ROBOTICS

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.

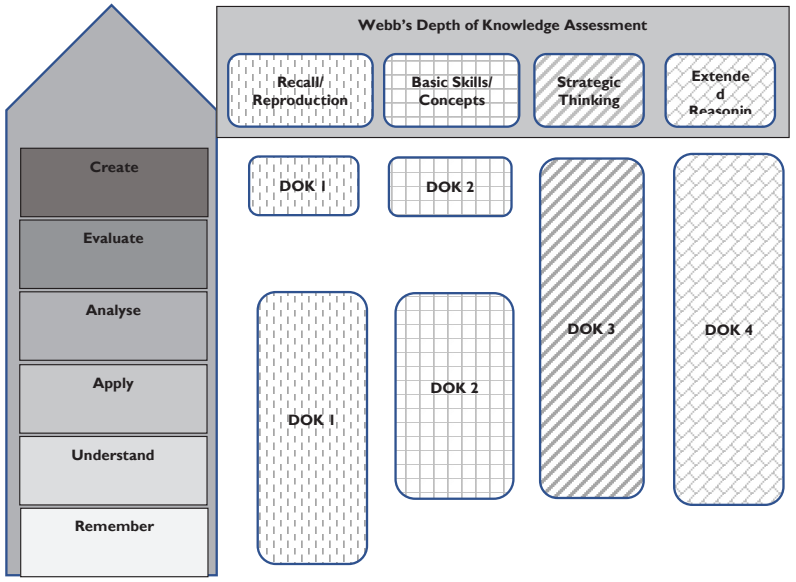

Figure 1: Revised Bloom Taxonomy combined with Webb's Depth of Knowledge for Teaching and Assessment

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 ROBOTICS

Philosophy

The next generation of creators and technology developers can be empowered through observation, curiosity and exposure to related robotic concepts and opportunities that leverage practical activities in a learner-centered 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 robot-based solutions for increasingly complex societal problems.

Goal

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

Contextual Issues

1. Limited GESI Balanced Role Models: The lack of gender equality and social inclusion (GESI) balanced role models in society can be a contextual issue that affects the interest and engagement of students, particularly girls, in robotics. The absence of visible role models representing diverse backgrounds and genders can create barriers to students' identification with the field and their motivation to pursue robotics.
2. Cost and Accessibility of Physical Resources: The heavy reliance on expensive physical resources for robotics education can be a contextual issue. In the Ghanaian context, where financial resources may be limited, the cost and availability of robotics equipment and materials can pose challenges to schools in implementing the curriculum effectively. Limited access to these resources can hinder hands-on learning experiences and practical application of robotics concepts.
3. Limited Preparatory Exposure in Junior High Schools: The lack of prior exposure to robotics in junior high schools can be a contextual issue that impacts the introduction of robotics in senior high schools. Without a foundation or prior knowledge in robotics, students and teachers may struggle to grasp the concepts and skills required in the senior high school curriculum. Additional support and bridging programs may be needed to address this contextual issue.
4. Limited Industrial Participation: The dependence on industrial participation for the success of the curriculum can be a contextual issue, particularly in areas where industrial involvement in robotics education is minimal or lacking. Limited collaboration with industries and the availability of real-world application opportunities can affect the practical relevance of the curriculum and the development of students' skills. Finding alternative ways to provide industry exposure and engagement, such as partnerships with local businesses or leveraging technology platforms, may be necessary to address this contextual issue.

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 robotics 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

Robotics Summary

S/N	STRAND	SUB-STRAND	YEAR 1			YEAR 2			YEAR 3		
			CS	LO	LI	CS	LO	LI	CS	LO	LI
1	Principles of Robotic Systems	Robots and Society	2	2	3	2	2	4	2	2	4
		Robot Control Principles	2	2	4	2	2	4	3	3	5
		Sensors and Actuators	2	2	4	2	2	4	1	1	2
2	Robot Design Methodologies	Digital and Analogue System Design	2	2	4	2	2	3	1	1	2
		Tools and Apps for Robot Design	1	1	2	1	1	1	-	-	-
3	Robot Construction and Programming	Higher Order Design Thinking	1	1	2	1	1	1	-	-	-
		Robot Construction	2	2	3	2	2	2	1	1	1
		Programming Robot	2	2	4	2	2	4	-	-	-
Total			**14**	**14**	**26**	**14**	**14**	**23**	**8**	**8**	**14**

Overall Totals (SHS 1 – 3)

Content Standards	36
Learning Outcomes	36
Learning Indicators	63

YEAR ONE

Subject ROBOTICS
Strand 1. Principles of Robotic Systems
Sub-Strand 1. Robots & Society

Learning Outcomes	21st Century Skills and Competencies	GESI[1], SEL[2] and Shared National Values
1.1.1.LO.1		
Appraise the peculiar characteristics of the various industrial revolutions and critically analyse the impact of performance on human-robot coexistence in working environments.	**Critical Thinking**: As learners watch these videos and interact with the other learning materials, they critically observe and analyse the defining characteristics of each revolution and how they differ from others. **Collaboration:** Learners sit in well-mixed (gender-balanced and culturally diverse) groups and take turns to relay their observations to their peers. The right ambience should be created to allow every learner to collaborate with others, building on points raised and putting down their collective observations while amicably resolving issues of differences in opinions. **Communication:** Learners express their thoughts among their peers in an environment that is unbiased and free from fear or intimidation, and they patiently listen to others. **Leadership:** As learners sit in groups and brainstorm, they create and share tasks and responsibilities among themselves to achieve set goals for the group. **Critical Thinking:** As learners critically analyse the narratives of the performance impacts of robots in these environments.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and individuals to the effective management and maintenance of the home. • be sensitive to the inter-relatedness of the various aspects of life. • value and promote justice at home and in society. **Leadership and Respect for Others' Views:** Inculcate the habit of leadership through teamwork and respect for individuals' views, beliefs, religions, and cultures.

[1] Gender Equality and Social Inclusion

[2] Socio-Emotional Learning

	Information Literacy: As learners critically analyse the narratives and reports, they begin to understand statistics and data.	**Diversity**: Promote divergent views to ensure inclusivity in the learning environment. **Equity:** Develop fair and impartial opportunities or resources for learners devoid of unwanted segregation or discrimination among learners. **Managing Transition:** This can be realised if teachers guide and facilitate learning by generating discourse among learners and challenging them to accept and share responsibility for their own learning based on their unique individual differences (including GESI and gifted and talented learners). **SEL:** Give responsibilities to everyone in the groups. As much as possible, offer all learners equitable opportunities to interact and use teaching and learning resources. **National Core Values**: • Tolerance • Friendliness • Open-mindedness • Patience • Hard work • Humility **Truth and Integrity:** Reward truth and honesty as strong moral principles, leading to responsible citizenship. **Tolerance:** Model tolerance among learners by creating opportunities for collaborative learning through mixed-ability grouping within differentiated classroom instruction. **Make use of socio-emotional activities such as** consolidating project reports/journal writing, reading

		project reports aloud, doing daily consultations on projects, holding class/group meetings, and talking about managing emotions.
1.1.1.LO.2		
Outline the essential economic and social benefits of using robots in 21st-century environments.	**Critical Thinking:** As learners elicit and prioritise benefits, they are made to think critically, providing justification for each decision they have made. **Information Literacy:** As learners comb through online resources for information on the benefits of robots, they develop research skills. **Collaboration:** Learners sit in well-mixed (gender-balanced and culturally diverse) groups and take turns relaying their thoughts to their peers. The right ambience should be created to allow every learner to collaborate with others, building on points raised and putting down their collective submissions while amicably resolving issues of differences in opinions. **Social Skills:** As learners meet and network, they develop social skills. **Communication:** Learners express their thoughts among their peers in an environment that is unbiased and free from fear or intimidation, and they patiently listen to others. **Leadership:** As learners sit in groups to brainstorm, they create and share tasks and responsibilities among themselves to achieve set goals for the group.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and individuals to the effective management and maintenance of the home. • be sensitive to the inter-relatedness of the various aspects of life. • value and promote justice at home and in society. **Leadership and Respect for Others' Views:** Inculcate the habit of leadership through teamwork and respect for individuals' views, beliefs, religions, and cultures. **Diversity**: Promote divergent views to ensure inclusivity in the learning environment. **Equity:** Develop fair and impartial opportunities or resources for learners devoid of unwanted segregation or discrimination among learners.

		Managing Transition: This can be realised if teachers guide and facilitate learning by generating discourse among learners and challenging them to accept and share responsibility for their own learning based on their unique individual differences (including GESI and gifted and talented learners). **SEL:** Give responsibilities to everyone in the groups. As much as possible, offer all learners equitable opportunities to interact and use teaching and learning resources. **National Core Values**: • Tolerance • Friendliness • Open-mindedness • Patience • Hard work • Humility **Truth and Integrity:** Reward truth and honesty as strong moral principles, leading to responsible citizenship. **Tolerance:** Model tolerance among learners by creating opportunities for collaborative learning through mixed-ability grouping within differentiated classroom instruction. **Make use of socio-emotional activities such as** consolidating project reports/journal writing, reading project reports aloud, doing daily consultations on projects, holding class/group meetings, and talking about managing emotions.

<table>
<tr><th>Content Standards</th><th>Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI</th><th>Assessment</th></tr>
<tr><td>1.1.1.CS.1</td><td>1.1.1.LI.1</td><td>1.1.1.AS.1</td></tr>
<tr><td rowspan="3">Demonstrate understanding of the role of robots as socio-technical systems.</td><td>Describe the distinct features and advancements that characterise the transition from each of the industrial revolutions.

Experiential Learning: Watch videos on the various industrial revolutions, document personal observations, and share them with the class. Learners comment on shared observations.

Collaborative Learning: Sit in groups and discuss learner observations on the peculiarities of each revolution and the transitions. Groups classify various machines under the identified industrial revolutions. Structure learners' contributions using a flowchart to reflect features of various phases of transition.

Illustrate with a chart</td><td>Level 1 Recall
Level 2 Skills of conceptual understanding
Level 3 Strategic reasoning
Level 4 Extended critical thinking and reasoning</td></tr>
<tr><td>1.1.1.LI.2</td><td>1.1.1.AS.2</td></tr>
<tr><td>Analyse how the four organisational performance indicators (price, quality, flexibility, and innovation) have been impacted by the interdependence of humans and robots in working environments.

