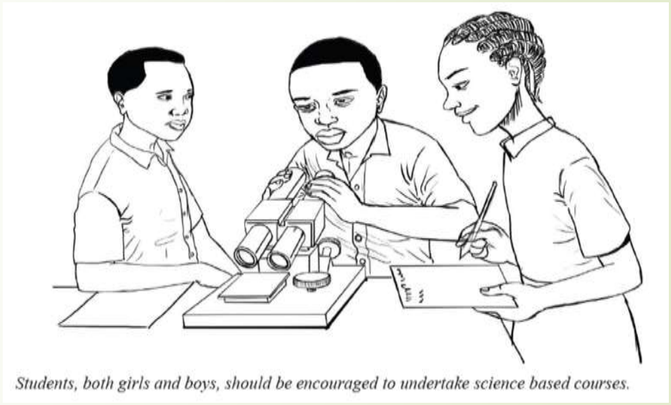
UNIT 1: Introduction To Science, Technology And Innovation

Introduction

- Science technology and innovation are recognized as the key to social progress and are essential common for sustainable development, economic development, poverty eradication, educational system and many more.
- Investment in science, technology and innovation (STI) is essential for economic development and social progress. Scientific advances and technological change are important drivers of recent economic performance.
- These changes imply that science, technology and innovation are now key to improving economic performance and social well-being.
- This unit aims to help you understand what Science, Technology and Innovation (ST&I) is all about.
- We shall look at the meaning, historical background, ST&I capabilities and its importance in relation to environment and resource management and the relationship between ICT and ST&I.



Students, both girls and boys, should be encouraged to undertake science based courses.

Learning Outcomes

Upon completion of this unit, you will be able to:

a) Define Science, Technology and Innovation (ST&I) in modern society
b) Describe the historical background of ST&I in Africa
c) Appreciate the role of indigenous knowledge in education.
d) Explain the importance of ST&I in social-economic development
e) Explain the importance of ST&I in relation to education, environment and resource management
f) Discuss the relationship between ICT, research and ST&I in the development of innovation

Concept of Science, Technology and Innovation (ST& I)

- The whole arena of science and technology deals with five fundamental components: knowledge, skills and techniques, discovery, understanding and application. It is the interplay between science and technology that leads to advances in modern society.
- ST&I is an acronym used to refer to the relationship between Science, Technology and Innovation.

a) **Science:** Is the pursuit and application of knowledge and understanding of the natural and social world following a systematic methodology based on evidence. Sciences include Agricultural and Natural Resource Sciences; Physical, Industrial and Energy Sciences; Biological and Health Sciences; Infrastructure, Information and Communication Sciences; Humanities and Social Sciences; earth and space sciences, and Agricultural and Natural Resource Sciences; Physical, Industrial and Energy Sciences; Biological and Health Sciences; Infrastructure, Information and Communication Sciences; Humanities and Social Sciences; earth and space sciences etc.

b) **Technology** is the use of scientific knowledge for practical purposes or applications, whether in industry or in our everyday lives. It involves the application of knowledge to meet set goals and provide goods and services for sustainable development. It is the process by which humans modify nature to meet their numerous needs and wants.

c) **Innovation**: Successful creation, development, and marketing of new products or successful application of new techniques or ways of working that improve the effectiveness of an individual and organization

Relationship between Science, Technology, and Innovation (ST&I)

These are three common terms among us. Science as defined in short is a study of the nature, structure, and behaviour of the physical and natural world through observation and experiment.

When this is scientifically applied to practical purposes in our daily life, we can name it ‘Technology’. And using this we create or invent something new that will be known as ‘Innovation’. And these we can together form progress from scientific researches to technological creations to innovative products.

Historical background of ST&I

- ST&I has been an integral part of the pre-historic man and thus integral to Africa and the evolution of mankind. Documented evidence suggests that Africa is among the most strategic continents in the history of ST&I globally. Making and using tools required imagination, planning, and abilities that go beyond just finding things in nature and using them. Some of the most important technological innovations for human survival have unique origins in Africa.

- Below is a description of the historical background of ST&I focusing on the tool-making industry, proto-technology, and sustainable development.

a) Tool-making industry:

- The first tools were made of stone, such as those of the Oldowan stone type found in Tanzania, and used from 2.3 to 1.4 million years ago. They further mastered the art of shaping stones and began creating more sophisticated tools such as those of the Acheulean type. Humans started using more refined materials, such as the sharp edges of obsidian, around 700,000 BC. In the past 100,000 years, the development and use of tools have accelerated significantly.

