverage of services to the entire community, which causes some of the respondents (14.4%) reveal an inappropriate view of the importance of scientific and technological development in the country's wealth.

Table 56. Pre-service teachers´ responses regarding whether more technology would improve the standard of living of Mozambicans.

Q19. More technology will improve the standard of living for Mozambicans. Your position, basically: (Please read from A to G, and then choose one.)

		Frequency	Percent	Valid Percent
Valid	A. Yes, because technology **has always** improved the standard of living, and there is no reason for it to stop now.	21	18.9	18.9
	B. Yes, because the more we know, the better we can solve our problems and take care of ourselves.	18	16.2	16.2
	C. Yes, because Technology creates jobs and prosperity. Technology helps life become easier, more efficient, and more fun.	21	18.9	18.9
	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.	10	9.0	9.0
	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.	17	15.3	15.3
	F. No. We are irresponsible with the technology we have now; for example, our production of weapons and using up our natural resources.	5	4.5	4.5
	G. I don´t understand; I don´t know enough about this topic to make a choice; None of these choices fit my viewpoint	19	17.1	17.1
Valid	Total	111	100.0	100.0

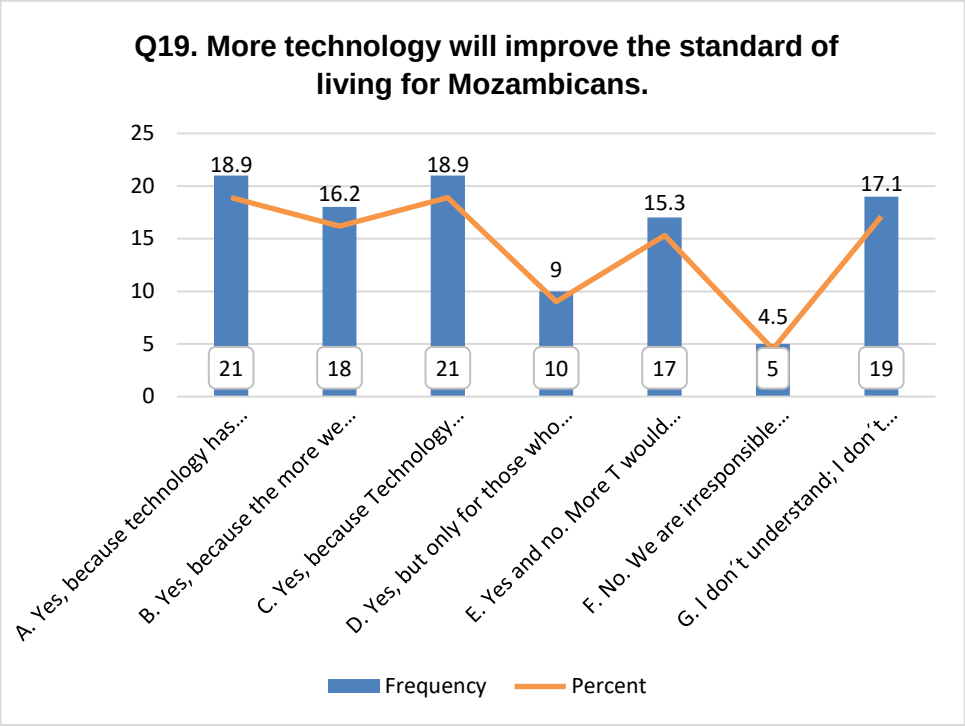


Figure 28. Pre-service teachers´ responses regarding whether more technology would improve the standard of living of Mozambicans

Question Q19 is similar to Q17 and the arguments can be found in the way the country has dealt with science and technology from colonial times to the present day.

Therefore, unlike Q17, the highest scores in Q19 show some optimism, accepting that technological development can improve Mozambicans' standard of living but with some balance in the arguments.

Options A and C have higher scores with 21% each, the first reiterates the need to maintain the use of this technology for development, while the second is about the advantages that can arise from the use of technology such as the creation of more jobs and some prosperity and also refer that technology can help life become easier, more efficient and funnier.

There is generally a slight balance in alternatives A; B; C and G and for a better reading of the students' vision we will use the following table.

Table 57. Pre-service teachers´ responses regarding whether more technology would improve the standard of living of Mozambicans (categorization question)

Q19. More technology will improve the standard of living for Mozambicans.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	R	17	15.3	15.3	15.3
	HM	49	44.1	44.1	59.5
	N	26	23.4	23.4	82.9
	Ne	19	17.1	17.1	100.0
	Total	111	100.0	100.0	

The results reveal that most students (44.1%) have a view with some merit regarding the importance of technology in improving the quality of life, followed by an inappropriate view of the subject in 23.4%. These results can come from the real impacts of the technology, which in different situations can help or hinder depending on the purpose and mode of application.

Additionally, the weak score for the Realistic view (R) shows the interference of technology that in some moments can affect the number of jobs, and in others can have a great impact on job quality. So “some are concerned that automation steals jobs, while others insist that it improves them. In reality, both of these are true”, (Saunder, 2018, p. 303).

Table 58. Pre-service teachers´ responses on whether science and technology influence our everyday thinking.

Q20. 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 G, and then choose one.)

		Frequency	Percent	Valid Percent
Valid	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.	45	40.5	40.5
	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.	29	26.1	26.1
	C. Science and technology influence our everyday thinking BUT the influence is mostly from new ideas, inventions and techniques which broaden our thinking.	2	1.8	1.8
	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.	9	8.1	8.1

	E. but because science and technology have changed the way we live.	5	4.5	4.5
	F. No, because our everyday thinking is mostly influenced by non-scientific things. Science and technology influence only a few of our ideas.	6	5.4	5.4
	G. I don´t understand; I don´t know enough about this topic to make a choice; None of these choices fit my viewpoint	15	13.5	13.5
	Total	111	100.0	100.0

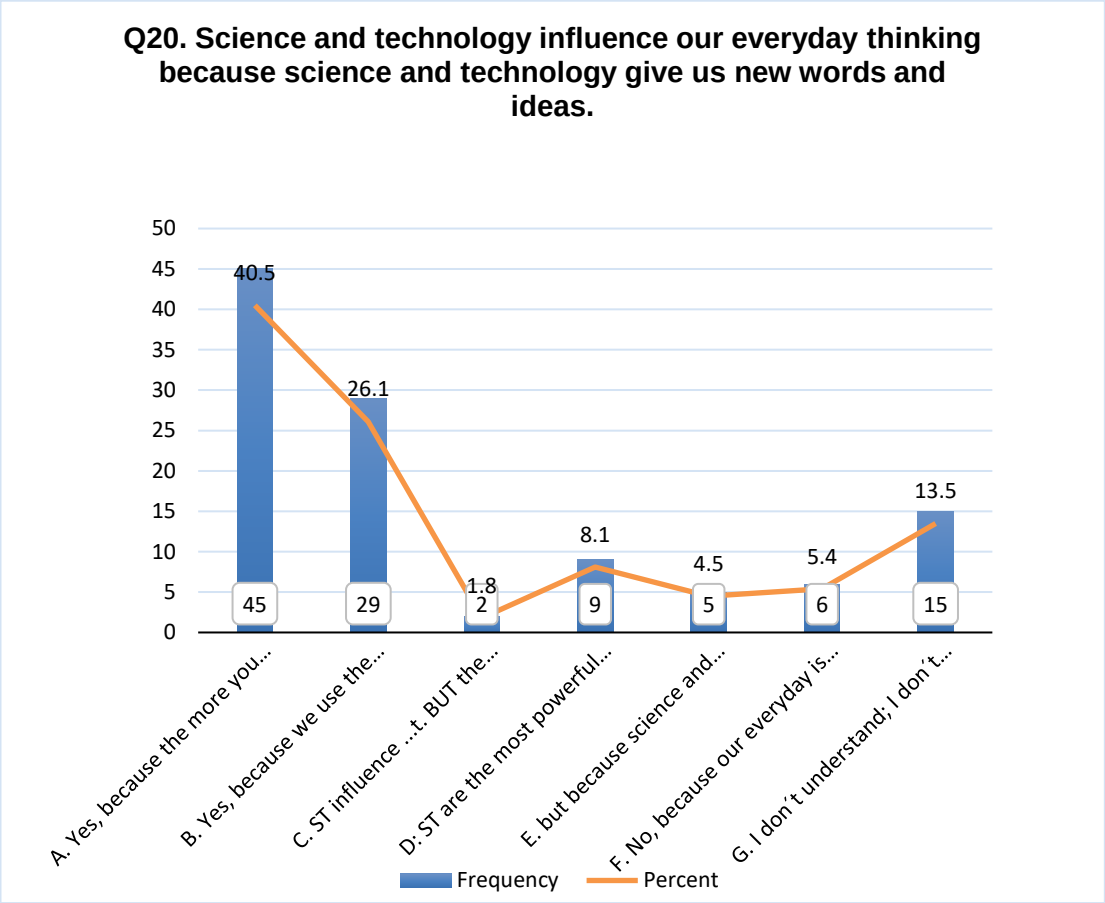


Figure 29. Pre-service teachers´ responses on whether science and technology influence our everyday thinking.

About the influence of science and technology in our daily life, the students again have an optimistic view, with the majority choosing option "A" with 40.5%, followed by option "B" with about 26% which means that they recognise the role of science and technology in their daily life and that through science and technology it is possible to obtain a variety of information and use it to solve the problems that bother them but also that it can help to produce new things and also help to change our conceptions.

The lowest score is in the alternative "E" with 4.5% which reveals that despite the belief that science and technology can change the way we live, there are a part of the pre-service teachers (few) who still do not feel that technology has changed their lives and

this view may be linked to the fact of weak use and mastery of technologies, access to information, weak purchasing power *vs*. high costs of technology among other factors.

The score also reduced in alternative "F" is also a positive sign that shows that the number of students who do not believe in technology is reduced on the one hand and the other hand reveals that there are students who still underestimate the importance of technology and believe in non-scientific interpretations such as superstition, religious beliefs, among others.

To better evaluate the students' vision regarding the influence of technology on their way of thinking: The answers were categorized in the table below:

Table 59. Pre-service teachers´ responses on whether science and technology influence our everyday thinking. (Categorised question)

Q20. Science and technology influence our everyday thinking because science and technology give us new words and ideas.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	R	5	4.5	4.5	4.5
	HM	31	27.9	27.9	32.4
	N	60	54.1	54.1	86.5
	Ne	15	13.5	13.5	100.0
	Total	111	100.0	100.0	

The results clearly show that more than half of the students surveyed have an inappropriate view of the influence of technology on their way of thinking and providing ideas for decision-making and development. This fact can be linked to the level of poverty that characterizes the majority of the Mozambican population and concretely to the weak investment in science and technology in the communities, schools, and public services but also the "elitization" of technology due to the considerably high prices.

The results are not surprising since Professor Glauco Arbix, commenting on the relationship between technology and social inequality, argues that "technological development, although growing, excludes half the world's population" (Arbix, 2019), which means that rich/developed countries invest more in technology to the detriment of poor/underdeveloped countries.

The low level of use and recognition of the importance of technology can also be seen in the lower percentage of 4.5% for the realistic alternative, and of course, the reasons are the same (poverty and weak investment in technology).

5.3.6. Capacity and background to teach using STS Approach

The teacher training process involves several aspects to consider, among which are the policy, philosophy, theory, and methodology of education. These aspects influence to a great extent the training model, the curricula design, and the quality of the training as methodology guiding instrument and result respectively in a macro perspective but also a micro perspective involves the methods, means, implementation conditions, etc., to be applied in the teaching-learning process to achieve the envisaged objectives.

Therefore after questions related to the mastery of subjects related to Systemic Approach and Science-Technology-Society Integration as sub-theories or teaching methodologies, we asked about Views on Science-Technology-Society concretely the importance and application of technology in the daily life of students and society in general and finally, we asked about pre-service teachers´ capacity and abilities to teach based on systemic approaches and STS or even School-Community Interaction where the results appear in the table below:

Table 60. Pre-service teachers´ responses regarding the ability to teach in school-community interaction.

Q21. The NES proposes an interaction between the school and the community. Do you think that the leavers (students) are well prepared to teach on this approach?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	I Strongly Agree	13	11.7	11.7	11.7
	I Agree	57	51.4	51.4	63.1
	I Disagree	14	12.6	12.6	75.7
	I Strongly Disagree	1	.9	.9	76.6
	I don´t understand; I don´t know enough about this topic to make a choice; None of these choices fit my viewpoint	26	23.4	23.4	100.0
	Total	111	100.0	100.0	

The results indicate a higher score (51.4%) for an optimistic view (I Agree), followed by a neutral view (I don't understand....) with 23.4% (about a third part of the respondents), which reveals that despite the educational policies through the law on the National Education System suggest a close link between the school and the community, in which the school acts as a centre for fostering the socio-economic and cultural development of the community (MINED, 1983).

The Mozambican teaching and learning process operates as a closed system, isolated from the communities in terms of contents, methodologies, and exchange or transfer of knowledge.

Additionally, a lack of consistency between policies-objectives-methodologies-investment can be noted, which makes that although the school is inserted in the community and the education law (law 4/83) establishes that the [...] The school receives the necessary guidance from the community to carry out an education and training course (MINED, 1983).

In practice, the interaction between the school and the community is still almost non-existent, especially concerning the scientific-technological interaction, which means that the Mozambican scientific development or the scientific production of the educational institutions of this country is not reflected significantly and effectively in the socio-economic and cultural development of the communities.

Therefore, in this context, the results suggest the need for curricula review and "alignment" between the policies outlined, objectives advocated methodologies (predefined, possible, and applied), and the investment made in the education sector as a fundamental assumption for the implementation of theories such as connectivism and or constructivism and teaching approaches (STS and systemic approach) that drive the use of technology and socio-economic development of society.

On the other hand, the results lead me to interpret that the teacher must have an artistic spirit, flexibility, and the ability to mould himself according to reality, making most undergraduates believe they are prepared to teach with CTS and Systemic

approaches in the future, even without a deep understanding of its features and functionality.

However, this “optimistic” thinking, even with the disparities that characterize Mozambican education, the poor quality, lack of teaching conditions, and deficit in the methodological domain of the approach to be used is somehow “positivist” which becomes an important presupposition for reforms and the introduction of these theories and approaches in the national curricula for teacher educations and secondary schools.

While there is no in-depth review of both the methodologies and the implementation of policies to overcome the problems facing the education sector, a feeling known as “burnout” is developing in the heart and mind of the teacher. “Burnout” is a bad feeling and means “the pain of the professional trapped between what to do and what he can actually do, between the sky of possibilities and the hell of structural limits, between victory and frustration” (Codo, 2002, p. 374).

Table 61. Pre-service teachers´ responses regarding whether teaching through school-community interaction can motivate learning and better understanding.

