ENGINEERING

CURRICULUM FOR SECONDARY EDUCATION (SHS 1 - 3)

NaCCA

NATIONAL COUNCIL FOR CURRICULUM & ASSESSMENT OF MINISTRY OF EDUCATION

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FOREWORD

Through the National Council for Curriculum and Assessment (NaCCA), Ghana's Ministry of Education has introduced a series of curriculum reforms to improve the quality and relevance of learning experiences in pre-tertiary schools in the country. These reforms will improve learning through the introduction of innovative pedagogies that encourage critical thinking and problem-solving. For a long time, our learners memorise facts and figures, which does not develop their analytical and practical skills. The Ministry recognises that learners need to be equipped with the right tools, knowledge, skills and competencies to deal with the fast-changing environment and the challenges facing their communities, the nation and the world.

These curriculum reforms were derived from the Education Strategic Plan (ESP 2018-2030), the National Pre-tertiary Education Curriculum Framework (NPTECF) and the National Pre-Tertiary Learning Assessment Framework (NPLAF), which were all approved by Cabinet in 2018. The new standards-based curriculum implemented in 2019 in basic schools, aims to equip learners to apply their knowledge innovatively to solve everyday problems. It also prioritises assessing learners' knowledge, skills, attitudes, and values, emphasising their achievements. The content of the basic school standards-based curriculum was therefore designed to promote a curriculum tailored to the diverse educational needs of the country's youth. It addresses the current curriculum's deficiencies in learning and assessment, especially in literacy and numeracy. These reforms have been carried out in phases. The curriculum for the basic school level – KG, Primary and Junior High School (JHS) – was developed and implemented from 2019 to 2021.

The curriculum for Senior High School (SHS), Senior High Technical School (SHTS) and Science, Technical, Engineering and Mathematics (STEM), which constitutes the next phase, is designed to ensure the continuation of learning experiences from JHS. It introduces flexible pathways for progression to facilitate the choice of subjects necessary for further study, the world of work and adult life. The new SHS, SHTS and STEM curriculum emphasises the acquisition of 21st Century skills and competencies, character development and instilling of national values. Social and Emotional Learning (SEL), Information Communications Technology, Gender Equality and Social Inclusion, have all been integrated into the curriculum. Assessment – formative and summative has been incorporated into the curriculum and aligned with the learning outcomes throughout the three-year programme.

The Ministry of Education's reform aims to ensure that graduates of our secondary schools can successfully compete in international high school competitions and, at the same time, be equipped with the necessary employable skills and work ethos to succeed in life. The Ministry of Education, therefore, sees the Senior High School (SHS) curriculum as occupying a critical place in the education system – providing improved educational opportunities and outcomes for further studies, the world of work and adult life – and is consequently prioritising its implementation.

ACKNOWLEDGEMENTS

This standards-based SHS curriculum was created using the National Pre-Tertiary Learning Assessment Framework (NPLAF), the Secondary Education Assessment Guide (SEAG), and the Teacher and Learner Resource Packs which include Professional Learning Community (PLC) Materials and Subject Manuals for teachers and learners. All the above-mentioned documents were developed by the National Council for Curriculum and Assessment (NaCCA). The Ministry of Education (MoE) provided oversight and strategic direction for the development of the curriculum with NaCCA receiving support from multiple agencies of the MoE and other relevant stakeholders. NaCCA would like to extend its sincere gratitude, on behalf of the MoE, to all its partners who participated in the professional conversations and discussions during the development of this SHS curriculum.

In particular, NaCCA would also like to extend its appreciation to the leadership of the Ghana Education Service (GES), the National School Inspectorate Authority (NaSIA), the National Teaching Council (NTC), the Commission for Technical and Vocational Education and Training (Commission for TVET), West African Examinations Council (WAEC) and other agencies of the MoE that supported the entire process. In addition, NaCCA acknowledges and values the contributions made by personnel from various universities, colleges of education Industry players, Vice Chancellors Ghana, Vice Chancellors Technical Universities as well as educators and learners working within the Ghana education landscape.

Special appreciation is extended to consultants who contributed to development of the curriculum. The development process involved multiple engagements between national stakeholders and various groups with interests in the curriculum. These groups include the teacher unions, the Association of Ghana Industries, and heads of secondary schools.

CONTENTS

THE SHS CURRICULUM OVERVIEW

The vision for this curriculum is to ensure the nation has a secondary education system that enables all Ghanaian children to acquire the 21st Century skills, competencies, knowledge, values and attitudes required to be responsible citizens, ready for the world of work, further studies and adult life. The nation's core values drive the SHS curriculum, and it is intended to achieve Sustainable Development Goal 4: 'Inclusive, equitable quality education and life-long learning for all'. Above all, it is a curriculum enabling its graduates to contribute to the ongoing growth and development of the nation's economy and well-being.

The curriculum is inclusive, flexible, and robust. It was written under the auspices of the National Council for Curriculum and Assessment by a team of expert curriculum writers across Ghana. It reflects the needs of critical stakeholders, including industry, tertiary education, the West African Examination Council, SHS learners, teachers, and school leaders. It has been written based on the National Pre-Tertiary Learning and Assessment Framework and the Secondary Education Policy.

The key features of the curriculum include:

- flexible learning pathways at all levels, including for gifted and talented learners and those with deficiencies in numeracy and literacy, to ensure it can meet the needs of learners from diverse backgrounds and with different interests and abilities.
- the five core learning areas for secondary education: science and technology, language arts, humanities, technical and vocational and business; with emphasis placed on STEM and agriculture as integral to each subject.
- a structured, standards-based approach that supports the acquisition of knowledge, skills and competencies, and transition and seamless progress throughout secondary education, from JHS to SHS and through the three years of SHS.
- a focus on interactive approaches to teaching and assessment to ensure learning goes beyond recall enabling learners to acquire the ability to understand, apply, analyse and create.
- guidance on pedagogy, coupled with exemplars, demonstrating how to integrate cross-cutting themes such as 21st Century skills, core competencies, the use of ICT, literacy and mathematics, Social Emotional Learning, Gender Equality and Social Inclusion as tools for learning and skills for life. Shared Ghanaian values are also embedded in the curriculum.

The curriculum writing process was rigorous and involved developing and using a Curriculum Writing Guide which provided systematic instructions for writers. The process was quality assured at three levels: through (a) evaluation by national experts, (b) trialling curriculum materials in schools and (c) through an external evaluation by a team of national and international experts. Evidence and insights from these activities helped hone the draft's final version. The outcome is a curriculum coherently aligned with national priorities, policies and the needs of stakeholders. A curriculum tailored to the Ghanaian context ensures that all learners benefit from their schooling and develop their full potential.

The following section highlights the details of the front matter of the draft curriculum. The vision, philosophy and goal of the curriculum are presented. This is followed by the details of the 21st Century skills and competencies, teaching and learning approaches, instructional design and assessment strategies. The template for the curriculum frame, which outlines the scope and sequence, the design that links the learning outcomes to particular 21st Century skills and competencies, as well as Gender Equality and Social Inclusion, Social and Emotional Learning and Ghanaian values are presented together with the structure of the lesson frame showing the links between the content standards, learning indicators with their corresponding pedagogical exemplars and assessment strategies.

INTRODUCTION

Effective implementation of this Senior High School (SHS) curriculum is the key to creating a well-educated and well-balanced workforce that is ready to contribute to Ghana's progress by harnessing the potential of the growing youth population, considering the demographic transition the country is currently experiencing (Educational Strategic Plan [ESP] 2018-2030). SHS curriculum aims to expand equitable, inclusive access to relevant education for all young people, including those in disadvantaged and underserved communities, those with special educational needs and those who are gifted and talented. Senior High School allows young people to develop further skills and competencies and progress in learning achievement, building from the foundation laid in Junior High School. This curriculum intends to meet the learning needs of all high school learners by acquiring 21st Century skills and competencies to prepare them for further studies, the world of work and adult life. Changing global economic, social and technological context requires life-long learning, unlearning, and continuous processes of reflection, anticipation and action.

Philosophy of Senior High School Curriculum

The philosophy underpinning the SHS curriculum is that every learner can develop their potential to the fullest if the right environment is created and skilled teachers effectively support them to benefit from the subjects offered at SHS. Every learner needs to be equipped with skills and competencies of interest to further their education, live a responsible adult life or proceed to the world of work.

Vision of Senior High School Curriculum

The vision of the curriculum is to prepare SHS graduates equipped with relevant skills and competencies to progress and succeed in further studies, the world of work and adult life. It aims to equip all learners with the 21st Century skills and competencies required to be responsible citizens and lifelong learners. When young people are prepared to become effective, engaging, and responsible citizens, they will contribute to the ongoing growth and development of the nation's economy and well-being.

Goal of Senior High School Curriculum

The goal of the curriculum is to achieve relevant and quality SHS through the integration of 21st Century skills and competencies as set out in the Secondary Education Policy. The key features to integrate into the curriculum are:

- Foundational Knowledge: literacy, numeracy, scientific literacy, information, communication and digital literacies, financial literacy and entrepreneurship, cultural identity, civic literacy and global citizenship
- Competencies: critical thinking and problem-solving, innovation and creativity, collaboration, and communication
- Character Qualities: discipline, integrity, self-directed learning, self-confidence, adaptability and resourcefulness, leadership, and responsible citizenship.

The JHS curriculum has been designed to ensure that learners are adequately equipped to transition seamlessly into SHS, where they will be equipped with the relevant knowledge, skills and competencies. The SHS curriculum emphasises character building, acquisition of 21st Century skills and competencies and nurturing core values within an environment of quality education to ensure the transition to further study, the world of work and adult life. This requires the delivery of robust secondary education that meets the varied learning needs of the youth in Ghana. The SHS curriculum, therefore, seeks to develop learners to become technology-inclined, scientifically literate, good problem-solvers who can think critically and creatively and are equipped to communicate with fluency, and possess the confidence and competence to participate fully in Ghanaian society as responsible local and global citizens – (referred to as 'Glocal citizens').

The SHS curriculum is driven by the nation's core values of truth, integrity, diversity, equity, discipline, self-directed learning, self-confidence, adaptability and resourcefulness, leadership, and responsible citizenship, and with the intent of achieving the Sustainable Development Goal 4: 'Inclusive, equitable quality education and life-long learning for all'. The following sections elaborate on the critical competencies required of every SHS learner:

Gender Equality and Social Inclusion (GESI)

- Appreciate their uniqueness about others.
- Pay attention to the uniqueness and unique needs of others.
- Value the perspective, experience, and opinion of others.
- Respect individuals of different beliefs, political views/ leanings, cultures, and religions.
- Embrace diversity and practise inclusion.
- Value and work in favour of a democratic and inclusive society.
- Be conscious of the existence of minority and disadvantaged groups in society and work to support them.
- Gain clarity about misconceptions/myths about gender, disability, ethnicity, age, religion, and all other excluded groups in society
- Interrogate and dispel their stereotypes and biases about gender and other disadvantaged and excluded groups in society.
- Appreciate the influence of socialisation in shaping social norms, roles, responsibilities, and mindsets.
- Identify injustice and advocate for change.
- Feel empowered to speak up for themselves and be a voice for other disadvantaged groups.

21st Century Skills and Competencies

In today's fast-changing world, high school graduates must be prepared for the 21st Century world of work. The study of Mathematics, Science, and Language Arts alone is no longer enough. High school graduates need a variety of skills and competencies to adapt to the global economy. Critical thinking, creativity, collaboration, communication, information literacy, media literacy, technology literacy, flexibility, leadership, initiative, productivity, and social skills are needed. These skills help learners to keep up with today's fast-paced job market. Employers want workers with more than academic knowledge. The 21st Century skills and competencies help graduates navigate the complex and changing workplace. Also, these help them become active citizens who improve their communities. Acquisition of 21st Century skills in high school requires a change in pedagogy from the approach that has been prevalent in Ghana in recent years. Teachers should discourage and abandon rote memorisation and passive learning. Instead, they should encourage active learning, collaboration, and problem-solving, project-based, inquiry-based, and other learner-centred pedagogy should be used. As well as aligning with global best practices, these approaches also seek to reconnect formal education in Ghana with values-based indigenous education and discovery-based learning which existed in Ghana in pre-colonial times. This is aligned with the 'glocal' nature of this curriculum, connecting with Ghana's past to create confident citizens who can engage effectively in a global world. Digitalisation, automation, technological advances and the changing nature of work globally mean that young people need a new set of skills, knowledge and competencies to succeed in this dynamic and globalised labour market.

Critical Thinking and Problem-Solving Competency

- Ability to question norms, practices, and opinions, to reflect on one's values, perceptions, and actions.
- Ability to use reasoning skills to come to a logical conclusion.
- Being able to consider different perspectives and points of view
- Respecting evidence and reasoning
- Not being stuck in one position
- Ability to take a position in a discourse
- The overarching ability to apply different problem-solving frameworks to complex problems and develop viable, inclusive, and equitable solution options that integrate the above-mentioned competencies, promote sustainable development,

Creativity

- Ability to identify and solve complex problems through creative thinking.
- Ability to generate new ideas and innovative solutions to old problems.
- Ability to demonstrate originality and flexibility in approaching tasks and challenges.
- Collaborating with others to develop and refine creative ideas
- Ability to incorporate feedback and criticism into the creative process
- Utilising technology and other resources to enhance creativity
- Demonstrating a willingness to take risks and experiment with new approaches
- Adapting to changing circumstances and further information to maintain creativity

- Integrating multiple perspectives and disciplines to foster creativity
- Ability to communicate creative ideas effectively to a variety of audiences

Collaboration

- Abilities to learn from others; to understand and respect the needs, perspectives, and actions of others (empathy)
- Ability to understand, relate to and be sensitive to others (empathic leadership)
- Ability to deal with conflicts in a group
- Ability to facilitate collaborative and participatory problem-solving
- Ability to work with others to achieve a common goal.
- Ability to engage in effective communication, active listening, and the ability to compromise.
- Ability to work in groups on projects and assignments.

Communication

- Know the specific literacy and language of the subjects studied
- Use language for academic purposes
- Communicate effectively and meaningfully in a Ghanaian Language and English Language
- Communicate confidently, ethically, and effectively in different social contexts.
- Communicate confidently and effectively to different participants in different contexts
- Ability to communicate effectively verbally, non-verbally and through writing.
- Demonstrate requisite personal and social skills that are consistent with changes in society
- Ability to express ideas clearly and persuasively, listen actively, and respond appropriately
- Ability to develop digital communication skills such as email etiquette and online collaboration.
- Ability to engage in public speaking, debate, and written communication.

Learning for Life

- Understand subject content and apply it in different contexts
- Apply mathematical and scientific concepts in daily life
- Demonstrate mastery of skills in literacy, numeracy, and digital literacy.
- Develop an inquiry-based approach to continual learning.
- Be able to understand higher-order concepts and corresponding underlying principles.
- Participate in the creative use of the expressive arts and engage in aesthetic appreciation.
- Use and apply a variety of digital technologies
- Be digitally literate with a strong understanding of ICT and be confident in its application.
- Be equipped with the necessary qualifications to gain access to further and higher education and the world of work and adult life
- Ability to apply knowledge practically in the workplace so that they are able to utilise theory by translating it into practice.
- Develop their abilities, gifts and talents to be able to play a meaningful role in the development of the country
- Be able to think critically and creatively, anticipate consequences, recognise opportunities and be risk-takers
- Ability to pursue self-directed learning with the desire to chart a path to become effective lifelong learners.
- Independent thinkers and doers who show initiative and take action.
- Ability to innovate and think creatively, building on their knowledge base so that they take risks to achieve new goals
- Ability to think critically and solve problems so that they become positive change agents at work, in further study and in their personal lives.
- Be motivated to adapt to the changing needs of society through self-evaluation and ongoing training
- Be able to establish and maintain innovative enterprises both individually and in collaboration with others.
- Be able to ethically prioritise economic values to ensure stability and autonomy
- Show flexibility and preparedness to deal with job mobility
- Be committed towards the improvement of their quality of life and that of others
- Feel empowered in decision-making processes at various levels e.g., personal, group, class, school, etc.

- Be able to seek and respond to assistance, guidance and/or support when needed.
- Ability to make and adhere to commitments.
- Adopt a healthy and active lifestyle and appreciate how to use leisure time well.
- Be enthusiastic, with the knowledge, understanding and skill that enable them to progress to tertiary level, the world of work and adult life.
- Ability to transition from school to the world of work or further study by applying knowledge, skills and attitudes in new situations.
- Be independent, have academic and communication skills such as clarity of expression (written and spoken), and the ability to support their arguments.
- Be innovative and understand the 21st Century skills and competencies and apply them to everyday life.

Global and Local (Glocal) Citizenship

- Appreciate and respect the Ghanaian identity, culture, and heritage
- Be conscious of current global issues and relate well with people from different cultures
- Act in favour of the common good, social cohesion and social justice
- Have the requisite personal and social skills to handle changes in society
- Appreciate the impact of globalisation on the society.
- Ability to be an honest global citizen displaying leadership skills and moral fortitude with an understanding of the wider world and how to enhance Ghana's standing.

Systems Thinking Competency

- Ability to recognise and understand relationships
- Ability to analyse complex systems
- Ability to think of how systems are embedded within different domains and different scales
- Ability to deal with uncertainty

Normative Competency

- Ability to understand and reflect on the norms and values that underlie one's actions
- Ability to negotiate values, principles, goals, and targets, in a context of conflicts of interests and trade-offs, uncertain knowledge and contradictions

Anticipatory Competency

- Ability to understand and evaluate multiple futures – possible, probable, and desirable
- Ability to create one's vision for the future.
- Ability to apply the precautionary principle
- Ability to assess the consequences of actions
- Ability to deal with risks and changes

Strategic Competency

- Ability to collectively develop and implement innovative actions that further a cause at the local level and beyond.
- Ability to understand the bigger picture and the implications of smaller actions on them

Self-Awareness Competency

- The ability to reflect on one's role in the local community and (global) society
- Ability to continually evaluate and further motivate one's actions
- Ability to deal with one's feelings and desires

Social Emotional Learning (SEL): Five Core Competencies with Examples

1. *Self-Awareness*

Understanding one's emotions, thoughts, and values and how they influence one's behaviour in various situations. This includes the ability to recognise one's strengths and weaknesses with a sense of confidence and purpose. For instance:

- *Integrating personal and social identities;*
- *Identifying personal, cultural, and linguistic assets;*
- *Identifying one's emotions;*
- *Demonstrating honesty and integrity;*
- *Connecting feelings, values, and thoughts;*

- *Examining prejudices and biases;*
- *Experiencing self-efficacy;*
- *Having a growth mindset;*
- *Developing interests and a sense of purpose;*

2. *Self-Management*

The capacity to control one's emotions, thoughts, and actions in a variety of situations and to realise one's ambitions. This includes delaying obtaining one's desires, dealing with stress, and feeling motivated and accountable for achieving personal and group goals. For instance:

- *Managing one's emotions;*
- *Identifying and utilising stress-management strategies;*
- *Demonstrating self-discipline and self-motivation;*
- *Setting personal and group goals;*
- *Using planning and organisation skills;*
- *Having the courage to take the initiative;*
- *Demonstrating personal and collective agency;*

3. *Social Awareness*

The capacity to comprehend and care for others regardless of their backgrounds, cultures, and circumstances. This includes caring for others, understanding larger historical and social norms for behaviour in different contexts, and recognising family, school, and community resources and supports. For instance:

- *Recognising others' strengths*
- *Demonstrating empathy and compassion*
- *Caring about others' feelings*
- *Understanding and expressing gratitude*
- *Recognising situational demands and opportunities*
- *Understanding how organisations and systems influence behaviour*

4. *Relationship Skills*

The capacity to establish and maintain healthy, beneficial relationships and adapt to various social situations and groups. This includes speaking clearly, listening attentively, collaborating, solving problems and resolving conflicts as a group, adapting to diverse social and cultural demands and opportunities, taking the initiative, and asking for or offering assistance when necessary. For instance:

- *Communicating effectively;*
- *Building positive relationships;*
- *Demonstrating cultural competence;*
- *Working as a team to solve problems;*
- *Constructively resolving conflicts;*
- *Withstanding negative social pressure;*
- *Taking the initiative in groups;*
- *Seeking or assisting when needed;*
- *Advocating for the rights of others.*

5. *Responsible Decision-Making*

The capacity to make thoughtful and constructive decisions regarding acting and interacting with others in various situations. This includes weighing the pros and cons of various personal, social, and group well-being actions. For example:

- *Demonstrating curiosity and an open mind;*
- *Solving personal and social problems;*
- *Learning to make reasonable decisions after analysing information, data, and facts;*
- *Anticipating and evaluating the effects of one's actions;*
- *Recognising that critical thinking skills are applicable both inside and outside of the classroom;*
- *Reflecting on one's role in promoting personal, family, and community well-being;*
- *Evaluating personal, interpersonal, community, and institutional impacts*

Learning and Teaching Approaches

Learning and teaching should develop learners as self-directed and lifelong learners. Learners must be helped to build up deep learning skills and competencies to develop the ability to acquire, integrate and apply knowledge and skills to solve authentic and real-life problems. Learners need to be exposed to a variety of learning experiences to enable them to collaborate with others, construct meaning, plan, manage, and make choices and decisions about their learning. This will allow them to internalise newly acquired knowledge and skills and help them

to take ownership of their education. The 21st Century skills and competencies describe the relevant global and contextualised skills that the SHS curriculum is designed to help learners acquire in addition to the 4Rs (Reading, wRiting, aRithmetic and cReativity). These skills and competencies, as tools for learning and teaching and skills for life, will allow learners to become critical thinkers, problem-solvers, creators, innovators, good communicators, collaborators, digitally literate, and culturally and globally sensitive citizens who are life-long learners with a keen interest in their personal development and contributing to national development.