Problem-Based Learning: Work in groups to do a comprehensive performance analysis of a narrative describing the pre-robot and post-robot integration in a working environment. Groups present their analysis for the class to comment on. Structure learners' presentation using a table comparing the two eras.</td><td>Level 1 Recall
Level 2 Skills of conceptual understanding
Level 3 Strategic reasoning
Level 4 Extended critical thinking and reasoning</td></tr>
<tr><td>Teaching and Learning Resources</td><td colspan="2">Video Documentaries
Charts
Articles
Narratives
Reports
Pictures/videos of simple physical machines</td></tr>
</table>

Content Standards	**Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI**	**Assessment**
1.1.1.CS.2	1.1.1.LI.1	1.1.1.AS.1
Identify the uses of robots and automated systems in different workplaces guided by roboethics.	**Identify the economic and social benefits of using robots in 21st-century environments (workplaces, smartly built environments such as smart homes and smart cities, playgrounds, etc.) within the confines of accepted standards and ethics.** **Diamond Nine:** Individually list three economic and three social benefits of robots in a 21st-century working environment. Team up and work in groups of three to prioritise their nine benefits in order of most significance and share with the class. **Problem-Based Learning:** In pairs or with an elbow partner, learners review ethical and standards documents, make personal ethical suggestions and elicit any ethical issues that apply to adopting and using robots at homes and workplaces. Share their thoughts 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	• Sticky Notes • Flip charts	• Online Resources • Standards and regulatory documents, Diamond Nine Sheet

Subject ROBOTICS
Strand 1. Principles of Robotic Systems
Sub-Strand 2. Robot Control Principles

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
1.1.2.LO.1		
Assess various systems, classify whether they fall under robotic or non-robotic systems, and outline the functions of the subsystems of robots.	**Media Literacy:** Learners, by watching videos, analyse, reflect and take action from media files. **Critical Thinking:** Learners listen keenly and contribute to discussions to meet lesson objectives. **Communication:** Learners contribute to the discussion by expressing their thoughts among their peers in an environment free from fear or intimidation and patiently listening to others. **Leadership:** As learners make contributions, convince their colleagues why they think their submissions are correct. **Technology Literacy:** As learners work with robots, they learn to use, comprehend, manage, and analyse technology effectively and responsibly. **Communication:** As learners document their observations, they develop effective writing and reporting skills.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and individuals to the effective management and maintenance of the home. • be sensitive to the inter-relatedness of the various aspects of life. • value and promote justice at home and in society. **Leadership and Respect for Others' Views:** Inculcate the habit of leadership

		through teamwork and respect for individuals' views, beliefs, religions, and cultures. **Diversity**: Promote divergent views to ensure inclusivity in the learning environment. **Equity:** Develop fair and impartial opportunities or resources for learners devoid of unwanted segregation or discrimination among learners. **Managing Transition:** This can be realised if teachers guide and facilitate learning by generating discourse among learners and challenging them to accept and share responsibility for their own learning based on their unique individual differences (including GESI and gifted and talented learners). **SEL:** Give responsibilities to everyone in the groups**.** As much as possible, offer all learners equitable opportunities to interact and use teaching and learning resources. **National Core Values**: • Tolerance • Friendliness • Open-mindedness • Patience • Hard work • Humility **Truth and Integrity:** Reward truth and honesty as strong moral principles, leading to responsible citizenship.

		Tolerance: Model tolerance among learners by creating opportunities for collaborative learning through mixed-ability grouping within differentiated classroom instruction. **Make use of socio-emotional activities such as** consolidating project reports/journal writing, reading project reports aloud, doing daily consultations on projects, holding class/group meetings, and talking about managing emotions.
1.1.2.LO.2		
Classify feedback and non-feedback loop systems and demonstrate the use of logic and loop diagrams in control systems design.	**Critical Thinking:** Learners critically analyse and prepare their research findings for presentation. **Collaboration:** Learners sit in well-mixed (gender-balanced and culturally diverse) groups and take turns to relay their individual research findings to their peers. The right ambience should be created to allow each and every learner to collaborate with others, building on points raised and putting down their collective findings while amicably resolving conflicting findings. **Communication:** Learners present their findings to their peers in an environment that is free from fear or intimidation. **Leadership:** As learners work in research groups, they create and share tasks and responsibilities among themselves to achieve set goals for the group. **Information Literacy:** Learners catalogue the results of their research and format them for presentation. **Critical Thinking:** Learners critically analyse narratives and make deductions for given assessments.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and individuals to the effective management and maintenance of the home. • be sensitive to the inter-relatedness of the various aspects of life.

	Technology Literacy: As learners work with CAD tools, they learn to use, comprehend, manage, and analyse technology effectively and responsibly.	• value and promote justice at home and in society. **Leadership and Respect for Others' Views:** Inculcate the habit of leadership through teamwork and respect for individuals' views, beliefs, religions, and cultures. **Diversity**: Promote divergent views to ensure inclusivity in the learning environment. **Equity:** Develop fair and impartial opportunities or resources for learners devoid of unwanted segregation or discrimination among learners. **Managing Transition:** This can be realised if teachers guide and facilitate learning by generating discourse among learners and challenging them to accept and share responsibility for their own learning based on their unique individual differences (including GESI and gifted and talented learners). **SEL:** Give responsibilities to everyone in the groups**.** As much as possible, offer all learners equitable opportunities to interact and use teaching and learning resources. **National Core Values**: • Tolerance • Friendliness • Open-mindedness • Patience • Hard work

		• Humility **Truth and Integrity:** Reward truth and honesty as strong moral principles, leading to responsible citizenship. **Tolerance:** Model tolerance among learners by creating opportunities for collaborative learning through mixed-ability grouping within differentiated classroom instruction. **Make use of socio-emotional activities such as consolidated project report/journal writing, reading project reports aloud, doing daily consultation on projects, holding class/group meetings, and** talking about managing emotions.

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 knowledge and understanding of robot subsystems and their functions.	**Describe robots and identify the differences between robotic and non-robotic systems.** **Initiating Talk for Learning:** Use **KWL** to explore what learners **Know, Want to know and Learn** about the topic (tabulate responses). Discuss what robotic systems are, emphasising their ability to provide intelligent services and interact with their environment. Review and critique different encounters with systems that will be considered robotic systems. **Experiential Learning**: Watch a documentary showcasing the differences between robotic and non-robotic systems and evaluate the concepts of design, construction, and programming of robots for sensory feedback and automated actuation. **Talk for Learning:** Learners think-pair-share observed characteristics of given systems and classify the systems as robotic or non-robotic systems. Using a think-pair-share approach, learners are given a few minutes to individually classify these examples by noting them in their books, then pair with any of their colleagues and share their justification for their classification. The pair then shared their	**Level 1 Recall** Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
	collective submissions and resolved their differences, if any, calling on the facilitator where needed. The facilitator finally asks various teams to share their joint classifications and justifications.	
	1.1.2.LI.2	1.1.2.AS.2
	Describe the attributes and functionalities of a robot's subsystems and how they interconnect. **Talk for Learning:** Through questioning, initiate a session with an interactive talk with learners on the sub-systems of robots and how they are interconnected. Structure thoughts of learners using concept maps. **Experiential Learning**: After identifying the various subsystems, learners work in groups using either a simulated robot or a real working robot. To help with their research on the role and significance of the various subsystems, they detach or disconnect the subsystems (in no particular order), one after the other, from the robot while documenting their observed effects and share with 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	• Videos • Pictures	• Assembled robots

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 knowledge of fundamental control principles in automation and robotics.	**Contrast non-feedback loop systems and feedback loop systems.** **Problem-Based Learning:** Work in balanced mixed-abilities groups to research and present on either non-feedback loop or feedback loop systems. **Managing Talk for Learning:** In a moderated discussion, learners draw out contrasting differences from their research findings and share them with the class for feedback. Encourage learners to tolerate feedback and comment on others respectfully.	**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
	Evaluate the use of logic and loop diagrams and demonstrate their use in control systems' design. **Problem-Based Learning:** Introduces learners to standard loop and logic diagram representations of components and how they are used in control systems' design. Learners draw loop and logic diagrams to represent given system narratives. Learners share drawings 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	• Textbooks Online • Resources	• Operational System Narratives • Diagrams	• Textbooks Online • Resources	• CAD tools

Subject **ROBOTICS**
Strand 1. **Principles of Robotic Systems**
Sub-Strand 3. **Sensors & Actuators**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
1.1.3.LO.1		
Analyse the similarities between robots and living organisms and outline critical scientific principles that underpin how sensing is achieved in robots.	**Critical Thinking:** Learners critically analyse videos and make deductions for given assessments. **Media Literacy:** Learners, by watching videos, analyse, reflect and take action from media files. **Social Skills:** As learners meet and network, they develop social skills. **Communication:** Learners express their thoughts among their peers in an environment that is unbiased and free from fear or intimidation, and they patiently listen to others.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and individuals to the effective management and maintenance of the home. • be sensitive to the inter-relatedness of the various aspects of life. • value and promote justice at home and in society. **Leadership and Respect for Others' Views:** Inculcate the habit of leadership through

		teamwork and respect for individuals' views, beliefs, religions, and cultures. **Diversity**: Promote divergent views to ensure inclusivity in the learning environment. **Equity:** Develop fair and impartial opportunities or resources for learners devoid of unwanted segregation or discrimination among learners. **Managing Transition:** This can be realised if teachers guide and facilitate learning by generating discourse among learners and challenging them to accept and share responsibility for their own learning based on their unique individual differences (including GESI and gifted and talented learners). **SEL:** Give responsibilities to everyone in the groups**.** As much as possible, offer all learners equitable opportunities to interact and use teaching and learning resources. **National Core Values**: • Tolerance • Friendliness • Open-mindedness • Patience • Hard work • Humility

		Truth and Integrity: reward truth and honesty as strong moral principles, leading to responsible citizenship. **Tolerance:** Model tolerance among learners by creating opportunities for collaborative learning through mixed-ability grouping within differentiated classroom instruction. **Make use of socio-emotional activities such as consolidating project reports/journal writing, reading project reports aloud, doing daily consultations on projects, holding class/group meetings, and** talking about managing emotions.
1.1.3.LO.2		
Experiment with varying linear sensors such as Light sensors, Colour Sensors, Ultrasonic Sensors, Temperature sensors, etc., explain their outputs and apply linear equations to calibrate them.	**Initiative:** Learners are given the opportunity to initiate and control their own experiments, leading them to the discovery of underlying scientific knowledge. **Flexibility:** Learners in their experimentation observe and change their experimental approaches as needed to achieve the target goal. **Technology Literacy:** As learners take sensor readings, observe defective values and calibrate sensors, they gain an experiential understanding of sensor imperfections and how to map defective sensor readings to standardised readings.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and

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		• Friendliness • Open-mindedness • Patience • Hard work • Humility **Truth and Integrity:** Reward truth and honesty as strong moral principles, leading to responsible citizenship. **Tolerance:** Model tolerance among learners by creating opportunities for collaborative learning through mixed-ability grouping within differentiated classroom instruction. **Make use of socio-emotional activities such as consolidating project reports/journal writing, reading project reports aloud, doing daily consultations on projects, holding class/group meetings, and** talking about managing emotions.