Q22. If there is a need for school-community interaction, is it correct to say that this motivates learning and improved understanding?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	I Strongly Agree	30	27.0	27.0	27.0
	I Agree	41	36.9	36.9	64.0
	I Disagree	13	11.7	11.7	75.7
	I Strongly Disagree	7	6.3	6.3	82.0
	I don´t understand; I don´t know enough about this topic to make a choice; None of these choices fit my viewpoint	20	18.0	18.0	100.0
	Total	111	100.0	100.0	

As in the previous question (Q21), here the results show a higher score for the "optimistic" view (I agree), but it differs in the second-highest option, as in the previous table there is the neutral view (I don't understand ....) with 23.4%, while in this table the second-highest option is the "super optimistic" view (I strongly agree) with 27%.

These findings show that students recognise that School-community interaction can

help in learning activities motivating learning, commitment to activities, improved understanding of phenomena, as well as the construction of consistent and lasting knowledge.

The neutral view as the third option with the highest score associated with two other views in the negative reflects the education model in Mozambique where local content and indigenous knowledge are not yet valued in schools and universities as they have been valued and used by the unschooled population or by the low level of education, especially in remote areas.

Schools need to be part of the community in an effective way and with these and other entities build a system that works as a whole because we need to work together as one system to nurture our schools for our particular community needs (O'Keefe, 2011). For a well-functioning school-community interaction O'Keefe (2011) suggests five steps:

- Expand Your Vision of School to Include Community
- Reach Out to All Stakeholders
- Create a Community Resource Map
- Connect with Curriculum
- A Design Challenge for the Community

5.4. Results and discussion of observation data from practical activities.

The practical activities took place at the school, at universities, and in the communities, and were divided into two different moments. The first phase was established as an initial phase and included three projects at Soalpo Secondary School, and the second was the main phase that included several university and community projects.

5.4.1. Practical activities at school

The first phase (three initial projects) was very important for this study and served to evaluate the feasibility of implementing practical projects in schools as well as to better explain some contents and phenomena in a more expressive, consistent, and effective way.

The three initial projects implemented in the school related to agriculture, energy, and environment, served as an indicator of the success of the introduction of integration of Science-Technology-society and a Systemic approach to the learning activities in the Mozambican curricula.

The results were satisfactory because the methodology and the preconceived objectives were successfully achieved. Taking as an example the project "production of fertilizer based on human urine for the planting of lettuce", which had the support of partners[23] and there was much collaboration from the communities in accepting to supply the urine in flasks, which made it possible in a short time (one week) to complete the 30 litres needed and used in the project.

With this project, it was possible to understand the fertilizing properties of human urine and to know that it is a good source of Nitrogen (N), Phosphorus (P), and Potassium (K), but it was also possible to frame and contextualize the experience of "the use of urine in lettuce production" in the content of the 9th-grade syllabus "Nitrogen and the elements of group V, Mineral Fertilizers” etc., (MINED, 2010b).

The project can also be used to transfer experience on environmental education, which is considered a cross-cutting theme, since most households in cities and rural areas in Mozambique use latrines that are not connected to a sewerage network, discarding urine and other waste directly into the soil (outdoors) or into precarious sewerage systems.

Anyway, these wastes can be taken by rainwater to fields or rivers, ponds, etc., causing problems for the environment and public health (Bruschi, Ribeiro, Peixoto, Santos, & Franco, 2002; Ribeiro & Rooke, 2010), but also negatively influence soil productivity or what can cause water-related diseases (following table).

[23] Laboratory at the Provincial Hospital (in Chimoio), which provided the sample collection containers and helped to carry out some urine tests that could not be done in the UniPúnguè laboratory

Table 62. Water-related diseases

Disease group	Ways of transmission	Main diseases	Ways of prevention
Transmitted via the fecal-oral route	The pathogen (disease-causing agent) is ingested.	Diarrhea and dysentery; cholera; giardiasis; amoebiasis; ascariasis (roundworm).	• protect and treat supply water and avoid the use of contaminated sources.
Controlled by cleaning with water (associated with insufficient water supply)	Lack of water and insufficient personal hygiene create favourable conditions for its spread	Skin and eye infections, such as trachoma and lice-related typhus, and scabies.	• provide adequate water and promote personal and domestic hygiene.
Associated with water (part of the life cycle of the infectious agent occurs in an aquatic animal)	The pathogen penetrates through the skin or is ingested.	Schistosomiasis.	• avoid contact of people with infected water; • protect water sources.
Transmitted by water-borne vectors	Diseases are spread by insects that are born in the water or bite near it.	Malaria; yellow fever; dengue; filariasis (elephantiasis).	• combat insects that transmit the disease; • eliminate conditions that may favour breeding sites.

(Barros et al., 1995)

However, the use of urine in soil fertilization for horticultural production is also one of the ways of helping to prevent the spread of diseases in the communities and according to Cavinatto (2012), preventing the spread of diseases carried by the waste in the form of sewage and rubbish is one of the main functions of basic sanitation. In this case, the professionals working in this area are also responsible for the supply and quality of the water that supplies the population.

The statements serve as a basis and stimulus for cooperation between partners from different areas and highlight the importance of the Science-Technology-Society integration and systemic approach in the teaching and learning process in Mozambique and worldwide.

The lettuce produced had as one of the objectives to offer to people from the communities (see appendices), this act was very emotional taking into account the satisfaction and gratification of the beneficiaries.

As explained in the methodology chapter, towards the end of the three initial projects developed at the school, classes were interrupted because of the spread of the COVID-19 pandemic.

With the interruption of classes, the project for the production of fertilizer based on foods west was transferred to the community and two others were transferred to laboratories at Púnguè university and partners to carry out some chemical and microbiological analyses.

The interruption of classes was announced after a decree-law that established lockdowns across the country. During the lockdown period, several other activities and projects continued to be developed, but with some limitations (particularly the impossibility of contacting secondary school students.

5.4.2. Practical activities at school, universities, and communities

After the first intervention, many other projects were carried out, some of which took place in communities, others by their nature took place simultaneously in communities and universities, some others were developed at the university, but there were also projects developed between universities.

These projects are all described in the point below which describes the occurrence and benefits of the people and institutions involved, and later summarized in a table for better understanding.

5.4.2.1. Profit: outputs and outcomes

The research activities carried out in this study brought benefits to all involved (pre-service teachers, students and teachers from secondary schools, lecturers, administrations, partners, and community) as a part of the system.

Each entity involved has interests, responsibilities, and obligations regarding the teaching and learning process, and therefore, their active participation in research to find solutions to individual/institutional and collective problems helps to improve their

profile, allowing them to develop technological tools to better contribute to the scientific and socio-economic development of the country.

The dissemination of the learning outcomes and research activities developed as a source of knowledge production constitutes an important tool to feed the industries and different sectors of the country such as agriculture, health, environment as well as the development of the education sector.

In a specific way, the companies involved execute their socio-economic and social responsibility plans, saving in some way the resources, because the connection between different entities with the same interest helps in great measure in the sharing of resources (human and financial), it also helps in the discussion of ideas which propitiates the taking of more assertive decisions possible and improvement of quality of their activities/intervention.

For the universities involved, the project was useful, not only as a part of social responsibility, accompanying the teachers (pre-service & on-service), but also as an excellent platform for scientific knowledge production (books, dissertations, scientific articles, other various projects, and prototypes), as a technology transfer center, and as an opportunity to exchange experiences between university, institutions, students, and community.

With this platform, communities can actively contribute to learning activities and at the same time solve or participate in solving their daily problems such as hunger, malnutrition, crime, and transport, and also participate in the production of cleaning and disinfection to prevent contracting diseases such as the COVID-19 pandemic, cholera, diarrhea, etc.

The students (pre-service teachers), learned to "be scientists" and instilled the philosophy that scientific knowledge has value when the goal is to solve concrete problems that affect them and their communities.

They also had the opportunity to interact with the real world, to participate in the development of various products (food, cosmetics, and different prototypes), but also had the opportunity and pleasure to personally produce scientific knowledge which

some used this knowledge to produce their scientific monographs (for degree/ "*Licenciatura"*).

The first intervention in the school was part of preparatory studies or pilot projects and took place between late 2019 to early 2020, after the documentary study and direct observation aimed to answer the first two research questions of this study, which aimed to identify:

i. the central elements for introducing the approaches in the Mozambican learning system and the respective modality of implementation.
ii. the structural and institutional preconditions for introducing these approaches.

5.4.2.1. 1. Publications of preliminary project results

The preliminary results were presented and published in the abstract book of the 28th Conference of the Southern African Association for Research in Mathematics, Science and Technology Education (SAARMESTE), which took place in Port Elizabeth, South Africa, from January 14 to 16, 2020 (see appendices).

A few months later, the three pre-service teachers who had developed the initial projects, produced their scientific monographs based on some analysis carried out on the results obtained. The monographs produced were as follows:

- Analysis of the efficiency of organic fertilizer produced based on urine vs inorganic (NKP). (Pre-service teacher: Charifo Azido Jamal Emílio)
- Biogas production from food waste "Xima" (Pre-service teacher: Ernesto António Sozinho)
- Efficiency analysis of biofertilizer produced from food waste vs inorganic fertilizer. (Pre-service teacher: Mupone Jemusse Vurande).

The first two monographs were defended in 2020 with emphasis and the third one was defended in 2022 (see appendices).

5.4.2.1. 2. Production of kale with the use of fertilizer based on food waste

The monograph about the biofertilizer produced from the food waste project had as its socio-economic objective the production of kale, which began in school, and because of the lockdown established, the project was later transferred to the community.

The kale produced in this project had a very good appearance and quality and was used to feed the student's family but also offered to neighbours (see appendices).

5.4.2.1. 3. Production of ash-based soap

During this lockdown period, part of the pre-service teachers involved in the school project started to carry out research focused on finding solutions to problems that affect the communities, with a greater focus on the COVID-19 pandemic, seeking sustainable alternatives to prevent and combat this disease.

Initially, the soap produced was based on saponification with sodium hydroxide, and then the product samples were subjected to laboratory analysis (pH and foam). Therefore, from the first ideas, the idea of producing soap in a more sustainable way for Mozambican communities emerged.

It was in this context that the production of soap based on saponification with ash and used oil began, and the prototype was subsequently improved at the UniPúnguè laboratory as can be seen in the images below.

Figure 30. Soap produced from ash as a saponification agent and used oil
(Group of pre-service teachers and I in the laboratory after producing soap based on ash)

5.4.2.1.4. Other projects that resulted in scientific monographs (for "*Licenciatura*")

In this new stage (period of lockdown) of the study, 3 other monographs were produced and all of them were defended, namely:

- Ethanol production from the reuse of rotting solid waste from a variety of potatoes (*ipomoea*) from the district of Báruè. (Pre-service teacher: Suraia Armando Bonzene);
- Rancidity levels of sunflower, palm, and soya oils in reuse in potato and fish frying. (Student from ISPM: Henriques Ricardo Mativera);
- Efficacy analysis of medicinal soaps from eucalyptus and guava leaves *vs* aloe vera, lemon leaves, and honey. (Pre-service teacher: Geraldo Bento Abrão Mwanza)

These monographs were defended with distinction, and due to the pertinence of the themes, the second had greater merit among them and belongs to a student from a partner university of UniPúnguè the *Instituto Superior Politécnico de Manica* (ISPM), where both the jury and the course director proposed that the results of the study be published as a scientific article in national and international research journals.

5.4.2.1.5. Nomination of the ash-based soap project to participate in the national competition in scientific innovation (a public event)

In the scope of the project, the university was invited to participate in the innovation competition and a group of six students participated in presenting our soap produced based on ashes and medicinal plants, both to support the communities and the university itself in the prevention of contamination by the pandemic of COVID-19.

This competition is a public event launched some years ago by the President of the Republic, which aims to discover, highlight and stimulate scientific research, especially for young students and researchers.

This is a public event with the participation of school students, university students, other innovators, partner institutions, and communities, in order to disseminate

scientific innovations and, at the same time, promote their application in solving the everyday problems of society.

The event was divided into different categories and our project was selected for the scientific innovation category. The pre-selection of candidates/projects started in May of 2021, and the competitions were divided into three different stages (district, provincial and national) which took place as follows:

- District stage – exhibition and workshop in Manica province on July 8th (the project won in the first place)
- Provincial stage - exhibition and workshop in Manica province on August 10, 2021 (the project won in second place), and finally
- National stage – in Cabo Delgado province on the 22nd of October (see appendices).

Therefore, because of the COVID-19 pandemic, there was just a classification of recorded videos for awards and closing ceremonies. In this stage, the project did not win one of the top 3 places but, it was highlighted and recommended to improve some aspects (quality of the video, packaging, and additives).

5.4.2.1.6. Technology transfer (production of alcohol for disinfection) to other universities

The benefits of the projects were also shared with other institutions, for example, part of the knowledge acquired in the projects carried out within the scope of this study also brought some direct benefits to partner higher education institutions, which is the case of *Instituto Superior Politécnico* of Manica (ISPM) and the Catholic University of Mozambique (*UCM*).

The experience gained from the results of the student's project, which produced alcohol in small quantities in the community based on potato waste, was presented to ISPM students of the Food Processing Technology course (*TPA*), on the subject of beverage production technology.

These students accepted the challenge of optimizing the production process and producing alcohol in sufficient quantities for disinfection throughout the institution. Therefore, the ISPM laboratory does not have the necessary conditions (distillers with a capacity of above 50 litres) for a practical lesson on alcohol distillation on a large scale. Therefore, ISPM purchased the reagents and contacted the UCM, which made its laboratory available for the aforementioned activity.

The practical activity lasted an average of two weeks where students discussed and learned the procedures and phenomena of fermentation and alcoholic distillation. The alcoholic fermentation took eight days and the distillation process took three days and the distillations were separated into five litres each, and then the alcoholic percentage was measured and then stored in 20L containers. The production cycle was under the following details:

- Day 1: production of 15 litres (1st - ethanol 58%; 2nd - ethanol 37% and 3rd - 20%);
- Day 2: 25-litre production (1st - ethanol 60%; 2nd - ethanol 58%; 3rd - ethanol 40%; 4th - ethanol 30%; and 1st - ethanol 20%)
- Day 3: 20-litre production (1st - ethanol 50%; 2nd - ethanol 43%; 3rd - ethanol 35.5%; and 4th - ethanol 30%)

The initial production was 60 litres of alcohol and they were kept in containers of 20 litres each. Then the alcohol produced was mixed to carry out the second distillation, to obtain alcohol with a percentage of at least 70%, which would be used for disinfection following the norms of the world health organization. (WHO)

In the second distillation 20 litres of concentrated alcohol were obtained, the first (5 litres) with 78% ethanol, the second (5 litres) with 73%, the third (5 litres) with 60%, and the fourth (5 litres) with 43% ethanol.