Given the diverse needs of learners, teachers need to have a thorough grasp of the different pedagogies as they design and enact meaningful learning experiences to meet the needs of different learners in the classroom. The teaching-learning techniques and strategies should include practical activities, discussion, investigation, role play, problem-based, context-based, and project-based learning. Active learning strategies have become increasingly popular in education as they provide learners with meaningful opportunities to engage with the material. These strategies emphasise the use of creative and inclusive pedagogies and learner-centred approaches anchored on authentic and enquiry-based learning, collaborative and cooperative learning, differentiated teaching and learning, holistic learning, and cross-disciplinary learning. They include experiential learning, problem-based learning, project-based learning, and talk-for-learning approaches. Some of the pedagogical exemplars to guide learning and teaching of the SHS curriculum include:

- **Experiential Learning:** Experiential learning is a hands-on approach to learning that involves learners in real-world experiences. This approach focuses on the process of learning rather than the result. Learners are encouraged to reflect on their experiences and use them to develop new skills and knowledge. Experiential learning can take many forms, including internships, service learning, and field trips. One of the main benefits of experiential learning is that it allows learners to apply what they have learned in the classroom to real-world situations. This can help them develop a deeper understanding of the material and make connections between different concepts. Additionally, experiential learning can help learners develop important skills such as critical thinking, problem-solving and communication.
- **Problem-Based Learning:** Problem-based learning is an approach that involves learners in solving real-world problems. Learners are presented with a problem or scenario and are asked to work together to find a solution. This approach encourages learners to take an active role in their learning and helps them develop important skills such as critical thinking and problem-solving. One of the main benefits of problem-based learning is that it encourages learners to take ownership of their learning. By working together to solve problems, learners can develop important skills such as collaboration and communication. Additionally, problem-based learning can help learners develop a deeper understanding of the material as they apply it to real-world situations.
- **Project-Based Learning:** Project-based learning is a hands-on approach to learning that involves learners in creating a project or product. This approach allows learners to take an active role in their learning and encourages them to develop important skills such as critical thinking, problem-solving, collaboration, and communication. One of the main benefits of project-based learning is that it allows learners to apply what they have learned in the classroom to real-world situations. Additionally, project-based learning can help learners develop important skills from each other and develop a deeper understanding of the material.
- **Talk for Learning Approaches:** Talk for learning approaches (TfL) are a range of techniques and strategies that are used to encourage learners to talk by involving them in discussions and debates about the material they are learning. This approach encourages learners to take an active role in their learning and helps them develop important skills such as critical thinking, collaboration and communication and also makes them develop confidence. One of the main benefits of TfL is that it encourages learners to think deeply about the material they are learning. By engaging in discussions and debates, learners can develop a deeper understanding of the material and make connections between different concepts.
- **Initiating Talk for Learning:** Initiating talk for learning requires the use of strategies that would encourage learners to talk in class. It helps learners to talk and participate meaningfully and actively in the teaching and learning process. Apart from developing skills such as communication and critical thinking, it also helps learners to develop confidence. Some strategies for initiating talk among learners are Activity Ball; Think-Pair-Share; Always, Sometimes, Never True; Matching and Ordering of Cards.
- **Building on What Others Say:** Building on what others say is an approach that involves learners in listening to and responding to their classmates'

ideas. This approach encourages learners to take an active role in their learning and helps them develop important skills such as critical thinking and communication. One of the main benefits of building on what others say is that it encourages learners to think deeply about the material they are learning. By listening to their classmates' ideas, learners can develop a deeper understanding of the material and make connections between different concepts. Additionally, building on what others say can help learners develop important skills such as collaboration and reflection. Some of the strategies to encourage learners to build on what others say are brainstorming, concept cartoons, pyramid discussion, and 5 Whys, amongst others.

- **Managing Talk for Learning:** Managing talk for learning requires the use of various strategies to effectively coordinate what learners say in class. Effective communication is a crucial aspect of learning in the classroom. Teachers must manage talk to ensure that learners are engaged, learning, and on-task in meaningful and purposeful ways. Some strategies for managing learners' contributions are debates, think-pair-share, sage in the circle etc.
- **Structuring Talk for Learning:** One effective way to shape learners' contributions is to structure classroom discussions. Structured discussions provide a framework for learners to engage in meaningful dialogue and develop critical thinking skills. Teachers can structure discussions by providing clear guidelines, such as speaking one at a time, listening actively, and building on each other's ideas. One popular structured discussion technique is the "think-pair-share" method. In this method, learners think about a question or prompt individually, and then pair up with a partner to discuss their ideas. Finally, the pairs share their ideas with the whole class. This method encourages all learners to participate and ensures that everyone has a chance to share their thoughts. Another effective way to structure talk for learning is to use open-ended questions. Open-ended questions encourage learners to think deeply and critically about a topic. They also promote discussion and collaboration among learners. Teachers can use open-ended questions to guide classroom discussions and encourage learners to share their ideas and perspectives. Other strategies that can be used are Concept/Mind Mapping, "Know," "Want to Know," "Learned" (KWL); Participatory Feedback; and the 5 Whys.
- **Diamond Nine:** The Diamond Nine activity is a useful tool for managing talk for learning in the classroom. This activity involves ranking items or ideas in order of importance or relevance. Learners work in groups to arrange cards or sticky notes with different ideas or concepts into a diamond shape, with the most important idea at the top and the least important at the bottom. The Diamond Nine activity encourages learners to think critically about a topic and prioritise their ideas. It also promotes collaboration and discussion among group members. Teachers can use this activity to introduce a new topic, review material, or assess student understanding.
- **Group Work/Collaborative Learning:** Group work or collaborative learning are effective strategies for managing talk for learning in the classroom. These strategies encourage learners to work together to solve problems, share ideas, and learn from each other. Group work and collaborative learning also promote communication and collaborative skills that are essential for success in the workplace and in life. To implement group work effectively, teachers must provide clear guidelines and expectations for group members. They should also monitor group work to ensure that all learners are participating and on-task. Teachers can also use group work as an opportunity to assess individual student understanding and participation.
- **Inquiry-Based Learning:** Learners explore and discover new information by asking questions and investigating.
- **Problem-Based Learning:** Learners are given real-world problems to solve and must use critical thinking and problem-solving skills.
- **Project-Based Learning:** Learners work on long-term projects that relate to real-world scenarios.
- **Flipped Classroom:** Learners watch lectures or instructional videos at home and complete assignments and activities in class.
- **Mastery-Based Learning:** Learners learn at their own pace and only move on to new material once they have mastered the current material.
- **Gamification:** Learning is turned into a game-like experience with points, rewards, and competition.

These strategies provide learners with opportunities to engage with the material in meaningful ways and develop important skills such as critical thinking, problem-solving, collaboration, and communication. By incorporating these strategies into their teaching, teachers can help learners develop a deeper understanding of the material and prepare them for success in the real world. Effective communication is essential for learning in the classroom. Teachers must manage talk to ensure that learners are engaged in learning and on-task. Strategies such as structuring

talk for learning, using Diamond Nine activities, and implementing group work/ collaborative learning can help teachers manage talk effectively and promote student learning and engagement. By implementing these strategies, teachers can create a positive and productive learning environment where all learners can succeed.

Universal Design for Learning (UDL) in the SHS Curriculum

The design of the curriculum uses UDL to ensure the creation of flexible learning environments that can accommodate a wide range of learner abilities, needs, and preferences. The curriculum is designed to provide multiple means of engagement, representation, and action and expression, so teachers can create a more inclusive and effective learning experience for all learners. UDL is beneficial for all learners, but it is particularly beneficial for learners needing special support and learners who may struggle with traditional teaching approaches. The integration of UDL in the pedagogy is aimed at making learning accessible to everyone and helping all learners reach their full potential. For instance, teachers need to:

- incorporate multiple means of representation into their pedagogy, such as using different types of media and materials to present information.
- provide learners with multiple means of action and expression, such as giving them options for how they can demonstrate their learning.
- consider incorporating multiple means of engagement into their choice of pedagogy, such as incorporating games or interactive activities to make learning more fun and engaging.

By doing these, teachers can help ensure that the curriculum is accessible and effective for all learners, regardless of their individual needs and abilities.

Curriculum and Assessment Design: Revised Bloom's Taxonomy and Webb's Depth of Knowledge

The design of this curriculum uses the revised Bloom's Taxonomy and Webb's Depth of Knowledge (DoK) as frameworks to design what to teach and assess.

The Revised Bloom's Taxonomy provides a framework for designing effective learning experiences. Understanding the different levels of learning, informed the creation of activities and assessments that challenge learners at the appropriate level and help them progress to higher levels of thinking. Additionally, the framework emphasises the importance of higher-order thinking skills, such as analysis, evaluation, and creation, which are essential for success in today's complex and rapidly changing world. This framework is a valuable tool for educators who want to design effective learning experiences that challenge students at the appropriate level and help them develop higher-order thinking skills. By understanding the six levels of learning and incorporating them into their teaching, educators can help prepare students for success in the 21st century. The six hierarchical levels of the revised Bloom's Taxonomy are:

1. **Remember** – At the foundation is learners' ability to remember. That is retrieving knowledge from long-term memory. This level requires learners to recall concepts—identify, recall, and retrieve information. Remembering is comprised of identifying, listing, and describing. Retrieving relevant knowledge from long-term memory includes, recognising, and recalling is critical for this level.
2. **Understand** – At understanding, learners are required to construct meaning that can be shown through clarification, paraphrasing, representing, comparing, contrasting and the ability to predict. This level requires interpretation, demonstration, and classification. Learners explain and interpret concepts at this level.
3. **Apply** – This level requires learners' ability to carry out procedures at the right time in a given situation. This level requires the application of knowledge to novel situations as well as executing, implementing, and solving problems. To apply, learners must solve multi-step problems.
4. **Analyse** – The ability to break things down into their parts and determine relationships between those parts and being able to tell the difference between what is relevant and irrelevant. At this level, information is deconstructed, and its relationships are understood. Comparing and contrasting information and organising it is key. Breaking material into its constituent parts and detecting how the parts relate to one another and an overall structure or purpose is required. The analysis also includes differentiating, organising and attributing.
5. **Evaluate** – The ability to make judgments based on criteria. To check whether there are fallacies and inconsistencies. This level involves information evaluation, critique, examination, and formulation of hypotheses.
6. **Create** – The ability to design a project or an experiment. To create, entails learners bringing something new. This level requires generating information—planning, designing, and constructing.

Webb's Depth of Knowledge (DoK) is a framework that helps educators and learners understand the level of cognitive engagement required for different types of learning tasks. The framework includes four levels. By understanding the four DoK levels, educators can design learning activities that challenge students to engage in deeper thinking and problem-solving. DoK is an essential tool for designing effective instruction and assessments. By understanding the different levels of DoK, teachers can design instruction and assessments that align with what they intend to achieve. DoK is a useful tool for differentiating instruction and providing appropriate challenges for all learners. Teachers can use DOK to identify students who need additional support or those who are ready for more advanced tasks. The four levels of Webb's' DoK assessment framework are:

- **Level 1: Recall and Reproduction –** Assessment at this level is on recall of facts, concepts, information, and procedures—this involves basic knowledge acquisition. Learners are asked specific questions to launch activities, exercises, and assessments. The assessment is focused on recollection and reproduction.
- **Level 2: Skills of Conceptual Understanding –** Assessment at this level goes beyond simple recall to include making connections between pieces of information. The learner's application of skills and concepts is assessed. The assessment task is focused more on the use of information to solve multi-step problems. A learner is required to make decisions about how to apply facts and details provided to them.
- **Level 3: Strategic Reasoning** – At this level, the learner's strategic thinking and reasoning which is abstract and complex is assessed. The assessment task requires learners to analyse and evaluate composite real-world problems with predictable outcomes. A learner must apply logic, employ problem-solving strategies, and use skills from multiple subject areas to generate solutions. Multitasking is expected of learners at this level.
- **Level 4: Extended Critical Thinking and Reasoning –** At this level of assessment, the learner's extended thinking to solve complex and authentic problems with unpredictable outcomes is the goal. The learner must be able to strategically analyse, investigate, and reflect while working to solve a problem, or changing their approach to accommodate new information. The assessment requires sophisticated and creative thinking. As part of this assessment, the learner must know how to evaluate their progress and determine whether they are on track to a feasible solution for themselves.

The main distinction between these two conceptual frameworks is what is measured. The revised Bloom's Taxonomy assesses the cognitive level that learners must demonstrate as evidence that a learning experience occurred. The DoK, on the other hand, is focused on the context—the scenario, setting, or situation—in which learners should express their learning. In this curriculum, the revised Bloom's taxonomy guided the design, and the DoK is used to guide the assessment of learning. The taxonomy provides the instructional framework, and the DoK analyses the assignment specifics. It is important to note that Bloom's Taxonomy requires learners to master the lower levels before progressing to the next. So, suppose the goal is to apply a mathematical formula. In that case, they must first be able to identify that formula and its primary purpose (remember and understand). The cognitive rigour is therefore presented in incremental steps to demonstrate the learning progression. When measuring assessments in DoK, learners move fluidly through all levels. In the same example, while solving a problem with a formula, learners recall the formula (DoK 1) to solve the problem (DoK 2 and DoK 3). Depending on the difficulty of the problem to be solved, the learner may progress to DoK 4.

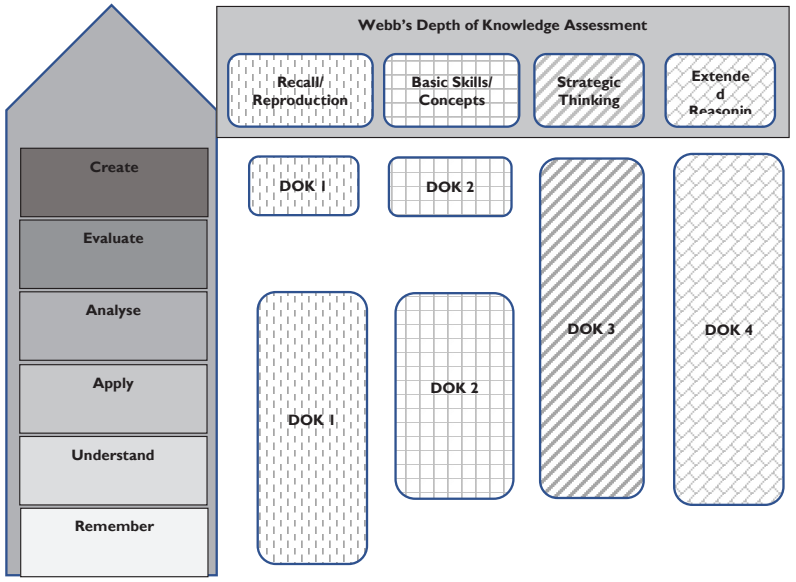

Figure 1: Revised Bloom Taxonomy combined with Webb's Depth of Knowledge for Teaching and Assessment

The structure of teaching and the assessment should align with the six levels of Bloom's knowledge hierarchy and DoK shown in Figure 1. Each level of DoK should be used to assess specific domains of Bloom's Taxonomy as illustrated in the table below:

Depth of Knowledge (DoK) Assessment	Bloom's Taxonomy applied to DoK
• Level 1: Recall and Reproduction	• Remembering, Understanding, Application, Analysis and Creation
• Level 2: Basic Skills and Concepts	• Understanding, Application, Analysis and Creation
• Level 3: Strategic Thinking	• Understanding, Application, Analysis, Evaluation and Creation
• Level 4: Extended Reasoning	• Understanding, Application, Analysis, Evaluation and Creation

In line with the National Pre-Tertiary Learning and Assessment Framework, the Secondary Education Assessment Guide (SEAG) requires that classroom assessments should cover **Assessment as learning (AaL), Assessment of learning (AoL) and Assessment for learning (AfL).** Therefore, teachers should align the Revised Bloom's Taxonomy with the DoK framework of assessment. Formative assessments should include classroom discussions, project-based assignments, and self-reflection exercises, while summative assessments should include standardised tests and rubric-based evaluations of learners' work. It is important to seek feedback from learners themselves, as they may have unique insights into how well they are developing these skills in the classroom.

To assess 21st Century skills and competencies in the classroom, teachers will have to use a combination of both formative and summative assessments to evaluate learners' acquisition of these skills and competencies. For instance:

- Identify the specific 21st Century skills and competencies to be assessed. For instance, you might want to assess *critical thinking, problem-solving, or creativity*.
- Align the skills and competencies with the DoK levels. For example, lower DoK levels might be more appropriate for assessing basic knowledge and comprehension, whereas higher DoK levels might be more appropriate for assessing more complex skills such as *analysis, synthesis, and evaluation*.
- Develop assessment items that align with the DoK levels and the skills and competencies you want to assess. These items should be designed to elicit evidence of learning across the different levels of the DoK framework.
- Administer the assessment and collect data. Analyse the data to gain insights into student learning and identify areas where learners may need additional support or instruction.

The DoK framework is a powerful tool for assessing the acquisition of 21st Century skills and competencies in the classroom, helping teachers to better understand how learners are learning and identify areas for improvement.

Educational success is no longer about producing content knowledge, but rather about extrapolating from what we know and applying the knowledge creatively in new situations.

The overall assessment of learning at SHS should be aligned with the National Pre-Tertiary Learning and Assessment Framework and the Secondary Education Assessment Guide. Formative and summative assessment strategies must be used.

Definition of Key Terms and Concepts in the Curriculum

- **Learning Outcomes:** It is a statement that defines the knowledge, skills, and abilities that learners should possess and be able to demonstrate after completing a learning experience. They are specific, measurable, attainable, and aligned with the content standards of the curriculum. It helps the teachers to determine what to teach, how to teach, and how to assess learning. Also, it communicates expectations to learners and helps them to better master the subject.
- **Learning Indicators:** They are measures that allow teachers to observe progress in the development of capacities and skills. They provide a simple and reliable means to evaluate the quality and efficacy of teaching practices, content delivery, and attainment of learning outcomes.
- **Content Standards:** It is a statement that defines the knowledge, skills, and understanding that learners are expected to learn in a particular subject area or grade level. They provide a clear target for learners and teachers and help focus resources on learner achievement.
- **Pedagogical Exemplars:** They are teaching examples used to convey values and standards to learners. Pedagogical Exemplars are usually demonstrated through teacher behaviour.
- **Assessment:** It is the systematic collection and analysis of data about learners' learning to improve the learning process or make a judgement on learner achievement levels. Assessment is aimed at developing a deep understanding of what learners know, understand, and can do with their knowledge because of their educational experiences. Assessment involves the use of empirical data on learners' learning to improve learning. Assessment is an essential aspect of the teaching and learning process in education, which enables teachers to assess the effectiveness of their teaching by linking learner performance to specific learning outcomes.
- **Teaching and Learning Resources:** Teaching and learning resources are essential tools for teachers to provide high-quality education to their learners. These resources can take various forms, including textbooks, audiovisual materials, online resources, and educational software. It is also important to avoid stereotypes and use inclusive language in teaching and learning resources. This means avoiding language that reinforces negative stereotypes and using language that is respectful and inclusive of all individuals regardless of their background. Using a consistent tone, style, and design is very important.

PHILOSOPHY, VISION AND GOAL OF ENGINEERING

Philosophy

The next generation of creators and technology developers can be empowered through observation, curiosity, exposure to related engineering concepts and opportunities that leverage practical activities in a learner-centred environment, leading to global and local ("glocal") relevance.

Vision

A skilled learner armed with 21st-century skills and competencies in critical thinking, designing, and development of engineering-based solutions for increasingly complex societal problems.

Goal

The goal of this course is to create and nurture sustained interest in practical engineering concepts among senior high school learners while preparing them for the world of work, adult life and further educational pursuits.

Contextual Issues

Engineering Education at Ghanaian Senior High Schools (SHS) is a new initiative arising from the desire of the Ministry of Education to strengthen the teaching of STEM in Ghanaian SHS. Although Science and Mathematics have been regular subjects at all times in the Secondary Education curriculum, the concept of STEM, which is a curriculum-based, interdisciplinary and integrated approach to teaching and learning based on four specific areas of Science, Technology, Engineering, and Mathematics (STEM) is a novelty at the SHS level. Contextually, the teaching of the Science and Mathematics is completely delinked from the skills and competencies that result from the teaching of STEM as defined above, as the Sciences and Mathematics are studied in their respective silos without the conceptual awareness of their relationships and applications.

Thus, Engineering Education, which is a component of STEM Education, must be a means to understanding the essential dynamics that lead to creativity and solving problems while recognising the level of such principles that are sufficient for the design and building of functional systems and devices. The focus should thus be on applying knowledge and principles to design and build devices and systems of technology aimed at solving problems by applying critical thinking, creativity and innovation, leading to the building of 21st-century skills and competencies necessary to make our country a nation of producers rather than one of consumers.

Rationale

Ghana has an opportunity to take a quantum leap in development by transforming its subsistence economy into a high-value-added, skill-based and technology-driven one. To realise this goal requires a computational, practical, and thinking-based education for learners. The rationale of this engineering curriculum is to encourage learners to take ownership of a learning process that allows them to think critically and practically create automation solutions targeted at the 4th industrial revolution using readily available resources, especially those obtained locally.