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
Relate nature-inspired sensing, mechanics and controls to applications in robot sensory, architecture and control systems.	**Draw a parallel relationship that relates the coordination of senses, brain and moving parts in living organisms to the coordination of sensors, processors and actuators in robots.** **Experiential Learning:** Watch videos of various bio-inspired robots, and for each robot, draw parallel feature maps to living organisms. Share drawings with the class for comments and feedback.	**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
	Discuss the scientific principles underlying the operation of sensors. **Talk for Learning:** Through questioning, discuss scientific principles underpinning various sensors' operation. **Experiential Learning**: Test and discuss the behaviour of the various Sensors in groups. Record the limits/boundary values for all the sensors and discuss real-life situations where and how these sensors can be employed. Groups share discussions and observations with 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	• Videos • Textbooks	• Online Resources • Demonstration with Sensors

Content Standards	**Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI**		**Assessment**
1.1.3.CS.2	1.1.3.LI.1		1.1.3.AS.1
Demonstrate knowledge and understanding of sensor outputs for performance improvement in robotic systems.	**Examine varying outputs of different linear sensors and explain the variations observed.** **Project-Based Learning:** Learners watch a video on linear sensors and share their observations. Guide learners in conducting various experiments using linear sensors and observing and documenting experiment results. Learners share results 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
	1.1.3.LI.2		1.1.3.AS.2
	Apply knowledge from linear equations to calibrate linear sensors and to scale sensor readings to fit within a desired max-min range. **Project-Based Learning:** Demonstrate how linear sensors can be calibrated using linear equations. In pairs, learners follow the same procedures to calibrate different kinds of linear sensors and share them with the class for feedback.		Level 1 Recall Level 2 Skills of conceptual understanding Level 3 Strategic reasoning **Level 4 Extended critical thinking and reasoning**
Teaching and Learning Resources	• Sensors • Graph Books	• Function Generators • Monitors	

Subject **ROBOTICS**
Strand 2. **Robot Design Methodologies**
Sub-Strand 1. **Digital and Analogue System Design**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
1.2.1.LO.1		
Correctly label the components of an electronic circuit, state their functions and interpret block and schematic diagrams.	**Information Literacy:** Learners deduce information from the media resources and various electronic devices shown to them. **Collaboration:** Learners sit in well-mixed (gender-balanced and culturally diverse) groups and take turns to relay their observations to their peers. The right ambience should be created to allow every learner to collaborate with others, building on points raised and putting down their collective observations while amicably resolving issues of differences in opinions. **Critical Thinking:** Learners critically analyse the results of their research and make deductions for their given assessments. **Critical Thinking:** Learners critically analyse their given circuits in deriving block and schematic diagrams.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and individuals to the effective management and maintenance of the home. • be sensitive to the inter-relatedness of the various aspects of life. • value and promote justice at home and in society.

		Leadership and Respect for Others' Views: Inculcate the habit of leadership through teamwork and respect for individuals' views, beliefs, religions, and cultures. **Diversity**: Promote divergent views to ensure inclusivity in the learning environment. **Equity:** Develop fair and impartial opportunities or resources for learners devoid of unwanted segregation or discrimination among learners. **Managing Transition:** This can be realised if teachers guide and facilitate learning by generating discourse among learners and challenging them to accept and share responsibility for their own learning based on their unique individual differences (including GESI and gifted and talented learners). **SEL:** Give responsibilities to everyone in the groups. As much as possible, offer all learners equitable opportunities to interact and use teaching and learning resources. **National Core Values**: • Tolerance • Friendliness • Open-mindedness • Patience • Hard work

		• Humility **Truth and Integrity:** Reward truth and honesty as strong moral principles, leading to responsible citizenship. **Tolerance:** Model tolerance among learners by creating opportunities for collaborative learning through mixed-ability grouping within differentiated classroom instruction. **Make use of socio-emotional activities such as consolidating project reports/journal writing, reading project reports aloud, doing daily consultations on projects, holding class/group meetings, and talking** about managing emotions.
1.2.1.LO.2		
Assemble electronic circuits from schematic diagrams and analyse their application in discrete and continuous-time machine design.	**Information Literacy:** Learners draw information from the configuration of breadboards. **Collaboration:** Learners work in groups to assemble and test electronic circuits on a solderless breadboard **Critical Thinking:** Learners use the pre-designed schematic diagram to build and test electronic components. **Curiosity**: Learners research ways to assemble and test electronic components.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development.

	Information Literacy: Learners are informed as they are introduced to analogue and digital signals. **Collaboration:** Learners work in groups to know the differences between analogue and digital output signals. **Critical Thinking:** Learners are able to distinguish between analogue and digital signals. **Curiosity**: Learners observe the input and output of these machines and classify them as analogue and digital.	• interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and individuals to the effective management and maintenance of the home. • be sensitive to the inter-relatedness of the various aspects of life. • value and promote justice at home and in society. **Leadership and Respect for Others' Views:** Inculcate the habit of leadership through teamwork and respect for individuals' views, beliefs, religions, and cultures. **Diversity**: Promote divergent views to ensure inclusivity in the learning environment. **Equity:** Develop fair and impartial opportunities or resources for learners devoid of unwanted segregation or discrimination among learners **Managing Transition:** This can be realised if teachers guide and facilitate learning by generating discourse among learners and challenging them to accept and share responsibility for their own learning based on their unique individual differences (including GESI and gifted and talented learners).

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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 familiarity with the concepts and principles that underpin the application of analogue and digital components in circuit building.	**Identify the components of an electronic circuit and their functions.** **Project-Based Learning:** Provide learners with pictures of various basic electronic components (e.g., Resistors, Capacitors, LEDs, Inductors, Circuit Breakers, Relays, Diodes, Transistors, etc.). Learners are then given electronic circuits from which they are made to identify the components on board and their ratings. Learners then research the functions of these components using textbooks and online resources. Finally, they document the identified components, their specifications and their function in the circuit.	**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
	Properly label and explain block and schematic diagram representations of electronic systems. **Project-Based Learning:** Introduce learners to schematic and block notations. Develop block and schematic representations of given circuit narratives. Learners then pick other schematic and block diagrams and, write descriptive summaries of what they observe, and share them with 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	• Pictures • Online resources • Circuit boards	• Datasheets • Schematic and Block Diagrams • PCB	• Online Resources • Textbooks

Content Standards	**Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI**				**Assessment**
1.2.1.CS.2	1.2.1.LI.1				1.2.1.AS.1
Demonstrate practical skills in assembling electronic circuits.	**Assemble and test electronic circuits on a solderless breadboard using pre-designed schematic diagrams.** **Project-Based Learning:** Explain the configuration of breadboards to learners and guide them in using monitoring tools like digital multimeters. Assemble and test electronic circuits on a solderless breadboard using pre-designed schematic diagrams.				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
	Critically analyse analogue and digital systems and observe how they relate to both discrete and continuous-time machine designs. **Project-Based Learning:** Introduce learners to analogue and digital signals. Learners observe and contrast the outputs of digital and analogue systems in an attempt to spot the differences. Provide learners with examples of discrete and continuous-time machines (e.g., analogue radio sets, ceiling fans, wall clocks, pulse meters, digital and analogue scales, etc). Observe the inputs and outputs of these machines and classify them as analogue or digital.				Level 1 Recall Level 2 Skills of conceptual understanding Level 3 Strategic reasoning **Level 4 Extended critical thinking and reasoning**
Teaching and Learning Resources	• Solderless Breadboards • Digital multimeters	• Schematic diagrams • Videos	• Pictures • Online resources	• Textbooks	

Subject **ROBOTICS**
Strand 2. **Robot Design Methodologies**
Sub-Strand 2. **Tools & Apps for Robot Design**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
1.2.2.LO.1		
Effectively use virtual platforms and simulation tools to design and test robots.	**Critical Thinking:** Learners, with the aid of online learning materials, familiarise themselves with the features of the tools. **Technology Literacy:** As learners are aided in installing robot design, programming and simulation tools, they learn to use, comprehend, manage and analyse these tools effectively and responsibly. **Critical Thinking:** Learners use their previous knowledge to design projects to meet specifications and make changes to their designs where necessary. **Curiosity**: Learners look out for ways to redesign and make changes to their designs. **Collaboration:** Learners sit in well-mixed (gender-balanced and culturally diverse) groups and take turns relaying their thoughts to their peers as they collaborate in solving the assignments. The right ambience should be created to allow every learner to collaborate with others, building on points raised and putting down their collective submissions while amicably resolving issues of differences in opinions.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and individuals to

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		opportunities to interact and use teaching and learning resources. **National Core Values**: • Tolerance • Friendliness • Open-mindedness • Patience • Hard work • Humility **Truth and Integrity:** Reward truth and honesty as strong moral principles, leading to responsible citizenship. **Tolerance:** Model tolerance among learners by creating opportunities for collaborative learning through mixed-ability grouping within differentiated classroom instruction. **Make use of socio-emotional activities such as consolidating project reports/journal writing, reading project reports aloud, doing daily consultations on projects, holding class/group meetings, and** talking about managing emotions.

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 abilities to use Integrated Development Environments, Modelling and Simulation tools needed for the design and testing of robots.	**Explore features of selected modelling, programming and simulation tools useful for the design of robots.** **Experiential Learning:** Guide learners in installing robot design, programming, and simulation tools. With the help of online learning tutorials, learners familiarise themselves with the features of these tools.	**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
	Design robots using virtual platforms and, simulation tools and programming IDEs to test the mechanics of the designed robots. **Project-Based Learning:** Based on prior experience and understanding of design tools, learners will take up various robot design projects and design them to meet specifications. Using simulation tools and programming IDEs, they test their designs and make changes to their design where necessary. At this point, students may not need to program but copy the already written codes from the building instruction guides to test their designs.	Level 1 Recall Level 2 Skills of conceptual understanding Level 3 Strategic reasoning **Level 4 Extended critical thinking and reasoning**
Teaching and Learning Resources	• Design and Simulation tools • Programming IDEs • Online Resources • Robot Building Instruction guide • Computers	

Subject ROBOTICS
Strand 3. Robot Construction & Programming
Sub-Strand 1. Higher Order Design Thinking

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
1.3.1.LO.1		
Use flowchart diagrams to implement algorithms for solutions to basic problems.	**Critical Thinking:** Learners are made to think critically as they are made to determine the input, process and output required to solve the challenge. **Collaboration:** Learners sit in well-mixed (gender-balanced and culturally diverse) groups and take turns relaying their thoughts to their peers. **Social Skills:** As learners meet and network, they develop social skills. **Critical thinking:** Learners critically think through the use of flowcharts, pseudo codes, and algorithms to represent the flow of inputs from processes to output. **Media Literacy:** Learners go online to pick resources to solve the problem.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and individuals to the effective management and maintenance of the home. • be sensitive to the inter-relatedness of the various aspects of life.

