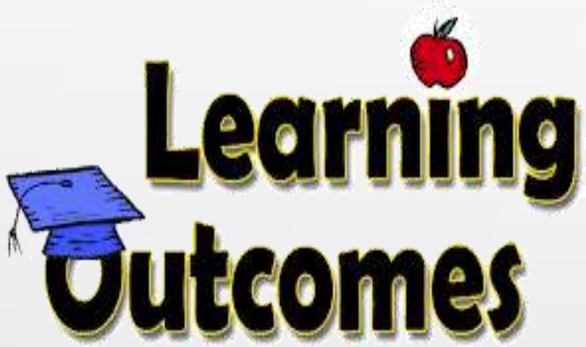
DIPLOMA IN EDUCATION LEADERSHIP AND MANAGEMENT
MODULE 7:LEADERSHIP IN SCIENCE, TECHOLOGY AND INNOVATION

UNIT 3:
SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS (STEM)

Introduction

- The adoption and utilization of Science, Innovation and Technology (ST&I) depends heavily on the foundation laid as young people go through the education system.
- The teaching of subjects aimed at preparing learners for ST&I required a curriculum that deliberately incorporates the teaching of ST&I-related subjects.
- In this unit, we will learn about Science, Technology, Engineering and Mathematics (STEM) Education.
- We will seek to understand the concept of STEM education and its importance in the promotion of ST&I. We will also learn about the theoretical framework for STEM education, the learning approach in STEM education and STEM teaching and learning methods.
- We will also look at STEM model schools in Kenya and issues concerning STEM education and STEAM education as an approach that aims at enhancing the effectiveness of STEM education in meeting the needs of modern societies.



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

a) Demonstrate understanding of the concept of STEM education

b) Assess the effectiveness of STEM implementation models

c) Demonstrate understanding of STEM education approaches

d) Evaluate learning methods appropriate for STEM education.

e) Differentiate between STEM and STEAM education

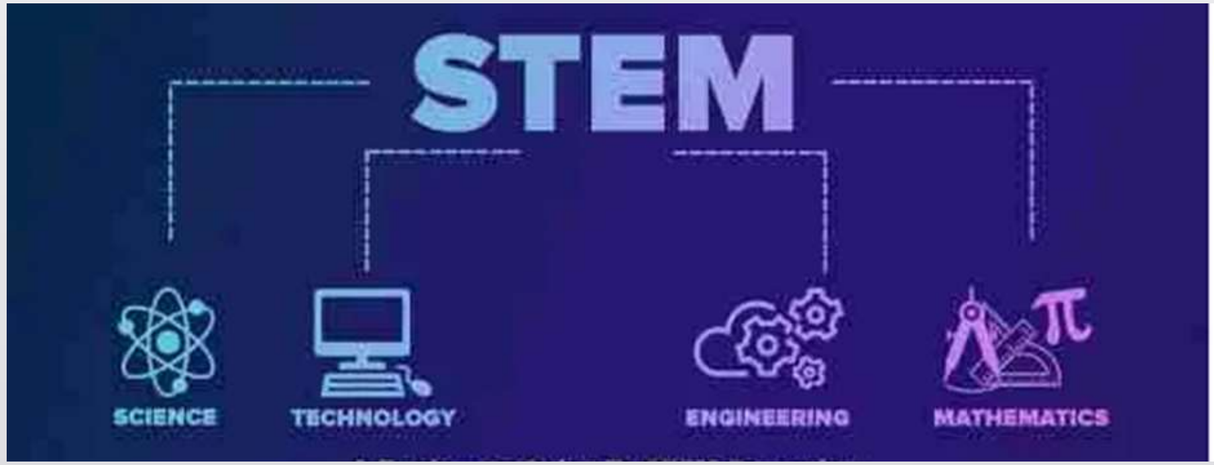
f) Appreciate the role of STEM education in national development