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SCOPE AND SEQUENCE

Engineering Summary

S/N	STRAND	SUB-STRAND	YEAR 1			YEAR 2			YEAR 3		
			CS 1	LO	LI	CS	LO	LI	CS	LO	LI
1.	Engineering Practice	Engineering In Society	1	2	5	1	1	2	1	2	4
		Health And Safety In Engineering Practice	1	2	4	1	2	6	1	2	4
		Ethics And Professional Practice	1	2	4	1	2	6	1	1	3
2	Energy System	Circuit And Machines	1	2	7	1	2	5	1	2	4
		Renewable Energy System	1	2	4	1	2	4	1	2	4
		Energy Efficiency And Conservation	1	2	4	1	2	4	1	2	4
3	Systems Design And Prototyping	Engineering Design	1	2	4	2	2	2	2	2	2
		Rapid Prototyping	1	1	1	2	2	2	2	2	2
4	Automation And Embedded System	Automation Technologies	1	2	2	1	1	1	1	2	2
		Embedded System	2	4	6	2	2	2	1	1	1
Total			**11**	**21**	**41**	**13**	**18**	**34**	**12**	**18**	**30**

Overall Totals (SHS 1 – 3)

Content Standards	36
Learning Outcomes	57
Learning Indicators	105

YEAR ONE

Subject ENGINEERING
Strand 1. ENGINEERING PRACTICE
Sub-Strand 1. ENGINEERING IN SOCIETY

Learning Outcomes	21st Century Skills and Competencies	GESI[1], SEL[2] and Shared National Values
1.1.1.LO.1		
Identify engineering footprints in learners' communities.	**Communication:** Learners hone their communication skills as they contribute to discussions. **Collaboration:** Learners develop the skill of collaboration as they work in groups. **Critical Thinking:** Learners develop this skill as they brainstorm engineering disciplines. **Communication Skills:** Learners develop this skill as the communicate their ideas to group members and present the works of groups to the entire class. **Social Skills:** Learners acquire social skills as they interact in groups.	**GESI:** As all learners are supported in an inclusive environment and given equal opportunities to succeed in an engineering class, they will: o appreciate, value, and embrace diversity as they are made to work in groups. o learn to amicably resolve conflicts and embrace differing opinions. o develop emotional intelligence as their submissions are critiqued by others. o develop emotional intelligence as others critique their submissions. **National Core Values:** o Tolerance o Integrity o Accountability o Humility o Assertiveness o Patriotism
1.1.1.LO.2		
Explain the role of	**Collaboration:** Learners develop the skill of collaboration as they	**GESI:** As all learners are supported in an

[1] Gender Equality and Social Inclusion

[2] Socio-Emotional Learning

professionals in the engineering disciplines.	work in groups. **Critical Thinking:** Learners develop critical thinking as they brainstorm common engineering skills. **Communication Skills:** o Learners develop this skill as theyy communicate their ideas to group members and present the works of groups to the entire class. o Learners hone their communication skills as they contribute to discussions. **Social Skills:** Learners acquire social skills as they interact in groups.	inclusive environment and given equal opportunities to succeed in an engineering class, they will; o appreciate, value, and embrace diversity as they are made to work in groups. o learn to amicably resolve conflicts and embrace differing opinions. o develop emotional intelligence as their submissions are critiqued by others. o develop emotional intelligence as others critique their submissions. **National Core Values:** o Tolerance o Integrity o Accountability o Humility o Assertiveness o Patriotism

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
1.1.1.CS.1	1.1.1.LI.1	1.1.1.AS.1
Demonstrate an understanding of the place of engineering in societal development.	**Classify the various engineering occupational disciplines.** **Managing Talk for Learning:** In a moderated discussion, learners share their understanding of (a) who an engineer is and (b) what engineering entails. Learners should further describe the work of any engineers they know and explain how important they perceive their work. Furthermore, learners should describe any engineering works they have seen in their communities, on television or through other media. **Initiating Talk for Learning:** The Facilitator introduces the various disciplines in engineering, starting with those that were previously mentioned by learners. For each discipline introduced, individual learners should discuss their role in national development. Use webbing or mind maps to organise learners' thoughts. **Experiential Learning:** Learners watch videos about engineers performing various tasks and discuss their observations. Organise learners' observations with board summaries	**Level 1 Recall** **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning Level 4 Extended critical thinking and reasoning
	1.1.1.LI.2	1.1.1.AS.2
	Outline the contributions of each engineering discipline in solving societal problems. **Collaborative Learning:** Learners work in different task groups, with each group assigned at least one engineering discipline, to brainstorm on the skills and knowledge requirement of the discipline, as well as their contributions to development. Each group should elect a representative to present the thoughts of the group to the class. **Building on What Others say:** Other groups add to the content presented by each group in a respectful manner. Groups should be encouraged to tolerate others' views.	Level 1 Recall **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
	1.1.1.LI.3	1.1.1.AS.3
	Establishing the interdependencies across the engineering disciplines. **Collaborative Learning:** Learners sit in groups, with each group assigned an engineering project, to discuss the engineering disciplines required to execute the project, as well as the specific roles each will play. A representative of each group should present their work.	Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic**

	Building on What Others say: Other groups add to the content presented by each group in a respectful manner. Groups should be encouraged to tolerate others' views.	**reasoning** Level 4 Extended critical thinking and reasoning
	1.1.1.LI.4	1.1.1.AS.4
	Outline the common skill set required by the respective engineering disciplines. **Managing Talk for Learning:** In a moderated discussion, learners share their understanding of the common skillset required by the respective disciplines. Organise or summarise their thoughts using webbing or concept maps. **Building on What Others say:** Other groups add to the content presented by each group in a respectful manner. Groups should be encouraged to tolerate others' views.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning Level 4 Extended critical thinking and reasoning
	1.1.1.LI.5	1.1.1.AS.5
	Explain the unique knowledge requirement of the disciplines – careers. **Managing Talk for Learning:** In a moderated discussion, learners explain the unique knowledge requirement of the engineering disciplines. Organise or summarise their thoughts using webbing or concept maps **Building on What Others say:** Other groups add to the content presented by each group in a respectful manner. Groups should be encouraged to tolerate others' views.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning Level 4 Extended critical thinking and reasoning
Teaching and Learning Resources	○ Projector ○ Laptop and videos on engineering works	

Subject **ENGINEERING**
Strand **1. ENGINEERING PRACTICE**
Sub-Strand **2. HEALTH AND SAFETY IN ENGINEERING PRACTICE**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
1.1.2.LO.1		
Examine the causes, effects and prevention of accidents in engineering practice.	**Communication:** o Learners hone their communication skills as they contribute to discussions. o Learners develop this skill as they communicate their ideas to group members and present the work of groups to the entire class. **Collaboration:** Learners develop the skill of collaboration as they work in groups. **Critical Thinking:** Learners develop this skill as they analyse videos on accidents. **Social Skills:** Learners acquire social skills as they interact in groups.	**GESI:** Providing the opportunity for diverse learners to participate in all lessons inclusively actively and using GESI responsive language as pedagogy ensures: o Awareness of personal biases and stereotypes in an engineering class. o Respect and tolerance for individuals' uniqueness and peculiarities. o Sensitivity to the interrelatedness of the various spheres of life, groups and individuals. **National Core Values:** o Patriotism o Faithfulness o Honesty o Loyalty o Discipline o Respect o Humility o Assertiveness o Good citizenship
1.1.2.LO.2		
Handle and operate workshop machinery and tools based on safety standards.	**Communication Skills:** Learners develop this skill as they contribute to discussions. **Thinking Skills:** Learners acquire/exhibit this skill as the apply	**GESI:** As facilitators steer discussions, they are mindful to stay off biases, stereotypes, and prejudices and place efforts to provide well-balanced examples. This will make learners;

	relevant protocols to handle tools/machinery. **Self-directing:** Learners develop this skill as they proceed to use various tools and machinery.	○ aware of their personal biases and stereotypes, embrace diversity, and practising inclusion.. ○ embrace tolerance and empathy among each other. ○ develop emotional intelligence as others critique their submissions. ○ learn to listen to others of different genders and abilities, thus developing tolerance and listening skills in an engineering class. **National Core Values:** ○ Tolerance ○ Friendliness ○ Open-mindedness ○ Patience ○ Commitment ○ Hard work

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
1.1.2.CS.1	1.1.2.LI.1	1.1.2.AS.1
Demonstrate an understanding of health and safety risks in engineering practice.	**Identify accidents that occur in engineering practice.** **Managing Talk for Learning:** In a moderated discussion, learners share their experiences on accidents they have been involved in or have seen. The experience sharing should cover the cause of the accident, the effect(s) and what could have prevented it. Further to this, learners list potential accidents in engineering practice. **Building on what others say:** Other groups add to the content presented by each group in a respectful manner. Groups should be encouraged to tolerate others' views. **Experiential Learning:** Watch pictures/videos on accidents in engineering practice and share observations with the rest of the class.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning Level 4 Extended critical thinking and reasoning
	1.1.2.LI.2	1.1.2.AS.2
	Identify the causes of accidents in engineering practice and explain their effects. **Initiating Talk for Learning:** In a question-and-answer session, learners' views on the causes of various accidents in engineering practice and their effects. In pairs, learners think and share views on the effects of accidents. Organise learners' thoughts on each accident using concept maps. **Experiential Learning and Collaborative Learning:** Learners watch a video on accidents in engineering practice and in groups and discuss the causes of the accidents and what could have been done to prevent them.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning Level 4 Extended critical thinking and reasoning
	1.1.2.LI.3	1.1.2.AS.3
	Explain the health and safety protocols associated with basic workshop tools/machinery. **Initiating Talk for Learning:** From videos and or pictures, learners identify workshop tools and machinery. In pairs, learners discuss and share with the whole class the uses of such equipment. **Managing Talk for Learning:** In a moderated discussion, learners outline their perceived health and safety protocols for each tool/machinery.	Level 1 Recall **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning Level 4 Extended critical thinking and

	Building on what others say: Individuals add to what others have said respectfully. Learners should be encouraged to tolerate others' views. **Digital Learning:** Learners watch videos on health and safety protocols in the use of workshop tools/machinery and share their observations with the whole class.	reasoning
	1.1.2.LI.4	1.1.2.AS.4
	Demonstrate the use of both hand and power tools according to proper health and safety protocols. **Experiential Learning:** At the workshop, each learner should be guided to use various tools and machinery in line with health and safety protocols. Other learners observe and comment on how equipment has been handled.	Level 1 Recall **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning Level 4 Extended critical thinking and reasoning
Teaching and Learning Resources	○ Projector ○ Laptop ○ Videos and pictures of accidents in engineering practice	○ Videos on health and safety in the use of workshop tools/machinery. ○ Various workshop tools and machinery

Subject **ENGINEERING**
Strand **1. ENGINEERING PRACTICE**
Sub-Strand **3. ETHICS AND PROFESSIONAL PRACTICE**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
1.1.3.LO.1		
Explain the importance of ethical behaviour in engineering practice.	**Communication Skills:** o Learners develop this skill as they partake in class discussions, communicate their ideas to group members, and present the works of groups to the entire class. o Learners develop this skill as they partake in class discussions. **Collaboration:** Learners develop the skill of collaboration as they work in groups. **Critical Thinking:** Learners develop this skill as they critique behaviours that are listed as ethical or unethical. **Social Skills:** Learners acquire social skills as they interact in groups.	**GESI:** Ensuring all learners in class irrespective of the diversity in ability, socio-cultural backgrounds, and gender and soliciting contributions from all learners ensures; o respect for individuals of varying beliefs, religions, backgrounds and cultures o knowledge of themselves and others' peculiarities, strengths and weaknesses o tolerance for diversity, and respect for all. **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment o Hard work
1.1.3.LO.2		
Outline key ethical behaviours in engineering practice.	**Communication Skills:** Learners develop this skill as they partake in class discussions. **Critical Thinking:** Learners develop this skill as they critically analyse scenarios and conducts. **Communication Skills:** Learners develop this skill as they communicate their ideas.	

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
1.1.3.CS.1	1.1.3.LI.1	1.1.3.AS.1
Demonstrate knowledge and appreciation of ethics in engineering practice.	**Explain ethical and unethical behaviour in the field of engineering.** **Managing Talk for Learning:** In a moderated discussion, learners explain their understanding of ethical and unethical behaviours in everyday life. Learners further share their experiences of such behaviours. **Building on what others say: The** Facilitator adds to the explanations offered and experiences shared. **Collaborative Learning:** Learners work in groups to list examples of ethical and unethical behaviours other than those previously discussed. Each group elects a representative to present their work. **Experiential Learning:** Learners watch videos on ethical and unethical behaviours in everyday life.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning: Level 4 Extended critical thinking and reasoning
	1.1.3.LI.2	1.1.3.AS.2
	Explain the relevance of ethics in engineering practice. **Managing Talk for Learning:** In a moderated discussion, individual learners explain the relevance of ethics in engineering practice. Learners critique what others say and add.	Level 1 Recall **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning Level 4 Extended critical thinking and reasoning
	1.1.3.LI.3	1.1.3.AS.3
	Distinguish between ethical and unethical behaviours in engineering practice. **Managing Talk for Learning:** In a moderated discussion, learners outline what they consider to be ethical and unethical behaviours in engineering practice. Summarise learners' thoughts using concept maps or webbing	**Level 1 Recall** **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning**

	Building on what others say: Learners build on what others say and catalogue ethical and unethical behaviours in engineering practice. **Digital Learning:** Learners watch videos on ethical and unethical behaviours in engineering practice and share observations with their colleagues.	Level 4 Extended critical thinking and reasoning
	1.1.3.LI.4	1.1.3.AS.4
	Demonstrate ethical behaviour in the field of engineering. **Collaborative Learning:** o Present various case study scenarios reflecting conduct by engineers for learners to discuss whether each conduct is ethical or unethical. o The facilitator presents various scenarios for learners to indicate their course of action while others critique or endorse the intended actions. o Learners come up with various scenarios for colleagues to express their possible actions for discussion. Encourage learners to accept and present views in a tolerant and respectful manner	Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
Teaching and Learning Resources	o Projector o Laptop	o Videos on ethical and unethical behaviours in everyday life. o Videos on ethical and unethical behaviours in engineering practice.

Subject ENGINEERING
Strand 2. ENERGY SYSTEMS
Sub-Strand 1. CIRCUIT AND MACHINES

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
1.2.1.LO.1		
Identify and explain the functions of the elements of dc and ac circuits.	**Communication Skills:** Learners develop this skill as they partake in class discussions. **Career/Life Skills:** Understanding of content puts learners on the path to becoming self-directed and independent learners.	**GESI:** Using GESI responsive pedagogies and language that supports all learners in an inclusive setting will; o Enable learners to freely ask questions without intimidation. o help learners embrace empathy and discipline among themselves. o help learners to be disciplined as deadlines are given for their projects. **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment o Hard work
1.2.1.LO.2		
Analyse simple dc and single-phase ac circuits.	**Communication Skills:** Learners develop this skill as they partake in class discussions. **Career/Life Skills:** Understanding of content puts learners on the path to becoming self-directed and independent learners. **Problem-solving Skills:** Learners sharpen this skill as they analyse various circuits.	**GESI:** Given equal opportunities to all learners irrespective of their background and soliciting views from all learners ensures; o respect for individuals of varying beliefs, religions, backgrounds and cultures o sensitivity to the inter-relatedness of the various spheres of life, groups and individuals o awareness of personal biases, peculiarities

	Critical Thinking: Learners sharpen this skill as they analyse circuits.	and stereotypes ○ tolerance for diversity **National Core Values:** ○ Tolerance ○ Friendliness ○ Open-mindedness ○ Patience ○ Commitment and hard work ○ Honesty and truthfulness

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
1.2.1.CS.1	1.2.1.LI.1	1.2.1.AS.1
Demonstrate knowledge of simple electric circuits based on first principles and through simulation tools.	**Identify the basic elements of DC electric and electronic circuit and sketch their circuit symbols** **Managing Talk for Learning:** Learners share experiences on the application and components of electric circuits they have observed or built. **Initiating Talk for Learning:** The facilitator explains the differences between electric and electronic circuits. He/She further explains the application of electric circuits, introduces the basic elements of dc and ac circuits (including their functions), and distinguishes DC and AC circuits. The facilitator aids learners in sketching the symbols of the circuit elements **Digital Learning:** Learners watch videos on the elements of dc and ac circuits. They also inspect circuit elements at the laboratory and share their observations	**Level 1 Recall** **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning Level 4 Extended critical thinking and reasoning
	1.2.1.LI.2	1.2.1.AS.2
	Classify circuit elements into passive and active elements. **Initiating Talk for Learning:** In a question-and-answer session, learners make a distinction between passive and active circuit elements. Use concept maps to organise the contributions and thoughts of learners. In small mixed-ability groups, learners classify the circuit elements as passive and active and share their reports with the whole class.	**Level 1 Recall** Level 2 Skills of conceptual understanding Level 3 Strategic reasoning **Level 4 Extended critical thinking and reasoning**

	1.2.1.LI.3	1.2.1.AS.3
	Explain Kirchhoff's laws. **Initiating Talk for Learning:** Guide learners to search for the Kirchhoff law and share it with the whole class. Through question-and-answer sessions, learners explain Kirchhoff's current and voltage laws. Critique their contribution and add to summarise.	Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
	1.2.1.LI.4	1.2.1.AS.4
	Use Kirchhoff's laws to find current and voltage in dc circuits. **Initiating Talk for Learning:** Provide learners with sources to read or watch videos and share their thoughts on how to apply Kirchhoff's current and voltage laws to find the currents and voltages in simple dc circuits. The examples used should not have more than two sources. Add to learners' views for clarity,	Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
	1.2.1.LI.5	1.2.1.AS.5
	Compute power in dc and single-phase ac circuits. **Initiating Talk for Learning:** The facilitator draws and explains the power training, including the power factor. The facilitator further provides all relevant equations. **Problem-based Learning:** Present various dc and ac circuit problems for the class to collectively discuss and solve. Learners sit in small mixed-ability groups to solve circuit problems and share their solutions with the whole class,	Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning

	1.2.1.LI.6	1.2.1.AS.6
	Use a software tool to simulate simple circuits to derive current, voltage and power in DC and AC circuits. **Problem-based Learning:** In a computer lab, explain to learners how to use software to simulate DC and AC circuits. Present various DC and AC circuits for learners to simulate and compare results with hand calculations.	Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
Teaching and Learning Resources	○ Projector ○ Laptop ○ Videos on dc and ac circuit elements ○ Assorted dc and ac electric circuit elements (e.g., Inductors, capacitors, resistors, switches, etc.)	○ Whiteboard and marker ○ Whiteboard and marker ○ Simulation software (e.g., Proteus)

Subject **ENGINEERING**
Strand **2. ENERGY SYSTEMS**
Sub-Strand **2. RENEWABLE ENERGY SYSTEMS**

Learning Outcomes	**21st Century Skills and Competencies**	**GESI, SEL and Shared National Values**
1.2.2.LO.1		
Discuss the benefits of renewable energy.	**Communication Skills:** Learners develop this skill as they partake in class discussions. T**hinking Skills:** o Learners improve their skills as they categorize energy sources. o Learners sharpen this skill as they present their thoughts on the topic.	**GESI:** Using mixed-ability and mixed-gender pairing, special attention given to the catch-up, regular and gifted and talented learners leads to; o Respecting individuals of varying abilities, beliefs, religions and cultures o Being sensitive to the inter-relatedness of the various spheres of life, groups and individuals o Being aware of personal biases and stereotypes o Embracing diversity and practising inclusion **National Core Values:** o Integrity o Tolerance o Open-mindedness o Patience o Integrity o Hard work
1.2.2.LO.2		
Explain the electricity production processes for the various renewable	**Career/Life Skills:** Understanding of content puts learners on the path to becoming self-directed and independent learners.	**GESI:** Ensuring all learners in class irrespective of the diversity in ability,

energy sources.	**Collaboration Skills:** Learners hone the skill as they work in teams. **Technology usage:** Learners sharpen their skills in technology usage as they employ computers and the internet to execute assigned tasks. **Communication Skills:** Learners develop this skill as they partake in class discussions. T**hinking Skills:** Learners sharpen this skill as they present their thoughts on the topic.	socio-cultural backgrounds, and gender and soliciting contributions from all learners ensures; o respect for individuals of varying beliefs, religions, backgrounds and cultures o knowledge of themselves and others' peculiarities, strengths and weaknesses o tolerance for diversity, and respect for all. **National Core Values:** Tolerance, friendliness, open-mindedness, patience, commitment and hard work.

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
1.2.2.CS.1	1.2.2.LI.1	1.2.2.AS.1
Demonstrate an understanding of the sources of renewable energy.	**Identify the sources of renewable energy.** **Managing Talk for Learning:** In a moderated discussion, learners mention the sources of energy and categorize them into renewable and non-renewable sources. **Experiential Learning:** Learners watch videos on renewable energy sources and share their observations with the whole class.	**Level 1 Recall** Level 2 Skills of conceptual understanding Level 3 Strategic reasoning Level 4 Extended critical thinking and reasoning
	1.2.2.LI.2	1.2.2.AS.2
	Explain how renewable energy sources benefit humanity and contribute towards the attainment of the SDGs. **Managing Talk for Learning:** In a moderated discussion, learners discuss the benefits derived from renewable energy sources and how they contribute to the realisation of the SDGs. Organise views of learners using concept maps.	Level 1 Recall **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning Level 4 Extended critical thinking and reasoning
	1.2.2.LI.3	1.2.2.AS.3
	Explain how electricity is generated from water, wind, solar, biomass, and biogas energy sources. **Initiating Talk for Learning:** Through questions and answers and watching videos from YouTube, learners share their views on processes for generating electricity from water, wind, solar, biomass, and biogas energy sources. **Project-based Learning:** Learners work in different task groups to research how power is generated from various sources. Groups share their findings with the whole class. Mixed ability/gender groups are given a company each to research that manufactures electricity generation systems for renewable energy sources. Groups share their findings with the whole class.	**Level 1 Recall** Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning

	1.2.2.LI.4	1.2.2.AS.4
	Compare electricity generation from the various renewable energy sources. **Managing Talk for Learning:** In different task groups, learners discuss the availability of resources, quantity of electricity that could be generated, ease of energy generation, cost of generation, and availability of technology for various electricity generation systems for renewable energy.	Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
Teaching and Learning Resources	○ Projector ○ Laptop and videos on renewable energy sources.	○ Videos on electricity generation from renewable energy sources. ○ Whiteboard and marker

Subject **Engineering**
Strand **2. Energy Systems**
Sub-Strand **3. Energy Efficiency and Conservation**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
1.2.3.LO.1		
Use various instruments to measure electrical and non-electrical quantities in renewable energy systems.	**Communication Skills:** Learners develop this skill as they partake in class discussions. **Thinking Skills:** Learners improve their skills as they contribute to the discussion. **Career/Life Skills:** Understanding of content puts learners on the path to becoming self-directed and independent learners. **Technology usage:** Learners sharpen their skills in technology usage as they handle various instruments.	**GESI:** As all learners are supported in an inclusive environment and given equal opportunities, they will; o appreciate, value, and embrace diversity as they are made to work in groups. o develop emotional intelligence as others critique their submissions. o embrace tolerance and empathy among each other. **National core values:** o Tolerance o Integrity o Accountability o Humility o Assertiveness and patriotism
1.2.3.LO.2		
Estimate and interpret energy consumption of electrical and mechanical equipment.	**Communication Skills:** Learners develop this skill as they partake in class discussions. **Thinking Skills:** o Learners sharpen this skill as they present their thoughts on the topic. o Learners improve their skills as they contribute to the discussion.	**GESI:** Ensuring all learners in class irrespective of the diversity in ability, socio-cultural backgrounds, and gender and soliciting contributions from all learners ensures; o respect for individuals of varying beliefs, religions, backgrounds and

	Career/Life Skills: Understanding of content puts learners on the path to becoming self-directed and independent learners.	cultures o knowledge of themselves and others' peculiarities, strengths and weaknesses o tolerance for diversity, and respect for all. **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment and Hard Work

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
1.2.3.CS.1	1.2.3.LI.1	1.2.3.AS.1
Develop the skill to measure, estimate, and analyse energy production and consumption in renewable energy systems.	**Identify instruments used for measuring electrical and non-electrical quantities in renewable energy systems.** **Managing Talk for Learning:** In a moderated discussion, learners discuss electrical and non-electrical parameters in renewable energy systems that require measurement and indicate the instrument that could be used. **Initiating Talk for Learning:** The facilitator presents a comprehensive list of electrical and non-electrical quantities in energy systems that require measurement and the associated instruments for measurement. **Experiential Learning:** Learners inspect the various instruments for the measurements.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
	1.2.3.LI.2	1.2.3.AS.2
	Use various instruments to accurately measure electrical and non-electrical quantities. **Experiential Learning:** Learners visit various renewable energy systems or watch videos of them and perform measurements of electrical and non-electrical quantities with facilitators' guidance.	Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
	1.2.3.LI.3	1.2.3.AS.3
	Extract data from nameplates of equipment. **Initiating Talk for Learning:** Through a question and answer session**,** individual learners explain what a nameplate is and its relevance. Learners are presented with nameplates (actual or photographs) of various equipment for them to inspect and share with the whole class.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning Level 4 Extended critical thinking and

		reasoning
	1.2.3.LI.4	1.2.3.AS.4
	Compute and interpret energy consumption from nameplates. **Problem-based Learning:** Learners are provided nameplates of equipment and asked to write down power, voltage, current, power factor, etc. Learners compute power (if not available) and energy over given periods, say 30 minutes, 1 hour, 2 hours, etc. Learners discuss the computations with the whole class. Encourage them to tolerate criticism and respect the views of other people.	Level 1 Recall **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
Teaching and Learning Resources	○ Projector ○ Laptops and assorted instruments used to measure electrical and non-electrical quantities in renewable energy systems.	○ Installed renewable energy systems and assorted instruments used to measure electrical and non-electrical quantities in renewable energy systems. ○ Nameplates (actual or photographs) of equipment.