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		• Friendliness • Open-mindedness • Patience • Hard work • Humility **Truth and Integrity:** Reward truth and honesty as strong moral principles, leading to responsible citizenship. **Tolerance:** Model tolerance among learners by creating opportunities for collaborative learning through mixed-ability grouping within differentiated classroom instruction. **Make use of socio-emotional activities such as** Consolidated project report/journal writing, reading project reports aloud, doing daily consultation on projects, holding class/group meetings, talking about managing emotions,

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 higher-order thinking (HOT – Analysis, Synthesis and Evaluation) in solving programming problems.	**Determine the Inputs, Processes and Outputs required to solve a particular problem.** **Problem-Based Learning:** Learners pick a recognised global robotics challenge (e.g., from the World Robot Olympiad) and work in groups to determine the inputs, processes and outputs required to solve the challenge.			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
	Define solutions to fundamental automated and robotic problems using algorithms, pseudocodes, and flowchart diagrams. **Problem-Based Learning:** Use flowcharts, pseudo-codes and algorithms to represent the flow of inputs through processes to outputs as determined in the learning experience of indicator			Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
Teaching and Learning Resources	• Selected global robotics challenge • Flowcharts	• Flip Charts • Flowcharts	• Online flowcharting tools	

Subject **ROBOTICS**
Strand 3. **Robot Construction & Programming**
Sub-Strand 2. **Robot Construction**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
1.3.2.LO.1		
Appraise the effects of mass and centre of gravity in designing structures that withstand forces.	**Critical Thinking:** Learners use their knowledge of physics and life experience to discuss how stability can be achieved. **Communication:** Learners contribute to the discussion by expressing their thoughts among their peers in an environment free from fear or intimidation and patiently listening to others. **Leadership:** As learners make contributions, they convince their colleagues why they think their submissions are correct. **Critical Thinking:** Learners use controls defined in earlier flowcharts to build sub-structures fit for actuation **Media Literacy:** Learners analyse and reflect on earlier flowcharts and other learning materials to build sub-structures **Collaboration:** Learners sit in well-mixed (gender-balanced and culturally diverse) groups and contribute to building sub-structures. The right ambience should be created to allow every learner to collaborate with others, building on points raised and putting down their collective	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and individuals to the effective management and maintenance of the home. • be sensitive to the inter-relatedness of the various aspects of life. • value and promote justice at home and in society.

	observations while amicably resolving issues of differences in opinions. **Leadership:** As learners sit in groups to brainstorm and build sub-structures, they create and share tasks and responsibilities among themselves to achieve set goals for the group.	**Leadership and Respect for Others' Views:** Inculcate the habit of leadership through teamwork and respect for individuals' views, beliefs, religions, and cultures. **Diversity**: Promote divergent views to ensure inclusivity in the learning environment. **Equity:** Develop fair and impartial opportunities or resources for learners devoid of unwanted segregation or discrimination among learners. **Managing Transition:** This can be realised if teachers guide and facilitate learning by generating discourse among learners and challenging them to accept and share responsibility for their own learning based on their unique individual differences (including GESI and gifted and talented learners). **SEL:** Give responsibilities to everyone in the groups As much as possible, offer all learners equitable opportunities to interact and use teaching and learning resources. **National Core Values**: • Tolerance • Friendliness • Open-mindedness

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1.3.2.LO.2		
Create robots using fabricated robotic materials or local materials to implement basic mechanic operations.	**Critical Thinking:** Learners use controls defined in earlier flowcharts to build fully functional robots fit for actuation. **Media Literacy:** Learners analyse and reflect on earlier flowcharts and other learning materials to build fully functional robots. **Collaboration:** Learners sit in well-mixed (gender-balanced and culturally diverse) groups and contribute to building the fully functional robot. The right ambience should be created to allow every learner to collaborate	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to

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<table>
<tr><th>Content Standards</th><th colspan="4">Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI</th><th>Assessment</th></tr>
<tr><td>1.3.2.CS.1</td><td colspan="4">1.3.2.LI.1</td><td>1.3.2.AS.1</td></tr>
<tr><td rowspan="3">Demonstrate a general understanding of rigid bodies and design processes for stable structures.</td><td colspan="4">Describe the effect of mass and centre of gravity on the stability of a structure or robot and strategies for designing systems that can withstand forces.

Building on What Others Say: Build on students' previous knowledge in physics and life experiences to discuss how stability can be achieved in building robots. Also, the relationships between the linear momentum of a system and the forces acting on it should be discussed.

Talk for Learning: Start a discussion to help learners identify the position/velocity/acceleration of the centre of mass for a system of objects given their masses and positions/velocities/accelerations.</td><td>Level 1 Recall
Level 2 Skills of conceptual understanding
Level 3 Strategic reasoning
Level 4 Extended critical thinking and reasoning</td></tr>
<tr><td colspan="4">1.3.2.LI.2</td><td>1.3.2.AS.2</td></tr>
<tr><td colspan="4">Build structures for a specified use case and test them for stability and ability to withstand forces.

Experiential Learning: Build sub-structures that fit the actuation of sub-controls defined in the flowcharts in the learning experience of the indicator.</td><td>Level 1 Recall
Level 2 Skills of conceptual understanding
Level 3 Strategic reasoning
Level 4 Extended critical thinking and reasoning</td></tr>
<tr><td>Teaching and Learning Resources</td><td>• Online Resources
• Textbooks
• Videos</td><td>• Flowcharts
• Local Materials
• Robotic Kits</td><td>• Pliers
• Glue guns</td><td>• Screwdrivers
• Power drills</td><td></td></tr>
</table>

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
1.3.2.CS.2	1.3.2.LI.1	1.3.2.AS.1
Demonstrate ability to create robots, vehicles, and other contraptions with moving parts.	**Sit in groups and create robots using robotic kits and/or local materials to build robots that address the problems of recognised global robotics challenges (e.g., the World Robotics Olympiad). They should make use of the following:** **Gears** • Gear Ratios • Compound Gear Systems • Changing the angle of rotation using gears • Using worm gears **Vehicles** • Driving robots with single motors • Driving robots with two motors **Moving Without Tires:** Walking Machines **Arms, Wings & Others** • Flapping Wings • Gripping Figures • Lifting Mechanisms **Talk for Learning:** Discuss how the arrangement of small and large gears determines if the gear train will increase torque or speed and how different gear combinations can be used to change the direction of forces.	Level 1 Recall Level 2 Skills of conceptual understanding Level 3 Strategic reasoning **Level 4 Extended critical thinking and reasoning**

	Project-Based Learning: Work in teams to determine the gear ratio and output speed/torque of gear trains. **Experiential Learning:** By giving use cases to problems that will require the use of gears for controlling seed, torque, timing and direction of forces, earners will work in groups to build fully functional robotic subsystems for the actuation of controls that satisfy conditions in the given use cases.		
Teaching and Learning Resources	• Flowcharts • Local Materials • Robotic Kits	• Pliers • Glue guns	• Screwdrivers • Power drills

Subject ROBOTICS
Strand 3. Robot Construction & Programming
Sub-Strand 3. Programming Robots

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
1.3.3.LO.1		
Create programs that make use of decision structures and loop conditions to control robots.	**Listening Skills**: Learners develop listening skills as they listen to the facilitator and the submission of their colleagues during the revision process. **Critical thinking:** As learners go through problem analysis to find solutions for project tasks, they think critically. They also engage in practical activities as they interact with various programming IDEs to which they are introduced. **Emotional Intelligence:** Learners develop the discipline of meeting deadlines and the set project objectives. **Collaboration:** Learners sit in well-mixed (gender-balanced and culturally diverse) groups and contribute to developing decision-making programs. The right ambience should be created to allow every learner to collaborate with others, building on points raised and putting down their collective observations while amicably resolving issues of differences in opinions. **Leadership:** As learners sit in groups to brainstorm and develop decision-making programs, they create and share tasks and responsibilities among themselves to achieve set goals for the group.	1. As facilitators provide resources, they are mindful of biases, stereotypes, and prejudices and place efforts to provide well-balanced examples. Also, with patience, facilitators encourage and provide opportunities for learners to contribute to discussions or ask questions without intimidation. 2. Facilitators provide unbiased, constructive verbal feedback to learners. 3. As learners work in groups, they are made aware of their personal biases and stereotypes, embrace diversity, and practice inclusion. The talk on learning the method of facilitation helps learners embrace empathy and establish tolerance among themselves.

	Social Skills: As learners meet and network, they develop social skills	
1.3.3.LO.2		
Design and program Finite State Machines	**Information literacy:** Learners are informed as they are guided through the flow of control programs **Critical thinking:** Learners use the knowledge in decision-making programs and flow of control programs to create finite-state controls that automate the behaviour of a built robot. **Emotional Intelligence:** Learners develop the discipline of meeting deadlines and the set project objectives. **Collaboration:** Learners sit in well-mixed (gender-balanced and culturally diverse) groups and contribute to developing decision-making programs. The right ambience should be created to allow every learner to collaborate with others, building on points raised and putting down their collective observations while amicably resolving issues of differences in opinions. **Leadership:** As learners sit in groups to brainstorm and develop decision-making programs, they create and share tasks and responsibilities among themselves to achieve set goals for the group. **Social Skills:** As learners meet and network, they develop social skills	1. As facilitators provide resources, they are mindful of biases, stereotypes, and prejudices and place efforts to provide well-balanced examples. Also, with patience, facilitators encourage and provide opportunities for learners to contribute to discussions or ask questions without intimidation. 2. Facilitators provide unbiased, constructive verbal feedback to learners. 3. As learners work in groups, they are made aware of their personal biases and stereotypes, embrace diversity, and practice inclusion as well as embrace empathy

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
1.3.3.CS.1	1.3.3.LI.1	1.3.3.AS.1
Establish the essence of programming and demonstrate skills in the use of programming constructs for robots.	**Create computer programs from pre-designed flowcharts that have single-decision conditions.** **Talk for Learning:** Through discussions, conduct a revision of learners' knowledge in programming and create functional decision-making programs that control a built robot in a familiar programming language or environment. **Project-Based Learning:** Work in groups to develop functional decision-making programs that implement single decision conditions identified in the flowcharts from the learning experience of indicator 3.1.1.2	**Level 4** Write and test computer programs progressively and iteratively on a built robot to address the challenge of a recognised global robotics challenge (e.g. from the World Robot Olympiad) using IDEs and present your robot in class for peer review. [Learners should work in groups for this assessment]
	1.3.3.LI.2	
	Create computer programs from pre-designed flowcharts that have nested decision conditions. **Project-Based Learning:** With the facilitator's guidance, learners will work in groups to develop decision-making programs that implement nested decision conditions identified in their flowchart in the learning experience of indicator 3.1.1.2	
	1.3.3.LI.3	
	Create computer programs from pre-designed flowcharts that have a controlled feedback loop with loop interrupts. **Talk for Learning:** Through discussions, conduct a revision of learners' knowledge in programming relating to the flow of control and create programs that implement controlled	

	feedback loops with loop interruptions to control a built robot in a familiar programming language or environment. **Project-Based Learning:** Work in groups to develop the flow of control programs that implement the control process identified in the flowchart from the learning experience of indicator 3.1.1.2			
Teaching and Learning Resources	• Programming IDEs • Online Resources	• Computers • Built Robot, etc.		