The concept of STEM education

- STEM Education, at its core, simply means educating students in four specific disciplines, namely, Science, Technology, Engineering, and Mathematics (collectively shortened as STEM). Instead of training students in any one of these domains, STEM combines all four in an interdisciplinary and applied approach, to better equip students to have a career and consider real-world applications.
- STEM subjects generally consist of the following, though it's worth mentioning that there are huge overlaps between them:
  - **Science:** This not only includes the obvious subjects such as biology, chemistry and physics but also subjects such as psychology, geology and astronomy.
  - **Technology:** This includes subject areas such as computer science, software development, artificial intelligence and programming.
  - **Engineering:** This includes the four main areas of engineering i.e. chemical, civil, mechanical and electrical engineering.
  - **Mathematics:** This includes geometry, fractions, algebra, and related subjects such as economics.
- Rather than teach the five disciplines as separate and discrete subjects, STEAM integrates them into a cohesive learning paradigm based on real-world applications. STEM is much more than just a way of grouping subjects; at its core, STEM is a teaching philosophy that integrates all four disciplines together into a single, cross-disciplinary program that offers instruction in real-world (as opposed to purely academic) applications and teaching methods.

Cont.

- As a philosophy, STEM is meant to create a program that integrates all four disciplines in a way that forces the student to use cross-disciplinary knowledge to solve problems.
- This essentially means that the traditional learning style typically in form of memorization and recitation of information is done away with.
- In STEM, learners are not provided with an explicit solution to a problem. Instead, they are required to use what they already know to figure out the right answer for themselves. This requires a significant amount of creativity and flexible thinking, as well as technical knowledge and mastery of each discipline.



Importance of STEM and STEM education

Today, there is a lot of emphasis on STEM education as evidenced by the Basic Education Curriculum Reforms in Kenya where STEM has been identified as a career pathway in senior school. To prepare learners for STEM education, they will be introduced to a general curriculum on science and technology in Middle School. The following are the reasons why STEM education is considered important.

1. STEM education goes beyond school subjects. It gives a skill set that governs the way we think and behave. Merging science, technology, engineering, and mathematics, STEM education helps us to solve the challenges the world faces today
2. STEM education gives people skills that make them more employable and ready to meet the current labour demand. It encompasses the whole range of experiences and skills.
3. The STEM approach to education fosters creativity and divergent thinking alongside fundamental disciplines. It motivates and inspires young people to generate new technologies and ideas. With a focus on practice and innovation, students get to learn from inquiry-based assignments.
4. STEM education exposes students to effective interdisciplinary communication. Scientists research and experiment, offering the team discoveries. Technology experts provide gadgets that can make the work of the team more effective. Engineers help to solve challenges by designing and running platforms that enable change. Mathematicians analyze information to eliminate mistakes and provide precise calculations. Our world is continuously changing.

5. Collaborative experience also helps to broaden the impact of STEM education. Working with local experts and our international colleagues, we can promote our values and move towards a single purpose. This way, we improve communities, offering new educational and employment opportunities. Such open access to world-class experience is possible only when we combine our knowledge and capabilities.
6. There is a high demand for STEM skills in society. STEM education enables people to make informed decisions within the discussed subject areas. Moreover, STEM awareness is necessary for any job as most industries are more or less connected to science and technology: from an essay writing service and college to a paper companies. Thus, such education will allow children to grow into active citizens who can speak up in STEM discussions with sound knowledge of the subject.
7. There is a high demand for STEM skills in society. STEM education enables people to make informed decisions within the discussed subject areas. Moreover, STEM awareness is necessary for any job as most industries are more or less connected to science and technology: from an essay writing service and college to a paper companies. Thus, such education will allow children to grow into active citizens who can speak up in STEM discussions with sound knowledge of the subject.
8. Sustainable Solutions to Challenges: STEM subjects are focused on providing solutions to the concerns society has today. Human history had seen years of thoughtless exhaustion of natural resources. Such a lack of environmental education led to numerous challenges. These issues affect the health and well-being of all living organisms on our planet. Our environment needs protection.