Subject **ENGINEERING**
Strand **3. SYSTEMS DESIGN AND PROTOTYPING**
Sub-Strand **1. ENGINEERING DESIGN**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
1.3.1.LO.1		
Outline the various stages in the Engineering Design Process and their roles in providing sustainable solutions to problems.	**Critical Thinking:** As learners watch the videos and interact with the other learning materials, they critically observe and analyse the engineering design process and its role in product development or solution provision. **Collaboration:** o Learners sit in well-mixed (gender-balanced and culturally diverse) groups and take turns to relay their observations to their peers. This provides the opportunity to learn from others to understand and respect the needs, perspectives, and actions of others. o Learners work on a given case study in groups. The groups are well structured to ensure gender balance, cultural and social diversity and inclusivity. This provides learners the opportunity to learn from others to understand and respect the needs, perspectives, and actions of others**.** **Communication:** Learners express their thoughts among their peers in an environment that is free from fear or intimidation. **Systems Thinking:** As learners analyse a given problem to come out with requirements, they develop the ability to break complex systems or problems down into subcomponents and establish relationships between them.	**GESI:** Involving all learners in class irrespective of their varying abilities, gender and backgrounds, supporting them to share their views and thoughts ensures; o respect for individuals of varying beliefs, religions, backgrounds and cultures o sensitivity to the inter-relatedness of the various spheres of life, groups and individuals o awareness of personal biases, peculiarities and stereotypes o tolerance for diversity **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment o Integrity
1.3.1.LO.2		
Conduct research to answer questions related to a given	**Systems Thinking:** As learners analyse a given problem to come out with requirements, they develop the ability to break complex systems or problems	

problem.	down into sub-components and establish relationships between them. **Collaboration:** Learners work on a given case study in groups. The groups are well structured to ensure gender balance, cultural and social diversity and inclusivity. This provides learners the opportunity to learn from others to understand and respect the needs, perspectives, and actions of others. **Communication:** Learners express their thoughts with their peers in an environment that is free from fear or intimidation.	

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
1.3.1.CS.1	1.3.1.LI.1	1.3.1.AS.1
Demonstrate an understanding of the Engineering Design Process.	**Identify the various elements within the engineering design process.** **Initiating Talk for Learning:** o The facilitator initiates a discussion by introducing the engineering design process and its role in providing sustainable solutions to problems and the development of innovative products. o Learners discuss how the engineering design process was used in the development of some common products around them, like cell phones and television sets and the solution to societal problems like sanitation, irrigation and food security. Use a flowchart to illustrate the design process. **Digital Learning:** Watch videos on the demonstration of the engineering design process and how it is applied to several problems and products. **Collaborative Learning**: Work in mixed-ability groups and discuss learner observations on the engineering design process. Groups should make presentations on their observations and tolerate the views of colleagues.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning Level 4 Extended critical thinking and reasoning
	1.3.1.LI.2	1.3.1.AS.2
	Document solution requirements for a given problem. **Initiating Talk for Learning:** Initiate a discussion by introducing the concept of requirements documentation for product and solution development. Through questions and answers, learners explain concepts and use concept maps to organise thoughts. **Problem-Based Learning:** Learners work on a case study to develop solution requirements and objectives. Present what has been developed to the whole class for comments.	Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
	1.3.1.LI.3	1.3.1.AS.3
	Develop relevant research questions for a given problem. **Collaborative Learning:** Learners work in groups on a given case study to document research questions for a given problem. Learners will make a presentation on the solution to the class.	Level 1 Recall Level 2 Skills of conceptual understanding

	Problem-Based Learning: Learners work on a case study to develop solution requirements and make presentations to the whole class.	**Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
	1.3.1.LI.4	1.3.1.AS.4
	Formulate research objectives for a given problem. **Collaborative Learning:** Learners work in groups on a given case study to document research objectives for a given problem. Learners will make a presentation on the solution to the class. **Problem-Based Learning:** Learners work on a case-study to develop solution objectives and make presentations to the whole class. Other groups critique and make suggestions. Encourage learners to tolerate the views of others.	Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
Teaching and Learning Resources	○ Video documentaries ○ Audio-visual equipment ○ Laptops with MS Office installed	

Subject **Engineering**
Strand **3. Systems Design and Prototyping**
Sub-Strand **2. Rapid Prototyping**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
1.3.2.LO.1		
Use major rapid prototyping technologies such as 3D printing, casting, PCB production and laser cutting.	**Critical Thinking:** As learners watch the videos and interact with the other learning materials, they critically observe and analyse the various RP technologies, their relative strengths and use cases for the production of prototypes. **Collaboration:** Learners sit in well-mixed (gender-balanced and culturally diverse) groups and take turns to relay their observations to their peers. This provides the opportunity to learn from others to understand and respect the needs, perspectives, and actions of others. **Communication:** Learners express their thoughts among their peers in an environment that is free from fear or intimidation. **Life-long Learning:** Learners learn how to use ICT tools to improve their presentation skills as group presentations are delivered through MS PowerPoint. Learners also develop an inquiry-based approach to continual learning in their attempt to use digital tools to research and present on various RP technologies.	**GESI:** Using inclusive strategies and pedagogies that promote all learners' wellbeing and develop their potential; o Respect for others and alternative views, as well as the awareness of own biases. o Protect the weak work for the betterment of society and make learners advocate for peace and justice. o Exhibit empathy towards people with special needs. **National Core Values:** o Sacrifice o Selflessness o Compassion o Fairness o Justice o Generosity o Co-operation o Commitment o Collaboration o Excellence o Resourcefulness o Self-discipline

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
1.3.2.CS.1	1.3.2.LI.1	1.3.2.AS.1
Use various Rapid Prototyping (RP) Technologies available and their specific applications.	**Describe the fundamental principles behind 3D printing, casting, PCB production and laser cutters and the specific use case applications.** **Initiating Talk for Learning:** The facilitator initiates a discussion by introducing the concept of rapid prototyping, its role in product design, the various rapid prototyping (RP) technologies and their use cases. The objective is to ignite and sustain the interest of learners to participate in open discussion. **Digital Learning:** Watch videos on 3D printing, casting, PCB production and laser cutting technology employed in RP. The videos will indicate the operating principles, use cases and strengths and weaknesses of the respective RPs. Learners will also visit RP workshops to have firsthand experience of 3D printing machines producing models as an example of RP technology. **Collaborative Learning:** Work in groups and discuss learner observations on the RP technologies. Groups should make presentations on their observations, critique and add to others' presentations.	Level 1 Recall **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** **Level 4 Extended critical thinking and reasoning**
Teaching and Learning Resources	○ Integrated 3D printing workshop ○ Video documentaries ○ Audio-visual equipment and laptops with MS Office installed	

Subject **ENGINEERING**
Strand **4. AUTOMATION AND EMBEDDED SYSTEMS**
Sub-Strand **1. AUTOMATION TECHNOLOGIES**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
1.4.1.LO.1		
Examine fundamental automation components and systems.	**Collaboration:** Working with others on projects or problems can help learners develop important teamwork and communication skills. **Critical thinking and problem-solving:** Problem-based learning and inquiry-based learning can help learners develop critical thinking and problem-solving skills as they work to apply their knowledge of automation system components to propose how some processes around them could be automated. **Digital Literacy:** Using online resources and simulations can help learners develop skills in using technology and finding and evaluating online information. **Adaptability:** Working on real-world projects or problems can help learners learn to adapt and be flexible as they encounter new challenges and changing requirements.	**GESI:** Creating equal opportunities for all learners to participate in class through the use of balanced gender groups leads to; o tolerance and respect for each other o confidence and efficacy in their ability to perform. o awareness of themselves and others, taking into consideration their biases and stereotypes. **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment o Integrity
1.4.1.LO.2		
Interpret basic engineering schematics and technical drawings related to the automation industry.	**Collaboration:** Working with others on projects or problems can help learners develop important teamwork and communication skills. **Critical Thinking and Problem-Solving:** Problem-based learning and	**GESI:** Ensuring all learners in class irrespective of the diversity in ability, socio-cultural backgrounds, and gender and soliciting contributions

	inquiry-based learning can help learners develop critical thinking and problem-solving skills as they interpret technical diagrams to implement a solution or troubleshoot systems. **Digital Literacy:** Using online resources and simulations can help learners develop skills in using technology and finding and evaluating online information. **Adaptability:** Working on real-world projects or problems can help learners learn to adapt and be flexible as they encounter new challenges and changing requirements. **Initiative:** Giving learners the opportunity to take the lead on projects and explore other resources on Engineering drawings on their own can help them develop initiative and self-direction.	from all learners ensures; o respect for individuals of varying beliefs, religions, backgrounds and cultures o knowledge of themselves and others' peculiarities, strengths and weaknesses o tolerance for diversity and respect for all **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment o Hard work

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
1.4.1.CS.1	1.4.1.LI.1	1.4.1.AS.1
Demonstrate knowledge and understanding of general concepts, components and systems in the Automation Industry.	**Identify basic automation components and materials and their respective functions or roles in the automation industry.** **Initiating Talk for Learning:** The facilitator initiates a discussion by introducing the history of automation, its role in industrialisation, common components such as relays, motors, switches, sensors, and PLCs and how they have been used in common automation systems around learners' community such as automated irrigation systems, automated street lights, water level controllers, automated doors and gates at public places. Learners discuss the specific roles components or subsystems play in each of the cited automated systems. **Experiential Learning:** Watch videos on different kinds of automated systems with a focus on the role of automation in industrialisation and the roles of system components or sub-systems in realising the specific automation systems. Learners should be taken on a tour of the automation workshop to see and experience the various automation components. They should also visit any local innovation hub or factory which has any automated system(s) installed to observe how the various components work together to achieve the design objective. **Collaborative Learning:** Work in groups and discuss learner observations on the role of automation in industrialisation as well as system component functions. Learners should be given a task to propose how some of the components could be put together to automate some activities within their communities. Groups should make presentations on their observations. **Self-Directed Learning:** Explore online resources: There are many online resources available that can help Learners learn more automation systems.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** **Level 4 Extended critical thinking and reasoning**

	1.4.1.LI.2	1.4.1.AS.2
	Interpret and connect system components according to technical drawings and vice versa. **Initiating Talk for Learning:** The facilitator initiates a discussion by introducing learners to the role of technical drawings in professional practice in general and automation in particular. **Experiential Learning:** Introduce learners to Electrical, pneumatic, hydraulic, and piping schematics using samples for them to identify distinguishing features and characteristics. Learners are also guided through hands-on experience on how to identify fluid and signal flows on given schematics. Learners are also exposed to the creation and interpretation of functional block diagrams for automation systems. **Project-based Learning:** Learners work on a project that involves interpreting and assembling components from a given electrical single-line wiring diagram. **Digital Learning:** Explore online resources. There are many online resources available that can help Learners learn more interpretation of engineering schematics and technical drawings. Learners should be tasked to look for more schematics and technical drawings from these sources implement and report on outcomes. **Collaborative Learning:** Work in groups on a mini project which involves interpreting and assembling system components from a given schematic. Display the project for the whole class to observe and comment. Encourage learners to comment respectfully and tolerate others' views.	Level 1 Recall Level 2 Skills of **conceptual understanding** **Level 3 Strategic reasoning** **Level 4 Extended critical thinking and reasoning**
Teaching and Learning Resources	○ Automation workshop ○ Video documentaries	○ Audio-visual equipment ○ Laptops with MS Office installed

Subject **ENGINEERING**
Strand **4. AUTOMATION AND EMBEDDED SYSTEMS**
Sub-Strand **2. EMBEDDED SYSTEMS**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
1.4.2.LO.1		
Explain the importance and applications of embedded systems.	**Problem-solving and Critical Thinking:** Embedded systems projects often require learners to analyse complex systems, design solutions, and troubleshoot problems. Through this process, they will develop their problem-solving and critical-thinking skills. **Collaboration and Teamwork**: Embedded systems projects often involve working with a team of peers. By collaborating with others, learners will develop their teamwork and communication skills. **Creativity and Innovation**: Through embedded systems projects, learners will be able to express their creativity and develop their innovation skills. They can come up with new ideas and designs and test them out to see if they work. **Technical Literacy:** By studying embedded systems, learners will develop their technical literacy and gain knowledge in specific technical areas such as programming, microcontroller architectures, and electronics. **Computational Thinking:** By understanding the concepts of embedded systems, learners will learn to think in computational terms and will have a better understanding of how algorithms, data structures and programming languages work. **Digital Literacy:** learners will be exposed to different digital technologies such as sensors and actuators, microcontroller development boards, and	**GESI:** Creating an inclusive learning environment for all to participate in lessons will enable learners; o Embrace diversity, practise inclusion, exhibit empathy towards people with special needs, respect the opinions of others and use gender-sensitive language. o Exercise empathy to users of the internet space and be sensitive to the inter-relatedness of the various expressions as a testament of spheres of life among groups and individuals. **National Core Values:** o Ingenuity o Hard work o Excellence o Cooperation o Collaboration o Patriotism o Cultural awareness

	programming software. They will learn how to work with digital tools, as well as how to analyse, evaluate and communicate information using digital technologies.	
1.4.2.LO.2		
Differentiate between the various microcontroller architectures.	**Problem-solving and Critical Thinking:** Embedded systems projects often require learners to analyse complex systems, design solutions, and troubleshoot problems. Through this process, they will develop their problem-solving and critical-thinking skills. **Collaboration and Teamwork:** Embedded systems projects often involve working with a team of peers. By collaborating with others, learners will develop their teamwork and communication skills. **Creativity and Innovation:** Through embedded systems projects, learners will be able to express their creativity and develop their innovation skills. They can come up with new ideas and designs and test them out to see if they work. **Technical Literacy:** By studying embedded systems, learners will develop their technical literacy and gain knowledge in specific technical areas such as programming, microcontroller architectures, and electronics. **Computational Thinking:** By understanding the concepts of embedded systems, learners will learn to think in computational terms and will have a better understanding of how algorithms, data structures and programming languages work.	**GESI:** Working with each other in an inclusive way, cross-sharing of knowledge and understanding between and among groups and individuals, for instance, leads to; o Respecting individuals of varying beliefs, religions and cultures o Being sensitive to the inter-relatedness of the various spheres of life, groups and individuals o Being aware of personal biases and stereotypes o Embracing diversity and practising inclusion. **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment o Hard work

	Digital Literacy: learners will be exposed to different digital technologies such as sensors and actuators, microcontroller development boards, and programming software. They will learn how to work with digital tools, as well as how to analyse, evaluate and communicate information using digital technologies.	
1.4.2.LO.3		
Explain the various memory architectures.	**Problem-solving and Critical Thinking:** Embedded systems projects often require learners to analyse complex systems, design solutions, and troubleshoot problems. Through this process, they will develop their problem-solving and Critical thinking skills. **Collaboration and Teamwork:** Embedded systems projects often involve working with a team of peers. By collaborating with others, learners will develop their teamwork and communication skills. **Creativity and Innovation:** Through embedded systems projects, learners will be able to express their creativity and develop their innovation skills. They can come up with new ideas and designs and test them out to see if they work. **Technical Literacy:** By studying embedded systems, learners will develop their technical literacy and gain knowledge in specific technical areas such as programming, microcontroller architectures, and electronics. **Computational Thinking:** By understanding the concepts of embedded systems, learners will learn to think in computational terms and will have a better understanding of how algorithms, data structures and programming languages work. **Digital Literacy:** Learners will be exposed to different digital technologies such as sensors and actuators, microcontroller development boards, and programming software. They will learn how to work with digital tools, as well as how to analyse, evaluate and communicate information using digital	**GESI:** Providing the opportunity for diverse learners to actively participate in all lessons in an inclusive manner and using GESI responsive language as pedagogy ensures; o Awareness of personal biases and stereotypes in the area of engineering o Respect and tolerance for an individual's uniqueness and peculiarities o Sensitivity to the interrelatedness of the various spheres of life, groups and individuals. **National Core Values:** o Patriotism o faithfulness o honesty o loyalty o discipline o respect o humility o assertiveness o good citizenship

	technologies.	
1.4.2.LO.4		
Use the Arduino IDE and configure the environmental variables appropriately.	**Problem-solving and Critical Thinking:** Embedded systems projects often require learners to analyse complex systems, design solutions, and troubleshoot problems. Through this process, they will develop their problem-solving and critical-thinking skills. **Collaboration and Teamwork:** Embedded systems projects often involve working with a team of peers. By collaborating with others, learners will develop their teamwork and communication skills. **Creativity and Innovation:** Through embedded systems projects, learners will be able to express their creativity and develop their innovation skills. They can come up with new ideas and designs and test them out to see if they work. **Technical Literacy:** By studying embedded systems, learners will develop their technical literacy and gain knowledge in specific technical areas such as programming, microcontroller architectures, and electronics. **Computational Thinking:** By understanding the concepts of embedded systems, learners will learn to think in computational terms and will have a better understanding of how algorithms, data structures and programming languages work. **Digital Literacy:** Learners will be exposed to different digital technologies such as sensors and actuators, microcontroller development boards, and programming software. They will learn how to work with digital tools, as well as how to analyse, evaluate and communicate information using digital technologies.	**GESI:** Encouraging all learners in class irrespective of the diversity in gender, ability and backgrounds and supporting each of them to share their views ensures; o respect for individuals of varying beliefs, religion, backgrounds and cultures o knowledge of themselves and others' peculiarities and stereotypes o tolerance for diversity and respect for all **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment o Hard work

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
1.4.2.CS.1	1.4.2.LI.1	1.4.2.AS.1
Demonstrate knowledge and understanding of features and application of embedded systems.	**Identify examples of embedded systems in the community.** **Initiating Talk for Learning:** o Initiates a discussion using questions and answers to introduce embedded systems, their evolution over time, features, application areas and some limitations. o Learners cite some electronic products within their environment, discuss the role of embedded systems within them, and also propose how some existing products could be improved by embedded systems. **Case studies:** learners can study real-world examples of computer systems that use CISC, RISC, and ARISC and learn about the trade-offs between performance, power consumption and cost. For example, they can compare how a modern smartphone using ARM RISC architecture uses less power than traditional x86 CISC-based laptops. **Project-based Learning:** learners research a specific computer architecture or type of memory and present their findings to the class. They can also compare and contrast different architectures and memory types in terms of their features, advantages, and disadvantages. **Classroom Discussions and Debates:** As learners learn about different computer architectures and memory types, they can engage in class discussions and debates about the pros and cons of each. **Talk for Learning:** Inviting a local IT professional or engineer to come and speak to the class about their experiences working with CISC, RISC, ARISC, and different types of memory can be a great way to make the material more relatable and engaging for learners. **Experiential Learning:** Virtual reality has great potential in teaching computer architectures and memory types. It will help learners to see computer architectures and memory types in an interactive way, making it easy to understand.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** **Level 4 Extended critical thinking and reasoning**