Content Standards	**Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI**		**Assessment**
1.3.3.CS.2	1.3.3.LI.1		1.3.3.AS.1
Demonstrate understanding and programming skills in the implementation of Finite State Machines (FSM).	**Formulate and program FSMs to control different use cases (e.g., temperature control, multi-state motor speed control, etc.).** **Project-Based Learning:** With the facilitator's guidance, work in groups to combine developed functional decision-making programs and flow of control programs to create finite-state controls that automate the behaviour of a built robot		**Level 3** Describe the steps to go through in the formulation of a finite-state machine. **Level 4** Formulate and program a finite-state machine for controlling a well-described use case.
Teaching and Learning Resources	• Programming IDEs • Online Resources	• Computers • Built Robot, etc.	

YEAR TWO

Subject **ROBOTICS**
Strand 1. **Principles of Robotic Systems**
Sub-Strand 1. **Robots & Society**

Learning Outcomes	**21st Century Skills and Competencies**	**GESI[3], SEL[4] and Shared National Values**
2.1.1.LO.1		
Justify the need for integrating robots in human-centred environments for positive impact and outline ethical/safety considerations for successful coexistence.	**Critical Thinking:** • As learners brainstorm in analysing the positive and negative impacts of robots on society. • Learners make deductions from their research when publishing their articles. **Collaboration:** • Sit in groups and take turns relaying their thoughts to their peers. The right ambience should be created to allow every learner to collaborate with others, building on points raised and putting down their collective observations while amicably resolving issues of differences in opinions. • Learners sit in groups and take turns relaying their thoughts to their peers. The right ambience should be created to allow every learner to collaborate with others, building on points raised and putting down their collective observations while amicably resolving issues of differences in opinions.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and individuals to the effective management and maintenance of the home.

[3] Gender Equality and Social Inclusion

[4] Socio-Emotional Learning

	Communication: • Learners express their thoughts among their peers in an environment that is unbiased and free from fear or intimidation, and they patiently listen to others. • Learners contribute to the global discussion on these topics, expressing their thoughts in written form for a wider audience to read. **Leadership:** As learners sit in groups and brainstorm, they create and share tasks and responsibilities among themselves to achieve set goals for the group. **Critical Thinking:** As learners brainstorm in analysing the cost-benefit analysis and finding plausible use cases for robots in society/industry. **Initiative:** Learners are given the opportunity to write on a topic they deem important to them in this area, sharing their thoughts with the world. **Media Literacy:** Learners have the opportunity to conduct a detailed literature review, analysing other people's works in the area they select. **Emotional Intelligence:** Learners develop the discipline of meeting deadlines and set objectives.	• be sensitive to the inter-relatedness of the various aspects of life. • value and promote justice at home and in society. **Leadership and Respect for Others' Views:** Inculcate the habit of leadership through teamwork and respect for individuals' views, beliefs, religions, and cultures. **Diversity**: Promote divergent views to ensure inclusivity in the learning environment. **Equity:** Develop fair and impartial opportunities or resources for learners devoid of unwanted segregation or discrimination among learners. **Managing Transition:** This can be realised if teachers guide and facilitate learning by generating discourse among learners and challenging them to accept and share responsibility for their own learning based on their unique individual differences (including GESI and gifted and talented learners). **SEL:** Give responsibilities to everyone in the groups**.** As much as possible, offer all learners equitable opportunities to interact and use teaching and learning resources. **National Core Values**: • Tolerance

		• Friendliness • Open-mindedness • Patience • Hard work • Humility **Truth and Integrity:** Reward truth and honesty as strong moral principles, leading to responsible citizenship. **Tolerance:** Model tolerance among learners by creating opportunities for collaborative learning through mixed-ability grouping within differentiated classroom instruction. **Make use of socio-emotional activities such as consolidating project reports/journal writing, reading project reports aloud, doing daily consultations on projects, holding class/group meetings, and** talking about managing emotions.
2.1.1.LO.2		
Identify possible career paths in the area of robotics.	**Initiative:** Learners are given the opportunity to research job postings they think are related to robotics. **Media Literacy:** Learners have the opportunity to conduct a detailed review of each posting, analysing the requirements and job responsibilities.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to:

	Critical Thinking: Learners make deductions from their research into what they think guarantees them consideration by an employer. **Communication:** Learners learn to prepare written CVs and share the results of their research with their colleagues, justifying any points made. **Emotional Intelligence:** Learners develop the discipline of meeting deadlines and set objectives.	• respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and individuals to the effective management and maintenance of the home. • be sensitive to the inter-relatedness of the various aspects of life. • value and promote justice at home and in society. **Leadership and Respect for Others' Views:** Inculcate the habit of leadership through teamwork and respect for individuals' views, beliefs, religions, and cultures. **Diversity**: Promote divergent views to ensure inclusivity in the learning environment.

		Equity: Develop fair and impartial opportunities or resources for learners devoid of unwanted segregation or discrimination among learners. **Managing Transition:** This can be realised if teachers guide and facilitate learning by generating discourse among learners and challenging them to accept and share responsibility for their own learning based on their unique individual differences (including GESI and gifted and talented learners). **SEL:** Give responsibilities to everyone in the groups. As much as possible, offer all learners equitable opportunities to interact and use teaching and learning resources. **National Core Values**: • Tolerance • Friendliness • Open-mindedness • Patience • Hard work • Humility

		Truth and Integrity: Reward truth and honesty as strong moral principles, leading to responsible citizenship. **Tolerance:** Model tolerance among learners by creating opportunities for collaborative learning through mixed-ability grouping within differentiated classroom instruction. **Make use of socio-emotional activities such as consolidated project report/journal writing, reading project reports aloud, doing daily consultation on projects, holding class/group meetings, and** talking about managing emotions.

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 knowledge, application and understanding of robots as socio-technical systems in making 21st-century environments better, safer and easier.	**Analyse and enumerate both the positive and negative impacts of robots on society.** **Collaborative Learning**: Sit in groups, brainstorm and document the positive and negative impacts of robots in society. Groups share thoughts with the class. Structure contributions using tables or mind maps.	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 need for robot coexistence with humans, taking into consideration safety and roboethics. **Talk for Learning:** In small mixed-ability groups, learners conduct a well-executed cost-benefit analysis on Robot-Human coexistence in a given 21st-century working environment. Groups share their thoughts with the class for contributions and comments.	Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** **Level 4 Extended critical thinking and reasoning**
	2.1.1.LI.3	2.1.1.AS.3
	Write publishable articles on topics related to ethics, safety and robot coexistence in society. **Inquiry-Based Learning:** In pairs, learners research and write and publish short articles in school magazines, online blogs, etc., targeted at demystifying the fear of Industry 4.0 technologies integration in human environments. Articles should be displayed in class for peers to read 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	• Flip charts • News articles	• Narratives • Online resources	• Reports • Research publications	• Narratives

Content Standards	**Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI**		**Assessment**
2.1.1.CS.2	2.1.1.LI.1		2.1.1.AS.1
Demonstrate knowledge of possible career opportunities in the area of robotics.	**Identify related job postings (online, newspapers, radio, etc.) and prepare sample responses.** **Inquiry-Based Learning:** Learners individually conduct research from different media sources on job postings related to robotics. Learners select one of the postings of their choice and outline the job requirements and responsibilities. They then pair with a colleague, and each of them shares the job they selected. Together, they work on sample CVs that they think will catch an employer's attention. They take turns critiquing each other's CVs, and each pair later presents their CVs to the class for comments. Structure presentations by outlining careers in robotics.		Level 1 Recall **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning **Level 4 Extended critical thinking and reasoning**
Teaching and Learning Resources	• Newspapers • Online Resources	• Radio	

Subject **ROBOTICS**
Strand 1. **Principles of Robotic Systems**
Sub-Strand 2. **Robot Control Principles**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
2.1.2.LO.1		
Convert an automated solution narrative into controlled feedback and non-feedback component designs.	**Social Skills:** Learners participate in a facilitated discussion to meet set goals. **Collaboration:** Learners sit in well-mixed (gender-balanced and culturally diverse) groups and take turns to relay their observations to their peers. The right ambience should be created to allow every learner to collaborate with others, building on points raised and putting down their collective observations while amicably resolving issues of differences in opinions. **Critical Thinking:** Learners work in groups to brainstorm, discuss and design solutions for problems **Listening Skills:** Learners develop listening skills as they listen to the facilitator. **Critical Thinking:** As learners listen to the facilitator, they critically analyse the information he/she shares on feedback systems.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and individuals to the effective management and maintenance of the home. • be sensitive to the inter-relatedness of the various aspects of life. • value and promote justice at home and in society.

		Leadership and Respect for Others' Views: Inculcate the habit of leadership through teamwork and respect for individuals' views, beliefs, religions, and cultures. **Diversity**: Promote divergent views to ensure inclusivity in the learning environment. **Equity:** Develop fair and impartial opportunities or resources for learners devoid of unwanted segregation or discrimination among learners. **Managing Transition:** This can be realised if teachers guide and facilitate learning by generating discourse among learners and challenging them to accept and share responsibility for their own learning based on their unique individual differences (including GESI and gifted and talented learners). **SEL:** Give responsibilities to everyone in the groups**.** As much as possible, offer all learners equitable opportunities to interact and use teaching and learning resources. **National Core Values**: • Tolerance • Friendliness • Open-mindedness

		• Patience • Hard work • Humility **Truth and Integrity:** reward truth and honesty as strong moral principles, leading to responsible citizenship. **Tolerance:** Model tolerance among learners by creating opportunities for collaborative learning through mixed-ability grouping within differentiated classroom instruction. **Make use of socio-emotional activities such as consolidating project reports/journal writing, reading project reports aloud, doing daily consultations on projects, holding class/group meetings, and** talking about managing emotions.
2.1.2.LO.2		
Formulate arithmetic and logical models for continuous-time and finite-state machines.	**Listening Skills:** Learners develop listening skills as they listen to the facilitator. **Critical Thinking:** Learners analyse the requirements of an automation system and formulate error detection and correction **Critical Thinking:** Learners analyse given requirements of a robotic system and formulate logically driven stately machines.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to

		home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and individuals to the effective management and maintenance of the home. • be sensitive to the inter-relatedness of the various aspects of life. • value and promote justice at home and in society. **Leadership and Respect for Others' Views:** Inculcate the habit of leadership through teamwork and respect for individuals' views, beliefs, religions, and cultures. **Diversity**: Promote divergent views to ensure inclusivity in the learning environment. **Equity:** Develop fair and impartial opportunities or resources for learners devoid of unwanted segregation or discrimination among learners. **Managing transition:** This can be realised if teachers guide and facilitate learning by generating discourse among learners and challenging them to accept and share responsibility for their own learning based on

		their unique individual differences (including GESI and gifted and talented learners). **SEL:** Give responsibilities to everyone in the groups. As much as possible, offer all learners equitable opportunities to interact and use teaching and learning resources. **National Core Values**: • Tolerance • Friendliness • Open-mindedness • Patience • Hard work • Humility **Truth and Integrity:** Reward truth and honesty as strong moral principles, leading to responsible citizenship. **Tolerance:** Model tolerance among learners by creating opportunities for collaborative learning through mixed-ability grouping within differentiated classroom instruction. **Make use of socio-emotional activities such as consolidating project reports/journal writing, reading project reports aloud, doing daily consultations on projects, holding class/group**

		meetings, and talking about managing emotions.