Benefits of STEM education

- STEM education is increasing in popularity and more schools are implementing STEM learning into their curriculum and making it an integral part of what they teach. Benefits of STEM education include the following:

1. **Encourages inquisition:** Young people have a sense of curiosity that constantly looks for activities that can challenge them. Keeping this inquisitiveness and curiosity sparked helps them to maximize their capacities. STEM education helps learners to draw inferences, drive connections, and explore deeper meaning and understanding of fields that interest them.
2. **Fosters ingenuity and creativity:** Ingenuity and creativity can pair with STEM and lead to new ideas and innovations. Without ingenuity and creativity, the recent developments in artificial intelligence or digital learning would not be possible. These technologies were created by people who learned that if the human mind can conceive it, the human mind can achieve it.
3. **Builds resilience:** During STEM education activities, students learn in a safe environment that allows them to fall and try again. STEM education stresses the value of failure as a learning exercise, which will enable students to embrace mistakes as part of the learning process. This allows learners to build confidence and resilience, which will enable them to keep going when the going gets rough. After all, failure is part of a process that ultimately leads to success.

4. **Encourages experimentation:** Without a little risk-taking, and experimentation, many of the technological advancements that have occurred in the last couple of decades would not be possible. Many of these innovations were created by people who were told that their ideas wouldn't work and their response was, "Let's try it and see." This type of attitude can be encouraged with STEM learning during the earlier years of learning. This can be accomplished by allowing students to experiment and take risks during learning activities.
5. **Encourages teamwork:** STEM education can be taught to learners of all ability levels. Learners of varying levels of ability can work together in teams to find solutions to problems, record data, write reports, give presentations, etc. The result is learners who understand how to collaborate with others and thrive in a team-oriented environment.
6. **Encourages knowledge application:** In STEM education, learners are taught skills that they can use in the real world.
7. This motivates students to learn, as they know that the skills that they acquire can be utilized immediately, and in ways that positively impact them and their loved ones. The ability to apply their knowledge to new and novel tasks will bode well for them when they enter the workforce.
8. **Encourages technology use**: STEM learning teaches learners about the power of technology and innovation. So, when learners encounter new technologies, they will be prepared to embrace them, instead of being hesitant or fearful. This will give them the upper hand in the global landscape, as the world is becoming increasingly tech-centred.
9. **Teaches problem-solving:** STEM education teaches students how to solve problems by using their critical thinking skills. By engaging in STEM learning experiences, learners learn how to examine problems and then create a plan to solve them.
10. **Encourages adaption:** To succeed in life, learners have to be able to apply what they have learned to a variety of scenarios. STEM education teaches them to adapt the concepts that they learn to various iterations of a problem or issue.

Models of STEM Implementation

- Different STEM approaches have been adopted in different educational contexts. Four models that premised the development of the Science, Technology, Engineering and Mathematics Education theoretical framework are:

a) **Separatist models**

The separatist or silo pathway is also considered a traditional approach that holds the isolated instruction of each individual STEM subject. Some symbolize this way of teaching as S-T-E-M to draw attention to its independent subject nature with no or minimal integration. In schools, this approach manifests as a traditional disciplinary list of subjects like science (chemistry, physics, biology, etc.), mathematics, technology and engineering. It also emphasizes that subjects like technology and engineering which were largely excluded in the school curricula be included.

a) **Integrated model**

This model is the integration of two of the four STEM disciplines. For example, schools using the integrated approach can concentrate on science and mathematics (STEM). Integrating science and mathematics (STEM) seems to be the preferred approach to STEM education in many curricula and may be thought of as discipline-based. In the integrated approach, individual fields or disciplines are taught as stand-alone, but attempts are made to connect the discipline with other subjects

c) Continuum Models

The continuum model involves integrating one of the STEM disciplines into the other three being taught. For example, engineering content can be integrated into science, technology and mathematics courses. This approach attempts to address the limitation of the integrated approach that focuses only on mathematics and science. However, it still conserves the discipline characteristics. This approach suggests that STEM integration can be achieved through using engineering or technology designs to create connections of concepts and practices from mathematics or science

d) Infused Model

In this model, all four disciplines are infused into each other to teach them as an integrated subject matter. This way of STEM teaching relates to the interdisciplinary meaning of STEM education. This approach entails the use of a blended approach that draws classroom practices (purpose, content, context, pedagogy, assessment and interactions) from all four fields and merges into one field. For example, STEM integration as interdisciplinary involves cutting across subject interconnections into interdisciplinary content and skills. The approach mixes STEM content areas into a one-subject learning area, an interdisciplinary teaching approach that removes the barriers among the four disciplines through the incorporation of all the knowledge domains and individual subject skills into one