	1.4.2.LI.2	1.4.2.AS.2
	Discuss the advantages of embedded systems over fixed electronic circuits for solving similar problems and their limitations for specific scenarios. **Initiating Talk for Learning:** Initiate a discussion using questions and answers to introduce embedded systems, their evolution over time, features, application areas and some limitations. Learners cite some electronic products within their environment, discuss the role of embedded systems within them, and also propose how some existing products could be improved by embedded systems. **Case Studies:** Learners can study real-world examples of computer systems that use CISC, RISC, and ARISC and learn about the trade-offs between performance, power consumption and cost. For example, they can compare how a modern smartphone using ARM RISC architecture uses less power than traditional x86 CISC-based laptops. **Project-based Learning:** Learners research a specific computer architecture or type of memory and present their findings to the class. They can also compare and contrast different architectures and memory types in terms of their features, advantages, and disadvantages. **Classroom Discussions and Debates:** As learners learn about different computer architectures and memory types, they can engage in class discussions and debates about the pros and cons of each. **Talk for Learning:** Inviting a local IT professional or engineer to come and speak to the class about their experiences working with CISC, RISC, ARISC, and different types of memory can be a great way to make the material more relatable and engaging for learners. **Experiential Learning:** Virtual reality has great potential in teaching computer architectures and memory types. It will help learners to see computer architectures and memory types in an interactive way, making it easy to understand.	Level 1 Recall **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** **Level 4 Extended critical thinking and reasoning**
	1.4.2.LI.3	1.4.2.AS.3
	Describe the CISC, RISC and ARISC architectures. **Initiating Talk for Learning:** The facilitator initiates a discussion by introducing embedded systems, their evolution over time, features, application areas and some limitations. Learners cite some electronic products within their environment, discuss the role of embedded systems within them and also propose how some existing products could be improved by embedded systems.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning**

	Case studies: Learners can study real-world examples of computer systems that use CISC, RISC, and ARISC and learn about the trade-offs between performance, power consumption and cost. For example, they can compare how a modern smartphone using ARM RISC architecture uses less power than traditional x86 CISC-based laptops. **Project-based Learning:** Learners research a specific computer architecture or type of memory and present their findings to the class. They can also compare and contrast different architectures and memory types in terms of their features, advantages, and disadvantages. **Collaborative Learning:** As learners learn about different computer architectures and memory types, they can engage in class discussions and debates about the pros and cons of each. **Talk for Learning:** Inviting a local IT professional or engineer to come and speak to the class about their experiences working with CISC, RISC, ARISC and different types of memory can be a great way to make the material more relatable and engaging for learners. **Experiential Learning:** Virtual reality has great potential in teaching computer architectures and memory types. It will help learners to see computer architectures and memory types in an interactive way, making it easy to understand.	**Level 4 Extended critical thinking and reasoning**
	1.4.2.LI.4	1.4.2.AS.4
	Specify use cases for RAM/ROM. **Initiating Talk for Learning:** Initiate a discussion by using questions and answers to introduce embedded systems, their evolution over time, features, application areas and some limitations. Learners cite some electronic products within their environment, discuss the role of embedded systems within them and also propose how some existing products could be improved by embedded systems. **Case studies:** Learners can study real-world examples of computer systems that use CISC, RISC, and ARISC and learn about the trade-offs between performance, power consumption and cost. For example, they can compare how a modern smartphone using ARM RISC architecture uses less power than traditional x86 CISC-based laptops. **Project-based Learning:** Learners research a specific computer architecture or type of memory and	Level 1 Recall **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** **Level 4 Extended critical thinking and reasoning**

	present their findings to the class. They can also compare and contrast different architectures and memory types in terms of their features, advantages, and disadvantages. **Collaborative Learning:** As learners learn about different computer architectures and memory types, they can engage in class discussions and debates about the pros and cons of each. **Talk for Learning:** Inviting a local IT professional or engineer to come and speak to the class about their experiences working with CISC, RISC, ARISC, and different types of memory can be a great way to make the material more relatable and engaging for learners. **Experiential Learning:** Virtual reality has great potential in teaching computer architectures and memory types. It will help learners see computer architectures and memory types in an interactive way, making it easy to understand.	
	1.4.2.LI.5	1.4.2.AS.5
	Describe the memory architectures of RAM and ROM. **Initiating Talk for Learning:** Initiate a discussion by introducing embedded systems, their evolution over time, features, application areas and some limitations. Learners cite some electronic products within their environment, discuss the role of embedded systems within them and also propose how some existing products could be improved by embedded systems. **Case Studies:** Learners can study real-world examples of computer systems that use CISC, RISC, and ARISC and learn about the trade-offs between performance, power consumption and cost. For example, they can compare how a modern smartphone using ARM RISC architecture uses less power than traditional x86 CISC-based laptops. **Project-based Learning:** Learners research a specific computer architecture or type of memory and present their findings to the class. They can also compare and contrast different architectures and memory types in terms of their features, advantages, and disadvantages. **Collaborative Learning:** As learners learn about different computer architectures and memory types, they can engage in class discussions and debates about the pros and cons of each. **Talk for Learning:** Inviting a local IT professional or engineer to come and speak to the class about	Level 1 Recall **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** **Level 4 Extended critical thinking and reasoning**

	their experiences working with CISC, RISC, ARISC and different types of memory can be a great way to make the material more relatable and engaging for learners. **Experiential Learning:** Virtual reality has great potential in teaching computer architectures and memory types. It will help learners to see computer architectures and memory types in an interactive way, making it easy to understand.	
Teaching and Learning Resources	○ Arduino Embedded System Kits ○ Video documentaries	○ Audio-visual equipment and laptops with MS Office installed

Content Standards	**Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI**		**Assessment**
1.4.2.CS.2	1.4.2.LI.1		1.4.2.AS.1
Demonstrate an understanding of the Arduino Platform	**Install and configure the environmental variables of the Arduino IDE and interface with the Arduino hardware successfully.** **Digital Learning:** Learners watch videos of Arduino IDE and how it functions. Learners make observations and share with the whole class by adding to what others say. Explain how both the interface and the platform works. **Game-based Learning:** Use games or simulations to teach Arduino to enable learners to visualise complex concepts, practice problem-solving, and experiment with different scenarios. Learners share ideas and experiences.		Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** **Level 4 Extended critical thinking and reasoning**
Teaching and Learning Resources	○ Arduino Embedded System Kits ○ Video documentaries	○ Audio-visual equipment and laptops with MS Office installed	

YEAR TWO

Subject ENGINEERING
Strand 1. ENGINEERING PRACTICE
Sub-Strand 1. ENGINEERING IN SOCIETY

Learning Outcomes	21st Century Skills and Competencies	GESI[3], SEL[4] and Shared National Values
2.1.1.LO.1		
Use systematic investigation to identify and provide solutions to problems.	**Communication Skills:** o Learners develop this skill as they partake in class discussions o Learners develop this skill as they partake in class discussions, communicate their ideas to group members, and present the works of groups to the entire class. **Collaboration:** Learners develop the skill of collaboration as they work in groups. **Critical Thinking:** Learners develop this skill as they come up with processes to investigate problems. **Social Skills:** Learners acquire social skills as they interact in groups. **Problem-solving Skills:** Learners develop this skill as they grasp the concept of systematic investigation.	**GESI:** Providing the opportunity for diverse learners to actively participate in all lessons in an inclusive manner and using GESI responsive language as pedagogy ensures; o Awareness of personal biases and stereotypes o Respect and tolerance for an individual's uniqueness and peculiarities o Sensitivity to the interrelatedness of the various spheres of life, groups and individuals. **National Core Values:** o Patriotism o Faithfulness o Honesty o Loyalty o Discipline

[3] Gender Equality and Social Inclusion

[4] Socio-Emotional Learning

		○ Respect ○ Humility ○ Assertiveness ○ Good citizenship

Content Standards	**Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI**	**Assessment**
2.1.1.CS.1	2.1.1.LI.1	2.1.1.AS.1
Demonstrate understanding of systematic investigation and model construction.	**Explain systematic investigation and its relevance in engineering professional practice.** **Managing Talk for Learning:** o In a moderated discussion, learners share experiences on any problem they have encountered that required investigation and how they went about the investigation. o Learners think pair and share their views on what systematic investigation is in their own words. Organise/summarise their thoughts using concept maps/webbing. In pairs, let them mention the usefulness of systematic investigation.	Level 1 Recall **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning Level 4 Extended critical thinking and reasoning
	2.1.1.LI.2	2.1.1.AS.2
	Explain the processes for systematic investigation. **Managing Talk for Learning:** In a moderated discussion, learners outline general processes for systematic investigation. Use flowcharts to illustrate the process and summarise their views. **Building on what others say:** The facilitator fine-tunes the processes outlined by learners by adding on. **Collaborative Learning:** Learners sit in groups, and each group is presented with a problem for the group to brainstorm and come up with a process to investigate it. Each group presents their process to the entire class for comments.	Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
Teaching and Learning Resources	o Projector and laptop	

Subject **ENGINEERING**
Strand **1. ENGINEERING PRACTICE**
Sub-Strand **2. HEALTH AND SAFETY IN ENGINEERING PRACTICE**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
2.1.2.LO.1		
Explain risk assessment	**Communication Skills:** Learners develop this skill as they partake in class discussions **Problem-solving Skills:** Learners hone this skill as they learn from the experiences shared by others. **Critical Thinking:** o Learners develop this skill as they determine the most appropriate situations to employ the various types of risk assessment. o Learners develop this skill as they brainstorm on approaches to assess presented risks. o Learners develop this skill as they brainstorm on approaches to control various hazards.	**GESI:** As facilitators steer discussions, they are mindful to stay off biases, stereotypes, and prejudices and place efforts to provide well-balanced examples. This will make learners; o aware of their personal biases and stereotypes, embrace diversity, and practise inclusion. o embrace tolerance and empathy among each other. o learn to listen to others of different gender and abilities, thus developing tolerance and listening skills. **National Core Values:** o Tolerance o friendliness o open-mindedness o patience o commitment o hard work
2.1.2.LO.2		

Perform risk assessment	**Communication Skills:** Learners develop this skill as they partake in group discussions. **Critical Thinking:** Learners develop this skill as they discuss the elements of the risk assessment matrix. **Problem-solving Skills:** Learners hone problem-solving skills as they perform risk assessments. **Critical Thinking:** Learners develop this skill as they brainstorm to generate assessment approaches. **Social Skills:** Learners hone social skills as they engage in group discussions.	**GESI:** As all learners are supported in an inclusive environment and given equal opportunities, they will; o appreciate, value, and embrace diversity as they are made to work in groups. o embrace tolerance and empathy among each other. o learn to resolve conflicts and embrace differing opinions amicably. o develop emotional intelligence as others critique their submissions. **National Core Values:** o Tolerance o Integrity o Accountability o Humility o Assertiveness o Patriotism

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
2.1.2.CS.1	2.1.2.LI.1	2.1.2.AS.1
Demonstrate understanding of risk assessment.	**Describe risk assessment and outline its relevance.** **Managing Talk for Learning:** • In a moderated discussion, learners share experiences on any risk they or others encountered and how they evaluated it. • Learners think pair and share views on what risk assessment is and explain its benefits. **Building on what others say:** Build on the understanding of learners, provide an enhanced definition of risk assessment and further fine-tune its benefits.	Level 1 Recall **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
	2.1.2.LI.2	2.1.2.AS.2
	Explain the types of risk assessment. **Initiating Talk for Learning:** Learners research the various types of risk assessments and share them with the class. **Collaborative Learning:** In small, different tasks in mixed-ability groups, learners discuss when to use the various types of risk assessment and share with the class. Summarise learners' views using mind maps.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
	2.1.2.LI.3	2.1.2.AS.3
	Explain the procedure for risk assessment. **Managing Talk for Learning:** In small mixed-ability groups, present various case studies and various risk scenarios for learners to discuss how to assess them and share them with the class. **Initiating Talk for Learning:** The Facilitator explains to learners the broad approaches to risk assessment and encourages them to ask questions for clarification. Organise views using flowcharts to illustrate procedures for risk assessment	Level 1 Recall **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning

	2.1.2.LI.4	2.1.2.AS.4
	Explain control measures for various hazards. **Initiating Talk for Learning:** Through questions and answers, learners mention hazards they know in pairs. Learners think and share views on control measures that can be adopted to overcome various hazards.	**Level 1 Recall** Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
	2.1.2.LI.5	2.1.2.AS.5
	Apply the risk assessment matrix to a given risk scenario. **Initiating Talk for Learning:** Learners watch videos or pictures on the risk assessment matrix and individually share their views on what it is. Guide learners to individually mention the importance of the matrix. Through questions and answers, learners discuss the elements of the matrix and how it can be applied. Add on what learners say to fine-tune their thoughts.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
	2.1.2.LI.6	2.1.2.AS.6
	Perform risk assessment through the use of case studies. **Collaborative and Problem-based Learning:** Learners sit in mixed-ability groups. The groups are presented with the same risk situation for each group to perform a comprehensive risk assessment and recommend control measures. The groups take turns to present their work to the class for critiquing.	Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
Teaching and Learning Resources	○ Projector and laptop	

Subject **ENGINEERING**
Strand **1. ENGINEERING PRACTICE**
Sub-Strand **3. ETHICS AND PROFESSIONAL PRACTICE**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
2.1.3.LO.1		
Explain the need for professionalism in engineering practice.	**Communication Skills:** o Learners develop this skill as they partake in class discussions o Learners develop this skill as they partake in class discussions. **Critical Thinking:** This skill is developed as learners distinguish between ethical and professional behaviour. **Social responsibility:** Learners develop social responsibility as they appreciate the benefits of professional behaviour.	**GESI:** Ensuring all learners in class irrespective of the diversity in ability, socio-cultural backgrounds, and gender and soliciting contributions from all learners ensures; o respect for individuals of varying beliefs, religions, backgrounds and cultures o knowledge of themselves and others' peculiarities, strengths and weaknesses o tolerance for diversity and respect for all **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment o Hard work
2.1.3.LO.2		
Identify professional behaviour in engineering practice.	**Communication Skills:** Learners develop this skill as they partake in class discussions.	**GESI:** Ensuring all learners in class irrespective of the diversity in ability,

	Social Skills: Learners develop social as they learn from the discussions **Social responsibility:** o Learners develop social responsibility as they discuss the attributes. o Learners develop social responsibility as they discuss the consequences.	socio-cultural backgrounds, and gender and soliciting contributions from all learners ensures; o respect for individuals of varying beliefs, religions, backgrounds and cultures o knowledge of themselves and others' peculiarities, strengths and weaknesses o tolerance for diversity and respect for all **National Core Values:** o Tolerance o friendliness o open-mindedness o patience o commitment o hard work

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
2.1.3.CS.1	2.1.3.LI.1	2.1.3.AS.1
Demonstrate understanding of professionalism and unprofessionalism in engineering practice.	**Explain professionalism in engineering practice.** **Initiating Talk for Learning:** In a moderated discussion, learners comment on the quality of civil and construction works around them. Provide cases and different scenarios for learners to determine what is professional or not. The facilitator explains professionalism in engineering, drawing partly from the comments passed by learners.	Level 1 Recall **Level 2 Skills of conceptual understanding** Level 3 Strategic Reasoning. Level 4 Extended critical thinking and reasoning
	2.1.3.LI.2	2.1.3.AS.2
	Explain professional behaviour. **Initiating Talk for Learning:** Through questions and answers, learners identify what professional behaviour is by giving examples. Fine-tune learners' understanding by explaining professional behaviour further. **Managing Talk for Learning:** Use concept cartoons reflecting ethical/unethical behaviour and professional behaviour. Learners debate the difference between them and examine what constitutes ethical and professional behaviour.	Level 1 Recall **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning Level 4 Extended critical thinking and reasoning
	2.1.3.LI.3	2.1.3.AS.3
	Spell out the benefits of professional behaviour. **Initiating Talk for Learning:** Through questions and answers class discusses the benefits of professional behaviour. Encourage individuals to share their thoughts and use webbing to organise their views.	Level 1 Recall: **Level 2 Skills of conceptual understanding:** Level 3 Strategic reasoning: Level 4 Extended critical thinking and reasoning:

	2.1.3.LI.4	2.1.3.AS.4
	Explain the characteristics of an ethical and professional workplace. **Initiating Talk for Learning: In pairs, think and share views on** the characteristics of workplaces where workers exhibit ethics and professionalism. Conversely, learners discuss the characteristics of workplaces where unethical and unprofessional conduct are exhibited. Provide various scenarios for learners to say whether the environment will promote ethical and professional behaviour or not.	Level 1 Recall **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
	2.1.3.LI.5	2.1.3.AS.5
	Outline the desired attributes of an engineer and explain how those attributes could be developed. **Managing Talk for Learning:** Individually, learners mention the desired characteristics of an engineer. Use webbing to summarise their views. In pairs, learners think about an agreed desired characteristic and discuss how engineers could inculcate them. Learner shares their thought with the whole class.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning Level 4 Extended critical thinking and reasoning
	2.1.3.LI.6	2.1.3.AS.6
	Describe the consequences of unprofessional behaviour. **Managing Talk for Learning:** In small groups, learners discuss and share thoughts on the consequences of unprofessional behaviour considering individual, organisational, and national dimensions. Groups add to what others have said in a polite manner.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
Teaching and Learning Resources	○ Projector and laptop	

Subject **ENGINEERING**
Strand **2. ENERGY SYSTEMS**
Sub-Strand **1. CIRCUITS AND MACHINES**

Learning Outcomes	**21st Century Skills and Competencies**	**GESI, SEL and Shared National Values**
2.2.1.LO.1		
Explain the use of basic analogue electronic circuit components	**Communication Skills:** Learners develop this skill as they partake in class discussions. **Thinking Skills:** Learners improve their skills as they contribute to the discussion. **Career/Life Skills:** The understanding of content puts learners on the path to becoming self-directed and independent learners.	**GESI:** Using GESI responsive pedagogies and language that supports all learners in an inclusive setting will; o Enable learners to freely ask questions without intimidation. o help learners to embrace empathy and discipline among themselves. o help learners to be disciplined as deadlines are given for their projects. **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment o Hard work
2.2.1.LO.2		
Apply the design process for simple electronic circuits.	**Thinking Skills:** Learners improve their thinking skills as they contribute to the discussion.	**GESI:** Given equal opportunities to all learners irrespective of their background and soliciting views from

	Career/Life Skills: The understanding of content puts learners on the path to becoming self-directed and independent learners. **Communication Skills:** Learners develop this skill as they partake in group discussions. **Social Skills:** Learners hone this skill as they interact in groups. **Collaboration Skills:** Learners enhance their ability to collaborate with others as they work in teams. **Information Literacy:** Learners develop the skill as they search for basic analogue electronic circuits to simulate and build. **Technology usage:** Learners learn to use various technologies as they work to simulate and build analogue electronic circuits. **Career/Life Skills:** The understanding of content puts learners on the path to becoming self-directed and independent learners.	all learners ensures; ○ respect for individuals of varying beliefs, religions, backgrounds and cultures ○ sensitivity to the inter-relatedness of the various spheres of life, groups and individuals ○ awareness of personal biases, peculiarities and stereotypes ○ tolerance for diversity **National Core Values:** ○ Tolerance ○ friendliness ○ open-mindedness ○ patience ○ commitment and hard work ○ honesty and truthfulness

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
2.2.1.CS.1	2.2.1.LI.1	2.2.1.AS.1
Develop an understanding of the design and construction processes for basic analogue electronic circuits.	**Explain the functions of the basic components of analogue electronic circuits.** **Initiating Talk for Learning:** In different task groups, each group researches the functions of a particular basic component of analogue electronic circuits. Learners share findings with the class and take comments and criticisms in a tolerant manner. **Experiential Learning:** Learners watch videos on the uses of basic analogue electronic circuit components and share observations with the whole class	Level 1 Recall **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
	2.2.1.LI.2	2.2.1.AS.2
	Apply knowledge of Electronic Components in designing Electronic Circuits **Experiential Learning:** Learners test various electronic components and share their observation with the whole class. The Facilitator guide learners to design fire alarm circuits, rain alarm circuits **Collaborative Learning:** Put learners in groups to design power supply circuit, fire alarm circuit and rain alarm circuit	Level 1 Recall **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** **Level 4 Extended critical thinking and reasoning**
	2.2.1.LI.3	2.2.1.AS.3
	Use CAD tools for the design and analysis of simple analogue electronic circuits. **Experiential Learning:** At the computer lab, the facilitator explains to learners how to use CAD tools (e.g., Proteus software) to design and analyse simple analogue circuits. The facilitator guides learners to design and simulate simple analogue circuits. **Problem-based and collaborative Learning:** In groups, learners search online for basic analogue	Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** Level 4 Extended

	electronic circuits to simulate and analyse. **Problem-based, Collaborative and Experiential Learning:** At the workshop, learners build and test the circuits they had simulated. Other groups observe and comment.	critical thinking and reasoning
Teaching and Learning Resources	○ Projector ○ Laptop	○ Assorted basic components of analogue electronic circuits and videos on the components of analogue electronic circuits

Subject **ENGINEERING**
Strand **2. ENERGY SYSTEMS**
Sub-Strand **2. RENEWABLE ENERGY SYSTEMS**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
2.2.2.LO.1		
Apply operating principles of photovoltaic and solar thermal systems.	**Communication Skills:** Learners develop this skill as they partake in class discussions. **Thinking Skills:** Learners improve their skills as they contribute to the discussion. **Career/Life Skills:** The understanding of content puts learners on the path to becoming self-directed and independent learners.	Special attention given to the catch-up, regular and gifted and talented learners leads to; o Respecting individuals of varying abilities, beliefs, religions and cultures o Being sensitive to the inter-relatedness of the various spheres of life, groups and individuals o Being aware of personal biases and stereotypes o Embracing diversity and practising inclusion. **National Core Values:** o Integrity o Tolerance o Open-mindedness o Patience o Integrity o Hard work
2.2.2.LO.2		
Design a simple photovoltaic and solar thermal energy system.	**Communication Skills:** Learners develop this skill as they partake in class discussions. **Thinking Skills:** Learners improve their skills as they contribute to the discussion.	**GESI:** Ensuring all learners in class irrespective of the diversity in ability, socio-cultural backgrounds, and gender and soliciting contributions from all learners ensures; o respect for individuals of varying beliefs, religions, backgrounds and cultures

	Career/Life Skills: The understanding of content puts learners on the path to becoming self-directed and independent learners. **Social Skills:** Learners hone this skill as they interact in groups. **Collaboration Skills:** Learners enhance their ability to collaborate with others as they work in teams. **Critical Thinking Skills:** Learners enhance their critical thinking skills as they design photovoltaic and solar thermal systems.	○ knowledge of themselves and others' peculiarities, strengths and weaknesses ○ tolerance for diversity and respect for all **National Core Values:** ○ Tolerance ○ friendliness ○ open-mindedness ○ patience ○ commitment ○ hard work

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
2.2.2.CS.1	2.2.2.L.1.1	2.2.2.AS.1
Demonstrate understanding of basic concepts in photovoltaic and solar thermal systems.	**Identify the basic components of photovoltaic and solar thermal systems.** **Experiential Learning:** Learners watch videos or pictures of photovoltaic and solar thermal systems and identify their basic components. Learners inspect basic components of photovoltaic and solar thermal systems and discuss their features. Further, learners watch videos on the installation of the two systems and share their observations with the whole class.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning Level 4 Extended critical thinking and reasoning
	2.2.2.L.1.2	2.2.2.AS.2
	Explain the functions of the basic components of photovoltaic and solar thermal systems. **Collaborative Learning:** In mixed-ability groups, different groups discuss the functions of the one basic component of photovoltaic and solar thermal systems and share their research with the whole class. Other groups critique and add their views. **Experiential Learning:** Learners watch videos on the functions of the basic components of photovoltaic and solar thermal systems, as well as the installation of the two systems and share their observations. Fine-tune learners' views and summarise their thoughts.	Level 1 Recall **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
	2.2.2.L.1.3	2.2.2.AS.3
	Operate and maintain simple photovoltaic and solar thermal energy systems. **Experiential Learning:** Learners watch videos or pictures on the operation and maintenance of photovoltaic and solar thermal systems. **Managing Talk for Learning:** In a moderated discussion, learners discuss how to operate and maintain photovoltaic and solar thermal systems. Use webbing to summarise learners' views.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning

	2.2.2.L.1.4	2.2.2.AS.4
	Design and install simple photovoltaic and solar thermal systems. **Digital Learning:** Learners watch videos on the design and installation of the two systems. In a moderated discussion, learners share their observations and discuss how photovoltaic and solar thermal systems are designed and installed. **Managing Talk for Learning:** Use a flowchart to illustrate the approach or processes to the basic design and installation of such systems. **Experiential and Problem-based Learning:** Learners visit a facility of installed photovoltaic and solar thermal systems to interact with engineers/technicians about the installations. Learners are given group assignments to design photovoltaic and solar thermal systems for a facility. Learners display for colleagues to observe and critique.	Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
Teaching and Learning Resources	○ Projector ○ Laptop and videos on the design and installation of photovoltaic and solar thermal systems. ○ Visit facilities with installed photovoltaic and solar thermal systems.	