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 knowledge and understanding of design skills in the implementation of controls for automation and robotics.	**Make use of component diagrams and system diagrams to design non-feedback systems for implementing controls in given scenarios.** **Initiating Talk for Learning:** The teacher leads a discussion to walk learners through design methodologies using component diagrams and system diagrams for designing non-feedback-controlled systems. **Collaborative Learning**: Learners work in small, well-balanced groups to design component and system diagrams for given use cases or a narrated automated solution to a problem guided by the following steps: • Brainstorm to understand the solution • Discuss candidate design ideas • Sketch out candidate design ideas on paper • Choose the best design • Use standard component and system diagrams to represent the chosen design	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
	Utilise component and system diagrams to design feedback systems for implementing controls in given scenarios. **Talk for Learning:** Host a focus group discussion on feedback loops as the basic element from which systems are assembled. The facilitator demonstrates the representation of feedback systems using component diagrams and system diagrams.	Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning

Teaching and Learning Resources	• Component Diagrams • System Diagrams • CAD Tools	• Brainstorming sheets • Flip Charts	• Online Resources • Textbooks

Content Standards	**Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI**			**Assessment**
2.1.2.CS.2	2.1.2.LI.1			2.1.2.AS.1
Demonstrate mathematical and logical modelling skills in the implementation of controls for automation and robotics.	**Analyse scenarios and derive mathematical models for implementing continuous-time machines.** **Initiating Talk for Learning:** Introduce learners to the principles of continuous-time system automation for "error detection and correction" and "error avoidance". In pairs, learners analyse the given requirements of automation systems and formulate the "error detection and correction" and "error avoidance" equations required for automation. Pairs share their findings 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
	2.1.2.LI.2			2.1.2.AS.2
	Analyse and derive logical models for the implementation of finite-state machines. **Experiential Learning:** Through questioning, learners analyse the given actuation requirements of a robotic system and formulate logically driven stately machines in conformance with the requirements. Comment on learners' findings to shape their thoughts.			Level 1 Recall Level 2 Skills of conceptual understanding: Level 3 Strategic reasoning **Level 4 Extended critical thinking and reasoning**
Teaching and Learning Resources	• Online resources • Textbooks • Videos	• Pictures • Charts • A built robot	• A commensurate robot actuation platform • Requirement documents	• Online resources • Textbooks

Subject **ROBOTICS**
Strand 1. **Principles of Robotic Systems**
Sub-Strand 3. **Sensors & Actuators**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
2.1.3.LO.1		
Examine sensor power source, input and output using appropriate measuring instruments and correctly classify them as either active-analogue, passive-analogue, active-digital or passive-digital sensors.	**Communication:** Learners observe and document as they are taken through discussions on analogue and digital systems. **Communication**: Learners contribute to the discussion by classifying and justifying their classification with scientific reasons and technical documentation. **Critical Thinking:** Learners justify their classification with scientific reason.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and individuals to the effective management and maintenance of the home. • be sensitive to the inter-relatedness of the various aspects of life.

		• value and promote justice at home and in society. **Leadership and Respect for Others' Views:** Inculcate the habit of leadership through teamwork and respect for individuals' views, beliefs, religions, and cultures. **Diversity**: Promote divergent views to ensure inclusivity in the learning environment. **Equity:** Develop fair and impartial opportunities or resources for learners devoid of unwanted segregation or discrimination among learners. **Managing Transition:** This can be realised if teachers guide and facilitate learning by generating discourse among learners and challenging them to accept and share responsibility for their own learning based on their unique individual differences (including GESI and gifted and talented learners). **SEL:** Give responsibilities to everyone in the groups. As much as possible, offer all learners equitable opportunities to interact and use teaching and learning resources. **National Core Values**: • Tolerance

		• Friendliness • Open-mindedness • Patience • Hard work • Humility **Truth and Integrity:** Reward truth and honesty as strong moral principles, leading to responsible citizenship. **Tolerance:** Model tolerance among learners by creating opportunities for collaborative learning through mixed-ability grouping within differentiated classroom instruction. **Make use of socio-emotional activities such as consolidating project reports/ journal writing, reading project reports aloud, doing daily consultations on projects, holding class/group meetings, and** talking about managing emotions.
2.1.3.LO.2		
Use mathematical knowledge for sensor data manipulation and application for digital control of actuators.	**Communication:** • Learners express their thoughts among their peers in an environment that is unbiased and free from fear or intimidation, and they patiently listen to the facilitator.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to:

	• Learners contribute to the discussion by expressing their thoughts among their peers in an environment free from fear or intimidation and patiently listening to others. **Leadership:** • As learners sit in groups to brainstorm, they create and share tasks and responsibilities among themselves to achieve set goals for the group. • As learners make contributions, they convince their colleagues why they think their submissions are correct**.** **Critical Thinking:** • As learners write programs which involve the use of mathematical equations that accept analogue sensor inputs to produce a specified finite number of digital outputs. • As learners derive mathematical relationships that relate the distance covered to the geometric dimensions of the robot used. • Learners listen keenly and contribute to discussions to meet lesson objectives. **Media Literacy:** Learners, by watching videos, analyse, reflect and take action from media files.	• respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and individuals to the effective management and maintenance of the home. • be sensitive to the inter-relatedness of the various aspects of life. • value and promote justice at home and in society. **Leadership and Respect for Others' Views:** Inculcate the habit of leadership through teamwork and respect for individuals' views, beliefs, religions, and cultures. **Diversity**: Promote divergent views to ensure inclusivity in the learning environment.

		Equity: Develop fair and impartial opportunities or resources for learners devoid of unwanted segregation or discrimination among learners. **Managing Transition:** This can be realised if teachers guide and facilitate learning by generating discourse among learners and challenging them to accept and share responsibility for their own learning based on their unique individual differences (including GESI and gifted and talented learners). **SEL:** Give responsibilities to everyone in the groups. As much as possible, offer all learners equitable opportunities to interact and use teaching and learning resources. **National Core Values**: • Tolerance • Friendliness • Open-mindedness • Patience • Hard work • Humility **Truth and Integrity:** Reward truth and honesty as strong moral principles, leading to responsible citizenship.

		Tolerance: Model tolerance among learners by creating opportunities for collaborative learning through mixed-ability grouping within differentiated classroom instruction. **Make use of socio-emotional activities such as consolidated project report/journal writing, reading project reports aloud, doing daily consultation on projects, holding class/group meetings, and** talking about managing emotions.

<table>
<tr><th>Content Standards</th><th colspan="4">Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI</th><th>Assessment</th></tr>
<tr><td>2.1.3.CS.1</td><td colspan="4">2.1.3.LI.1</td><td>2.1.3.AS.1</td></tr>
<tr><td rowspan="3">Demonstrate knowledge and understanding of sensor classifications.</td><td colspan="4">Explain the striking features that categorise sensors as analogue or digital (based on the output signal) and as either active or passive (based on their power source).

Initiating Talk for Learning: Lead a discussion to walk learners through understanding analogue & Digital Signals, analogue and Digital Systems, Basic Digital Devices and terminologies/principles in analogue and digital sensor technologies. Structure thoughts and contributions using charts, mind maps or concept maps.</td><td>Level 1 Recall
Level 2 Skills of conceptual understanding
Level 3 Strategic reasoning
Level 4 Extended critical thinking and reasoning</td></tr>
<tr><td colspan="4">2.1.3.LI.2</td><td>2.1.3.AS.2</td></tr>
<tr><td colspan="4">Classify sensors as either active-analogue, passive-analogue, active-digital or passive-digital.

Experiential Learning: Learners watch videos on sensors and share their observations. Introduce a wide range of sensors and guide learners in small groups to classify them while justifying their classification with scientific reasons and technical documentation derived from experimenting with the sensors. Groups share their classifications with the class for comments and feedback.</td><td>Level 1 Recall
Level 2 Skills of conceptual understanding
Level 3 Strategic reasoning
Level 4 Extended critical thinking and reasoning</td></tr>
<tr><td>Teaching and Learning Resources</td><td>• Sensors
• Measuring Instruments</td><td>• Online materials
• Pictures</td><td>• Textbooks,
• Flip boards</td><td colspan="2">• Real analogue and digital sensors
• Online materials</td></tr>
</table>

<table>
<tr><th>Content Standards</th><th colspan="3">Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI</th><th>Assessment</th></tr>
<tr><td>2.1.3.CS.2</td><td colspan="3">2.1.3.LI.1</td><td>2.1.3.AS.1</td></tr>
<tr><td rowspan="3">Demonstrate knowledge of the application of equations in the programmatic implementation of analogue to digital conversion and control of actuators.</td><td colspan="3">Apply mathematical methods to programmatically convert continuous-time sensor output to discrete-time digital output.

Project-Based Learning: Use demonstrations and illustrations to guide learners in writing programs to implement mathematical equations that accept and sample continuous analogue sensor inputs to produce any specified finite number of digital output values. Individual learners share what they have done with the class for comments.</td><td>Level 1 Recall
Level 2 Skills of conceptual understanding
Level 3 Strategic reasoning
Level 4 Extended critical thinking and reasoning</td></tr>
<tr><td colspan="3">2.1.3.LI.2</td><td>2.1.3.AS.2</td></tr>
<tr><td colspan="3">Plot a Rotation-Distance graph for different scenarios of wheeled robots and observe how the resultant graph relates to the geometric dimensions of a robot.

Project-Based Learning: Use a rotation distance graph to explain linear and angular distances covered by wheeled robots and derive mathematical relationships that relate the distances covered to the geometric dimensions of the robot used.