STEM Education Approaches

While scientific inquiry involves the formulation of a question that can be answered through investigation, design thinking involves the formulation of a problem that can be solved through construction and evaluation during the post-design stage. STEM education brings these two concepts together through all four disciplines.

Scientific Inquiry

- Scientific inquiry is a form of problem-solving and questioning that helps people come to a greater understanding of observable phenomena. An understanding of this style of scientific reasoning forms the basis upon which the nature of science itself rests.

From encouraging scientific queST&Ions to facilitating well-reasoned conclusions, the scientific inquiry process helps illuminate our understanding of the world. Here are seven core elements of the scientific inquiry process:

i. **Asking constant questions:** At the centre of both the scientific method and general scientific inquiry lies the ability to ask questions well. Make observations about a particularly interesting phenomenon and then pose questions about why such a thing happens. Let preexisting scientific theories guide your questioning, but keep in mind every theory continues to be just that—a theory—until scientific inquiry definitively proves or disproves it.
ii. **Testing your inferences:** Scientific progress hinges on your ability to experiment and test inferences about evidence. To do so, you need to set up an independent variable (something
iii. you will use to test) and a dependent variable (the thing or things you are testing). Seeing how well your inferences or predictions match up with the reality of a given experiment is essential to scientific inquiry.
iv. **Making connections:** As you make observations about a specific phenomenon, make connections with every other relevant topic you can remember from your past science lessons or research. Scientific knowledge is as much a result of old realizations as it is of new discoveries.

v. **Seeking evidence:** As you seek to understand the natural world, there's no substitute for hard evidence. Collect data and gather evidence relentlessly throughout your scientific investigations. The more evidence you have to answer your initial questions, the more ironclad your ultimate case will be when you draw conclusions.

vi. **Classifying data correctly:** Science is as much a process of data collection and classification as it is of asking and answering questions. This means knowing how to elucidate or graph out your discoveries in a way other people can understand. It also means using citations from other scientific journals and texts to bolster your ultimate argument as to why a particular phenomenon occurs.

vii. **Drawing conclusions:** Eventually, you need to draw conclusions from the data you collect. After you've made an exhaustive study of your specific focus, use inductive reasoning to make sense of all the new evidence you've gathered. Scientific ideas are always malleable and never completely concrete—alternative explanations are always possible, and new evidence should lead to new questions and conclusions.

viii. **Sharing findings:** Science is an innately group-centred discipline. The more people interpret data, the better chance there is to ensure there are no loopholes in the new research. No one person's understanding of science content is infinite, so it's important to let other qualified people ask questions about your conclusions. Natural science is more of a never-ending collaborative process than one with a concrete point of termination.

Design thinking

- Design thinking is a non-linear, iterative process that teams use to understand users, challenge assumptions, redefine problems and create innovative solutions to prototype and test. Involving five phases—Empathize, Define, Ideate, Prototype, and Test—it is most useful to tackle problems that are ill-defined or unknown.



Stage 1: Empathize—Research Your Users' Needs

- Here, you should gain an empathetic understanding of the problem you're trying to solve, typically through user research. Empathy is crucial to a human-centred design process such as design thinking because it allows you to set aside your own assumptions about the world and gain real insight into users and their needs.

Stage 2: Define—State Your Users' Needs and Problems

- It's time to accumulate the information gathered during the Empathize stage. You then analyze your observations and synthesize them to define the core problems you and your team have identified. These definitions are called problem statements. You can create personas to help keep your efforts human-centred before proceeding to ideation.