The alcohol obtained from the first three containers was mixed to obtain 15 litres of alcohol with 70.3% that the ISPM administration took for institutional use for disinfection of staff and students and the remaining 5 litres of 43% was given to the

UCM administration for laboratory use in the process of sanitization and/or chemical experiments.

With this project the ISPM saved and could still save a lot of money in the purchase of alcohol for institutional disinfection, the UCM could also save money in the purchase of alcohol for cleaning and some laboratory experiments, and the students learned about the alcohol production process and the phenomena involved in both alcoholic fermentation and distillation.

In addition to the scientific and economic gains, the project was important in strengthening the understanding and friendship between the directors of the two educational institutions and also between their teachers and researchers, as the UCM researchers revealed that they had never managed to reach 56% of ethanol in the first distillation.

However, UCM researchers positively appreciated our results (alcoholic performance) and showed interest in collaborating with us in the next production they have where they intend to try out the protocol (of reagents and procedures) developed in our activities.

The pictures below show part of this process.

Figure 31. Production of alcohol for disinfection (class content: alcoholic fermentation and distillation)
A - Groups of students preparing the sugar substrate for alcoholic fermentation. B - Reagents and containers for fermentation. C - Primary fermentation of corn bran before mixing with leftover sweet potato, sugar, and yeast. D - Distillation. E – 60 liters of alcohol.

5.4.3. Summary of developed projects

In addition to the projects presented, other small projects were developed combining science-technology-society and a systemic approach such as:

- Production of shoe polish
- Production of wax for polishing wooden materials
- production of preservatives to protect maize from insect attacks in warehouses/barns.

Therefore, each project had its specificities, and some of them were developed from the communities, but because the products could not be offered to the communities before prior quality evaluations, the products were taken for analysis at the Púnguè university as well as in some partner laboratories.

After verifying the quality of the products, some of them were improved and later offered to the community. But the other products that were within the quality standards did not need improvement, these groups of products were offered as they were produced.

But also, some products that are not dangerous for the community, these could be produced and offered immediately. Therefore, the strategy used was to start benefiting the neighbours, who are the closest people and who live the student's day-to-day life; and perhaps expect to see the advantages of the knowledge that this can bring from the university.

For a better understanding of the projects developed in the study, below is the summary table where the projects are listed, the location developed, some summarized descriptions; and also, the specific partners of each project.

Table 63. Summary table of developed projects

Ord	Projects	Place of implementation and research activities	Description	Partner
01	Production of kale with the use of fertilizer based on food waste. Title: Analysis of the efficiency of organic fertilizer produced based on urine vs inorganic (NKP).	• Community • Soalpo Secondary School, • Púnguè University, and • Provincial Hospital of Chimoio	• The Provincial Hospital offered 25 containers of 500ml each, increasing the number of existing ones for urine collection • The urine used was collected in the community • Then she was taken for treatment and some analysis in the UniPúnguè laboratory; • After the initial treatment, urine was applied to the school's flower beds for lettuce production • The final product was taken for some analysis in the laboratory of UniPúnguè and the laboratory of the Provincial Hospital of Chimoio; • The lettuce produced was offered to some people from the neighbouring community and some school and university employees • The results were discussed and used to produce a scientific monograph	• Provincial Administration of Education; • Provincial Hospital of Chimoio; • Community

02	Biogas production from food waste "Xima" Title: Biogas production from food waste "Xima"	• Community • Soalpo Secondary School, • Púnguè University.	• Food scraps were collected and sorted in the communities; • The biodigester was built and installed at the school; • The construction of the biodigester had the support of the *FIPAG* engineer and technician; • The results have been discussed and used to produce a scientific monograph	• The biogas obtained was collected and tested at UniPúnguè;	• Provincial Administration of Education; • Municipality; • Water provider (*FIPAG*); • Community
03	Production of kale with the use of fertilizer based on food waste. Title: Efficiency analysis of biofertilizer produced from food waste vs inorganic fertilizer.	• Community • Soalpo Secondary School, • Púnguè University.		• The production of kale took place in the community; • Part of the kale produced was offered to neighbours for food and the other part for food for the family of the pre-service teacher involved.	• Provincial Administration of Education; • Municipality; • Water provider (FIPAG); • Community
04	Ash-based soap project	• Community • Púnguè University	• The first soap samples (based on Sodium Hydroxide) were produced in the communities; • The samples were then analysed at the university laboratory; • Samples within the standards were offered to the communities (neighbours of the pre-service teachers);		• Provincial Administration of Education; • Some hotels and

			• After in-depth research, the ash-based soap prototype was developed and improved; • Basic raw material, namely ash, has been collected at the bakery near UniPúnguè and from the homes of students, lecturers, and neighbours, and used oil has been supplied by hotels and restaurants in the city. • Ash-based soap was offered to the communities but also to the University administration and started to be used in sanitation throughout UniPúnguè. • The soap was highlighted as a scientific innovation project and with the project participated in the national competition “young innovator” • Soap has been constantly being improved and invited to participate in various political, scientific, commercial, etc. events. • The project became the “flag project” of UniPúnguè	restaurants in the city of Chimoio; • Bakery near UniPúnguè • Community
05	Alcohol production from discarded and rotten sweet potatoes.	• Community • Púnguè University.	• The rotten and discarded sweet potatoes were harvested in the communities • The instruction of the distillation process was carried out by experienced women from the communities (ladies);	• Community

	Title: Ethanol production from the reuse of rotting solid waste from a variety of potatoes (*ipomoea*) from the district of Báruè.		• The fermentation and distillation process took place in the communities; • Alcohol percentage analysis was performed at the UniPúnguè Laboratory; • The results have been discussed and used to produce a scientific monograph.	
06	Rancidity of oil reused in frying. Title: Rancidity levels of sunflower, palm, and soya oils in reuse in potato and fish frying.	• Fast food outlets (take away) in the city; • Olam oil factory; • Superior Polytechnic Institute of Manica (*ISPM*)	• Virgin oils were purchased in supermarkets; • The frying process was carried out and the samples were extracted and housed; • Other comparative samples were acquired in the "take away" • The physical-chemical analysis was carried out in the city of Beira, in the laboratory of the Olam oil factory. • The results have been discussed and used to produce a scientific monograph.	
07	Production of medicinal soap. Title: Efficacy analysis of medicinal soaps (eucalyptus	• Community • UniPúnguè	• Plant leaves and lemons were acquired from the community; • The soaps were produced in the UniPúnguè laboratory; • The pH and foam tests were carried out at the laboratory of UniPúnguè;	• Community

	and guava leaves) vs (aloe vera, lemon leaves, and honey).		• The soaps produced were offered to the communities for use and evaluation for effectiveness • The results have been discussed and used to produce a scientific monograph (to be defended shortly).	
08	Alcohol production for disinfection	• Superior Polytechnic Institute of Manica (*ISPM*); • Catholic University of Mozambique (*UCM*-Chimoio)	• The theoretical studies and organization of teams were done at ISPM based on results from the production process of project number five of this table; • The raw material was purchased in supermarkets and markets by ISPM; • Part of used bran was offered by the community; • The alcoholic fermentation and distillation process was carried out in the UCM laboratory • The alcohol produced in sixty litres is refined (re-distilled/concentrated) to fifteen litres of 70.3% alcohol and 5 litres of 40% alcohol • Alcohol at 70.3% was delivered to the ISPM administration for use in institutional cleaning and presence against COVID-19; • 40% of alcohol was delivered to the UCM administration for laboratory classes.	• UniPúnguè; • *ISPM* • *UCM*
09	Production of shoe polish.	• Community • UniPúnguè	• Reagents were purchased from the community	• Community

			• Part of the grease produced was applied to cleaning the shoes of people in the communities; • Another part of the grease was used for scientific exhibition and presentation at the scientific conferences of UniPúnguè	
10	Production of wax for polishing wooden materials	-Community -UniPúnguè	• Reagents were purchased from the community • Part of the wax produced was used to clean the shoes of people in the communities; • Another part of the wax left for scientific exhibition at UniPúnguè	• Community
11	Production of preservatives (natural insecticide) to protect maize from insect attacks in warehouses/barns.	-Community -UniPúnguè	• Reagents were purchased from the community; • The explanation of the method of preparation was given in the community by some women with some experience in corn conservation. • The experience of producing the preservative was carried out in the community; • The preservative was tested in the UniPúnguè laboratory; • The application of the preservative was done in the community • Presentation at the scientific conferences of UniPúnguè	• Community

These projects demonstrate the affectivity that can result from the application of STS integration and a systemic approach to learning activities. Because, students actively participate in solving problems such as hunger, poverty alleviation, crime reduction, etc., problems that happen in their communities. This involvement stimulates the learning and production of knowledge applicable in practice and everyday life for development and well-being.

5.5. Results and discussion of data set from questionnaire 2 (motivational questionnaire)

The questionnaire is divided into six categories, namely: Intrinsic motivation and personal relevance; Intrinsic motivation and personal interest; Perceived Competence; Effort/Importance; Value/Usefulness, and Collaborative Work Relatedness.

5.5.1. Intrinsic motivation and personal relevance

The questions in this first category relate to the students' affinity or liking for the natural sciences, motivated by individual and socio-cultural issues, and the importance of the area of training for their lives, and future profession. The combination of these factors can positively or negatively influence the choice of a degree in natural sciences and chemistry, as well as the area of higher education, preparation for employment, and future life.

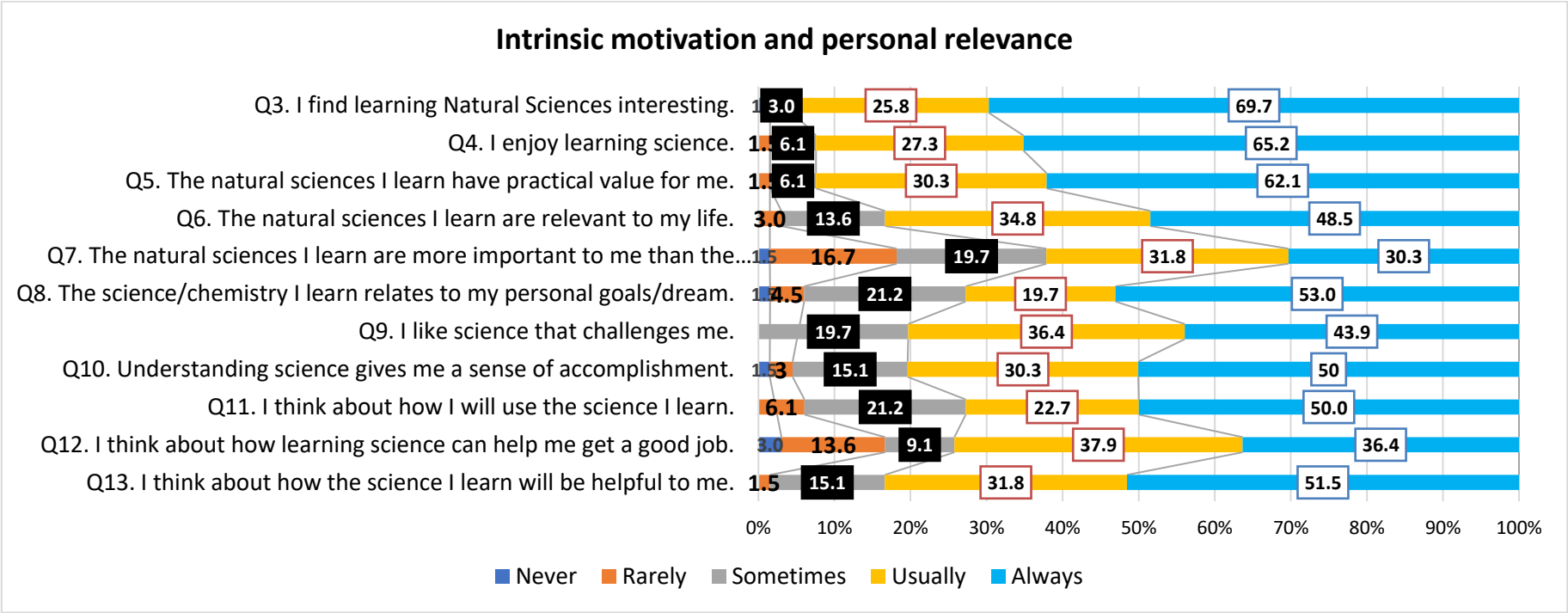


Figure 32. Pre-service teachers´ responses about intrinsic motivation and personal relevance

From the responses on average, 51.5% of the respondents responded positively to the highest scale of motivation, followed by approximately 30% to the second high scale, which reveals that the level of motivation is high.

"Motivational tendency can be related to issues based on an individual's culture and history." (Stirling, 2014, p. 5), where the example of success both in the family and in the community has played a very important role in the choice of training area. But also

motivation can come from the results of socio-cultural constructs (Pintrich, 2003; Skinner, 1953; Todorov & Moreira, 2005) proposed as a motivation factor, having as motivational aspect the habits, customs, job opportunities, especially the importance that the country gives to the area of natural sciences, especially chemistry.

With the curricular reform of 1983, which was motivated by the need to form the "new man", there was only a change from capitalist-dictatorial to socialist and democratic ideologies, but the systems of organization of teaching by the subject that followed the Portuguese curricula were kept (Pastore & Barros, 2018).

Between 1976 and 1992 the country experienced a civil war and during all this time there was no discussion about the need to incorporate aspects of ethnicity, culture, linguistic diversity, and existing multiculturalism as a motivational aspect and to guarantee access to education for all children, something that may have contributed in large part to the absences, dropouts, and failures of many of the children (Castiano & Ngoenha, 2013; Mugime & Leite, 2015).

The motivational paradigms for the choice of training area in Mozambique are very much linked in some way to historical factors of the country. After independence, the country lacked the technical capacity to operate machinery, produce fertilizers and food, produce hygiene products and cosmetics, and even lack Doctors and paramedical personnel to save lives in hospitals, health posts, etc.

This inability to act in several areas of natural sciences forced the country to massify the training of personnel in all areas, with emphasis on agriculture, medicine, machine operations, and administration, adopting the strategy of support and partnerships with friendly countries such as Tanzania with special focus on the "Mozambican Institute" created in Dar Es Salaam in 1963 (Gasperini, 1989), Algeria and China and based on international scholarships in Western countries, especially in the former German Democratic Republic (Germany) and socialist countries such as the former Soviet Union (Russia) and Cuba.

With the development of the country, especially with the discovery and exploitation of coal mining in Tete, the demand for training in natural sciences, specifically chemistry or chemical engineering, has increased as a way to respond to the challenges of the

country, especially in the central region. This factor may have contributed greatly to the choice of natural sciences as the preferred area of training for many Mozambicans.

Therefore, based on the results of the questionnaire, can be seen that questions Q3, Q4, Q5, Q8, Q10, Q11, and Q13 contributed more than 50%, with Q1 having the highest percentage of approximately 70%, followed by Q4 with 65.2%.