Learners observe a demonstration and plot a rotation distance graph reflecting it. Learners share with the class for comments.</td><td>Level 1 Recall
Level 2 Skills of conceptual understanding
Level 3 Strategic reasoning
Level 4 Extended critical thinking and reasoning</td></tr>
<tr><td>Teaching and Learning Resources</td><td>• Computers with required programming IDEs
• Sensors connected to a processing unit or a built programmable robot</td><td>• Built and programmable Robots
• Graph books</td><td colspan="2">• Mathematical Sets
• French Curves</td></tr>
</table>

Subject ROBOTICS
Strand 2. Robot Design Methodologies
Sub-Strand 1. Digital and Analogue System Design

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
2.2.1.LO.1		
Use boolean algebra to define automation solutions and apply Karnaugh Maps to simplify and optimise boolean-defined combinational digital systems.	**Critical Thinking:** As learners critically analyse the narratives of the performance impacts of robots in these environments. **Listening Skills:** Learners develop the skills of listening as well as hands-on skills while they interact with various Programming IDEs that they are introduced to group discussions as well as through problem analysis while finding solutions to project tasks help learners to develop skills in emotional intelligence, discipline in meeting deadlines, and analytical skills. **Collaboration:** Learners have discussions on the maps and their application for digital systems. **Critical Thinking**: Learners begin to think critically as they are made to design and optimise combinational circuits for defined problems. **Communication:** Learners work in groups to solve defined problems.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and individuals to the effective management and maintenance of the home. • be sensitive to the inter-relatedness of the various aspects of life. • value and promote justice at home and in society. **Leadership and Respect for Others' Views:** Inculcate the habit of leadership through teamwork

		and respect for individuals' views, beliefs, religions, and cultures. **Diversity**: Promote divergent views to ensure inclusivity in the learning environment. **Equity:** Develop fair and impartial opportunities or resources for learners devoid of unwanted segregation or discrimination among learners. **Managing Transition:** This can be realised if teachers guide and facilitate learning by generating discourse among learners and challenging them to accept and share responsibility for their own learning based on their unique individual differences (including GESI and gifted and talented learners). **SEL:** Give responsibilities to everyone in the groups As much as possible, offer all learners equitable opportunities to interact and use teaching and learning resources. **National Core Values**: • Tolerance • Friendliness • Open-mindedness • Patience • Hard work • Humility

		Truth and Integrity: Reward truth and honesty as strong moral principles, leading to responsible citizenship. **Tolerance:** Model tolerance among learners by creating opportunities for collaborative learning through mixed-ability grouping within differentiated classroom instruction. **Make use of socio-emotional activities such as consolidating project reports/journal writing, reading project reports aloud, doing daily consultations on projects, holding class/group meetings, and** talking about managing emotions.
2.2.1.LO.2		
Build and test basic combinational circuits on printed circuit boards.	**Critical Thinking:** Learners use the right instruments to take the measurements and deduce component ratings from measured values. **Collaboration:** Learners sit in pairs to convert schematic diagrams into soldered circuits on PCB.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and individuals to the effective management and maintenance of the home.

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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
Demonstrate Understanding of Digital Systems and Logic Design principles.	**Explain and apply Boolean Algebra in the definition and design of digital systems.** **Initiating Talk for Learning:** Lead a discussion to walk learners through basic logic gates -- AND, OR & NOT, XOR, XNOR and their application in the design methodologies and simplification for combinational circuit designs using Boolean Algebra. **Project-Based Learning:** Work independently or in small teams to design schematics of simple logic circuits using logic gates and share them 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**
	2.2.1.LI.2	2.2.1.AS.2
	Apply Karnaugh Maps to optimise digital systems. **Initiating Talk for Learning:** Discuss Karnaugh Maps and their application for digital circuit optimisation using working examples. **Project-Based Learning:** Task learners in small mixed-ability/gender groups to follow processes in designing and optimising combinational circuits for defined problems (as a narrative). The following steps should be evident in the design process: ∇ Brainstorm and write out functional requirements from the narrative ∇ Identify the required number of inputs and outputs ∇ Translate the functional requirements into a Truth Table ∇ Write out the Boolean equation that maps the identified inputs to the outputs ∇ Draw a commensurate K-Map for the Truth Table ∇ Derive a simplified Boolean logic using the K-Map ∇ Draw a schematic representation of the final and optimised circuit.	**Level 1 Recall** **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning **Level 4 Extended critical thinking and reasoning**

Teaching and Learning Resources	• Real circuit board containing various • Gates,	• Breadboards • Electronic kit	• Flip boards • Graphs	• Online materials • Computers with required information

Content Standards	**Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI**			**Assessment**
2.2.1.CS.2	2.2.1.LI.1			2.2.1.AS.1
Demonstrate knowledge of practical skills in the design and building of electronic circuits.	**Solder and test electronic circuits on a Printed Circuit Board (PCB) using pre-designed schematic diagrams.** **Talk for Learning:** In pairs, **l**earners watch a video or do a search on electronic circuits. Identify components such as resistors, capacitors, LEDs, inductors, circuit breakers, relays, diodes, and transistors, as well as their ratings, and explain their purposes in electronic circuits. **Experiential Learning:** In pairs, learners use appropriate measuring instruments to take relevant readings, deduce component ratings from measured values, and share them with the class. **Project-Based Learning:** Learners work in pairs to convert schematic diagrams into soldered circuits on Printed Circuit Boards (PCBs) and share work with the class for comments and feedback.			Level 1 Recall **Level 2 Skills of conceptual understanding** **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
Teaching and Learning Resources	• LEDs • Capacitors	• Inductor • Circuit breakers and transistors	• Diodes	

Subject ROBOTICS
Strand 2. Robot Design Methodologies
Sub-Strand 2. Tools & Apps for Robot Design

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
2.2.2.LO.1		
Use computer-aided design tools to design 3D models of robot parts and operate a 3D printer for fabrication of prototype robot parts.	**Listening Skills:** Learners develop listening skills as well as hands-on skills while they start with basic designs for 3D modelling and focus on rapid prototyping and design concepts. **Critical Thinking:** As learners are guided to use CAD software to design3Dmodels of machine parts **Listening Skills:** Learners develop the skills of listening as well as hands-on skills when they start with basic designs for 3D modelling as well through problem analysis; finding solutions to project tasks helps learners to develop skills in emotional intelligence, discipline in meeting deadlines, and analytical skills.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and individuals to

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Content Standards	**Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI**		**Assessment**
2.2.2.CS.1	2.2.2.LI.1		2.2.2.AS.1
Demonstrate understanding of skills in the use and management of 3D printers.	**Use a CAD tool to model parts of robotic systems.** **Talk for Learning:** Through questioning, **i**ntroduce learners to basic design skills for 3D modelling, focusing on rapid prototyping and design concepts (specially designed for digital fabrication and rendering). **Experiential Learning:** In small mixed-ability groups, learners use CAD software (e.g., Fusion, SketchUp, etc.) to design 3D models of machine parts and save files as 3D STL files. Share the design with the class for comments. **Experiential Learning:** In the same smaller groups, learners use 3D rendering tools (e.g., Cura, etc.) to format and slice existing STL files and prepare them in conformity with the requirements of specific 3D printers. Learners operate a 3D printer to print their 3D models and display them in class for peers to comment on.		**Level 1 Recall** **Level 2 Skills of conceptual understanding** Level 3 Strategic reasoning **Level 4 Extended critical thinking and reasoning**
Teaching and Learning Resources	• Flip boards • 3D CAM software	• 3D CAD software • Videos	

Subject **ROBOTICS**
Strand 3. **Robot Construction and Programming**
Sub-Strand 1. **Higher Order Design Thinking**

Learning Outcomes	**21st Century Skills and Competencies**	**GESI, SEL and Shared National Values**
2.3.1.LO.1		
Use algorithms, pseudocodes and flowcharts to implement low-level design specifications from high-level designs.	**Information Literacy:** As learners use flowcharts to depict defined solutions to problems **Communication:** Learners express their thoughts among their peers in an environment that is unbiased and free from fear or intimidation, and they patiently listen to others.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and individuals to the effective management and maintenance of the home. • be sensitive to the inter-relatedness of the various aspects of life.

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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
Analyse, Synthesise, and Evaluate flowcharts and pseudocodes for complex programming problems in automation and robotics.	**Define solutions for control and feedback systems using algorithms, pseudocodes, and flowchart diagrams.** **Project-Based Learning:** • Demonstrate how flowcharts and pseudocodes are used to depict defined solutions to problems. In pairs, learners develop flowcharts, Analyse, Evaluate, Review and critique each other's flowcharts. • Learners should consider the comments and reviewer's feedback to improve their works and use digital tools to design and submit their final flowcharts with corresponding narratives or pseudocodes. **Information Literacy:** As learners comb through online resources for information on the benefits of robots, they develop research 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	• Flip boards • Computers	• Flowchart Software • Rubrics and Evaluation Criteria

Subject ROBOTICS
Strand 3. Robot Construction and Programming
Sub-Strand 2. Robot Construction

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
2.3.2.LO.1		
Analyse robots with closed-chain designs and formulate navigation equations for traversing specific trajectories.	**Collaboration**: Learners sit in well-mixed (gender-balanced and culturally diverse) groups and take turns relaying their thoughts to their peers. The right ambience should be created to allow every learner to collaborate with others, building on points raised and putting. **Critical Thinking**: Learners listen keenly and contribute to discussions to meet lesson objectives **Communication**: Learners express their thoughts among their peers in an environment that is unbiased and free from fear or intimidation, and they patiently listen to others.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and individuals to the effective management and maintenance of the home. • be sensitive to the inter-relatedness of the various aspects of life.

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		• Friendliness • Open-mindedness • Patience • Hard work • Humility **Truth and Integrity:** reward truth and honesty as strong moral principles, leading to responsible citizenship. **Tolerance:** Model tolerance among learners by creating opportunities for collaborative learning through mixed-ability grouping within differentiated classroom instruction. **Make use of socio-emotional activities such as consolidating project reports/journal writing, reading project reports aloud, doing daily consultations on projects, holding class/group meetings, and** talking about managing emotions.
2.3.2.LO.2		
Create robots using fabricated robotic materials or local materials to implement basic mechanics.	**Collaboration**: Learners sit in well-mixed (gender-balanced and culturally diverse) groups and take turns relaying their thoughts to their peers. The right ambience should be created to allow every learner to collaborate with others, building on points raised and putting. **Critical Thinking**: Learners listen keenly and contribute to discussions to meet lesson objectives.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds.

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		Managing Transition: This can be realised if teachers guide and facilitate learning by generating discourse among learners and challenging them to accept and share responsibility for their own learning based on their unique individual differences (including GESI and gifted and talented learners). **SEL:** Give responsibilities to everyone in the groups. As much as possible, offer all learners equitable opportunities to interact and use teaching and learning resources. **National Core Values**: • Tolerance • Friendliness • Open-mindedness • Patience • Hard work • Humility **Truth and Integrity:** reward truth and honesty as strong moral principles, leading to responsible citizenship. **Tolerance:** Model tolerance among learners by creating opportunities for collaborative learning through mixed-ability grouping within differentiated classroom instruction.

		Make use of socio-emotional activities such as consolidating project reports/journal writing, reading project reports aloud, doing daily consultations on projects, holding class/group meetings, and talking about managing emotions.