Stage 3: Ideate—Challenge Assumptions and Create Ideas

- Now, you're ready to generate ideas. A solid background of knowledge from the first two phases means you can start to "think outside the box", look for alternative ways to view the problem, and identify innovative solutions to the problem statement you've created. Brainstorming is particularly useful here.

Stage 4: Prototype—Start to Create Solutions

- This is an experimental phase. The aim is to identify the best possible solution for each problem found. Your team should produce some inexpensive, scaled-down versions of the product (or specific features found within the product) to investigate the ideas you've generated. This could involve simply paper prototyping.

Stage 5: Test—Try Your Solutions Out

- Evaluators rigorously test the prototypes. Although this is the final phase, design thinking is iterative: Teams often use the results to redefine one or more further problems. So, you can return to previous stages to make further iterations, alterations, and refinements – to find or rule out alternative solutions.
- Overall, you should understand that these stages are different modes that contribute to the entire design project, rather than sequential steps. Your goal throughout is to gain the deepest understanding of the users and what their ideal solution/product would be.

Importance of Design Thinking

- Twenty-first-century organizations from a wide range of industries find design thinking a valuable means to problem-solve for the users of their products and services.
- Design teams use design thinking to tackle ill-defined/unknown problems (aka wicked problems) because they can re-frame these in human-centric ways and focus on what's most important for users. Of all design processes, design thinking is almost certainly the best for "thinking outside the box". With it, teams can do better user experience research, prototyping and usability teST&Ing to uncover new ways to meet users' needs.
- With design thinking, teams have the freedom to generate ground-breaking solutions. Using it, your team can get behind hard-to-access insights and apply a collection of hands-on methods to help find innovative answers.

Instructional approaches that promote STEM education

- The interdisciplinary approach to teaching STEM Education defines the use of a combination of methods and insights from several established disciplines or traditional fields of study.
- It involves the teachers and students, connecting and bringing together various perspectives in the pursuit of a better understanding of STEM.
- Student performance in learning, particularly STEM is largely influenced by the method adopted by the teachers. Today, teaching and learning science is rather teacher-centered.
- This means the learning experience revolves around the teacher, oftentimes making the students passive.
- It is also worthy to note that with this current practice, the teachers are seen as conveyors of knowledge and because they rarely apply innovative teaching techniques that would engage the learners and stimulate their interests, we lose whatever interest in STEM would have been developed by the learners.

When STEM is effectively taught to students here are some of the skills the students are likely to develop;

- Problem Solving
- Critical thinking
- Team Work
- Independent thinking
- Communication
- Critical thinking
- Digital Literacy.

The following are the effective teaching and learning methods for STEM:

i. **Project-Based Learning (PBL)**

- This is an instructional methodology that encourages learners to learn and apply knowledge and skills through engaging classroom experiences. In this learning method, the teacher is seen more as a facilitator than a bearer of knowledge and information.
- The projects may be suggested by the teacher but they are all executed and planned by the students themselves.
- Many have however argued about the demerits of using PBL to teach STEM, stating that it is not a very cost-effective method of learning as it requires space and resources for the projects to be carried out.
- Another argument put forward is that the PBL cannot exhaust all the topics of learning in the various STEM subjects thus hindering knowledge in certain areas.
- These, however, do not take away the fact that this method is highly effective when working with early learners in STEM as it excites them by improving their sensory, cognitive and critical thinking skills, enhancing teamwork and achieving more interest in STEM.

ii. Problem-Based Learning:

- This is a method of teaching and learning which requires a high level of thinking.
- The learners analyze, create and evaluate a problem posed. Such problems are often open-ended and might not have solutions, however, the learners can proffer probable solutions and questions already set principles or narratives.
- The problem-based learning which is similar to another learning method, Inquiry-Based Learning(IBL), encourages learners to ask questions and work in groups whereas, in IBL, the learners are required to work individually.
- Problem-Based Learning is sometimes paired with Project-Based learning as they are both collaborative, requiring the learners to work in groups and involve active learning.
- The teams of students could be interdisciplinary cutting across various fields in the sciences all working together to proffer a solution. Often this problem is provided by the teacher and presented to the learners, who work in groups to apply critical thinking skills to analyse and proffer solutions.