These results lead us to conclude that personal issues such as admiration (Q3), Satisfaction (Q4), values which can be moral or ethnic (Q5), self-esteem, dreams, and well-being (Q8, Q10), practicality (Q11 & Q13) contributed the most in deciding for the choice of the course they are attending.

These results reveal that, in part, the motivation for the study area is related to the discriminatory system that existed in the colonial period, where people were classified into two different groups, where some were assigned the category of assimilated and others were considered as indigenous.

The assimilates were the most favoured and characterized as being members of the native population who spoke Portuguese and adopted European habits such as eating with a knife and fork, having a Catholic religion, and abandoning African cultural practices (Souza, 2019).

The lifestyle of the indigenous people was contrary to that of the assimilated ones, as they were despised, mistreated, and considered people in a state of savagery and low civilization, a group to which rights were not recognized, the underprivileged. Indigenous people constituted the majority of the Mozambican population,

According to Gasperini:

> "*The discriminatory school system was presented as a natural and inevitable response to unequal needs, traditions, and abilities. The school for homo sapiens was white, urban, secular, and cultivated thought, the sciences, and "knowing how to say" to the detriment of "knowing how to do". The school for homo faber, black, manual worker, rural, was religious and practical. Both mutilated the personality of their students depriving them of a complete development that integrated*

> *thought and action, "knowing how to think" and "knowing how to do", "knowing how to say" and "knowing how to be", science and technique"* (Gasperini, 1989, p. 14).

Questions Q6, Q7, Q9, and Q12 contributed low values as a motivational factor for choosing a course, with Q7 having the lowest percentage of 30.3% followed by Q12 with 36.4%.

These questions also reinforce the idea that the major motivation behind choosing the area of natural sciences is not linked to the relevance to future life Q6 as a scientist, nor necessarily to future employment but the status of being a graduate is in turn more important than science as such Q7 and this, in turn, is combined with Q9 where a large proportion of students reveal that they do not like science which challenges them.

Therefore, although the four questions Q6, Q7, Q9, and Q12 contribute with reduced values, adding the two highest levels of motivation, they still contribute to the motivational factor. However since the majority of students attending public schools in Mozambique are from low-income families, then the philosophy that the choice of the course with a greater focus on practical activities, in this case, natural sciences has been determined by historical and individual factors (Stirling, 2014) and were the main motivational factors.

5.5.2. Intrinsic motivation and personal interest

The second category "Intrinsic motivation and personal interest" consists of 8 questions of which two (Q17 and Q18) are inversely formulated and were re-categorized at the time of statistical processing as explained in detail in the methodology and the remaining 6 were processed normally.

The questions were related to practical work in general and subdivided into: levels of participation (Q14); levels of satisfaction (Q15, Q16, and 18); degree of attention (Q17), and levels of interest (from Q19 to Q21).

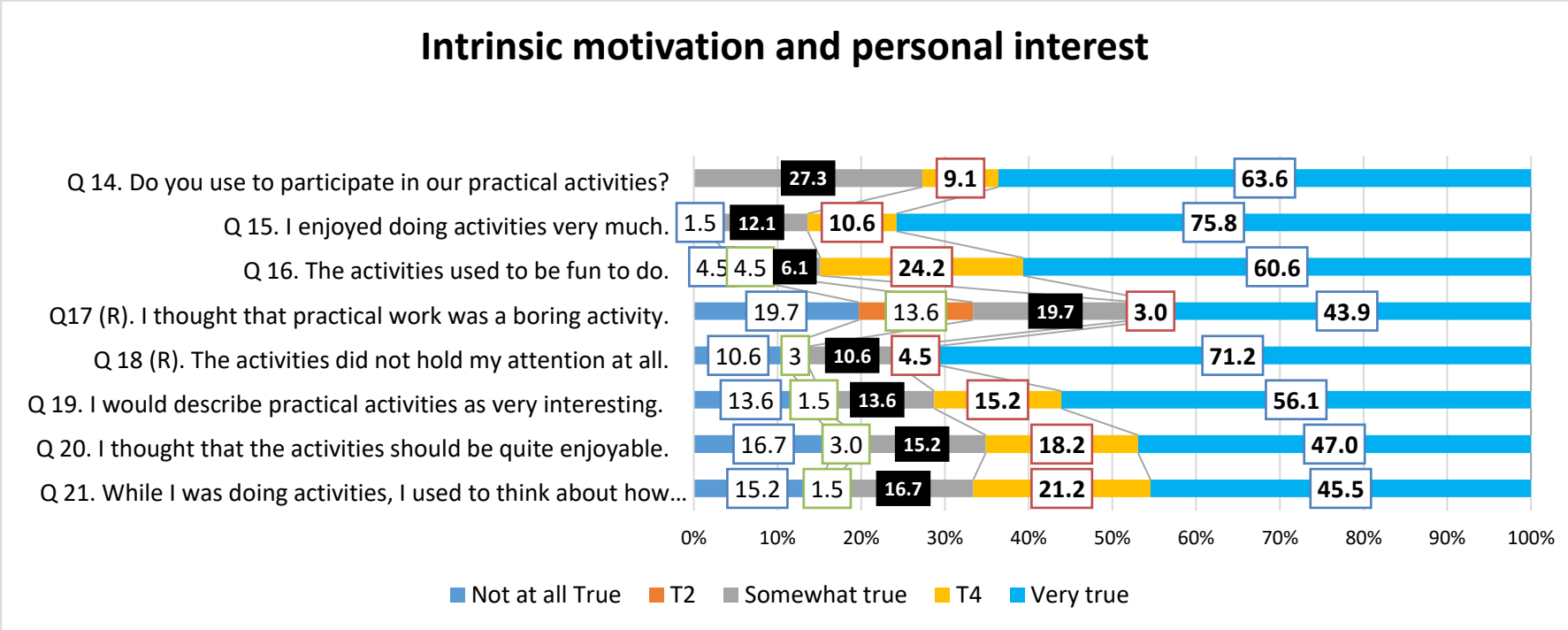


Figure 33. Pre-service teachers´ responses about intrinsic motivation and personal interest.

In this category, the levels of motivation show values above the previous category, therefore, from the answers given by pre-service teachers, an average of 58% indicated a high level of intrinsic motivation, followed by two other antecedent motivation scales with scores of 15.1% and 13.25, respectively.

“The motivational bias must be based on an individual's history" (Stirling, 2014, p. 5) as in the previous category, so in this category individual interests may exert greater influence to the detriment of historical factors but the motivation may otherwise come from manual work that is somehow linked to historical factors of the country.

Since the colonial period, most of the Mozambican population (indigenous) was devoted to agriculture, pastoralism, and other manuals/practical work, because the Portuguese curriculum "institutionalized two different types of education: education for those considered indigenous, not civilized; and the other education for Portuguese citizens, including assimilated Africans and Asians" (Mugime & Leite, 2015, p. 6), the first establishing an education of practical activities and the second education of intellectual activities.

But contemporary learning theories advocate learner-centred learning or a network of those involved and interested, which presupposes that the actors are the protagonists of the learning process in a context where their interests (individual/collective and societal) are safeguarded.

These assumptions influence to a great extent the intrinsic motivation and guarantee the improvement of learning outcomes because in this way learning is effective, contextualized, sustainable, and affective.

Studies show that both playfulness and contact with nature, supported by the constructivist theory which states that "the learner is at the centre of the learning environment as well as being actively involved in constructing knowledge individually", serve as highly motivational factors, content retention, and affective learning (Dunlosky et al., 2013; Rawson et al., 2018).

In this research the cluster of three learning theories namely cognitivism, constructivism, and connectivism were used through two theoretical bases, the first being Aikenhead's Science-Technology-Society interaction where students:

- interacted with the communities to better understand some aspects to gather experience and then
- based on scientific-technological knowledge they designed actions to solve these problems, which were also their problems.
- The second theoretical basis was Bertalanffy's systemic approach, which proclaims
- the maximum utilization of resources which is very important in low-income countries such as Mozambique

- collaborative work, given that the “learning results in different kinds of human behaviours” (Ayalew, 2012, p. 6), which allows for greater interaction and mutual learning and:
- the holistic vision that helps to look at institutions as a whole and not as parts, which makes both the university and other institutions involved act to improve the quality of life in the community.
- In the various practical work carried out as part of this study, the students followed the main objectives of natural science as they had the opportunity to:
- understand the natural world (pure research)
- explain the events of the natural world (analysis of facts)
- research to solve a particular problem (applied research)
- solve identified problems (intervention work/technology) (Baimyrzaeva, 2018; Harrison & Mannion, 1996; McMullin, 1984).

All these aspects, both, the applied learning theories and the opportunity to participate in solving their problems or the problems of the community where they are inserted (contextualizing the learning), but also the practical work and the interactions with the environment, had a determinant role in the motivational process what was reflected in the answers of questions Q14, Q15, Q16, Q18, and Q19, but also the remaining questions present values close to 50% of the highest level of motivation.

5.5.3. Perceive the competence

In this third category, the questions all (five) are closely related to the competence acquired after carrying out the different activities in Science-Technology-Society interaction and systemic approach.

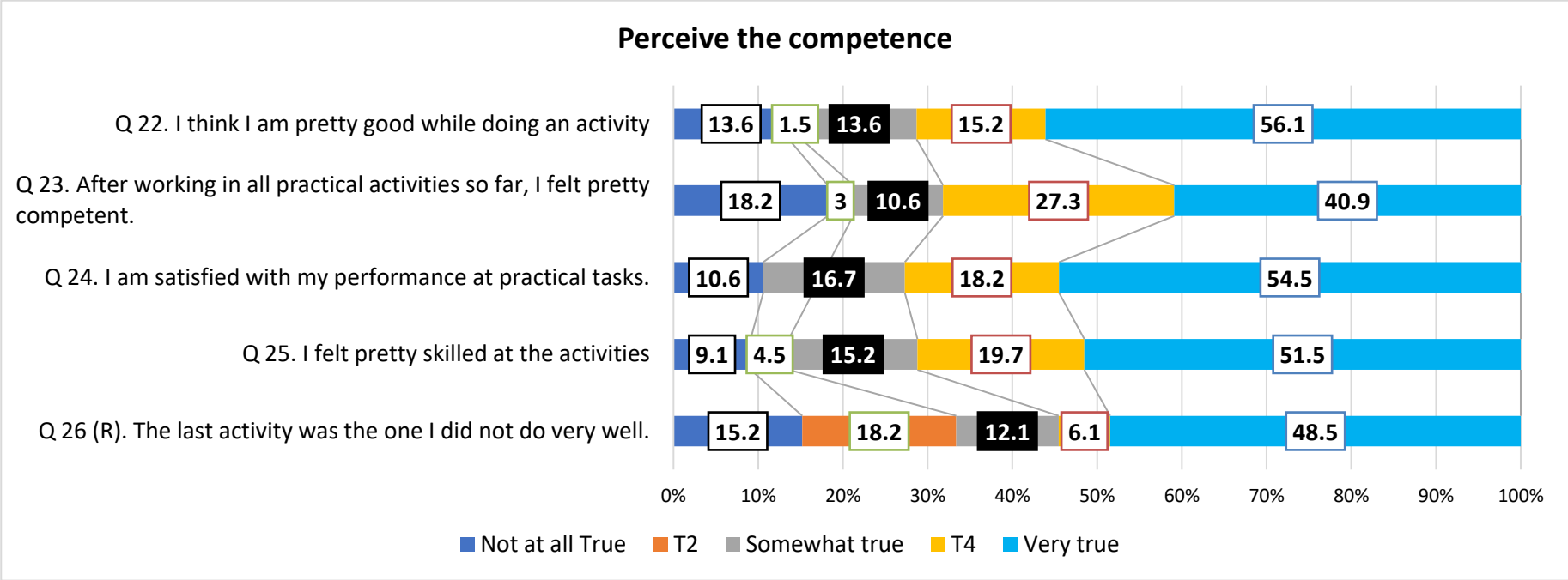


Figure 34. Pre-service teachers´ responses about perceived competence.

The motivational values are still satisfactory, whereas the higher motivational scales have higher scores compared to the others and make up 50.3% in total. Despite the positive values, this category presents lower values compared to the other categories and may be associated with the fact that skills are built over time, sometimes depending on several repetitions/practices (Fulbrook, 2019), as argued in behaviourism and the hierarchies of competence but also reveals somehow that the valorisation of local knowledge is still a challenge for the Mozambican educational systems.

For students in the natural sciences course, particularly the chemistry course, their greatest expectation may be behind scientific highlights such as the discovery of a new chemical formula, rocket production, or explosives formulas than necessarily using science and local knowledge to solve problems (hunger, poverty, disease, etc.) in their community.

For students in the natural sciences course, particularly the chemistry course, their greatest expectation may be behind scientific highlights such as the discovery of a new chemical formula, rocket production, or explosives formulas than necessarily using science and local knowledge to solve problems (hunger, poverty, disease, etc.) in their community.

The results may reflect the requirements of employers (required qualifications and skills) but may also derive from the curriculum used at Púnguè university (teaching of chemistry and laboratory management), as they have been doing laboratory experiments since the first year and already feel somehow competent to handle complex laboratory apparatus (labour market demands).

Therefore, experiments with easily accessible materials and learning beyond school could have a greater impact on students from secondary schools compared to pre-service teachers.

Perceived competence is conceived in the theoretical framework of self-determination theory (Rodgers, Markland, Selzler, Murray & Wilson, 2014) and deals with issues such as:

- impact of social contexts on intrinsic motivation where competence and autonomy are considered crucial aspects of motivation
- continuous internalization as a means to develop autonomy concerning extrinsic conditions
- concerns about individual guidelines concerning environments
- environments that support the three basic needs “autonomy, competence and relationship” promote psychological well-being

- Intrinsic and extrinsic motivation: a contrast between goals with intrinsic value (i.e. personal and community growth) and goals that are extrinsically oriented (i.e., wealth and fame) (Stirling, 2014).

The aspects listed above contribute greatly to the emotional balance and sense of individual and collective achievement, but also contribute to personal satisfaction according to preconceived expectations and individual ambitions. This set of feelings strongly influences the perception of competence.

Cognitive theorists (Jean Piaget, David Ausubel, Robert Gagne) assume that “learning results in different kinds of human behaviours” (Ayalew, 2012, p. 6), which means that, each individual makes different sense of the same environment and situations, taking into account their different experiences, cognitive processing undertaken, needs, expectation, aspirations, and motivations.

Furthermore, self-determination theory argues that "goals that support the three basic needs of autonomy, relatedness and competence will support psychological well-being, while extrinsic goals will have a negative impact on well-being" (Stirling, 2014, p. 7), and this positive and negative influence on well-being is reflected in the results obtained in this research.