Historical background of ST&I

a) **Stone tool:** Stone tools and other artefacts offer evidence about how early humans made things, how they lived, interacted with their surroundings, and evolved.



- **Early Stone Age Tools**
  - The earliest stone tool-making developed at least 2.6 million years ago. The Early Stone Age began with the most basic stone implements made by early humans. These Oldowan toolkits include hammerstones, stone cores, and sharp stone flakes. By about 1.76 million years ago, early humans began to make Acheulean hand axes and other large cutting tools.
- **Middle Stone Age Tools**
  - Explore some examples of Middle Stone Age tools. By 200,000 years ago, the pace of innovation in stone technology began to accelerate. Middle Stone Age toolkits included points, which could be hafted onto shafts to make spears; stone awls, which could have been used to perforate hides; and scrapers that were useful in preparing hide, wood, and other materials.
- **Later Stone Age Tools**
  - Explore some examples of Later Stone Age tools. During the Later Stone Age, the pace of innovations rose. People experimented with diverse raw materials (bone, ivory, and antler, as well as stone), the level of craftsmanship increased, and different groups sought their own distinct cultural identities and adopted their ways of making things.

Historical background of ST&I

ii. Bone tool:

- A significant development, which influenced the later stone tool industry, is the creation of bone tools and black blades in Southern and Eastern Africa between 90,000 and 60,000 BC.



- **iii. Iron tool**
- The use of iron in smelting and forging of tools appeared in West Africa around 1200 BC making it the first birthplace of the iron age. Before 1800, Africa‘s methods of extraction were employed in Brazil, until more advanced European methods were instituted. Copper smelting developed independently in West Africa around 900 AD.

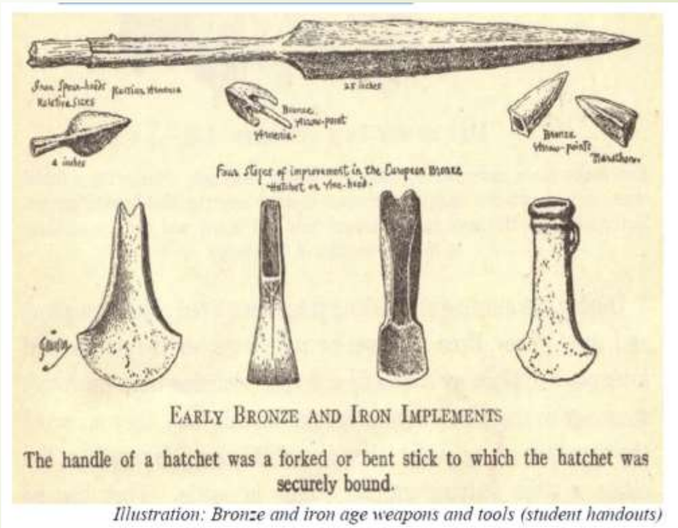


Illustration: Bronze and iron age weapons and tools (student handouts)

Historical background of ST&I

iv. Calendar invention

Timekeeping goes as far back as the Neolithic period, but actual calendars weren't around until the Bronze Age in 3100 BC. The Sumerians in Mesopotamia (Egypt) made the very first calendar, which divided a year into 12 lunar months, each consisting of 29 or 30 days.



a) Proto-technology

- The 'proto-technology of the modern world is traceable to the iron-ore mining 43,000 years ago in Southern Africa and the emergence of pro-mathematics' from Africa's Great Lakes region over 25,000 years ago. From these humble beginnings, science and technology underwent a steady development in Africa, with the continent reputed to be the remotest origin of formal mathematics, astronomy, engineering, architecture, navigation, and map-making. The recent discoveries of the Timbuktu manuscripts rekindled confidence that Sub- Sahara Africans were studying mathematics and astronomy at least over 300 years ago.
- However, the current state of ST&I in Africa raises many questions. The tide has since changed towards a new world order in which scientific knowledge and modern technologies are largely produced in the Global North and consumed by the Global South, with Africa's productivity in ST&I ranking amongst the lowest globally.

Historical background of ST&I

a) Sustainable Development

- We need to remember that the development of technologies that add value to Kenya‘s indigenous resources and which provide holistic and optimal solutions that are suited to Kenyan social-cultural-economic values are necessary for sustainable development.
- The objective is to exploit the full potential of Science, Technology, and Innovation through generation, protection, preservation, evaluation, updating, adding value to and utilizing the extensive indigenous resources and traditional knowledge, as applicable to national development.
- This will be accomplished through evaluating and updating the extensive indigenous resources and traditional knowledge and promoting partnership between the government, private sector, NGOs, and other stakeholders.
- This will enhance the utilization of Indigenous Resources and Traditional knowledge (IRTK) results for national development that are Kenyan in origin and character.