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iii. Inquiry-Based Learning (IBL)

- This learning method focuses on questioning, critical thinking and problem-solving. In this, the learners are very involved in the learning process with them being allowed to ask exhaustive questions on everything concerning the subject matter.
- Often, IBL is confused with Problem Based Learning where the problems provided are open-ended and most times without a definite/set solution, IBL questions have definite answers and solutions.
- Using IBL to teach STEM helps learners understand the various set principles that are involved in the final answers to the problems posed which ensures that they fully understand and can apply the knowledge where necessary

Assessment of STEM learning

- **T**raditional methods such as exams and short tests don't generally mix well with such practical approaches used in STEM. Formative assessment is more suitable to check learners' progress. This is because formative assessment methods provide ongoing feedback which is designed to improve teaching and learning.
- More specifically, formative assessments help learners to identify their strengths and weaknesses, allowing them to easily pinpoint areas that need improvement. They also help teachers recognize common areas where learners are struggling so they can quickly address any issues.
- This kind of assessment is ideal for STEM learning because it's closer to how real-world scenarios play out, encourages active engagement in lessons, and doesn't rely on memory power. Summative assessments, such as exams, can push some students away from learning if they know they're not very good at them. This can be the case, particularly in science and maths, where written tests can be very difficult. STEM shouldn't be about whether you're a strong writer or memoriser, it's more about practical creativity and problem-solving.

Examples of formative assessments include asking learners to:

i. Create a research proposal
ii. Write or draw a quick summary of what they learned in class
iii. Draw a concept map to show they understand a topic
iv. Build a prototype for a project

How to engage students in STEM

The following proposals have been made on how to encourage learners to study STEM education:

- Promote a range of STEM role models and heroes, including different genders and ethnicities. Organize talks with these people or show your students inspiring videos.
- Try to create educational programs or clubs for underrepresented groups in STEM, such as a girls' STEM club or engineering club.
- Create an inclusive and welcoming environment for both genders. The University of Washington reported that girls were three times more likely to join a computer science class in a classroom that is decorated with nature posters, lamps, and plants instead of science fiction posters and books.
- Connect students with STEM mentors. These could be older students who can encourage them or help them with projects, or STEM volunteers from outside of school who have careers within STEM fields.
- Engage students by making the lessons fun! And remember, if you’re enjoying the lesson, they probably will too. Teachers can involve the learners in; field trips, competitions, educational games, etc

STEM learning Programmes

- STEM-based learning goes against age-old learning methods. It allows students to gain tactical, hands-on experience and take a break from their 6 to 8-hour school days in the classic lecture-style classroom.
- STEM provides learning through trial and error, rather than being fed information, the instructor is more of a guide who transfers information. It is not about memorization, it is about synthesizing everything they have learned, and triumphing after strenuous hours of work.
- This offers a fresh new way for students to connect to what they are learning and tap into different sides of themselves that they might not have reached without STEM.
- In addition to providing an alternative classroom, STEM promotes many different types of learning and helps students gain a number of extremely necessary 21st-century skills.
- Through the use of robotics and in several robotics competitions, students are able to strengthen their hand-eye coordination. When building these machines, students must be very diligent about where they place every piece as a robot’s design must be precise.

Robotics and STEM education

- Robotics has assisted teachers to combine technology and engineering topics to concretize science and mathematics concepts in real-world applications.
- As a result, benefits in different concepts and skills, as well as positive long-term effects, have been observed.
- Learning with educational robotics provides students, who usually are the consumers of technology, with opportunities to stop, question, and think deeply about technology.
- When designing, constructing, programming, and documenting the development of autonomous robots or robotics projects, students not only learn how technology works but also apply the skills and content knowledge learned in school in a meaningful and exciting way.
- Educational robotics is rich with opportunities to integrate not only STEM but also many other disciplines, including literacy, social studies, dance, music, and art while allowing students to find ways to work together to foster collaboration skills, express themselves using the technological tool, problem-solve, and think critically and innovatively.
- Most importantly, educational robotics provides a fun and exciting learning environment because of its hands-on nature and the integration of technology