The interpretation of the results can also be done in function of the connectivist theory where they find a perfect reason, because according to this theory "knowledge is not necessarily constructed and stored in the brain of each individual" participant in the working group but, it can be constructed and stored in the brain of the other, in a prototype, in the computer, in the electronic clouds, in the paper, in the research field, etc., on the one hand.

On the other hand, the connectivist thesis that “the knowledge is distributed across a network of connections” (Downes, 2012), better explains the balance in the values of the results, which shows that the students proved to be competent and able to adapt to new teaching methodologies.

5.5.4. Effort/Importance

The questions in this category are related to the committed effort, dedication, and importance that the implementation of the activities had for the students involved.

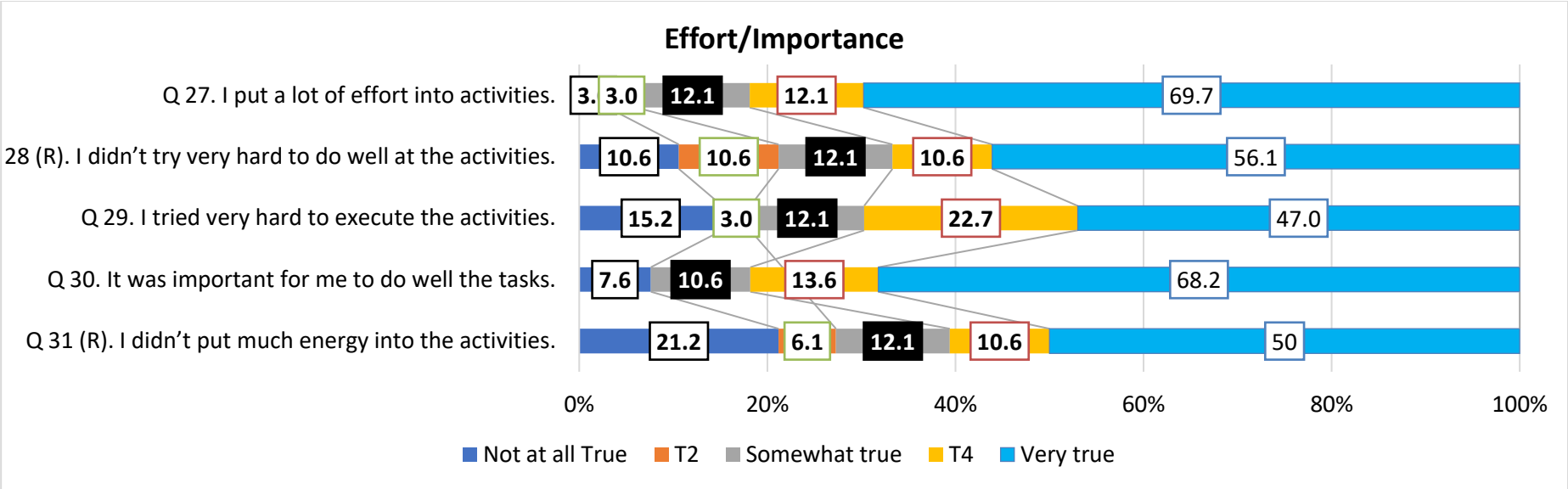


Figure 35. Pre-service teachers´ responses regarding the effort/importance of the practical work carried out.

Of the responses an average of 58.2% responded positively to the highest scale of motivation, followed by the second high scale with approximately 13.92%. Similar to the study from Waterman “when Effort Is Enjoyed: Two Studies of Intrinsic Motivation for Personally Salient Activities“ (Waterman, 2005), the motivational tendency was associated with greater interest, flow, and feelings of personal expressiveness.

The similarities deepen further to the results obtained by Waterman when we subdivided the five questions into subcategories. Therefore, the highest scores in both our study and Waterman's were for both self-realization values 69.7% and importance 68.2%.

The motivational tendencies for effort/importance may also find some scientific support in the discussion of happiness from a perspective of humanistic ethics which postulates that happiness and joy as its main virtues, but at the same time it assumes that nothing valuable is easy, however, hard/challenging tasks are those that provide man with the feeling of greater capacity, skills, the full development of his productiveness, pride, and satisfaction (Fromm, 1947; Waterman, 2005).

The answers in Q29 and Q31 reflect that the tasks were not necessarily hard, and did not require the execution of activities in an arduous manner or even the need to apply a lot of energy. In any case, the overall score for these questions reveals that there was some dedication and that the activities performed have some importance in the lives of the participants.

5.5.5. The value/usefulness of practical activities

In this category of motivation, the questions are related to the value and usefulness of the activities for the participants individually (Q32, Q33, Q35) but also for the communities involved or even where each student is inserted (Q33) and society in general (Q34). Q36 speaks of the value of the activities in the perception of chemistry and natural sciences.

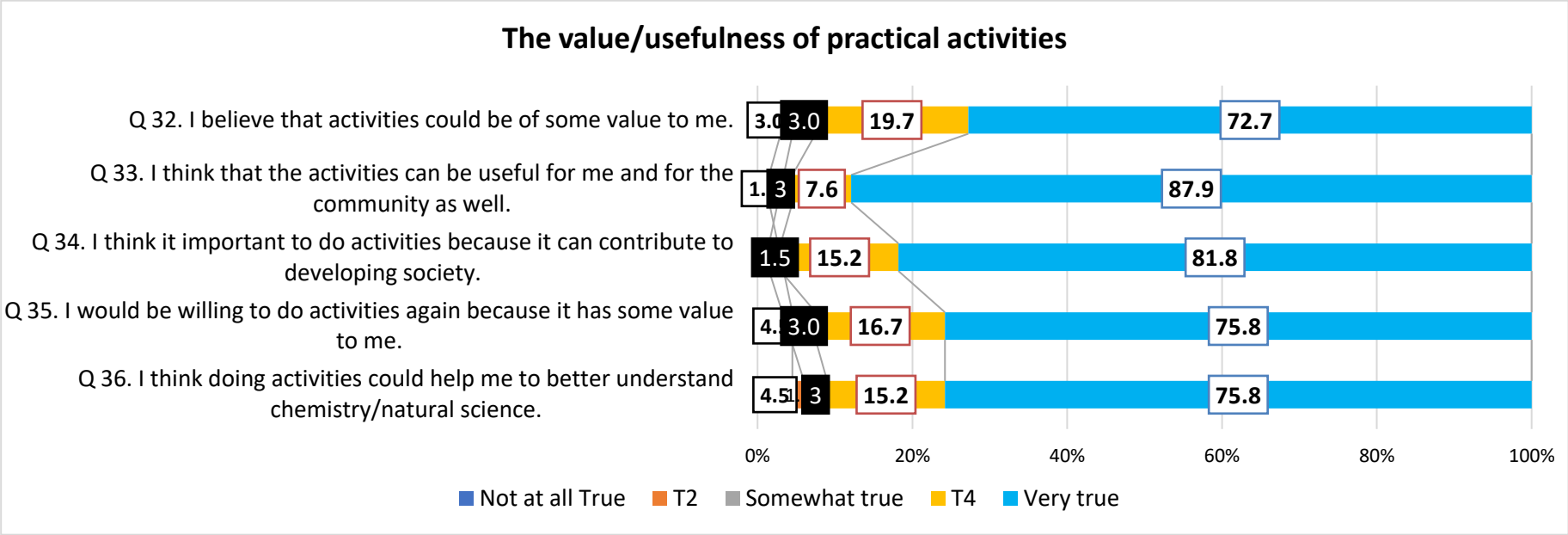


Figure 36. Pre-service teachers´ responses regarding the value/usefulness of practical activities.

With an average of approximately 80% for the highest motivation scale followed by the second high motivation scale with approximately 15%. This category has higher scores compared to the other five motivational categories used in the study.

“Practical activities have great value and importance in promoting learning science concepts, raising motivation, and promoting inquiry-based learning” (Said, Friesen, & Al-Ezzah, 2014), this fact influenced to a great extent in decision making and was noticeable in the activities by the commitment, dedication, curiosity and creativity of the students and also in the involvement of communities and

companies in the exchange of experiences, transfer of technologies and resolution of concrete problems that support them as a system.

The results in the table above also highlight the importance and influence of practical activities in the motivation and production of knowledge, however, Gasperini goes a little deeper into the subject when he makes the comparison between the abstract and the concrete or even between the use of memorization vs. the use of hands in the process of knowledge construction and relates this subject to prehistory, arguing the following:

> "*Children and savages have practical intelligence, more homo faber than homo sapiens. Both children and uncivilised people have a greater tendency toward the concrete, the malleable, the intuitive, and the unsystematic. They reveal enormous limits in abstract, logical, and speculative thinking. [...] In this practical intelligence, thought, impregnated with magical elements, is dissociated from action" [...]. For them the school should be based "almost exclusively on the use of the hands*" (Gasperini, 1989, p. 14).

"If only we could understand how students make sense of their natural world, we could design a science curriculum so that science makes sense to all students" (Aikenhead, 1996). Using this statement, I can affirm that according to the results from this study, can be designed Mozambican curriculum addressing connectivism as learning theory using a systemic approach and integrating STS to improve learning and understanding of science, promoting cooperative learning, understanding abilities and making informed decisions.

The results strongly reveal that the theories and approaches used in the study and the use of contextualised learning, exploring the resources available in the community and applying them to solve the day-to-day problems of this same community where the student is inserted, undoubtedly makes learning in three follows way:

(i) effective: which manifests itself in applying innovative and appropriate strategies for solving their problems and using the outcomes for day-by-day living and the future.

(ii) emotional: which is revealed in the cognitive ability to identify, assess, and control one's own emotions, the emotions of others, and that of groups (Goleman, 1995).

(iii) sustainable: This is demonstrated in the use of disposable materials for the synthesis of products such as soap, fertilisers, shoe polish, wax, etc., thus reducing environmental contamination and pollution.

5.5.6. Assessment of collaborative work-relatedness

This last motivational category is the most complex because it involves, besides the group work, some intimate feelings such as trust, friendship, closeness, complicity, reciprocity, etc., feelings that are difficult to measure and that its construction or deconstruction also depends on other intrinsic factors (e. g. interest, will, gains, etc.) and extrinsic factors (e. g. time, personality, behaviour, ethnic and tribal issues, etc.).

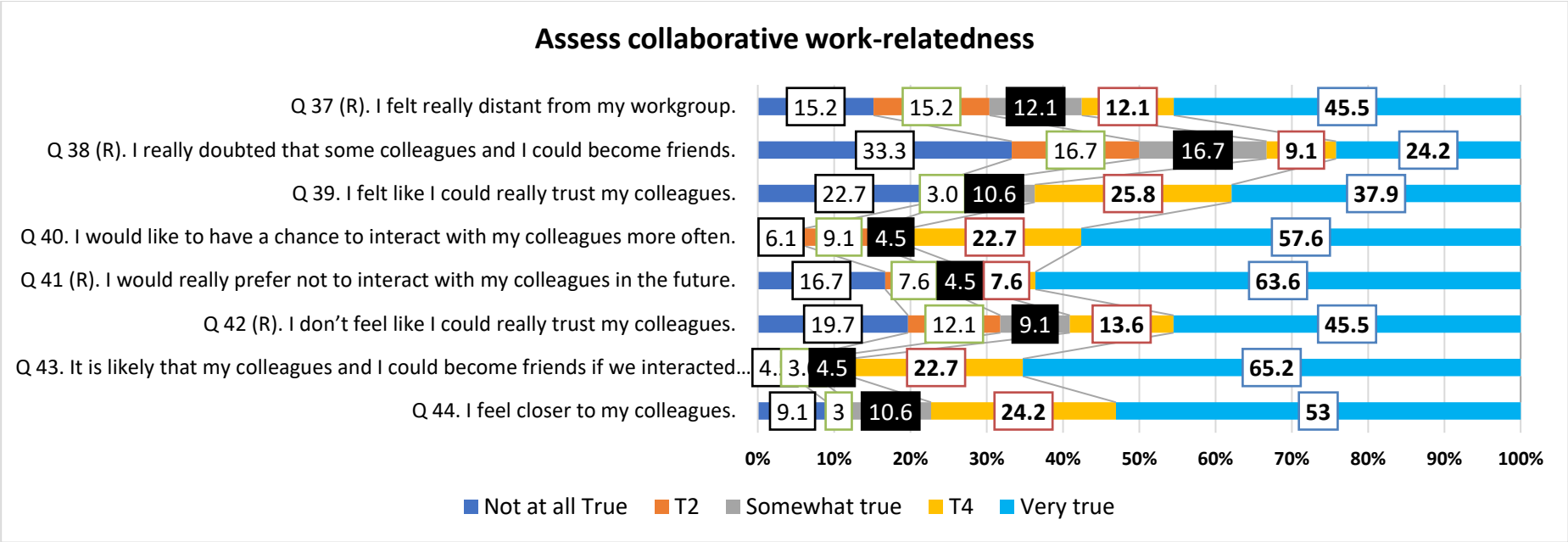


Figure 37. Pre-service teachers´ responses regarding the collaborative work-relatedness.

Of the responses an average of 49% responded positively to the highest motivational scale, followed by approximately 17% for the second high motivational scale. The questions can be subdivided into two small categories (i) closeness Q37, Q44 (ii) friendship Q 38 (iii) trust Q39, Q42, (iv) Collaborative work Q40, Q41 and (v) friendship resulting from collaborative work Q43.

Out of the above five subcategories, the category (i) has 49.25% of response in very true, with Q44 scoring higher than Q37, as despite the same category the fact that question Q37 was worded inverted may have contributed to the result. Sub-category (ii) has the lowest value among all categories with 24.2% of response in very true. It shows that despite being classmates, they still face huge challenges in becoming friends on one hand, and on the other hand the reversal of the question conveys a bit of ambiguity which is noticeable with the balance between indifferent and the second value of demotivation.

The subcategory about trust has an average of 41.7% of response in very true. This category of "trust" among students becomes in this way the second to contribute with low values after the category that talks about friendship. The subcategory (iv) contributes 60.6% where the two questions have values above 56% and finally the subcategory (v) with 65.2% presents the highest motivational score.

The results of the subcategories (i.e., friendship and trust) reveal that the students, despite being colleagues, are not friends and do not trust each other. This fact might have been strongly influenced by ethnohistorical and tribal aspects of the country.

In some African countries and Mozambique in particular, tribalism interferes to a great extent in the process of selecting people, creating bonds of friendship, establishing trust in employment opportunities and academic development (for instance; opportunity for entry into good universities, acquisition of scholarships, and acquisition of technical and scientific skills, etc.).

Accusations of choice and privilege based on tribalism of this kind are not new in Mozambique, "indeed the question of identity-ethnicity has been and continues to be an omnipresent issue in the discourses of the Mozambican elites (politicians, academics, etc.)” (Chichava, 2008).