Indigenous Knowledge

- Indigenous knowledge is a set of ideas, beliefs, and practices (some of which have indigenous religious underpinnings) of a specific locale that has been used by its people to interact with their environment and other people over a long period.
- In Africa, especially in the sub-Saharan region, the so-called indigenous communities have always found value in their local forms of knowledge. Societies across the world depend on their indigenous knowledge to solve their day-to-day socio-economic problems, address various environmental challenges, and adapt to change.

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Indigenous Knowledge in Educational Systems

- Indigenous knowledge in education system will help us to:

i. **De-Racialise African Educational Systems**

Local languages are the means for preserving, transmitting, and applying traditional knowledge in schools. Bilingual or multilingual education allows the full participation of all learners; it allows learners to confront, in a positive sense, the knowledge of their community with knowledge from elsewhere.

ii. Promote innovative thinking as it provides the basis for problem-solving strategies for local communities

Inclusion of students' prior knowledge into educational curricula promotes and enhances innovative thinking and constructivism. This is because learners will be afforded the chance to abstract understanding from their personal experiences, their understanding of the local conditions, and what they already know from their respective communities.

i. **Evaluate the effectiveness of conventional science and indigenous knowledge**

Through the inclusion of indigenous knowledge into the curriculum, students are afforded the opportunity to compare and contrast different forms of knowledge for their own good and that of the society of which they are part. For instance, many communities teach their members about beliefs and practices related to plant growth, human nutrition, childbearing, pregnancy, food preparation and preservation, medicine, animal husbandry, and others. All these areas are also taught at school in science and agriculture, which means that indigenous knowledge, represents an important component of the so-called "global knowledge" on different issues.

Indigenous Knowledge in Educational Systems

iv. motivate and generate interest in learners

- Since indigenous knowledge is the knowledge that arises directly out of the children's real-life experiences, its incorporation into the school curriculum can motivate and bolster the intellectual fortunes and interests of the learners as students realize that recognition is given to what they already do, know, and say in their communities.

v. Teach language and instill a sense of self-consciousness and cultural identity

- Indigenous knowledge could also be used to teach language, recount history, reclaim humanity and dignity, and promote a sense of self-consciousness and cultural identity in learners. Cultivation of oral and written fluency in local African languages is important in building self-esteem, preserving culture, and advancing the literary output and identity of African Peoples.

vi. Promote dissemination of indigenous knowledge across cultures

- The inclusion of indigenous knowledge in school curricula will help different cultures/societies to share their knowledge. This is because people from different cultural backgrounds will be made to share and interact with indigenous knowledge from other cultures in a way that will allow them to appreciate and emulate them where necessary.

Science, Technology, and Innovations (ST& I) capabilities

- A nation's ability to solve problems and initiate and sustain economic growth depends partly on its capabilities in science, technology, and innovation. Science and technology are linked to economic growth; scientific and technical capabilities determine the ability to provide clean water, good health care, adequate infrastructure, and safe food.

- STI capabilities are defined as follows:

a) **Scientific capabilities** – the ability to learn, understand and apply scientific knowledge and skills to solve problems.

b) **Technological capabilities** – the ability to learn, understand and master the use of existing (both traditional and modern) technologies to solve problems; the ability to produce new technologies.

c) **Innovative capabilities** – the ability to create new inventions. Not only do innovations contribute to prosperity, but they are also increasingly important in addressing the many social challenges created by our quest for prosperity.

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Importance of ST&I

ST&I is important because it is a key driver for the socio-economic development and social progress of any society and economy. In Kenya, they have the ability to create, distribute and exploit knowledge and have become the major source of competitive advantage aimed at achieving the Kenya Vision 2030 through the following:

a) Creation of wealth.

b) Economic growth and the improvement of the quality of life.

c) Reduction of poverty.

d) Improvement in education.

e) Health, nutrition and trade and

f) Building new capacities and capabilities that are critical in the 21st century.