Coding

- Computer coding is the use of computer programming languages to give computers and machines a set of instructions on what actions to perform.
- It’s how humans communicate with machines.
- It’s what allows us to create computer software like programs, operating systems, and mobile applications. Simply put, coding is used for communicating with computers. People use coding to give computers and other machines instructions on what actions to perform.
- Further, we use it to program the websites, apps, and other technologies we interact with every day.

8 STEM Model Schools in Kenya

- The Centre for Mathematics, Science, and Technology Education in Africa (CEMASTEA) is the implementing institution, on behalf of the Ministry of Education, tasked to transform the102 selected public secondary schools into model schools for STEM.
- Two secondary schools in every county bringing to a total of ninety-four (94) and eight (8) regional schools were selected based on their performance, locality, and centrality in consultation with local stakeholders.
- STEM Model School Program has five keys aspects: making the school climate inviting by focusing on interrelationships or people, programs, policies, processes, and physical environment or place; enhancing students' creativity or innovativeness through the creation of maker spaces and introducing robotics; educating students for sustainability by involving them in school projects such production of food (i.e. farming, animal husbandry, etc.) as learning opportunity; incubating students' innovation and supporting their patenting and scale up; and using innovative teaching and learning approaches such as Inquiry-based learning using the 5 E (Engage, Explore, Explain, Elaborate & Evaluate) instructional model.

- In 2016, 329 teachers from the 102 schools were trained in 8 regional venues namely Moi Girls Eldoret for North Rift Region, Kisumu Girls for Nyanza Region, Aldina Visram Boys for Coast Region, Kangaru Girls for Lower Eastern Region, Menengai Mixed for South Rift Region, Chania Girls for Metropolitan and North Eastern Regions, Mukumu Girls for Western Region, and Tumu Tumu Girls for Central Region.
- The training then focused on the Interdisciplinary Approach, education for sustainability, creativity, makerspace, and introduction to robotics science
- Teachers from the model schools have undergone training.
- The overall purpose of the training is to train teachers on how to use EV 3 robotic kits for teaching and learning. CEMASTEA has developed a module for taking the teachers (step-by-step) through the educational kit to enhance students' 21st Century skills. Of great interest is international recognition of the Kit for being effective in promoting collaboration, communication, problem-solving, teamwork, imagination, and critical thinking skills among students.

Issues in STEM education

i. Mission-Driven Leadership

ii. STEM Culture

iii. Student Outreach, Recruitment, and Retention

iv. Teacher Selection, Development, and Retention

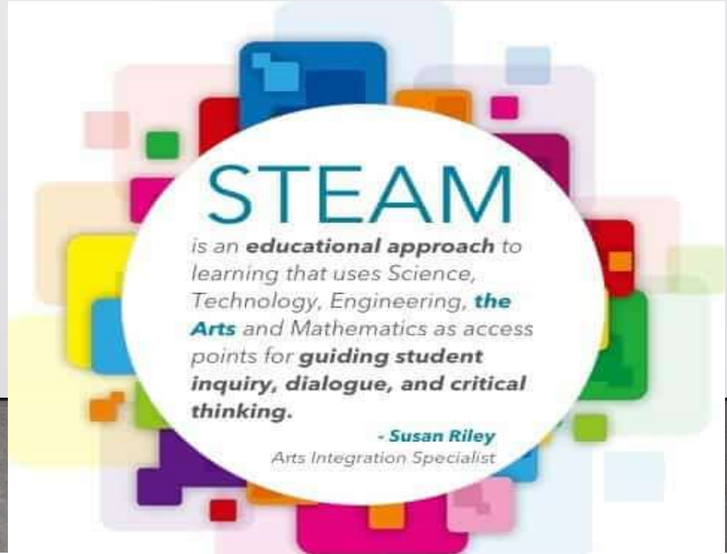
v. Curriculum, Instruction, and Assessment

vi. Strategic Alliances

vii. STEM education Advancement and Sustainability

STEAM EDUCATION

- This is an approach to learning that uses Science, Technology, Engineering, the Arts and Mathematics as access points for guiding student inquiry, dialogue, and critical thinking.
- STEAM education results in learners who take thoughtful risks, engage in experiential learning, persist in problem-solving, embrace collaboration, and work through the creative process. These are the innovators, educators, leaders, and learners of the 21st century.