The attempt to eliminate differences based on tribe, ethnicity, race, language, etc., is evident in the intention of the then-president Samora Machel who aimed at the union of all Mozambicans and for this, he said in his speech that "beyond the diverse traditions and languages, it requires that in our consciousness the tribe dies so that the Nation is born" (Machel, 1973, p. 4). This was combined with a discourse that advocated "the formation of the new man", free of prejudice and with a patriotic spirit (MINED, 1983).

Despite the intention and various speeches, the attempt failed and the marks both of the failure and the concerns about differences, mistrust, and devaluation of the other based on provenance/culture/tribe/ethnicity in Mozambique are noted in Sérgio Vieira's statement that "[...] I stopped despising that person for being Changana or Maconde or Ajawa, or Nhungue, or because he is Sena... one begins to enter into this notion that from Rovuma to Maputo we are a single people. There is no superior or inferior tribe, there is no tribe, we are all Mozambican people" (Macagno, 2009; Mosse, 2021; Vieira, 1978).

The results of the subcategory (i- closeness) suggest some closeness between students, which shows that somehow, they live with each other and share some ideas and perhaps feelings as students mainly those related to their student life. And the subcategory (iv- about collaborative work) with 60.6% of response in very true. This is a good indicator of the relationship between group work, mutual help, the rapport between students, and the connection of these when the subject is schoolwork.

The work was carried out using a cluster of learning theories (connectivism, constructivism, and cognitivism), with connectivism as the predominant theory and which advocates the union of people with the same objective and interest and also the sharing of resources, something extremely important for populations from low-income countries, which is the case of Mozambique.

Overall, the results about collaborative work-relatedness show that students have developed some skills and according to the PISA 2012 statement "skills empower people to meet the challenges of everyday life" for solving problems that afflict them where poverty, crime, and lack of affection are examples of the country's challenges.

PISA goes further writing that beyond better outcomes for the individual or working group, skills also provide the vital glue for resilient communities and well-functioning societies, by strengthening inclusiveness, tolerance, trust, [...], collaboration, and effective democratic processes (OECD, 2014).

Therefore, based on the evidence above, the results suggest that Mozambican society still faces some challenges regarding the assumptions for its good functioning, the proof of which are the constant tensions (discrimination, strikes, and armed conflicts), ethnic and tribal conflicts, attempts to divide the country, such as the "SOTEMAZA[24]" project and the recent "autonomous regions" project of the late opposition leader Afonso Dhlakama which aimed to divide the country from Save bridge and govern the central and northern parts of the country, among other examples.

The rifts, tensions between tribes and intentions to divide the country, and difficulty in developing friendship and trust result from the lack of satisfaction with the needs of belonging and love because according to a hierarchy of Maslow "the need for interpersonal relationships motivates behaviour, examples include friendship, intimacy, trust, and acceptance, receiving and giving affection and love. Affiliating, being part of a group (family, friends, work)" (Maslow & Frager, 1987, p. 64).

In spite of the constraints the great outcome of the research can be found in the subcategory (v) friendship resulting from collaborative work Q43 with 65.2% which reveals that for the improvement of the quality of education one should apply learning theories that allow repairing the country as a whole and that the problems of the country concern everyone as a stakeholder and that these should be solved through STS interaction and systemic approaches in the teaching-learning process, since "one of the first concerns that education should transmit is that of the unity of the People (Machel, 1978, p. 14).

The study also reveals that connectivism and collaborative work play a very important role in both the development of individual and collective technical-scientific characteristics but also contribute strongly to the coexistence between those involved,

[24] Project which aimed to empower only the provinces in the central part of the country (Sofala, Manica, Tete, and Zambézia)

thus developing affection and trust, friendship as part of the psychological needs that in turn contribute positively to the production and sharing of scientific and technological knowledge, thus improving the quality of education and technical-scientific and socio-economic development of the country and the world.

5.6. Results and discussion of interview data

5.6.1. Motivations to choose natural sciences/chemistry

The first question of the interview seeks to know the assumptions that led students to attend the natural sciences, specifically the chemistry course because of the motivations or reasons that lead people to choose a particular course or activities, significantly influencing the motivation and consequently the performance of activities and learning.

Motivational issues play an extremely important role in the performance of activities because they serve as a set of forces that lead people to engage in one activity over the other, with a willingness and intention to obtain the best possible results (Griffin & Moorhead, 2006, 2013).

This engagement is the key to determination, dedication, focus, will, and objectivity in the tasks, which makes the individual successfully overcome barriers, achieve dreams, fulfil desires, and reach or even surpass the preconised goals.

People have different goals, interests, and objectives, so the way (individual, induced, or forced) in which they choose a course can interfere positively or negatively with their engagement, significantly influencing their motivation and consequently reducing or increasing their performance.

The interview question 1 contained seven alternative answers (personal, family, historical, socio-cultural, environmental, and employment opportunities, others) which were derived from the literature studies resulting from the discussions of the findings of the motivation questionnaire.

Of the alternatives present in the interview, only three were indicated as motivating aspects and these are shown in the following table.

Table 64. Pre-service teachers´ responses regarding aspects that motivated them to choose natural science/chemistry

Q1. What aspects motivated you to do/choose natural sciences /chemistry

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Personal	7	58.3	58.3	58.3
	Family	1	8.3	8.3	66.7
	employment opportunities	4	33.3	33.3	100.0
	Total	12	100.0	100.0	

The results point to personal motives as the biggest cause for choosing the course and followed by the need for employment. These results serve as a good indicator for both motivation and performance of activities.

The students' dedication and their will to learn and also to carry out their tasks successfully were evident during project activities, which reveals that they have developed a taste for science even before they enter university, but that they also see the chemistry course as the door to employment, bearing in mind the levels of investment in the carbo-chemical, petrochemical, chemical and chemical engineering sectors in recent years in Mozambique.

The approaches used in the study provided more time for interaction with chemistry and part of the prototypes or projects carried out can serve as self-employment, which gives some satisfaction and coincides with the reasons that led students to choose the course.

5.6.2. Science-Technology-Society integration and Systemic approach

Two different and complementary approaches were used for the study which are the Science-Technology-Society integration and the systemic approach in the teaching and learning process. About these approaches, the findings indicate that the first (STS) is slightly known while the second (systems approach) is completely unknown.

The relationship between science-technology and society is an old subject and has been addressed in some documents such as the laws (first and second) of Mozambican education, namely law 4/83 (MINED, 1983), and law 6/92 (MINED, 1992), but also in strategic plans, teaching programmes, political speeches, etc.

There are very few studies in this area in Mozambique, but we can highlight the study by Madeira (2016) which investigated “students' conceptions about the relationship between science-technology-society” and it may have been one of the few studies that awaken the need to introduce this approach in the teaching process in the country.

However, besides that, there are some other studies but most of these are only focused on the development of science and technology, and Turpin and Martinez-Fernandez (2003) address the influence of these policies on developing economies, the case of Mozambique, Monteiro (2010) surveys the production of knowledge in Mozambique between 2003 and 2008 based on science and technology, Brouwer (2010) studied the application of science and technology through the use of mobile phones.

Therefore, despite the majority (58.3%) having heard of STS, the difference between those who had heard of it and those who had not is very small, which leads us to conclude that the approach is still new in the country as well as on the African continent.

It can also be noted that there is some difference between hearing about science-technology and society as concepts or "things" that relate to each other and hearing about an STS integration approach in the learning process.

Table 65. Pre-service teachers´ responses regarding Science Technology and Society (STS)

Q2. Have you ever heard about Science Technology and Society (STS) before our activities?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	7	58.3	58.3	58.3
	No	5	41.7	41.7	100.0
	Total	12	100.0	100.0	

For the systemic approach, the findings are very different from the previous approach as almost all interviewed students (91.7 %) revealed that they had not

heard of the systemic approach in the teaching and learning process and only 8.3% answered that they would have heard of it.

Table 66. Pre-service teachers´ responses regarding a systemic approach

Q3. Have you ever heard about a systemic approach in the teaching-learning process, before the activities?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	1	8.3	8.3	8.3
	No	11	91.7	91.7	100.0
	Total	12	100.0	100.0	

Even though this approach was created in the 1960s by von Bertalanffy (1968), it has already been applied in educational reform as an emerging approach to the learning process in the United States of America and other developed countries such as Britain, Canada, and Germany (Jacobson & Berne, 1993).

The systemic approach was also used to mobilise the participation of family members and society in the process of teaching children in the classroom in India (Gupta & Gupta, 2013), to "understand the sustainability of a problem-solving pedagogical innovation" in Singapore (Kin et al., 2019), as well as in the teaching of mathematics, physics, and sport in Ukraine (Lopatiev et al., 2017).

The systemic approach was further implemented in some African countries such as Kenya, Tanzania, and Uganda, exploring the challenges and lessons learned from each of the countries in developing and strengthening pre and in-service training in order to improve teacher education in the sub-Saharan region as a whole (Hardman et al., 2011), and Egypt as an "attractive educational strategy in teaching and learning chemistry" where, therefore, researchers believe that improving the learning of chemistry would result in improving social sustainability (Awad, 2017).

However, there is still very little research and scientific articles related to the systemic approach, which justifies the position of pre-service teachers in the ignorance of it, not clear so that this is the first study that implements a systemic approach in the teaching and learning process in Mozambique.

5.6.3. Collaborative and interdisciplinary work

Collaborative and or interdisciplinary work has been recurrently used as one of the main strategies for the development of the country because of the communism that reigned soon after independence but also because of the living conditions (low income) of the Mozambican population, the culture of brotherhood and associativism/ cooperativism that has been applied in various branches of development in the country such as health (Kishimoto & Ito, 2017), agriculture, trade, and education (FGS, 2017).

Table 67. Pre-service teachers´ responses regarding collaborative and/or interdisciplinary work

Q4. Have you ever heard of collaborative and/or interdisciplinary work in the teaching-learning process before the activities?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	12	100.0	100.0	100.0

As noted above, all (100%) pre-service teachers responded positively, and this shows that the modalities of collaborative and/or interdisciplinary work are well known to them. These working methods are often included in syllabuses and are encouraged to be applied in homework, group work, and various other collective school activities, especially from secondary school onwards (grade 8).

5.6.4. School-University and business partnerships

About the partnership of different entities in the teaching-learning process in Mozambique, the majority (58.3%) revealed having no knowledge and the rest (41.7%) revealed having heard about it as shown in the following table.

Table 68. Pre-service teachers´ responses about School-University and business partnerships

Q5. Have you ever heard of a School-University and Business partnership in the teaching-learning process before the activities?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	5	41.7	41.7	41.7
	No	7	58.3	58.3	100.0
	Total	12	100.0	100.0	

Currently, several studies elucidate the importance of public-private partnerships in the

development of the education sector (Fernandez, Rosa, Carraro, Shikida, & Carvalho, 2019; Lima, 2015; Nhampossa, 2014),

In addition, the Education Strategic Plan (2012-2016) of Mozambique recognizes that the right to education is not only the responsibility of the State and that all (parents, families, communities, non-governmental organizations, and partners) are invited to contribute to the development of the education sector and in learning (MINED, 2012). Additionally, there is still the idea that educational problems are complex and the school cannot solve them alone (Perinasso, 2011).

Despite all this, very little has been done to establish such partnerships, and as a result of this, several schools face difficulties alone and many students have never experienced or even benefited from partnerships between schools, universities, and other governmental and non-governmental institutions in the teaching and learning process, as can be seen by the findings of this study.

5.6.5. Outcomes of practical activities carried out based on STS and Systemic approaches

The findings in the following table indicate that all (100%) pre-service teachers interviewed reacted satisfactorily to the activities and additionally revealed that they had learned a lot of new things and others that they used daily but had no notion that it was about chemistry or that it could be used as an object of learning, knowledge production and solving concrete problems in the communities where they live.

Table 69. Pre-service teachers' responses about learning something relevant during activities carried out through a systemic approach

Q6. During the activities on STS and the systemic approach in which you were involved, did you learn something relevant to society and your personal life?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	12	100.0	100.0	100.0

In the open question on the same subject, the pre-service teachers were instructed to indicate concrete examples if they responded positively and highlighted some projects

carried out, namely: the use of ash and discarded oil for soap production for the hygiene and prevention of diseases, particularly COVID-19, the production of greases based on peanut shells and the production of organic fertilizer. Some of the interviewees also reveal that they never imagined that someday it would be possible to produce soap at home and with discarded material/reagents such as ash.

For some pre-service teachers, the satisfaction is increased by knowing that it was possible to "take from the blackboard and the books" those complex and complicated chemical formulas to handle them and produce something concrete that could help themselves and others, and they also said that this type of activities helps a lot in the production of new knowledge and its retention, but also provides the pride of learning and applying the knowledge learned in everyday life.

The above revelations are reflected in the following two tables, wherein first, all of them (100%) admitted to having changed their conception about the importance of science in the world, especially in the relationship and role of science and technology in the development of society.

Table 70. Pre-service teachers' responses regarding conception (importance of science in the world and the relationship between STS

Q7. At the end of all activities, something changed in your life about its conception (importance of science in the world and the relationship between Science, Technology, and Society)?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	12	100.0	100.0	100.0

In the next question, about "whether or not they thought there were improvements in their skills", all (100%) admitted to having improved and this position results from the testimonies of teachers in training about the new skills and knowledge acquired, satisfaction and pride that the approaches and practical activities provided them.

Table 71. Pre-service teachers´ responses regarding skill development

Q8. After the practical work is done, how do you rate the development of your skills?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	12	100.0	100.0	100.0

5.6.6. Motivational factors (pride and self-esteem)

Issues related to pride, and self-esteem are very complex (Fromm, 1947; Waterman, 2005), and constitute "mixed" feelings but at the same time, they are remarkable and determinant in the motivational factor of each individual. This "sentimental confusion" comes from the contradiction between what provides personal and community growth (intrinsic motivation) and what provides fame (extrinsic motivation) (Stirling, 2014).

The findings reveal some slight differences in feelings, with the majority (58.3%) of pre-service teachers feeling that "fame" or for example being singled out as "a student producer of rockets, atomic bombs or even discovery of some chemical formula" would make their colleagues feel more competent rather than for example "If they could solve a problem in their community".

Table 72. Pre-service teachers´ responses regarding classmates' sense of competence

Q9. What do you think would make your classmates feel competent as a university student of chemistry?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	If they could solve a problem (hunger, poverty, disease, etc.) in their community	5	41.7	41.7	41.7
	If they could produce rockets or atomic bomb formulas, etc. in the laboratory	7	58.3	58.3	100.0
	Total	12	100.0	100.0	

When asked the same question but for each student to answer for themselves and not for others, the findings (in the table below), reveal that there is a balance (50%) for each of the options, meaning that there are students who, according to their aspirations and dreams, find motivation in affective aspects such as finding solutions to their problems, those of their families and their communities while the other group of students find motivation for example in distinction from others and in aspects of individual promotion or fame.