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Science, Technology, and Innovation: Impact on Education, skills, and work

- Understanding how technology and science developments affect education and development can facilitate decision-making in society. Research and development enable policymakers to achieve innovations leading to the creation of employment opportunities and high demand for expertise.
- To meet the employment demands, colleges and universities modify their academic programs to suit specific needs. When students use technology and science to support communication, they play an active role as information recipients.
- Technology and science influence student education and employment in the following way:
  i. Increased motivation
  ii. Increased flexibility
  iii. Greater accessibility and occupational employment
  iv. Education became more accessible

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Importance of ST&I in relation to environment and resource management

- The environment is the source of natural resources; food, medicines, and a source of recreation and, therefore, a resource for improved wellbeing and inputs for an industry that needs to be utilized sustainably.
- Environmental management combines science, policy, and socioeconomic application in finding solutions to practical problems that people face in cohabitation with the environment, resource exploitation, and waste production. Environmental degradation has been recognized locally and worldwide.
- Application of ST&I to all aspects of the management of the environment would enhance sustainability.
- Science, technology, and innovation play an important role in conserving the environment, and exploring and exploiting natural resources within the context of effective management for human development. Further, our environment needs proper planning and timely application of mitigation measures whenever disaster and security threats occur.

The following are strategies for conserving and managing the environment:

a) Promote scientific ways of conserving the environment within the educational system.
b) Devise ICT-driven education and training programmes in science and mathematics in primary and secondary education.
c) Enhance the capacity of personnel in educational institutions in emerging technologies such as biotechnology, nanotechnology, and material science.
d) Increase the number of students in higher institutions of learning registered in science-related disciplines.
e) Revamp the practice of industrial attachments for technical and vocational education as well as science, technology, and engineering students.

The role of ICT in ST&I

a) **Diffusion of information:** ICT networks can make the diffusion of information about innovations faster, enabling close links between innovators and consumers as well as reducing geographical barriers.

b) **Networking:** ICT also facilitates and enhances collaboration across networks leading to the exchange of ideas between researchers, innovators, and other stakeholders. Such collaborations assist them to be more responsive to innovative ideas. For example; the internet is a rich source of information that helps businesses to keep up with customer trends, and market demands and get rapid user feedback. Such information is crucial in identifying opportunities for all types of innovation.

c) **Innovations:** The ICT sector is in itself a source of innovation as people work on the development of hardware and software and ICT infrastructure. Through R & D activities, industries and educational institutions can form collaborations for hardware and software development. Mobile telephony is a good example of how ICTs can spur innovation.

d) **Production**: ICT enhances the capabilities of industries and organizations through the improvement of the process of production. Such enhanced capabilities require innovation.

e) Patenting: ICT helps in creating a databank to support ST&I. The documentation of ST&I plays an important role in facilitating patenting and the transfer of knowledge.

f) **Promotion:** Innovation centers with ICT backbone and software development help in supporting and promoting ST&I initiatives.

g) **Competition:** National ICT innovation competitions can also be organized at all levels of education.

h) **Marketing:** The internet also provides media for the marketing of innovative products. The use of a website gives a global presence to an innovation.

Role of Research in ST&I

- Research-based competence plays an increasingly important role in the development of innovations and new technology. Research and Development play a critical role in the innovation process. It's essentially an investment in technology and future capabilities which is transformed into new products, processes, and services.
- Knowledge is created through research, science, and technology development. This knowledge, when adopted, helps in solving or alleviating constraints to development. It, as well, enables new opportunities for development to be explored. Research can contribute in many different ways and at all stages of the innovation process.

  i. R&D results in support of product and process development.
  ii. Access to academic networks for collaboration.
  iii. Competence building.
  iv. Direct business opportunities.
  v. Access to funding opportunities through national R&D funding agencies.

Dissemination of ST&I

Another important element of ST&I is the dissemination of ST&I. The following approaches can be adopted to disseminate ST&I information:

i. Develop and implement dynamic ST&I communication, education, and publicity activities in education-related programmes such as encouraging Science, Mathematics, and Technology in Schools.
ii. Develop a participatory framework to promote technological learning within the education programmes to close the competency and knowledge gaps between policymakers, education practitioners, and industrial consumers.
iii. Establish national and county ST&I museums that will be used as reference and study centers.
iv. Establish a platform for public dialogue involving researchers to promote public awareness, acceptance, and support for science, technology, and innovation activities.
v. Establish a knowledge management information system for disseminating and sharing research findings.
vi. Develop and implement an effective and efficient web-based mechanism for monitoring, reviewing, and reporting of ST&I policy implementation process.
vii. Establish national, regional, and county incubation centres for ST&I innovations.
viii. Establish community centres of learning, where mentorship and coaching can be done.
ix. Establish linkages between education institutions and the corporate sector for ST&I support.

Summary

Science, technology, and innovation are cornerstones of the Kenya economy. ST&I aims to increase collective well-being through combining new scientific and technological breakthroughs with social and economic actions.

Therefore, harnessing innovations and emerging technologies can support teaching and learning which will eventually spur economic and social wellbeing of the society. .