STEM vs. STEAM

- The STEM to STEAM movement has been taking root over the past several years and is surging forward as a positive mode of action to truly meet the needs of a 21st century economy. STEM alone misses several key components that many employers, educators, and parents have voiced as critical for our children to thrive in the present and rapidly approaching future.
- Much has been proclaimed about the need for more STEM "programs" in our schools. The logic is simple: the wave of future economic prosperity lies in a workforce that is well-versed in rising job markets like science, technology, engineering and math. Thus, there has been an increased investment in STEM initiatives in schools.
- This includes:
  - providing mobile devices for students (sometimes in the forms of computer labs, and other times in the form of 1:1 – a single device for each student)
  - after-school STEM clubs or programs
  - STEM curriculum, where projects using STEM practices are embedded
  - BYOD initiatives (bring your own device)
  - STEM days to encourage hands-on exploration within each of these disciplines
  - robotics programs

- While these initiatives are a wonderful start into the exploration of these four areas of study, the critical process of creativity and innovation is missing.
- Students in STEM programs may have more experiential learning opportunities, but they are limited to only science, technology, engineering and math.
- Our economy requires so much more than an understanding of these areas – it requires application, creation and ingenuity. STEM alone does not foster these essential nutrients.
- STEAM is a way to take the benefits of STEM and complete the package by integrating these principles in and through the arts.
- STEAM takes STEM to the next level; it allows learners to connect their learning in these critical areas together with arts practices, elements, design principles, and standards to provide the whole pallet of learning at their disposal.
- STEAM removes limitations and replaces them with wonder, critique, inquiry, and innovation.

Importance of STEAM Education

- Integrating concepts, topics, standards and assessments is a powerful way to disrupt the typical course of events for our students and to help change the merry-go-round of "school."
- It takes what we do when we open the doors to the real world and places those same practices in our cycles of teaching and learning. STEAM education helps us to remove the brick walls and classroom doors to get at the heart of learning.
- Recent research shows that STEAM is a promising approach to positively impacting student achievement and teacher efficacy. In a 2016 study, researchers investigated the impact of STEAM lessons on physical science learning in grades 3 to 5 in high poverty elementary schools in an urban district. Findings indicated that students who received just nine hours of STEAM instruction made improvements in their science achievement *(Brouillette, L., & Graham, N. J.)*.
- Another study from 2014 shows the connecting STEAM and literacy can positively impact cognitive development, increase literacy and math skills, and help students reflect meaningfully on their work and that of their peers *(Cunnington, Marisol, Andrea Kantrowitz, Susanne Harnett, and Aline Hill-Ries.)*. This is further supported by a study on the relationship between theater arts and student literacy and mathematics achievement from 2014. *"Results showed that students whose language arts curricula were infused with theater arts often outperformed their control group counterparts, who received no arts integration, in both math and language arts" (Inoa, R., Weltsek, G., & Tabone, C.)*.

Conclusion

- In this unit, we have looked at the concept of STEM education where we have learned about its importance and benefits.
- We have also examined various models that have been used in the implementation of STEM education.
- For learning purposes, we looked at the scientific inquiry and design thinking approaches.
- We have also learned about the most effective learning methods in STEM education.
- Moreover, we looked at STEM programs in robotics and coding and the STEM model schools in Kenya.
- We also looked at STEAN education briefly as an approach that incorpoarteas ART subjects into STEM in order to produce an all-rounded learner.
- We hope that you can now make a linkage between the teaching of STEM to learners and the promotion of Science, Technology, and Innovations.