Subject **ENGINEERING**
Strand **2. ENERGY SYSTEMS**
Sub-Strand **3. ENERGY EFFICIENCY AND CONSERVATION**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
2.2.3.LO.1		
Design energy management plan and basic energy audit plan.	**Communication Skills:** Learners develop this skill as they partake in class discussions. **Thinking Skills:** Learners improve their skills as they contribute to the discussion. **Career/Life Skills:** The understanding of content puts learners on the path to becoming self-directed and independent learners. **Social Skills:** Learners hone this skill as they interact in groups. **Collaboration Skills:** Learners enhance their ability to collaborate with others as they work in teams. **Critical Thinking Skills:** Learners enhance their critical thinking skills as they perform walk-through energy audits.	**GESI:** As all learners are supported in an inclusive environment and given equal opportunities, they will; o appreciate, value, and embrace diversity as they are made to work in groups. o embrace tolerance and empathy among each other. o learn to resolve conflicts and embrace differing opinions amicably. o develop emotional intelligence as others critique their submissions. **National Core Values:** o Tolerance o Integrity o Accountability o Humility o Assertiveness o Patriotism
2.2.3.LO.2		
Explain energy-saving methods for electrical and thermal systems.	**Communication Skills:** Learners develop this skill as they partake in group discussions.	**GESI:** Ensuring all learners in class irrespective of the diversity in ability, socio-cultural backgrounds, and

	Social Skills: Learners hone this skill as they interact in groups. **Collaboration Skills:** Learners enhance their ability to collaborate with others as they work in teams. **Critical Thinking Skills:** Learners enhance their critical thinking skills when discussing energy-saving measures. **Career/Life Skills:** The understanding of content puts learners on the path to becoming self-directed and independent learners.	gender and soliciting contributions from all learners ensures; o respect for individuals of varying beliefs, religions, backgrounds and cultures o knowledge of themselves and others' peculiarities, strengths and weaknesses o tolerance for diversity and respect for all **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment o Hard work

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
2.2.3.CS.1	2.2.3.LI.1	2.2.3.AS.1
Demonstrate an understanding of energy management principles.	**Develop energy management plans.** **Managing Talk for Learning:** In pairs, learners think and share views on what they understand by energy management. In moderated discussions, learners discuss the importance of energy management in facilities as well as the benefits of developing a plan for it. **Initiating Talk for Learning:** Through questions and answers, learners explain the key components of an energy management plan and the processes involved in developing a plan for a facility. In small groups, guide learners to sketch energy management plans with the aid of a sample. Groups share their sketches with the whole class for comments and additions. Encourage them to share views in a respectful manner and tolerate the opinions of others.	Level 1 Recall **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning Level 4 Extended critical thinking and reasoning
	2.2.3.LI.2	2.2.3.AS.2
	Perform a walk-through energy audit of a facility and identify sources of energy wastage. **Initiating Talk for Learning:** In a moderated discussion, learners discuss what an audit (in general) is, its importance, and processes. From the general understanding, learners explain what an energy audit is. Share with learners the procedure for performing a walk-through energy audit of a facility and how to prepare a report. **Problem-based, experiential and collaborative Learning:** Learners grouped and tasked to perform a walk-through energy audit of a selected facility in their school, e.g. classroom, offices, dormitories, etc in their school. The groups present their report to the class for questions and observations.	Level 1 Recall **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
	2.2.3.LI.3	2.2.3.AS.3
	Identify energy-saving tips for electrical equipment. **Managing Talk for Learning:** In a moderated discussion, learners discuss energy conservation measures for electrical equipment. Furthermore, learners compare varied measures to achieve common	Level 1 Recall **Level 2 Skills of conceptual understanding**

	saving goals in various equipment and systems. **Experiential Learning:** Learners watch videos on energy savings in electrical equipment. **Problem-based, Experiential and Collaborative Learning:** In groups, learners assess selected facilities in their school to know the energy-saving measures in place and those that could be deployed. The groups present their findings to the class for comments	**Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
	2.2.3.LI.4	2.2.3.AS.4
	Identify appropriate energy-saving tips for thermal equipment. **Managing Talk for Learning:** In a moderated discussion, learners discuss energy conservation measures for thermal equipment. Furthermore, learners compare varied measures to achieve common saving goals in various equipment and systems. **Experiential Learning:** Learners watch videos on energy savings in thermal equipment. **Problem-based, Experiential and Collaborative Learning:** In groups, learners assess facilities in the school to know the energy-saving measures in place and those that could be deployed. The groups present their findings to the class.	Level 1 Recall **Level 2 Skills of conceptual understanding:** **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
Teaching and Learning Resources	○ Projector ○ Laptop and videos on energy-saving measures for thermal equipment.	○ Videos on energy-saving measures for electrical equipment

Subject **ENGINEERING**
Strand **3. SYSTEMS DESIGN AND PROTOTYPING**
Sub-Strand **1. ENGINEERING DESIGN**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
2.3.1.LO.1		
Consider all possible solutions and select the most suitable solution(s) based on a set of constraints.	**Critical Thinking:** As learners attempt to find the best solution to a given problem, they critically observe and analyse the various RP technologies, their relative strengths and use cases for the production of prototypes. **Collaboration:** Learners sit in well-mixed (gender-balanced and culturally diverse) groups and take turns to relay their observations to their peers. This provides the opportunity to learn from others to understand and respect the needs, perspectives, and actions of others. **Communication:** Learners express their thoughts among their peers in an environment that is free from fear or intimidation. **Lifelong Learning:** Learners, through self-directed learning, learn how to use ICT tools to improve their knowledge presentation skills as group presentations are delivered through MS PowerPoint. Learners also develop an inquiry-based approach to continual learning in their attempt to use digital tools to research and present on various RP technologies. **Problem-Solving**: Learners identify a problem and design solutions for the identified problems.	**GESI:** Involving all learners in class irrespective of their varying abilities, gender and backgrounds, supporting them to share their views and thoughts ensures; o respect for individuals of varying beliefs, religions, backgrounds and cultures o sensitivity to the inter-relatedness of the various spheres of life, groups and individuals o awareness of personal biases, peculiarities and stereotypes o tolerance for diversity. **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment o Integrity
2.3.1.LO.2		
Design prototypes based on given solution requirements.	**Critical Thinking:** As learners attempt to find the best solution to a given problem, they critically observe and analyse the various RP technologies, their	

	relative strengths and use cases for the production of prototypes. **Collaboration:** Learners sit in well-mixed (gender-balanced and culturally diverse) groups and take turns to relay their observations to their peers. This provides the opportunity to learn from others to understand and respect the needs, perspectives, and actions of others. **Communication:** Learners express their thoughts among their peers in an environment that is free from fear or intimidation. **Lifelong Learning:** Learners, through self-directed learning, learn how to use ICT tools to improve their knowledge presentation skills as group presentations are delivered through MS PowerPoint. Learners also develop an inquiry-based approach to continual learning in their attempt to use digital tools to research and present on various RP technologies. **Problem-Solving**: Learners identify a problem and design solutions for the identified problems.	

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
2.3.1.CS.1	2.3.1.LI.1	2.3.1.AS.1
Demonstrate the ability to select an optimal solution from a given set of solutions to a problem.	**Analyse critically a set of possible solutions to a given problem and justify the choice of an optimal solution.** **Initiating Talk for Learning:** Initiate a discussion on the evaluation of solutions to a complex real-world problem based on prioritised criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. **Problem-based Learning:** Learners are given a case study to critically analyse the possible solutions and make a report on the justification of selected solution(s) based on a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts. **Collaborative Learning:** Learners work in groups and make presentations on their solution to a case study to the whole class for comments	Level 1 Recall **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** **Level 4 Extended critical thinking and reasoning**
Teaching and Learning Resources	○ 3D Modelling Software, for example, Autodesk Fusion 360, Tinkercad and SketchUp 3D Printer Online Tutorials on the 3D printers and modelling software ○ Case studies: Case studies of real-world applications of 3D printing and rapid prototyping ○ Textbooks	

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
2.3.1.CS.2	2.3.1.LI.1	2.3.1.AS.1
Demonstrate the ability to design and build working prototypes to model a solution to any given problem.	**Design a working prototype based on design requirements.** **Initiating Talk for Learning:** Show learners how a 3D printer works (using a 3D printer, software, or a digital model) and walk the class through the process of creating simple objects. **Experiential Learning:** Have learners design and print their own objects. Give learners a project in which they have to design and print their own objects using 3D modelling software. These could be simple objects like a keychain, the power button of a laptop, a phone housing, etc. Have learners design and print their own objects and award the best 3 designs. **Collaborative Learning:** Work in groups and discuss learners' observations on the strengths and weaknesses of 3D printing as well as the future of 3D printing. Groups should make presentations on their observations.	Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** **Level 4 Extended critical thinking and reasoning**
Teaching and Learning Resources	○ 3D Modelling Software, example Autodesk Fusion 360, Tinkercad and SketchUp 3D Printer, Online Tutorials on 3D printers and modelling software, ○ Case studies: Case studies of real-world applications of 3D printing and rapid prototyping ○ Textbooks	

Subject **ENGINEERING**
Strand **3. SYSTEMS DESIGN AND PROTOTYPING**
Sub-Strand **2. RAPID PROTOTYPING**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
2.3.2.LO.1		
Navigate the CAD tools and perform basic operations and functions associated with model design.	**Collaboration**: Working with others on projects or problems can help learners develop important teamwork and communication skills. **Creativity**: Inquiry-based learning and project-based learning can allow learners to explore and think creatively about creating models using CAD and CAM tools. **Critical Thinking and Problem-Solving**: Problem-based learning and inquiry-based learning can help learners develop critical thinking and problem-solving skills as they work to apply their knowledge of CAD and CAM tools to design and produce innovative models. **Digital Literacy:** Using online resources and simulations can help learners develop skills in using technology and finding and evaluating online information. **Adaptability**: Working on real-world projects or problems can help learners learn to adapt and be flexible as they encounter new challenges and changing requirements. **Initiative**: Giving learners the opportunity to take the lead on projects and explore 3D production technologies on their own can help them develop initiative and self-direction.	**GESI:** Using inclusive strategies and pedagogies that promote all learners' well-being and develop their potential; o Respect for others and alternative views, as well as the awareness of own biases. o Protect the weak work for the betterment of society and make learners advocate for peace and justice. o Exhibit empathy towards people with special needs, **National Core Values:** o Sacrifice o selflessness o compassion o fairness o justice o generosity, o co-operation o commitment o collaboration o excellence o resourcefulness o self-discipline

2.3.2.LO.2		
Implement CAD models using 3D printing systems.	**Collaboration**: Working with others on projects or problems can help learners develop important teamwork and communication skills. **Creativity**: Inquiry-based learning and project-based learning can allow learners to explore and think creatively about creating models using CAD and CAM tools. **Critical Thinking and Problem-Solving**: Problem-based learning and inquiry-based learning can help learners develop critical thinking and problem-solving skills as they work to apply their knowledge of CAD and CAM tools to design and produce innovative models. **Digital Literacy:** Using online resources and simulations can help learners develop skills in using technology and finding and evaluating online information. **Adaptability**: Working on real-world projects or problems can help learners learn to adapt and be flexible as they encounter new challenges and changing requirements. **Initiative**: Giving learners the opportunity to take the lead on projects and explore 3D production technologies on their own can help them develop initiative and self-direction.	**GESI:** Creating equal opportunities for all learners to participate in class through the use of balanced gender groups leads to; o tolerance and respect for each other o confidence and efficacy in their ability to perform o awareness of themselves and others, taking into consideration their biases and stereotypes. **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment o Integrity

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
2.3.2.CS.1	2.3.2.LI.1	2.3.2.AS.1
Demonstrate understanding of the use of CAD tools for the design of models.	**Apply CAD tools to create models** **Talk for Learning**: Begin by introducing learners to the fundamental concepts and principles of CAD, such as the user interface, basic drawing and modelling techniques, and the use of layers. **Experiential Learning:** Provide learners with examples of real-world designs and have them practice creating similar designs on their own. This will help them understand how to apply the concepts they are learning in a practical setting. **Self-Directed Learning**: Explore online resources: There are many online resources available that can help Learners learn more about CAD and how to use it. Some good options include online tutorials, instructional videos, and forums where learners can ask questions and get feedback from experts. Learners learn additional knowledge and experiences of 3D printing and present individual reports. **Project-based Learning**: Incorporate hands-on projects that allow learners to apply their CAD skills to real-world design challenges. This can help them develop their problem-solving skills and better understand the design process.	Level 1 Recall **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** **Level 4 Extended critical thinking and reasoning**
Teaching and Learning Resources	○ Computers with CAD Software installed (Sketchup, Solid Works) ○ Video Tutorials for Self-Directed Learning ○ Textbooks and Design manuals for CAD practice assignments ○ Integrated 3D printing machines with CAM functionality	

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
2.3.2.CS.2	2.3.2.LI.1	2.3.2.AS.1
Demonstrate ability to implement CAD models using 3D printers.	**Set up, configure and utilise a 3D printer to produce CAD prototype models.** **Initiating Talk for Learning:** Shows learners how a 3D printer works (using a 3D printer, software, or a digital model) and walks the class through the process of creating simple objects. **Experiential Learning:** Have learners design and print their own objects. Give learners a project in which they have to design and print their own objects using 3D modelling software. These could be simple objects like a keychain, the power button of a laptop, a phone housing, etc. Have learners design and print their own objects and award the best 3 designs. **Collaborative Learning:** Work in groups on a design challenge. Groups will compete to design and produce models using the suite of CAD / CAM tools available according to design requirements or constraints given by the facilitator. Each group should assign a specific role(s) to members towards the solution of the challenge. Roles may, for example may, be modelled after typical design and production teams in the industry to give them relevant exposure and develop team and collaborative skills in them.	Level 1 Recall **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** **Level 4 Extended critical thinking and reasoning**
Teaching and Learning Resources	○ Computers with CAD Software installed (Sketchup, Solid Works) ○ Video Tutorials for Self-Directed Learning ○ Textbooks and Design manuals for CAD practice assignments ○ Integrated 3D printing machines with CAM functionality.	

Subject **ENGINEERING**
Strand **4. AUTOMATION AND EMBEDDED SYSTEMS**
Sub-Strand **1. AUTOMATION TECHNOLOGIES**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
2.4.1.LO.1		
Utilise basic electronic components for simple automation tasks.	**Collaboration:** Working with others on projects or problems can help learners develop important teamwork and communication skills. **Critical Thinking and Problem-Solving:** Problem-based learning and inquiry-based learning can help learners develop critical thinking and problem-solving skills as they interpret technical diagrams to implement a solution or troubleshoot systems. **Digital Literacy:** Using online resources and simulations can help learners develop skills in using technology and finding and evaluating online information. **Adaptability:** Working on real-world projects or problems can help learners learn to adapt and be flexible as they encounter new challenges and changing requirements. **Initiative:** Giving learners the opportunity to take the lead on projects and explore other resources on Engineering drawings on their own can help them develop initiative and self-direction.	**GESI:** Ensuring all learners in class irrespective of the diversity in ability, socio-cultural backgrounds, and gender and soliciting contributions from all learners ensures; o respect for individuals of varying beliefs, religions, backgrounds and cultures o knowledge of themselves and others' peculiarities, strengths and weaknesses o tolerance for diversity and respect for all **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment o Hard work

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
2.4.1.CS.1	2.4.1.LI.1	2.4.1.AS.1
Demonstrate understanding of the concepts of basic electronics for automation systems.	**Design and build simple automation systems using basic electronic components like transistors, resistors, capacitors, relays, LEDs, LDRs, motors, etc.** **Experiential Learning:** The facilitator guides learners to assemble electronic components on a breadboard to build a simple automated circuit, such as an automated streetlight with LDR and explains the functions of each component in the circuit. Learners are then left to modify the circuit to increase its functionality and complexity by adding timing functions or motion sensors, for example. Learners should be given schematics of common automation circuits to assemble and practice with them by modifying components to vary performance. **Project-based Learning:** Learners work on a project that involves designing and implementing an electronic circuit for an automation problem, given the requirements. **Self-Directed Learning:** Learners are given access to online resources to explore further electronic automation circuits for implementation and experimentation. Learners should be motivated to individually build and test at least three (3) of such circuits on their own. **Collaborative Learning:** Learners work in groups to design, implement, test and document an electronic circuit for an automation problem. Each group should assign a specific role(s) to members towards the solution of the challenge. Roles may, for example may, be modelled after typical design and production teams in the industry to give them the relevant exposure and develop team and collaborative skills in them.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** **Level 4 Extended critical thinking and reasoning**
Teaching and Learning Resources	○ Industrial Automation Workshop ○ Video documentaries ○ audio-visual equipment ○ laptops with MS Office installed	

Subject **ENGINEERING**
Strand **4. AUTOMATION AND EMBEDDED SYSTEMS**
Sub-Strand **2. EMBEDDED SYSTEMS**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
2.4.2.LO.1		
Use the IDE of Arduino to write simple programmes in C and upload them onto the Arduino microcontroller.	**Collaboration:** Working with others on projects or problems can help learners develop important teamwork and communication skills. **Critical Thinking and Problem-Solving:** Problem-based learning and inquiry-based learning can help learners develop critical thinking and problem-solving skills as they interpret technical diagrams to implement a solution or troubleshoot systems. **Digital Literacy:** Using online resources and simulations can help learners develop skills in using technology and finding and evaluating online information. **Adaptability:** Working on real-world projects or problems can help learners learn to adapt and be flexible as they encounter new challenges and changing requirements. **Initiative:** Giving learners the opportunity to take the lead on projects and explore other resources on Engineering drawings on their own can help them develop initiative and self-direction.	**GESI:** Working with each other in an inclusive way, cross-sharing of knowledge and understanding between and among groups and individuals, for instance, leads to; o Respecting individuals of varying beliefs, religions and cultures o Being sensitive to the inter-relatedness of the various spheres of life, groups and individuals o Being aware of personal biases and stereotypes o Embracing diversity and practising inclusion. **National Core Values:** o Tolerance o Friendliness o Open-Mindedness o Patience o Commitment o Hard Work

2.4.2.LO.2		
Develop applications which interface with simple hardware like switches, LEDs, LCDs, Relays, IR Sensors, Seven and Multi-Segment Displays, as well as other digital sensors.	**Collaboration:** Working with others on projects or problems can help learners develop important teamwork and communication skills. **Critical Thinking and Problem-Solving:** Problem-based learning and inquiry-based learning can help learners develop critical thinking and problem-solving skills as they interpret technical diagrams to implement a solution or troubleshoot systems. **Digital Literacy:** Using online resources and simulations can help learners develop skills in using technology and finding and evaluating online information. **Adaptability:** Working on real-world projects or problems can help learners learn to adapt and be flexible as they encounter new challenges and changing requirements. **Initiative:** Giving learners the opportunity to take the lead on projects and explore other resources on Engineering drawings on their own can help them develop initiative and self-direction.	**GESI:** Encouraging all learners in class, irrespective of the diversity in gender, ability and background and supporting each of them to share their views ensures; o respect for individuals of varying beliefs, religions, backgrounds and cultures o knowledge of themselves and others' peculiarities and stereotypes o tolerance for diversity and respect for all **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment o Hard work