Table 73. Pre-service teachers´ responses about their own sense of competence

Q10. And in your case, which of the two options?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	If you could solve problems for yourself and your community?	6	50.0	50.0	50.0
	If you could produce rockets or atomic bomb formula, etc. in the laboratory and be internationally known	6	50.0	50.0	100.0
	Total	12	100.0	100.0	

5.6.7. Trust as an influential factor in good relationships and collaborative work

The question on trust contained four (4) answer options "very much"; “slightly”; “a little bit”; and, “no, I do not trust them”. This question was designed to gauge how closely the pre-service teachers relate to each other and to reinforce the answers from questions Q39 and Q42 of the motivation questionnaire in the "collaborative work-relatedness" category where they revealed that they are not very close and also do not trust each other.

The findings reveal that the majority (83.3%) admit to having slight trust and the minority (16.2%) admit to having little trust, so no one revealed having a lot of trusts but also no one said they did not trust their colleagues as can be seen in the following table.

Table 74. Pre-service teachers´ responses regarding trust in colleagues

Q11. Do you trust your colleagues?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	slightly	10	83.3	83.3	83.3
	a little bit	2	16.7	16.7	100.0
	Total	12	100.0	100.0	

The findings in the table above are associated with the ethnohistorical and tribal aspects (Chichava, 2008), feelings, and "modus vivendi" that come from the colonial

era to the present day. These aspects contribute a lot to the reduction of productivity, to the lack of collaboration between students in schoolwork, and in institutions and, in the end, these situations contribute negatively to the development of education, and the economy, consequently harming the socio-economic development of the country.

5.6.8. Collaborative *versus* individual work

Although the pre-service teachers are not friends and do not trust each other, the majority (66.7%) prefer and feel very comfortable working with other colleagues rather than alone as illustrated in the table below.

Table 75. Pre-service teachers´ responses about how comfortable they feel working with colleagues or alone

Q12. Did you feel comfortable working with your colleagues or would you have preferred to work alone? If you felt comfortable with your colleagues, tell us how.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	very comfortable	8	66.7	66.7	66.7
	slightly comfortable	4	33.3	33.3	100.0
	Total	12	100.0	100.0	

The findings in the table above clearly show a preference for collaborative work, which is not by chance, as learning or collaborative work provides social, psychological, academic, and assessment benefits (Laal & Ghodsi, 2012), especially in underdeveloped countries where there are few resources (material and financial) and the sharing of these resources plays a very important role in reducing socio-economic asymmetries, psychological pressure, but also discrimination.

A study carried out by Laal and Ghodsi (2012) based on the application of Johnson's survey of educational research shows that cooperation provides advantages compared to competitive and individualistic efforts, resulting in:

- higher achievement and greater productivity
- more caring, supportive, and committed relationships, and
- greater psychological health, social competence, and self-esteem.

Collaborative learning is considered by W. Johnson (1981) as a "neglected variable in

education" and he further argues that: “experiences with peers are not a superficial luxury to be enjoyed during lunch and after school. Constructive student-student relationships are probably an absolute necessity for maximal achievement, socialization, and healthy development” (p. 1).

Therefore, “when students are actively involved in collaborative (group) learning, the outcomes can be as good as or better than those for traditional classes” (Hiltz, Coppola, Rotter, Turoff, & Benbunan-Fich, 2000), I fully agree with this argument and it was possible to notice it in this study, by the tendencies of the answers but also by the interaction between students and above all by the quality of the results of the practical activities carried out.

5.6.9. Personal satisfaction with the application of a systemic approach in practical activities and learning

Despite their unfamiliarity with the approach, which is new and being applied for the first time in Mozambique, as we can see in the table below, almost all pre-service students (91.7%) revealed that they were satisfied with the work carried out based on this approach.

Table 76. Pre-service teachers´ responses about their feelings for the activities carried out in a systemic approach.

Q13. Are you personally happy with the work you have done in the Systemic Approach

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	11	91.7	91.7	91.7
	not so much	1	8.3	8.3	100.0
	Total	12	100.0	100.0	

The systemic approach brings many advantages, which make the students feel comfortable and find opportunities for contact with institutions, and communities that facilitate their insertion but also the possibility of being part of the solution of their problems and of the community in which they live.

5.7. General Discussion

5.7.1. Data about preconditions

Before introducing the science-technology-society integration and the systemic approach in the learning activities, as one of the objectives of this study, the documentary study, the observation, and the questionnaire were applied as a priori, respectively to verify the legal, structural, and intellectual preconditions existing as basic conditions or preconditions.

The Mozambican laws that regulate the activities of education are essentially two and are called "Law of the National System of Education" which was established in 1983 and called the "first law" or simply law 4/83 (MINED, 1983), and the second one drawn up in 1992, established as a reform and adaptation of the first law to the reality that came to be called the "second law" or "law 6/92" (MINED, 1992).

But some other documents help the two main laws, which are the "economic plan for education", the "national policy of education and strategies", "strategic plans for education", etc. These documents, although they are more detailed and specific and aim to guide the management of the education process based on the socio-economic situations of each established period, nevertheless closely follow what is stated in the laws and should be applied based on these laws.

However, both in education laws and in auxiliary and specific documents, it was noted that these set out rules and strategies so that:

- There should be "a link between learning that takes place both in schools and in universities with socially useful productive work (business and society)".
- Promote "a close link between the school and the community, where they can interact actively in promoting the scientific, socio-economic and cultural development of society".
- Emphasize the need to have "constant staff training for the needs of economic and social development" according to the challenges of each moment.

The rules established and the strategies outlined in the documents that regulate education in Mozambique clearly show that schools need to grow and develop together with companies and communities, and this is a major assumption and central condition for the introduction of specific educational policies and learning approaches that aim to materialise the intention of this development and joint work as a single system and that within it there is a strong interaction between science-technology and society.

In the observations of the actual existing conditions, it was noted that the schools are built in different residential areas (communities) and their design (in Chimoio City and Mozambique in general) has been made by adopting a structure that establishes the construction of an administrative block for the administration including the director and his deputies, classrooms, teachers' room, spaces reserved for recreational activities, exercises, sports and also an open space that can house any kind of project or creative activities[25].

Therefore, the structural conditions of schools, with a greater focus on their integration within communities, the interaction and sharing of the same environment between the school board, students, and teachers, but also the existence of reserved spaces for the installation of different projects, constitute potential preconditions for introducing learning approaches that unite all direct stakeholders and partners to solve common problems.

The findings of questionnaire-I, specifically the questions (Q7 and Q8) related to the domain of information about the integration of science - technology - society and systemic approach, as preconditions for its introduction in the Mozambican curricula, the question (Q14) related to the partnership between schools and public-private institutions and the question (Q21) related to the level of preparation of pre-service teachers to deal with these approaches.

From this finding, we can say that most of the pre-service teachers somehow have information about the subject, but they do not dominate the learning modalities based

[25] e.g., projects in agriculture, animal husbandry, experiments, health activities, production of various prototypes)

on these approaches. So, for this to become a potential precondition for the introduction and implementation of the proposed approaches, there was a need to conduct some additional training to familiarise the pre-service teachers on the subject which strengthened their intervening capacities.

However, integrating the data from the three methodologies used to collect information related to preconditions for introducing science-technology-society integration and systemic approaches, one concludes that there is a great potential in Mozambique that can be explored to introduce these approaches for the development of the education sector, the application of several projects and at the same time the development of companies and the socio-economic development of the country.

5.7.2. Integration Science-Technology-Society and Systemic Approach

Data on these questions were collected based on the I-questionnaire, and interviews, which aim to understand how pre-service teachers dominate issues related to the application of these approaches.

But data were also collected based on a document review study to identify countries that have already applied the systemic approach at a global level. It was found that the approach had already been applied in some countries such as the USA, Great Britain, Canada, Germany, Ukraine, Singapore, India, Kenya, Tanzania, and Uganda. With the countries already identified, information was collected on the results achieved with the application of this approach in the learning activities.

This information is important to evaluate the impacts of these approaches on the development of the educational sector, the scientific-technological development, and the socio-economic development of the country, continent, and the world.

In the questionnaire-I, the questions related to the knowledge of the concept of system (Q9, Q10, Q11, Q12, and Q13) and on the application of this as an approach in learning (Q7 and Q8), present an average percentage below 50% while those related to the integration science-technology-society (Q14, Q21, and Q22) present an average of

approximately 70% which reveals a greater domain on issues related to this approach concerning the previous one (systemic).

In the literature review, it was noted that the systemic approach is still considered very new, and few countries have already conducted studies on it, and very few have used it as a learning approach, which justifies the answers of the pre-service students that reveal some ignorance of its existence and application in the education sector.

According to the questions in questionnaire-I, there is a possibility of misunderstanding between system-related information, which is one of the contents taught in chemical-physical, and the systemic approach, which is a "methodology" used in some countries, especially developed countries, to improve the quality of education and develop business, science, and technology, but also for socio-economic development.

To clarify things and reduce as much as possible ambiguities related to system and systemic approaches, but also to better understand the level of mastery of each of the following approaches (science-technology-society integration and systemic approach) and the difference of knowledge of one to the other, it was necessary to include questions related to these issues in the interview.

In the interview two questions were prepared, one related to the approaches: (i) integration of science-technology-society (Q2) and the other related to the systemic approach (Q3). The findings revealed that pre-service teachers have more information about science-technology-society integration than the approach.

The same conclusions were verified in the questionnaire-I and the documental study, but in the interview, the conclusions show that there is a big difference concerning the knowledge of the approaches, because while the integration of science - technology - society presents a value of approximately 58%, the vast majority (91.8%) revealed that before the activities, they did not know about applying the systemic approach to learning activities.

These results justify the fact that the teams had to be trained specifically for the school projects before they go to the practical activities at schools, universities, communities, as well as to companies.

Teaching based on this approach requires a change in the system in terms of people's behaviour, school programs, teaching methodologies, forms of intervention and management of companies, etc., a fact that demands that it be ensured that these changes do not harm any of these parties involved.

5.7.3. Triangulation of data about Views on Science, Technology, and Society

The student's views on the application and importance of science and technology in society were collected through the questionnaire-I and interview. In questionnaire-I, this subject was in the 6 questions (15, 16, 17, 18, 19, and 20) taken from the Aikenhead et al. (1989) VOSTS questionnaire, and in the interview, it is addressed in 4 questions, namely questions 6, 7, 8, and 9, question 6 being adapted from the study of Madeira (2016).

The questions related to students' views on the role of science and technology taken from the I-questionnaire were summarised and grouped (in the following figure), and it can be observed that in most cases, teachers in training have a view with some merit. (HM) that science and technology influence in some positive way in the resolution of their problems and the problems of society, providing, among several health benefits, well-being, such as the development of the country.

Pre-service teachers also believe that science and technology can help in making some decisions that are not simply technical or political but are moral decisions, on the one hand.

On the other hand, it is noted that students do not believe that science and technology can help to clarify crimes in courts of law, or that they can be used in various sectors of justice as a lie detector to arrive at the material truth and to do justice. They also reveal a lack of knowledge, that is, they do not believe that science and technology play an important role in the production of new words, vocabulary, and ideas for the development of the country and the world.

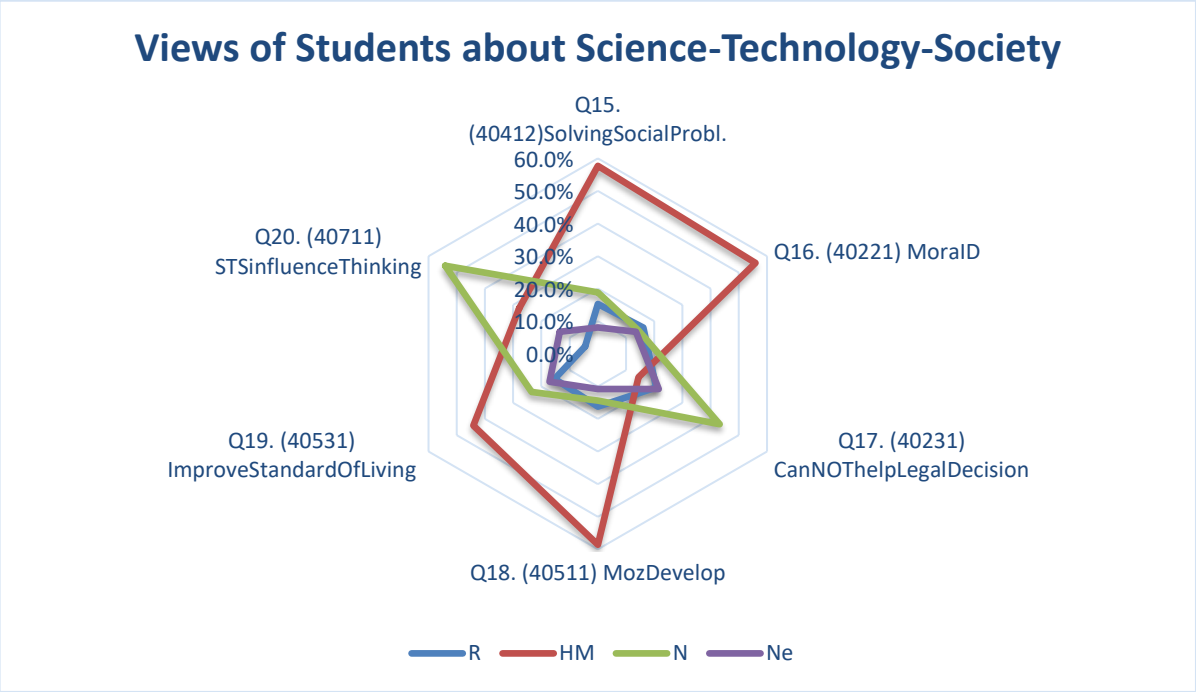


Figure 38. Views of Students (N=46) about Science-Technology-Society.

The findings of the interviews show that all pre-service teachers (100%) revealed that they had learned many things relevant to their lives and also to society (Q6), additionally, they highlighted both the importance of science in the world and the importance of science-technology-society integration both for the development of the education sector and for the socio-economic development of the communities, the country, and the world.

Despite accepting the relevance and importance of science and technology for personal and societal development in previous questions (Q6 and Q7), one can notice some ambiguity, i.e., they show divided views on the application of science and technology in questions Q9 and Q10, where two choices are presented, the first being to solve problems (hunger, poverty, disease, etc.) in their community and the second to produce rockets or atomic bomb formulas, etc. in the laboratory.

This ambiguity is a very important finding for society as a whole, as we can see that if students have had this perception and if we look at what is happening all over the world, we can see a balance and indecision between need and fame, as in most cases science and technology have been used for competitiveness and measuring forces or confrontations between countries and institutions, instead of being used to solve basic and essential problems (food, health, and welfare).