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
2.4.2.CS.1	2.4.2.LI.1	2.4.2.AS.1
Demonstrate an ability to programme in the Arduino Environment.	**Declare variables and constants, perform control actions and loops, write functions in C, test and debug programmes within the Arduino IDE.** **Experiential Learning:** Guide learners through the basics of navigating the Arduino microcontroller and IDE through hands-on exercises. The facilitator should guide the learners to implement simple concepts in C programming like variable and constant declarations, loops, if else decisions, functions and debugging within the Arduino IDE. Simple hardware interfacing with LEDs and switches should be employed to demonstrate these concepts. **Project-based Learning:** Learners work on a simple mini project like a traffic light where they apply their programming skills to solve the given problem. **Digital Learning:** Learners are encouraged to use the available online resources to explore more tutorials and programming projects involving Arduino-embedded kits. **Collaborative Learning:** Learners work in groups on a mini project. Each group should assign a specific role(s) to members towards the solution of the challenge. Roles may, for example may, be modelled after typical design and production teams in the industry to give them the relevant exposure and develop team and collaborative skills.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** **Level 4 Extended critical thinking and reasoning**
Teaching and Learning Resources	○ Arduino Embedded System Kits ○ Video documentaries ○ audio-visual equipment and laptops with MS Office installed	

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
2.4.2.CS.2	2.4.2.LI.1	2.4.2.AS.1
Demonstrate an ability to interface with general hardware.	**Design simple Arduino-based embedded systems which interface with basic hardware like switches, LEDs, LCDs, Relays, IR Sensors, Seven and Multi-Segment Displays, as well as other digital sensors.** **Project-based experiential Learning:** Through simple projects, the facilitator guides learners to assemble circuits involving hardware such as switches, LEDs, LCDs, Relays, IR Sensors, Seven and Multi-Segment Displays as well as other digital sensors on solderless breadboards to be interfaced with the Arduino microcontroller. The facilitator uses these mini projects to demonstrate the relevant sections of code for interfacing these respective hardware and leaves the learners to manipulate the hardware and code to observe the changes which occur. These projects should be carefully selected to have relevance to the environment and interest of the learners. Examples of such projects could be but are not limited to the following: ***the display of current date and time on LCDs, intelligent traffic light displays, stopwatches, countdown timers, intelligent street lights, and the display and scrolling of names on multi-segment displays.*** **Self-Directed Learning:** Learners are given access to online resources to explore further hardware interfacing projects for implementation and experimentation. Learners should be motivated to individually build and test at least three (3) of such projects on their own and in groups and present to peers. **Collaborative Learning:** Learners work in groups to design, implement, test and document simple embedded solutions involving interfacing with hardware like switches, LEDs, LCDs, Relays, IR Sensors, Seven and Multi-Segment Displays, as well as other digital sensors. Each group should assign a specific role(s) to members towards the solution of the challenge. Roles may, for example may, be modelled after typical design and production teams in the industry to give them the relevant exposure and develop team and collaborative skills in them.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** **Level 4 Extended critical thinking and reasoning**
Teaching and Learning Resources	○ Arduino Embedded System Kits ○ Video documentaries	○ Audio-visual equipment and laptops with MS Office installed

YEAR THREE

Subject ENGINEERING
Strand 1. ENGINEERING PRACTICE
Sub-Strand 1. ENGINEERING IN SOCIETY

Learning Outcomes	21st Century Skills and Competencies	GESI[5], SEL[6] and Shared National Values
3.1.1.LO.1		
Demonstrate an understanding of the role of engineering in the attainment of the sustainable development goals.	**Communication Skills:** Learners develop this skill as they partake in class discussions. **Thinking Skills:** Learners hone their thinking skills through the discussions. **Social responsibility**: ○ Learners develop social responsibility as they discuss the SDGs. ○ Learners develop social responsibility as they discuss the SDGs.	**GESI:** Promoting inclusivity in the classroom by encouraging every learner to actively participate in lessons and cross-sharing of ideas and thoughts between and among groups and individuals ensures; ○ Respecting individuals of varying beliefs, religions and cultures ○ Being sensitive to the inter-relatedness of the various spheres of life, groups and individuals ○ Being aware of personal biases and stereotypes ○ Embracing diversity and practising inclusion. **National Core Values:** ○ Tolerance ○ Friendliness ○ Open-mindedness ○ Patience ○ Commitment ○ Hard work ○ Integrity
3.1.1.LO.2		

[5] Gender Equality and Social Inclusion

[6] Socio-Emotional Learning

Propose solutions to engineering-related SDGs.	**Communication Skills:** Learners develop this skill as they partake in class discussions. **Thinking Skills:** Learners hone their thinking skills through discussions. **Social responsibility:** o Learners develop social responsibility as they discuss the SDGs. o Learners develop social responsibility as they work to propose solutions to engineering-related SDGs. **Critical Thinking:** Learners hone their critical thinking capabilities as they work to develop innovative solutions. **Social Skills:** Learners enhance this skill as they interact in project groups. **Information Literacy:** Learners develop this skill as they search various databases to obtain information to develop the required solutions. **Creativity:** The creativity of learners is honed through the project execution.	**GESI:** Ensuring all learners in class irrespective of the diversity in ability, socio-cultural backgrounds, and gender and soliciting contributions from all learners ensures; o respect for individuals of varying beliefs, religions, backgrounds and cultures o knowledge of themselves and others' peculiarities, strengths and weaknesses o tolerance for diversity and respect for all. **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment o Hard work

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
3.1.1.CS.1	3.1.1.LI.1	3.1.1.AS.1
Engineering in Society.	**Define the sustainable development goals.** **Managing Talk for Learning:** In a moderated discussion, learners discuss the membership and activities of the UN. **Initiating Talk for Learning:** The Facilitator explains the rationale for setting the SDGs and further outlines the SDGs. **Managing Talk for Learning:** In a moderated discussion, learners discuss the extent of attainment of the SDGs in relation to Ghana. **Experiential Learning:** Learners watch videos on the SDGs.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
	3.1.1.LI.2	3.1.1.AS.2
	Explain the role of the SDGs in societal development. **Initiating Talk for Learning:** Through questions and answers, learners brainstorm the role of the SDGs in societal development. In small mixed-ability/gender groups, learners select one SDG, discuss how it can be addressed, and share findings with the class	Level 1 Recall **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning Level 4 Extended critical thinking and reasoning
	3.1.1.LI.3	3.1.1.AS.3
	Describing engineering solutions for attaining specific SDGs. **Collaborative Learning:** In their small groups, learners discuss selected SDGs and how engineering can be used to provide solutions. Groups share findings with the whole class for comments. Summarise learners' thoughts using webbing or maps for each SDG and proffered solutions.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** Level 4 Extended critical thinking and

		reasoning
	3.1.1.LI.4	3.1.1.AS.4
	Designing and developing innovative solutions towards the attainment of SDGs **Problem-based Learning:** Learners in groups select and execute group projects by conceiving and developing innovative engineering solutions to address at least one SDG. The groups present their projects to the class for comments.	Level 1 Recall Level 2 Skills of conceptual understanding Level 3 Strategic reasoning **Level 4 Extended critical thinking and reasoning**
Teaching and Learning Resources	○ Projector, laptop and videos on the SDGs ○ Assorted components	○ Tools and machinery as may be required to execute the projects

Subject ENGINEERING
Strand 1. ENGINEERING PRACTICE
Sub-Strand 2. HEALTH AND SAFETY IN ENGINEERING PRACTICE

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
3.1.2.LO.1		
Implement good housekeeping measures.	**Communication Skills:** Learners develop this skill as they partake in class discussions. **Thinking Skills:** Learners hone their thinking skills through the discussions. **Critical thinking Skills:** Learners hone critical thinking skills as they develop housekeeping rules.	**GESI:** Given equal opportunities to all learners irrespective of their background and soliciting views from all learners ensures; o respect for individuals of varying beliefs, religions, backgrounds and cultures o sensitivity to the inter-relatedness of the various spheres of life, groups and individuals o awareness of personal biases, peculiarities and stereotypes o tolerance for diversity. **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment and hard work o Honesty and truthfulness
3.1.2.LO.2		
Administering appropriate first aid for various workplace accidents.	**Communication Skills:** Learners develop this skill as they partake in class discussions. **Critical thinking Skills:** o Learners hone critical thinking skills as they bring up materials and tools for first aid. o Learners hone critical thinking skills as they generate	**GESI:** Using mixed-ability and mixed-gender pairing, special attention given to the catch-up, regular and gifted and talented learners leads to; o Respecting individuals of varying abilities, beliefs, religions and cultures o Being sensitive to the inter-relatedness of the various spheres of life, groups and individuals

	approaches to administer first aid. **Problem-solving**: Learners acquire skills to address workplace accidents.	○ Being aware of personal biases and stereotypes ○ Embracing diversity and practising inclusion. **National Core Values:** ○ Integrity ○ Tolerance ○ Open-mindedness ○ Patience ○ Integrity hard work

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
3.1.2.CS.1	3.1.2.LI.1	3.1.2.AS.1
Demonstrate understanding of workplace safety and welfare.	**Explain the need for good housekeeping.** **Initiating Talk for Learning:** In a moderated discussion, learners discuss how they keep their dormitories and homes in order. Furthermore, learners discuss the benefits derived from such housekeeping. In a learner-led discussion, explain housekeeping in engineering practice and highlight its importance. Summarise views using webbing.	Level 1 Recall **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning Level 4 Extended critical thinking and reasoning
	3.1.2.LI.2	3.1.2.AS.2
	Explain the consequences of poor housekeeping. **Collaborative Learning:** In small groups, learners discuss the adverse effects of poor housekeeping and share their views with the whole class. Add to what groups say to fine-tune their thoughts.	Level 1 Recall **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning Level 4 Extended critical thinking and reasoning
	3.1.2.LI.3	3.1.2.AS.3
	Outline housekeeping rules at construction sites, manufacturing/production areas, and offices. **Initiating Talk for Learning:** In a question-and-answer session, learners discuss housekeeping rules at construction sites, manufacturing/production areas, and offices and the relevance of each rule.	Level 1 Recall **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning Level 4 Extended critical thinking and reasoning

	3.1.2.LI.4		3.1.2.AS.4
	Administer first aid to victims of common workplace accidents. **Initiating Talk for Learning:** In a learner-led/moderated discussion, learners share experiences on what first aid is and the administration of first aid. Furthermore, learners discuss the importance of first aid and list basic tools and materials used. **Experiential Learning:** Learners watch videos on tools and materials for first aid and how they are used. Learners discuss how to administer first aid to victims of common workplace accidents. Learner roleplay workplace accidents for some colleagues to administer first aid. Other learners observe and comment.		**Level 1 Recall** Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** **Level 4 Extended critical thinking and reasoning**
Teaching and Learning Resources	○ Projector ○ Laptop ○ basic materials and tools for first aid	○ Videos on tools and materials for first aid. ○ Videos on the administration of first aid to accident victims	

Subject ENGINEERING
Strand 1. ENGINEERING PRACTICE
Sub-Strand 3. ETHICS AND PROFESSIONAL PRACTICE

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
3.1.3.LO.1		
Demonstrate an understanding of professional codes of ethics.	**Communication Skills:** Learners develop this skill as they partake in class discussions. **Thinking Skills:** Learners hone their thinking skills through the discussions. **Information Literacy:** Learners develop the skill as they search for ethical codes of professional bodies. **Social Responsibility Skills:** o Learners imbibe the skill as they review the ethical codes of professional bodies. o Learners imbibe the skill as they review conduct in line with ethical codes. **Critical Thinking:** o This skill is developed as learners assess the ethical codes o The skill is honed as learners judge various conducts.	**GESI:** Using GESI responsive pedagogies and language that supports all learners in an inclusive setting will; o enable learners to freely ask questions without intimidation. o help learners embrace empathy and discipline among themselves. o help learners to be disciplined as deadlines are given for their projects. **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment o Hard work

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
3.1.3.CS.1	3.1.3.LI.1	3.1.3.AS.1
Ethics and Professional Practice.	**Describe the nature, relevance, and mandate of professional bodies.** **Initiating Talk for Learning: The** Facilitator leads a discussion to list professional bodies in Ghana. In small groups, learners select and discuss a particular professional body and their relevance and mandate. Groups share findings with the whole class.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
	3.1.3.LI.2	3.1.3.AS.2
	Explain the importance and nature of professional codes of ethics. **Initiating Talk for Learning:** In a learner-led moderated discussion, learners discuss the nature and importance of their school's code of conduct. Furthermore, learners discuss the importance of professional ethical codes. Through questions and answers, learners explain the differences between codes of ethics and codes of conduct. Add to learners' views and fine-tune their thoughts. **Collaborative Learning:** In groups, learners are tasked to visit the websites of some engineering professional bodies in Ghana and report on their code of conduct. In a facilitator-moderated discussion, learners discuss the appropriateness or otherwise of the codes of ethics presented by the groups.	Level 1 Recall **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning Level 4 Extended critical thinking and reasoning
	3.1.3.LI.3	3.1.3.AS.3
	Determine whether or not a conduct violates a code of ethics. **Initiating Talk for Learning:** In a moderated discussion, the facilitator presents various cases or scenarios of conduct for learners to assess whether they violate any professional ethical code. Learners also present various conducts for review by the class.	Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic Reasoning:** Level 4 Extended

		critical thinking and reasoning
Teaching and Learning Resources	○ Projector and laptop	

Subject **ENGINEERING**
Strand **2. ENERGY SYSTEMS**
Sub-Strand **1. CIRCUITS AND MACHINES**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
3.2.1.LO.1		
Explain the types and uses of various electrical machines.	**Communication Skills:** Learners hone this skill as they partake in class discussions. **Career/Life Skills:** The understanding of content puts learners on the path to becoming self-directed and independent learners.	**GESI:** Given equal opportunities to all learners irrespective of their background and soliciting views from all learners ensures; o respect for individuals of varying beliefs, religions, backgrounds and cultures o sensitivity to the inter-relatedness of the various spheres of life, groups and individuals o awareness of personal biases, peculiarities and stereotypes o tolerance for diversity **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment and hard work o Honesty and truthfulness
3.2.1.LO.2		
Demonstrate how to operate various electrical machines.	**Communication Skills:** Learners hone this skill as they partake in class discussions. **Career/Life Skills:** The understanding of content puts learners on the path to becoming self-directed and independent learners.	**GESI:** Using mixed-ability and mixed-gender pairing, special attention given to the catch-up, regular and gifted and talented learners leads to; o Respecting individuals of varying abilities, beliefs, religions and cultures

		○ Being sensitive to the inter-relatedness of the various spheres of life, groups and individuals ○ Being aware of personal biases and stereotypes ○ Embracing diversity and practising inclusion. **National Core Values:** ○ Integrity ○ Tolerance ○ Open-mindedness ○ Patience ○ Integrity ○ Hard work

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
3.2.1.CS.1	3.2.1.LI.1	3.2.1.AS.1
Demonstrate understanding of the application of electrical machines.	**Identify various electrical machines.** **Initiating Talk for Learning:** The Facilitator provides a comprehensive list (with pictures) of the types of electrical machines. **Experiential Learning:** Learners familiarise themselves with various electrical generators, motors, and transformers In a moderated discussion, learners discuss the physical features of the machines they have familiarised themselves with.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning Level 4 Extended critical thinking and reasoning
	3.2.1.LI.2	3.2.1.AS.2
	Explain the uses of transformers, DC & AC motors, DC and AC generators, and special electrical machines (i.e., stepper motors, servo motors, etc.) **Experiential Learning:** Learners watch videos about the applications of the various machines. Learners share their observations on the uses of the various electrical machines.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
	3.2.1.LI.3	3.2.1.AS.3
	Operate (connect, control, and disconnect) electrical machines. **Experiential Learning:** Learners are assisted to turn on the electrical machines, vary their speed, power output, torque, etc., as applicable, and finally turn them off. Furthermore, learners watch videos on how to operate the various machines.	Level 1 Recall **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning Level 4 Extended critical thinking and reasoning

	3.2.1.LI.4	3.2.1.AS.4
	Explain the safety measures associated with the use of the various electrical machines. **Collaborative Learning:** In mixed-ability groups, learners use a type of machine and discuss the safety precautions that should be observed when operating the various electrical machines. **Experiential Learning:** Learners watch videos on safety precautions in the use of electrical machines. Through questioning, learners provide a comprehensive list of precautionary measures and their relevance.	Level 1 Recall **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning Level 4 Extended critical thinking and reasoning
Teaching and Learning Resources	○ Videos on the applications of electrical machines ○ Projector ○ Laptop ○ Transformers ○ AC and DC generators	○ AC and DC motors ○ special electrical machines, including stepper and servo motor ○ Videos on the applications of electrical machines ○ Videos on safety measures in the use of electrical machines.

Subject **ENGINEERING**
Strand **2. ENERGY SYSTEMS**
Sub-Strand **2. RENEWABLE ENERGY SYSTEMS**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
3.2.2.LO.1		
Explain wind and bioenergy systems.	**Communication Skills:** Learners develop this skill as they partake in class discussions. **Thinking Skills:** Learners improve their skills as they contribute to the discussion. **Career/Life Skills:** The understanding of content puts learners on the path to becoming self-directed and independent learners.	**GESI:** Ensuring all learners in class irrespective of the diversity in ability, socio-cultural backgrounds, and gender and soliciting contributions from all learners ensures; o respect for individuals of varying beliefs, religions, backgrounds and cultures o knowledge of themselves and others' peculiarities, strengths and weaknesses o tolerance for diversity, and respect for all. **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment o Hard work
3.2.2.LO.2		
Explain the architecture of wind and bioenergy systems.	**Communication Skills:** Learners develop this skill as they partake in class discussions.	**GESI:** Ensuring all learners in class, irrespective of the diversity in ability, socio-cultural backgrounds, and

	Thinking Skills: Learners improve their skills as they contribute to the discussion. **Career/Life Skills:** The understanding of content puts learners on the path to becoming self-directed and independent learners. **Social Skills:** Learners hone this skill as they interact in groups. **Collaboration Skills:** Learners enhance their ability to collaborate with others as they work in teams. **Critical Thinking Skills:** Learners enhance their critical thinking skills as they design wind and bioenergy systems.	gender and soliciting contributions from all learners ensures; o respect for individuals of varying beliefs, religions, backgrounds and cultures o knowledge of themselves and others' peculiarities, strengths and weaknesses o tolerance for diversity and respect for all **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment o Hard work

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
3.2.2.CS.1	3.2.2.LI.1	3.2.2.AS.1
Demonstrate understanding of basic wind and bioenergy systems.	**Identify the basic components of wind and bioenergy systems.** **Initiating Talk for Learning:** In a moderated discussion, learners identify and discuss the basic components of wind and bioenergy systems. **Experiential Learning:** Learners inspect basic components of wind and bioenergy systems and discuss their features. Further, learners watch videos on the installation of the two systems and share their observations.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning Level 4 Extended critical thinking and reasoning
	3.2.2.LI.2	3.2.2.AS.2
	Explain the functions of the basic components of wind and bioenergy systems. **Initiating Talk for Learning:** In small groups, learners select a component of wind and bioenergy systems and discuss its functions. **Experiential Learning:** Learners watch videos on the functions of the basic components of wind and bioenergy systems, as well as the installation of the two systems, and share observations.	Level 1 Recall **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
	3.2.2.LI.3	3.2.2.AS.3
	Design and install simple wind and bioenergy systems. **Experiential Learning:** Learners watch videos on the operation and maintenance of wind and bioenergy systems or research and share their findings with the class.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning

	3.2.2.LI.4	3.2.2.AS.4
	Operate and maintain simple wind and bioenergy systems. **Experiential Learning:** Learners watch videos on the design and installation of the two systems. Learners share their observations with the class **Initiating Talk for Learning:** The facilitator explains to learners a comprehensive approach to the basic design and installation of such systems and summarises the process using a flowchart. **Experiential Learning:** Learners visit a facility of installed wind and bioenergy systems to interact with engineers/technicians about the installations. **Problem-based and Collaborative Learning:** Learners are given group assignments to design wind and bioenergy systems for a facility. Learners present the project to the class for comments.	Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
Teaching and Learning Resources	○ Projector ○ Laptop ○ Basic components of wind and bioenergy systems ○ Videos on the functions of the basic components of wind and bioenergy systems	○ Videos on the maintenance of wind and bioenergy systems ○ Videos on the design and installation of wind and bioenergy systems ○ Visit facilities with installed wind and bioenergy systems.