The ambiguities noted above may sometimes have been the cause of inappropriate or not legitimate views of the importance and application of science and technology in society. This Naïve (N) view was noted in two questions in the questionnaire-I, which are: (i) question 17 which talks about "whether science and technology help in making moral decisions" and (ii) question 20 which talks about "whether science and technology help in creating new concepts and way of thinking".

In the specific case of Mozambique, this vision is a reflection of the unpleasant and shocking memories caused by constant war, crime and corruption, injustice, immunity or acquittal of criminals in courts, and legal, political, and cultural barriers to the use of technology for crime reduction in homes, on the roads, state institutions, private, etc.

In many cases, these barriers derive from weak capacity and mastery of technologies by legislators, political will, or even in some cases by the fact that crimes/injustices are committed by the people of sectors[26], who have the additional responsibilities in combating and preventing crime and establishing injustice.

These scenarios give rise to people's incredulity as to the importance and real intentions of the application of science and technology in society, because in many cases these have been used to harm rather than help society, facts that should be seen by all as matters of great concern and serve as a basis for reflection, both by agents driving scientific and technological development and by society as a whole.

5.7.4. Triangulation of data about collaborative work

Information on collaborative work was collected through observation of field activities, through questionnaire-II, consisting of questions drawn from Glynn et al. (2009) “science motivation questionnaire” from questions Q37 to Q44, and was also collected through the interview, in question number twelve (12).

[26] such as the State Information and Security Services (SISE), National Criminal Investigation Services (SERNIC), Police, Magistrates, Judges, Governments (President, Ministers, Directors, etc.,).

From direct observation it was found that the pre-service teachers are used to working in groups and collaboratively and from time to time it was to be appreciated the debates and disagreement on some issues but, more than that, it was more interesting to see them when they reached some consensus.

It was also interesting to see when one of them managed to convince that he is right, then the others paid much attention to the explanations revealing the willingness to learn and in some moments the pleasure of learning something new or different understanding and better elaborated.

In the case of the questions contained in questionnaire-II, "collaborative" work was in the same category with "relationship" being that the questions closely related to collaborative work (Q40 and Q41) had an average score of 60.6% while those related to relationship had a relatively low average (41.22%).

However, in this same questionnaire, one can notice in question Q43, the great gain of the practical activities carried out through collaborative work that indicates the level of friendship resulting from the interaction between them in the collaborative work.

This question had the highest score (65.2%) which is a very good indicator of the success of the approaches applied in this study but also serves as a very strong variable for the objective of the work which is to introduce the approaches in the Mozambican curricula and at the same time improve the quality of teaching.

The above findings resemble those of the interview, as they reveal that even though pre-service teachers did not state that they trust each other very much in question Q11, the majority (66.7%) in question Q12 revealed that they feel comfortable working with colleagues rather than alone.

In this study, the results of the collaborative work showed this to be a very important tool for learning and socio-economic development, as it enabled the exchange of ideas, experience, the discovery of differences, and identification of common aspects but also served to bring people together, which is fundamental for the weakening or even destruction of barriers caused by ethnic, racial and tribal discrimination.

The approaches that allow the sharing of ideas, material, and financial resources play a very important role in education systems, especially in poor countries such as Mozambique, because they allow learning to occur in a harmonious way, where students with better financial conditions can help those who need it, thus capitalising on the few resources available and at the same time reducing the asymmetries and differences between them, which can positively contribute to the motivation and academic profile of students.

5.7.5. Triangulation of data about practical activities and motivation

Information on practical activities and motivation was collected using direct observation of field activities and indirect observation by videos and photos, but also through questionnaire-II (science motivation questionnaire) as well as through interviews.

According to what was observed and reported in videos and images (some of which are included in the previous chapter), it was found that, despite it being a new way of approaching the contents, the pre-service teachers adhered with great satisfaction, commitment, and dedication.

This behaviour can be explained by the following statement:

> *"[…] in schools, the facilitation of more self-determined learning requires classroom conditions that allow satisfaction of these three basic human needs that is that support the innate needs to feel connected, effective, and agentic as one is exposed to new ideas and exercises new skills". (Ryan & Deci, 2000a, p. 65)*

The fact that the students had to make decisions about the projects to implement, choose the methodology to apply, decide about the companies or entities to contact in almost all stages of the project, and the teachers act only as supporters, contributes a lot to satisfaction and self-determination. These two feelings give them a lot of responsibility and engagement that become intrinsic motivation, which helps to improve learning and skill development.

Taking into account both the statement of Ryan and Deci (2000a), as well as the arguments above, we can say that; the science-technology-society integration and the systemic approach play an important role and act as extrinsic motivation and promote self-determination and intrinsic motivation for learning.

In questionnaire-II, there are forty-two (42) questions to collect information related to motivation and it was applied to the pre-service teachers after the practical activities. The questionnaire is composed of the "Likert scale" and was subdivided into 6 subcategories, namely: (i) Intrinsic motivation and personal relevance, (ii) Intrinsic motivation and personal interest, (iii) Perceive the competence, (iv) Effort/Importance, (v) The value/usefulness of practical activities and (vi) Assess collaborative work-relatedness.

From questionnaire II, it was found that pre-service teachers showed high levels of performance and motivation, where:

- Category (i-intrinsic motivation and personal relevance), with eleven questions (Q3 to Q13), shows an average score of approximately 82% referring to the positive statement about "intrinsic motivation and personal relevance", subdivided into an average of 51.5% indicating the highest scale and 30% for the average of the preceding positive scale.
- Category (ii- intrinsic motivation and personal interest) with eight questions (Q14 to Q21) presents an average score of approximately 74% for the positive statement on "intrinsic motivation and personal interest", subdivided into an average of 58% indicating the highest and 15.1% indicating the average of the preceding positive scale.
- Category (iii- perceive the competence) with five questions (Q22 to Q26), presents an average total score of 67.6% referring to the positive statement about "perceive the competence", subdivided into an average of 50.3% indicating the highest scale and 17.3% for the average of the preceding positive scale.
- Category (iv- Effort/Importance) with also five questions (Q27 to Q31) presents a total average score of approximately 72% concerning the positive statement on the "effort/Importance of practical activities", subdivided into averages of 58.2%

indicating the highest scale and 13.92% indicating the average of the preceding positive scale.

- Category (v- The value/usefulness of practical activities) with five questions (Q32 to Q36), presents an average total score of 95% referring to a positive statement about "the value/usefulness of practical activities", subdivided into an average of 80% indicated for the highest scale and 15% for the average of the preceding positive scale.
- Category (vi- collaborative work-relatedness) with eight questions (Q37 to Q44) is the last and presents an average total score of 66% referring to a positive affirmation about "collaborative work-relatedness", subdivided into an average of 49% indicating for the higher scale and 17% for the average of the preceding positive scale.

It can be said that according to the data from questionnaire-II, the practical activities motivated the global order by approximately 76%. For this percentage, the category “the value/usefulness of practical activities” with 95% was the one that contributed the most positively, which reveals that almost all trainees admit that practical activities played a very important role in their lives and their communities.

The category “collaborative work-relatedness” stands out, but negatively, with the lowest value (66%), namely in matters related to relationships and friendship contributing with about 39%, which reveals that there is still some work to be done to increasingly unify Mozambican students.

In the interviews, question Q13, related to satisfaction and motivation for practical activities was sought to know if the pre-service teachers were personally happy with the work they did by a "Systemic approach" and the majority (91.7%) answered positively and at the same time wrote some statements in the open space for general comments about the participation in the activities, for example:

- A: "I liked learning how to produce fertiliser and I made two vegetable gardens at home...I also liked learning how to make soap, but unfortunately, my soap did not come out well”.

- B: “I don't trust my colleagues for fear of betrayal and sometimes they don't carry out the tasks on time, however, I would suggest using the same methodology if there is another opportunity to learn”.
- C: I don't trust my colleagues very much because not all of them have the same capacity to deliver on the activities but also because I can be betrayed by them”.
- D “The interaction was quite enjoyable, I never imagined that I would be able to make soap in my life, and never would I have imagined it possible with disposable materials and homemade, never”.

However, all the results (from observation, questionnaires, and interviews, prove that learning based on practical activities, especially in interaction with the community collaboratively and systemically brings a feeling of affectivity and satisfaction. This process allows for internationalization and integration which for Ryan and Deci (2000a, p. 65) are “the processes through which extrinsically motivated behaviour become more self-determined”.

In these activities, the actors involved, particularly the students, apply in practice and actively the knowledge theoretically acquired at school to the resolution of personal day-to-day and community problems, and according to Ryan and Deci (2000a, p. 65) "when this happens, people not only feel competent and related but also self-determined, in carrying out extrinsically valued activities".

However, these activities contribute, significantly to motivation, engagement, and capacity development, but also in preparing students for future life, improving their profile, competencies, and skills that allow them to actively participate in the scientific and technological, and socio-economic development of the communities, the country, and the world.

Chapter VI- CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Any change in educational paradigms (be they policies, philosophies, approaches, or methodologies) goes through a complex process and depends on many variables, among which the pre-disposition of students, teachers, and the acceptance of this change by the administrators of the education sector, among other dependent variables.

Therefore, in this study, for the introduction of science-technology-society integration and systemic approach taking into account the dependent variables, the following is concluded:

- There are core elements and infrastructural preconditions for introducing the science-technology-society integration and systemic approach in the Mozambican curricula for teacher education and secondary schools;
- According to the normative documents and socio-economic conditions of the country, these should be established and executed as "school project and community development".
- Most pre-service teachers present a view with some legitimacy/merit (HM) in most questions about “Views on Science-Technology-Society” and with a cumulative average of about 54%, and in the case of the other few questions, the results indicated an inappropriate view (Naïve/N) with the cumulative average of 49%.
- In evaluating the results from VOSTS questions and issues related to the systemic approach, it was found that pre-service teachers have an unrealistic view of how to deal with science-technology and society, as well as a systemic approach, which is why they must undergo training before introducing the approaches into the learning activities.

Additionally, it was noted that it is very important to make a combination of learning theories, as this study showed that this fact can bring better results.

During the study, several projects were developed by the students, based on the contents of the curricula (for teachers' education and secondary schools), but also government documents and policies, such as the activity and social responsibility plans of the partner institutions.

These projects were developed as practical activities applying science-technology-society integration and a systemic approach, so at the end of the activities it was concluded that:

- The pre-service teachers show high levels of motivation, with the subcategory "the value/usefulness of practical activities" having the highest score (80%) and the subcategory "relationship to collaborative work" having the lowest score (49%).
- The pre-service teachers cannot handle these approaches right from the start, and almost none had heard of the systemic approach, as this is a new approach and applied in some such as the U.S.A. Great Britain, Canada, Germany, Ukraine, Singapore, and India and with less focus on Africa and in particular on Mozambique, although it has already been used in Kenya, Tanzania, and Uganda.
- Therefore, despite the lack of knowledge of the approaches, all (100%) pre-service teachers were satisfied with the use of Science-Technology-Society integration and systemic approach in practical work carried out by them.
- However, it was noted that ethnic and tribal divisions, as well as trauma caused by unpleasant and shocking memories, contributed negatively to learning in collaborative work, but the use of approaches in the form of "school design and community development" plays a role. a fundamental role in the production of knowledge applicable to communities.
- Despite the above, it is noted that applying knowledge collaboratively and in a systemic approach to solving everyday problems in communities, promotes the development of skills, and makes knowledge lasting, affective, and effective, where approaches play an important role in establishing trust, friendship, and the unification of peoples.

- Based on the results obtained from the triangulation of data collected using different methodologies, taking into account the strict control of dependent variables, but also the results obtained in different projects, it is concluded that this experience can be transferred to other universities and schools controlling the dependent variables.
- Finally, with the approaches applied in this study, schools and universities can develop several sustainable projects that would help maximize financial resources, earn money, but also help to develop communities, improve learning and improve the profile of both students and teachers, as well as the profile of universities and schools.

Recommendations

To educational administrators.

It is recommended that education sector administrators:

- To develop curricula and learning modalities that are good for education and the development of factual knowledge and skills. Therefore, skills are developed through practical activities and not simply theoretical classes.
- To understand that each content must be updated, contextualized, and learned or developed in practical activities, which can contribute to the country's scientific, technological, and socioeconomic development.
- Create a joint learning system (schools, universities, partners, and society) to develop and discuss the content that should be taught. The system needs to be functional and systematically (annual, semester, or quarterly) come together to discuss the learning activities to be developed, and the role and responsibility of each participant.
- Seeks to establish a participatory education system, where contents are learned by applying science-technology-society integration and a systemic approach as a way to share and maximize resources (human, financial, and material), and encourage greater productivity and development of the stakeholder profile.

For other researchers and scientists in the education sector, it is recommended:

- to have authorization and support from administrators who regulate the education sector before implementing these approaches in schools in your research
- to seek partners interested in the development of schools, universities, and communities, so that there is greater interaction and productivity
- to give students the freedom to find the best place to discuss and implement their projects, so that they feel responsible for the success of their work, which is a very determining factor for self-determination, motivation, and performance.
- That, in addition, when developing similar research, realize that students are primarily responsible for the activities and for recording the images (videos and photos), preventing the images from being recorded by another person, which can positively or negatively influence the results. Because the presence of other people can interfere with students' behaviour.

For stakeholder

For stakeholders, it is recommended that:

- When preparing the activities or business plans, also consider the development of the education sector and communities as part of the system, and that in some way contributes to the development of your company.
- Realize that contributing to the improvement of the quality of teaching and in the development of student's skills is to be contributing to a quality workforce for companies, which can result in providing high-quality services and products, increasing the volume of business, and creating economic stability in the company.
- Believe that working together with the education sector can help to share resources (financial and human), which reduces production costs and increases company profits.

For lecturers and teachers

For this group of actors who, in line with the current Mozambican teaching model, are at the centre of the teaching process, the following is recommended:

- When preparing the lesson plans, try to find practical activities that will help develop students' skills.
- To progressively diminish the “active” role in the teaching process, taking on a “passive” role, thus giving the student the main responsibility for learning.
- To be able to monitor students in discovering their trends and skills to better guide them in further education and future employment.

Parents and guardians

It is recommended that parents and guardians:

- To help and monitor their children's learning and educate them from the beginning grades to better understand their abilities and tendencies;
- To create conditions for linking theory and practice through some activities at home.
- Do not let the responsibility for learning fall 100% on teachers and schools.

Students from schools and universities.

To this group that, despite being the last, are the first and main learning actors, the following is recommended:

- To pay attention to learning content as an opportunity to produce knowledge and develop skills;
- To discover your talent and tendency at an early age to better choose your training area and future profession.
- To realize that education is universal, meaning that skills developed by students and scientists from other countries can also be developed by them.
- Always think that the knowledge learned in schools is to be used in real life to solve problems and contribute to the development of the country and the world.

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