Subject **ENGINEERING**
Strand **2. ENERGY SYSTEMS**
Sub-Strand **3. ENERGY EFFICIENCY AND CONSERVATION**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
3.2.3.LO.1		
Demonstrate understanding of devices for energy conservation.	**Communication Skills:** Learners develop this skill as they partake in class discussions. **Thinking Skills:** Learners improve their skills as they contribute to the discussion. **Career/Life Skills:** The understanding of content puts learners on the path to becoming self-directed and independent learners.	**GESI:** Working with each other in an inclusive way, cross-sharing of knowledge and understanding between and among groups and individuals, for instance, leads to; o Respecting individuals of varying beliefs, religions and cultures o Being sensitive to the inter-relatedness of the various spheres of life, groups and individuals o Being aware of personal biases and stereotypes o Embracing diversity and practising inclusion. **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment o Hard work
3.2.3.LO.2		
Design simple solutions for energy conservation in the use of lighting and consumer appliances.	**Career/Life Skills:** The understanding of content puts learners on the path to becoming self-directed and independent learners. **Communication Skills:** Learners develop this skill as they partake in group discussions.	**GESI:** Involving all learners in class irrespective of their varying abilities, gender and backgrounds and supporting them to share their views and thoughts ensures; o respect for individuals of varying beliefs,

	Social Skills: Learners hone this skill as they interact in groups. **Collaboration Skills:** Learners enhance their ability to collaborate with others as they work in teams. **Critical thinking Skills:** Learners enhance their critical thinking skills as they design and construct various energy conservation devices.	religions, backgrounds and cultures o sensitivity to the inter-relatedness of the various spheres of life, groups and individuals o awareness of personal biases, peculiarities and stereotypes o tolerance for diversity **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment o Hard work

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
3.2.3.CS.1	3.2.3.LI.1	3.2.3.AS.1
Develop the skills to design and construct devices for Energy Conservation.	**Describe devices used for energy conservation.** **Initiate Talk for Learning:** In a question and answer session, learners brainstorm and share views on the importance of energy conservation and further share their experiences on energy conservation efforts. **Experiential Learning**: Learners watch videos or pictures of devices used to aid energy conservation (e.g., photocells, timer switches, dimmers, occupancy sensors, motion sensors, etc.) Learners familiarise themselves with various energy conservation devices and share their observations.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning:
	3.2.3.LI.2	3.2.3.AS.2
	Explain the application areas for the various devices used for energy conservation. **Initiating Talk for Learning:** In a facilitator-led discussion, explain the application areas for various devices. **Experiential Learning:** Learners watch videos on the application of various devices for energy conservation and share their observations with the class.	Level 1 Recall **Level 2 Skills of conceptual understanding** Level 3 Strategic Reasoning: Level 4 Extended critical thinking and reasoning
	3.2.3.LI.3	3.2.3.AS.3
	Explain the methodology for designing devices for energy conservation. **Initiating Talk for Learning:** Use a flowchart to explain the methodology for designing devices for energy conservation. Through questions, learners explain the methodology using the flowchart.	Level 1 Recall **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning Level 4 Extended critical thinking and reasoning

	3.2.3.LI.4	3.2.3.AS.4
	Design and construct energy management systems solutions for lighting and consumer appliances. **Problem-based and Collaborative Learning:** Learners are put in groups, and each group is assigned a lighting/consumer appliance to design and construct an energy conservation device for. Share their projects later with the class for comments.	Level 1 Recall Level 2 Skills of conceptual understanding: Level 3 Strategic reasoning **Level 4 Extended critical thinking and reasoning**
Teaching and Learning Resources	○ Projector ○ Laptop ○ variety of devices for energy conservation	○ Videos on the application of various devices for energy conservation ○ Assorted electrical and electronic components for devices for energy conservation

Subject **ENGINEERING**
Strand **3. Systems Design and Prototyping**
Sub-Strand **1. Engineering Design**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
3.3.1.LO.1		
Evaluate a prototype and test it using all possible variable constraints.	**Collaboration**: Working with others on projects or problems can help learners develop important teamwork and communication skills. **Critical Thinking and Problem-Solving**: Problem-based learning and inquiry-based learning can help learners develop critical thinking and problem-solving skills as they work to apply their knowledge in testing and validating a prototype. **Digital Literacy:** Using online resources and simulations can help learners develop skills in using technology and finding and evaluating online information. **Adaptability**: Working on real-world projects or problems can help learners learn to adapt and be flexible as they encounter new challenges and changing requirements. **Initiative**: Giving learners the opportunity to take the lead on projects and explore casting technologies on their own can help them develop initiative and self-direction.	**GESI:** Encouraging all learners in class, irrespective of the diversity in gender, ability and background and supporting each of them to share their views ensures; o respect for individuals of varying beliefs, religions, backgrounds and cultures o knowledge of themselves and others' peculiarities and stereotypes o tolerance for diversity and respect for all **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment o Hard work
3.3.1.LO.2		
Use feedback and observations made from testing and evaluation to improve a solution or	**Collaboration**: Working with others on projects or problems can help learners develop important teamwork and communication skills.	**GESI:** o Learners appreciate, value, and embrace diversity as they

prototype.	**Critical thinking and problem-solving**: Problem-based learning and inquiry-based learning can help learners develop critical thinking and problem-solving skills as they work to apply their knowledge in testing and validating a prototype. **Digital Literacy:** Using online resources and simulations can help learners develop skills in using technology and finding and evaluating online information. **Adaptability**: Working on real-world projects or problems can help learners learn to adapt and be flexible as they encounter new challenges and changing requirements. **Initiative**: Giving learners the opportunity to take the lead on projects and explore casting technologies on their own can help them develop initiative and self-direction.	are made to work in groups. ○ Learners learn to amicably resolve conflicts and embrace differing opinions.

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI		Assessment
3.3.1.CS.1	3.3.1.LI.1		3.3.1.AS.1
Demonstrate the ability to test and evaluate prototypes.	**Test and validate a prototype** **Inquiry-based Learning:** Encourage learners to ask questions, gather information, and come up with their own solutions to problems. This can be a useful approach for prototype testing, as it allows learners to develop critical thinking skills and approach testing with a sense of curiosity and creativity. **Project-based Learning:** Involve learners in the design and testing of a prototype. Learners to apply their knowledge and skills in a hands-on, experiential way. **Problem-based Learning:** Learners are presented with a real-world problem and encouraged to work together to find a solution. This can be a useful approach for prototype testing, as it allows learners to develop problem-solving skills and think critically about the testing process. **Collaborative Learning:** Involves learners working together in small groups to complete tasks and projects. This can be an effective way to learn about prototype testing, as it allows learners to learn from one another and share ideas and approaches to testing.		**Level 1 Recall** **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** **Level 4 Extended critical thinking and reasoning**
Teaching and Learning Resources	○ Video documentaries ○ Audio-visual equipment	○ Laptops with MS Office installed	

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
3.3.1.CS.2	3.3.1.LI.1	3.3.1.AS.1
Apply iteration to improve engineering designs.	**Analyse failures associated with prototypes and provide appropriate remedies.** **Hands-on experimentation**: Have learners test prototypes under different conditions and analyse the results to identify any failures. Encourage learners to come up with potential solutions to these failures and test them through further experimentation. **Design Thinking:** Use design thinking principles to guide learners through the process of failure testing and correction. This involves encouraging learners to empathize with users, define problems, ideate solutions, prototype, and test their prototypes. **Collaborative Learning:** Learners work in teams to test and evaluate prototypes. This can involve dividing learners into small groups and having each group work on a different prototype or having learners work together to test and evaluate a single prototype. **Project-based Learning:** Use a project-based learning approach to teach failure testing and correction of prototypes. This involves having learners work on a real-world design challenge, such as creating a new product or improving an existing one and using failure testing and correction as part of the design process. **Inquiry-based Learning:** Posing questions or problems for learners to explore, encouraging them to come up with their own hypotheses and test them through experimentation, and helping them to analyse and interpret their results.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** **Level 4 Extended critical thinking and reasoning**
Teaching and Learning Resources	○ Video documentaries ○ Audio-visual equipment ○ Laptops with MS Office installed	

Subject **ENGINEERING**
Strand **3. SYSTEMS DESIGN AND PROTOTYPING**
Sub-Strand **2. RAPID PROTOTYPING**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
3.3.2.LO.1		
Translate the content of a schematic diagram into a breadboard circuit implementation.	**Critical thinking and problem-solving**: Learners will need to think critically and creatively in order to design and create prototypes using laser cutting. They will also need to troubleshoot problems and find solutions as they work. **Collaboration and Communication**: Collaborative learning approaches, such as group projects, can help learners develop teamwork and communication skills. They will need to work effectively with others in order to complete their project and share their ideas and knowledge. **Creativity and Innovation:** Laser cutting allows learners to be creative and innovative as they design and create prototypes. They can explore different materials, shapes, and patterns and use their imagination to come up with new ideas. **Digital Literacy:** Using CAD software and laser cutting equipment requires learners to have a certain level of digital literacy. They will need to be able to navigate and use these tools effectively in order to complete their projects. **Leadership and responsibility**: Learners can learn leadership skills as they work on projects and take on various roles within their group. They will also need to be responsible and manage their time and resources effectively in order to complete their project on schedule. **Global Citizenship**: By exploring the applications and capabilities of laser cutting, learners can learn about the global impact of this technology and the	**GESI:** Promoting inclusivity in the classroom by encouraging every learner to actively participate in lessons. Cross-sharing of ideas and thoughts between and among groups and individuals ensures; o Respecting individuals of varying beliefs, religions and cultures o Being sensitive to the inter-relatedness of the various spheres of life, groups and individuals o Being aware of personal biases and stereotypes o Embracing diversity and practising inclusion. **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment o Hard work o Integrity

	ways in which it can be used to address real-world challenges.	
3.3.2.LO.2		
Convert electronic schematic diagrams into PCB format and produce a corresponding functioning PCB board.	**Critical thinking and problem-solving:** Learners will need to think critically and creatively in order to produce high-quality PCBs. They will also need to troubleshoot problems and find solutions as they work. **Collaboration and communication**: Collaborative learning approaches, such as group projects, can help learners develop teamwork and communication skills. They will need to work effectively with others in order to complete their project and share their ideas and knowledge. **Digital Literacy:** Using CAD software and PCB production equipment requires learners to have a certain level of digital literacy. They will need to be able to navigate and use these tools effectively in order to complete their projects. **Leadership and responsibility**: Learners can learn leadership skills as they work on projects and take on various roles within their group. They will also need to be responsible and manage their time and resources effectively in order to complete their project on schedule.	**GESI:** Encouraging all learners in class irrespective of the diversity in gender, ability and background and accepting contributions from all learners ensures; o respect for individuals of varying beliefs, religions, backgrounds and cultures o knowledge of themselves and others' peculiarities and stereotypes o tolerance for diversity and respect for all **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment o Hard work

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
3.3.2.CS.1	3.3.2.LI.1	3.3.2.AS.1
Demonstrate an ability to interpret electronic schematic diagrams and convert them to solderless breadboard circuits.	**Convert a given schematic diagram into a breadboard circuit implementation and proceed to assemble components on the solderless breadboard and test the circuit.** **Experiential Learning: G**uide learners to assemble electronic components on the breadboard by interpreting given schematic diagrams. Learners also test assembled circuits by using digital multimeters to test for continuity, measure voltage across components and make observations on circuit performance. **Project-based Learning:** Learners work on a project that involves interpreting and assembling components from a given schematic diagram on a solderless breadboard. The learners should test the assembled circuit by following test instructions and observing and reporting on results. **Self-Directed Learning:** Explore online resources: There are many online resources available that can help Learners learn more about solderless breadboard circuit construction and assembly. Learners should be tasked to look for more schematics from these sources implement and report on outcomes.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** **Level 4 Extended critical thinking and reasoning**
Teaching and Learning Resources	○ Video tutorials, Computers with KiCad EDA installed ○ PCB Prototype machine ○ PCB materials	

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI		Assessment
3.3.2.CS.2	3.3.2.LI.1		3.3.2.AS.1
Demonstrate an ability to convert electronic schematic diagrams into Printed Circuit Board (PCB) formats.	**Convert a given electronic circuit into a PCB and produce a functioning PCB board using CAD and CAM tools.** **Initiating Talk for Learning:** The facilitator shows learners how a PCB prototype machine works and explains the different techniques of producing PCBs. The facilitator walks the class through the basic principles of designing a PCB layout from a given schematic layout using CAD software such as KiCad EDA. This should be limited to single-sided PCB layouts. **Experiential Learning:** The facilitator guides learners to create single-layer PCB layouts using a CAD tool like KiCad EDA. Learners also produce PCBs from the single layout designs using CAM with a PCB prototyping machine. Learners are also exposed to testing procedures for single-layer PCBs. **Self-Directed Learning**: Explore online resources: There are many online resources available that can help Learners learn more about PCB layout design and production. Learners should be tasked to look for more schematics from these sources implement and report on outcomes. **Project-based Learning:** Learners work on a project that involves the design of a single-layer PCB layout, production, assembly of components and testing of the complete product.		Level 1 Recall **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
Teaching and Learning Resources	○ Video tutorials ○ Computers with KiCad EDA installed	○ PCB Prototype machine ○ PCB materials	

Subject **ENGINEERING**
Strand **4. AUTOMATION AND EMBEDDED SYSTEMS**
Sub-Strand **1. AUTOMATION TECHNOLOGIES**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
3.4.1.LO.1		
Explain the roles of motors, fluid power systems, sensors and actuators, switches and relays in industrial automated systems.	**Problem-solving and Critical Thinking:** Embedded systems projects often require learners to analyse complex systems, design solutions, and troubleshoot problems. Through this process, they will develop their problem-solving and critical thinking skills. **Collaboration and Teamwork:** Embedded systems projects often involve working with a team of peers. By collaborating with others, learners will develop their teamwork and communication skills. **Creativity and Innovation:** Through embedded systems projects, learners will be able to express their creativity and develop their innovation skills. They can come up with new ideas and designs and test them out to see if they work. **Technical Literacy:** By studying embedded systems, learners will develop their technical literacy and gain knowledge in specific technical areas such as programming, microcontroller architectures, and electronics. **Computational Thinking:** Understanding the concepts of embedded systems, learners will learn to think in computational terms, and will have a better understanding of how algorithms, data structures and programming languages work. **Digital Literacy:** learners will be exposed to different digital technologies such as sensors and actuators, microcontroller development boards, and programming	**GESI:** Working with each other in an inclusive way, cross-sharing of knowledge and understanding between and among groups and individuals, for instance, leads to; o Respecting individuals of varying beliefs, religions and cultures o Being sensitive to the inter-relatedness of the various spheres of life, groups and individuals o Being aware of personal biases and stereotypes o Embracing diversity and practising inclusion. **National Core Values:** o Integrity o Tolerance o Open-mindedness o Patience o Integrity o Hard work

	software. They will learn how to work with digital tools, as well as how to analyse, evaluate and communicate information using digital technologies.	
3.4.1.LO.2		
Design simple industrial automation systems using programmable logic controllers (PLC).	**Problem-solving and Critical Thinking:** Embedded systems projects often require learners to analyse complex systems, design solutions, and troubleshoot problems. Through this process, they will develop their problem-solving and Critical thinking skills. **Collaboration and Teamwork:** Embedded systems projects often involve working with a team of peers. By collaborating with others, learners will develop their teamwork and communication skills. **Creativity and Innovation:** Through embedded systems projects, learners will be able to express their creativity and develop their innovation skills. They can come up with new ideas and designs and test them out to see if they work. **Technical Literacy:** By studying embedded systems, learners will develop their technical literacy and gain knowledge in specific technical areas such as programming, microcontroller architectures, and electronics. **Computational Thinking:** By understanding the concepts of embedded systems, learners will learn to think in computational terms and will have a better understanding of how algorithms, data structures and programming languages work. **Digital Literacy:** learners will be exposed to different digital technologies such as sensors and actuators, microcontroller development boards, and programming software. They will learn how to work with digital tools, as well as how to analyse, evaluate and communicate information using digital technologies.	**GESI:** Encouraging all learners in class irrespective of the diversity in gender, ability and background and accept contributions from all learners ensures; o respect for individuals of varying beliefs, religions, backgrounds and cultures o knowledge of themselves and others' peculiarities and stereotypes o tolerance for diversity and respect for all **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment o Hard work

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
3.4.1.CS.1	3.4.1.LI.1	3.4.1.AS.1
Demonstrate ability to characterise general industrial automation control devices and implement simple automated systems.	**Design and implement simple industrial automated systems using a combination of motors, fluid power systems, sensors and actuators, switches and relays based on design requirements** **Talk for Learning:** The facilitator provides basic theory in the area of motor starter and control circuits, contactors and relays, switches, fluid power systems, sensors and PLCs and how they are integrated for industrial control. Learners are also introduced to the ladder programming language for PLCs. **Experiential Learning:** **Field Trip:** Learners take a trip to a factory or site with a PLC-based industrial automation system in place and observe the roles of the various components, such as motors, sensors, contactors, relays, and fluid power systems in the respective installation, taking note of the engineering diagrams and other documentation for the site. Learners could also tour the industrial automation laboratory for a similar experience. **Project-based hands-on sessions:** Learners are taken through simple concepts of industrial automation using simple PLC-based projects such as an ***Automated door opening system, an Automated room light controller with a bi-directional visitor counter, an Elevator controller, a Water pumping controller, etc.*** The learners begin with connecting components within the respective projects according to diagrams and downloading programmes onto the PLCs interfaced with the hardware for control. The facilitator explains the function of each component and code (in the case of ladder programming) in the respective project and leaves learners to further explore by manipulating components and observing system behaviour. In some projects, the facilitator may start with the simplest version of the implementation and move through the modifications systematically with the learners to gradually introduce more complex functions or features. **Guest Speaker:** Inviting automation engineers to share experiences with learners will enhance the learning experience and make it more relevant. **Self-Directed Learning:** Explore online resources: There are many online resources available that can help Learners learn more about PLC programming and automation. Some good options include	Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** **Level 4 Extended critical thinking and reasoning**

	online tutorials, instructional videos, and forums where learners can ask questions and get feedback from experts. Learners learn additional knowledge and experiences of PLC-based industrial control and present individual reports. **Project-based Experiential Learning:** Incorporate hands-on projects that allow learners to apply their CAD skills to real-world design challenges. This can help them develop their problem-solving skills and better understand the design process. **Collaborative Learning:** Learners work in groups to design, implement, test and document simple PLC-based automation systems. Each group should assign specific role(s) to members towards the solution of the challenge. Roles may, for example may, be modelled after typical design and production teams in the industry to give them the relevant exposure and develop team and collaborative skills in them.	
	3.4.1.LI.2	3.4.1.AS.2
	Learners should be able to programme PLCs and use them in combination with other components to implement simple industrial automation systems based on design criteria. **Talk for Learning:** The facilitator provides basic theory in the area of motor starter and control circuits, contactors and relays, switches, fluid power systems, sensors and PLCs and how they are integrated for industrial control. Learners are also introduced to the ladder programming language for PLCs. **Experiential Learning:** **Field Trip:** Learners take a trip to a factory or site with a PLC-based industrial automation system in place and observe the roles of the various components, such as motors, sensors, contactors, relays, and fluid power systems in the respective installation, taking note of the engineering diagrams and other documentation for the site. Learners could also tour the industrial automation laboratory for a similar experience. **Project-based hands-on sessions:** Learners are taken through simple concepts of industrial automation using simple PLC-based projects such as an ***Automated door opening system, an Automated room light controller with a bi-directional visitor counter, an Elevator controller, a Water pumping controller, etc.*** The learners begin with connecting components within the respective projects according to diagrams and downloading programmes onto the PLCs interfaced with the hardware for control. The facilitator explains the function of each component and code (in	**Level 1 Recall** **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** **Level 4 Extended critical thinking and reasoning**

	the case of ladder programming) in the respective project and leaves learners to further explore by manipulating components and observing system behaviour. In some projects, the facilitator may start with the simplest version of the implementation and move through the modifications systematically with the learners to gradually introduce more complex functions or features. **Guest Speaker:** Inviting automation engineers to share experiences with learners will enhance the learning experience and make it more relevant. **Self-Directed Learning:** Explore online resources: There are many online resources available that can help Learners learn more about PLC programming and automation. Some good options include online tutorials, instructional videos, and forums where learners can ask questions and get feedback from experts. Learners learn additional knowledge and experiences of PLC-based industrial control and present individual reports. **Project-based Experiential Learning:** Incorporate hands-on projects that allow learners to apply their CAD skills to real-world design challenges. This can help them develop their problem-solving skills and better understand the design process. **Collaborative Learning:** Learners work in groups to design, implement, test and document simple PLC-based automation systems. Each group should assign a specific role(s) to members towards the solution of the challenge. Roles may, for example may, be modelled after typical design and production teams in the industry to give them the relevant exposure and develop team and collaborative skills in them.	
Teaching and Learning Resources	○ PLC Automation Workshop ○ Video documentaries,	○ Audio-visual equipment ○ Laptops with MS Office installed	

Subject ENGINEERING
Strand 4. AUTOMATION AND EMBEDDED SYSTEMS
Sub-Strand 2. EMBEDDED SYSTEMS

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
3.4.2.LO.1		
Design embedded systems to interface with sensors such as Humidity, Proximity, IR Motion, Accelerometer, Sound, Light Distance, Pressure, thermal and actuators such as motors, buzzers,	**Collaboration:** Working with others on projects or problems can help learners develop important teamwork and communication skills. **Critical thinking and problem-solving:** Problem-based learning and inquiry-based learning can help learners develop critical thinking and problem-solving skills as they interpret technical diagrams to implement a solution or troubleshoot systems. **Digital Literacy:** Using online resources and simulations can help learners develop skills in using technology and finding and evaluating online information. **Adaptability:** Working on real-world projects or problems can help learners learn to adapt and be flexible as they encounter new challenges and changing requirements. **Initiative:** Giving learners the opportunity to take the lead on projects and explore other resources on Engineering drawings on their own can help them develop initiative and self-direction.	**GESI:** Ensuring all learners in class irrespective of the diversity in ability, socio-cultural backgrounds, and gender and soliciting contributions from all learners ensures; o respect for individuals of varying beliefs, religions, backgrounds and cultures o knowledge of themselves and others' peculiarities, strengths and weaknesses o tolerance for diversity and respect for all **National Core Values:** o Tolerance o Friendliness o Open-mindedness o Patience o Commitment o Hard work

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI		Assessment
3.4.2.CS.1	3.4.2.LI.1		3.4.2.AS.1
Demonstrate ability to design embedded systems to work with sensors and actuators.	**Learners should be able to design embedded systems to interface with sensors and actuators given design objectives.** **Project-based experiential Learning:** Through simple projects, the facilitator guides learners to assemble circuits involving sensors such as Humidity, Proximity, IR Motion, Accelerometer, Sound, Light Distance, Pressure, thermal and actuators such as motors, buzzers on solderless breadboards to be interfaced with the Arduino microcontroller. The facilitator uses these mini projects to demonstrate the relevant sections of code for interfacing these respective hardware and leaves the learners to manipulate the hardware and code to observe the changes which occur. These projects should be carefully selected to have relevance to the environment and interest of the learners. Examples of such projects could include but are not limited to the following: ***weather station, heartbeat monitor, digital thermometer, home security system, digital tachometer, water bottling system, water flow and volume measurement, and soil moisture measurement.*** **Self-Directed Learning:** Learners are given access to online resources to explore further hardware interfacing projects for implementation and experimentation. Learners should be motivated to individually build and test at least three (3) of such projects on their own and in groups and present to peers. **Collaborative Learning:** Learners work in groups to design, implement, test and document simple embedded solutions involving interfacing with sensors such as Humidity, Proximity, IR Motion, Accelerometer, Sound, Light Distance, Pressure, thermal and actuators such as motors and buzzers. Each group should assign a specific role(s) to members towards the solution of the challenge. Roles may, for example may, be modelled after typical design and production teams in the industry to give them the relevant exposure and develop team and collaborative skills.		**Level 1 Recall** **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** **Level 4 Extended critical thinking and reasoning**
Teaching and Learning Resources	○ Arduino Embedded System Kits ○ Video documentaries	○ Audio-visual equipment ○ Laptops with MS Office installed	