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 kinematics of closed-chains, velocity kinematics and trajectory kinematics.	**Discuss closed-chains, velocity and trajectory as they are used in mechanics.** **Talk for Learning:** • Through questioning, learners discuss the concept and definitions of average position, average velocity, and average acceleration. • Learners analyse scenarios or narratives and compute average positions, average velocity, and average accelerations from basic quantities or measurements. • Through questioning, learners discuss the concept and definitions of instantaneous position, velocity, speed, and acceleration. They analyse scenarios or narratives and compute instantaneous position, velocity, speed, and acceleration from basic quantities or measurements, plotting these quantities as a function of time.	Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
	2.3.2.LI.2	2.3.2.AS.2
	Analyse and perform basic calculations involving velocity and trajectory motions and apply trajectory calculations to robot navigations. **Talk for Learning:** Through demonstration, guide learners to identify the direction of velocity and general direction of acceleration at any point in time when given the trajectory of an object in space. Share their finding with the class for comments. **Talk for Learning:** In pairs, learners think about the meaning of "equations of motion" and discuss how to compute position and velocity as a function of time when given the acceleration as a function of time, initial velocity and position. Discuss it for both linear and angular position and velocity.	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 and flip board showing how distance, velocity, acceleration and time are measured • Videos, real objects presentation using the human arm	

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 the ability to create robots, vehicles, and other contraptions with moving parts.	**Create robots using robotic kits and/or local materials to implement basic mechanics for actuations that make use of the following:** **Gears** Swinging Mechanisms Reciprocating Mechanisms Cam Mechanisms Intermittent Motion **Vehicles** Using Caster Wheels Crawlers **Moving Without Tires** Moving like an inchworm **Arms, Wings & Others** Shooting robots Automatic Doors Raking up or out Creating Wind **Talk for Learning:** Lead a discussion on how the arrangement and combination of different gears can be used to realise Swinging Mechanisms, Reciprocating Mechanisms, Cam Mechanisms and Intermittent Motion in control systems. **Experiential Learning:** Provide use cases for problems that will require the use of gears to achieve swinging mechanisms, reciprocating mechanisms, cam mechanisms, and intermittent motion in control systems. Learners work in groups to build fully functional	Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning

	robotic subsystems for the actuation of controls that satisfy conditions in the given use cases. The following steps should be adapted for this activity: • Learners brainstorm Ideas & Solutions for the given Use Case • Learners discuss the brainstormed design ideas. • Learners consider building components needed and available. • Choose the best design. • Sketch out their design ideas on paper. • Learners build a prototype of the best design using robotics kits or local materials. Discuss the following items with your team and be prepared to share them with the rest of the class. • How did the team arrive at the final design solution? • Is the design realistic and well-proportioned? • How did each team member contribute towards the overall design? • Do you feel like everyone had an equal opportunity to contribute to the creative process?	
Teaching and Learning Resources	• Robotic kits and Virtual labs (PC with software such as MATLAB-Simulink, LabView, Proteus, Electronic workbench, Crocodile, etc.) • Local materials.	

Subject **ROBOTICS**
Strand 3. **Robot Construction and Programming**
Sub-Strand 3. **Programming Robots**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
2.3.3.LO.1		
Implement a PID controller and experiment with the effects of proportional gain, derivative gain, and integral gain on the navigation efficiency of PID-controlled two-wheeled rover robots.	**Critical thinking:** As learners interact with the other learning materials, they critically observe and analyse the defining characteristics of each revolution and how they differ from others. **Communication:** Learners express their thoughts among their peers in an environment that is unbiased and free from fear or intimidation, as well as working together **Critical Thinking:** As learners critically observe the effect of the various gains in PID controllers. **Communication:** Learners express their thoughts among their peers in an environment that is unbiased and free from fear or intimidation, as well as working together.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and individuals to the effective management and maintenance of the home. • be sensitive to the inter-relatedness of the various aspects of life. • value and promote justice at home and in society. **Leadership and Respect for Others' Views:** Inculcate the habit of leadership through

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		Truth and Integrity: reward truth and honesty as strong moral principles, leading to responsible citizenship. **Tolerance:** Model tolerance among learners by creating opportunities for collaborative learning through mixed-ability grouping within differentiated classroom instruction. **Make use of socio-emotional activities such as consolidating project reports/journal writing, reading project reports aloud, doing daily consultations on projects, holding class/group meetings, and** talking about managing emotions.
2.3.3.LO.2		
Critically analyse and assess built robots for algorithmic, design and coding flaws.	**Critical Thinking:** As learners interact, identify errors and fix those **Information Literacy:** As learners review codes and their corresponding flow charts.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and

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Content Standards	**Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI**	**Assessment**
2.3.3.CS.1	2.3.3.LI.1	2.3.3.AS.1
Demonstrate understanding and programming skills in the implementation of PID controllers.	**Implement PID controllers for line and wall following robots.** **Project-Based Learning:** Guide students to understand the implementation of PID controllers programmatically and supervise learners to program a two-wheeled rover to follow a line on a surface.	Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning
	2.3.3.LI.2	2.3.3.AS.2
	Apply the principle of variation and proportionality to experiment with the effect of proportional, derivative and integral gains on the efficiency of a PID-controlled robot. **Project-Based Learning:** Link learners' understanding of PID controllers to experiment and observe the effect of the various gains (proportional, derivative and integral gain) on the performance of a PID-controlled system. The observed trends should be documented as a report and submitted as an assessment document.	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 • A computer with required programming software	• Flip boards

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
2.3.3.CS.2	2.3.3.LI.1	2.3.3.AS.1
Demonstrate understanding of Program testing, debugging, verification and validation.	**Observe and identify flaws in an operational robot and trace them to either algorithm flaws, design flaws or coding errors.** **Project-Based Learning:** • For a given non-functional robot designed and programmed to perform a known task, learners should review the codes and their corresponding flowcharts and fix identified errors. The following steps can be adopted: ***1.*** Discuss and brainstorm on the following questions a. What is the robot used to do? b. What does it actually do? c. Are the identified errors likely algorithmic or programming flaws? d. Have you encountered these types of problems before? If yes, how did you fix it? e. Where and why do you think the errors occurred? ***2.*** Localize the problem until the error has been tracked and fixed ***3.*** Integrate and test the robot to see if the holistic system works. ***4.*** Repeat steps A - D until all errors are fixed.	Level 1 Recall Level 2 Skills of conceptual understanding Level 3 Strategic reasoning **Level 4 Extended critical thinking and reasoning**
	2.3.3.LI.2	2.3.3.AS.2
	Use a series of iterations to fix the identified flaws or improve the performance of solutions. **Project-Based Learning:** • For a given non-functional robot designed and programmed to perform a known task, learners should review the codes and their corresponding flowcharts and fix identified errors. The following steps can be adopted: • Discuss and brainstorm on the following questions	Level 1 Recall Level 2 Skills of conceptual understanding Level 3 Strategic reasoning **Level 4 Extended critical thinking and reasoning**

	a. What is the robot used to do? b. What does it actually do? c. Are the identified errors likely algorithmic or programming flaws? d. Have you encountered these types of problems before? If yes, how did you fix it? e. Where and why do you think the errors occurred? • Localize the problem until the error has been tracked and fixed • Integrate and test the robot to see if the holistic system works. • Repeat steps A - D until all errors are fixed.			
Teaching and Learning Resources	• A computer with required programming tools • Robots	• Flipcharts • Flowcharts	• Videos • Online resources	• Group discussion

YEAR THREE

Subject **ROBOTICS**
Strand 1. **Principles of Robotic Systems**
Sub-Strand 1. **Robots & Society**

Learning Outcomes	21st Century Skills and Competencies	GESI[5], SEL[6] and Shared National Values
3.1.1.LO.1		
Conceive, evaluate and document high-level robot-based solutions to real-world problems.	**Initiative**: Learners are given the opportunity to research job postings they think are related to robotics. **Media Literacy**: Learners have the opportunity to conduct a detailed review of each posting, analysing the requirements and job responsibilities. **Critical Thinking**: • Learners make deductions from their research into what they think guarantees them consideration by an employer. • As learners write programs which involve the use of mathematical equations that accept analogue sensor inputs to produce a specified finite number of digital outputs. **Communication**: • Learners learn to prepare written CVs and share theresults of their research with their colleagues, justifying any points made.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of

[5] Gender Equality and Social Inclusion
[6] Socio-Emotional Learning

	• Learners express their thoughts among their peers in an environment that is unbiased and free from fear or intimidation, and they patiently listen to the facilitator. **Emotional Intelligenc**e: Learners develop the discipline of meeting deadlines and set objectives. **Leadership:** As learners sit in groups to brainstorm, they create and share tasks and responsibilities among themselves to achieve set goals for the group.	different groups and individuals to the effective management and maintenance of the home. • be sensitive to the inter-relatedness of the various aspects of life. • value and promote justice at home and in society. **Leadership and Respect for Others' Views:** Inculcate the habit of leadership through teamwork and respect for individuals' views, beliefs, religions, and cultures. **Diversity**: Promote divergent views to ensure inclusivity in the learning environment. **Equity:** Develop fair and impartial opportunities or resources for learners devoid of unwanted segregation or discrimination among learners. **Managing Transition:** This can be realised if teachers guide and facilitate learning by generating discourse among learners and challenging them to accept and share responsibility for their own learning based on their unique individual differences (including GESI and gifted and talented learners). **SEL:** Give responsibilities to everyone in the groups.

		As much as possible, offer all learners equitable opportunities to interact and use teaching and learning resources. **National Core Values**: • Tolerance • Friendliness • Open-mindedness • Patience • Hard work • Humility **Truth and Integrity:** Reward truth and honesty as strong moral principles, leading to responsible citizenship. **Tolerance:** Model tolerance among learners by creating opportunities for collaborative learning through mixed-ability grouping within differentiated classroom instruction. **Make use of socio-emotional activities such as consolidating project reports/journal writing, reading project reports aloud, doing daily consultations on projects, holding class/group meetings, and** talking about managing emotions.

3.1.1.LO.2		
Prepare and justify technical reports for an envisioned solution to a problem and critique technical reports on proposed solutions to known problems.	**Critical Thinking:** Learners listen keenly and contribute to discussions to meet lesson objectives. **Communication:** Learners contribute to the discussion by expressing their thoughts among their peers in an environment free from fear or intimidation and patiently listening to others. **Leadership:** As learners make contributions, they will have to convince their colleagues why they think their submissions are correct. Learners embrace empathy and establish tolerance.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and individuals to the effective management and maintenance of the home. • be sensitive to the inter-relatedness of the various aspects of life. • value and promote justice at home and in society. **Leadership and Respect for Others' Views:** Inculcate the habit of leadership

		through teamwork and respect for individuals' views, beliefs, religions, and cultures. **Diversity**: Promote divergent views to ensure inclusivity in the learning environment. **Equity:** Develop fair and impartial opportunities or resources for learners devoid of unwanted segregation or discrimination among learners. **Managing Transition:** This can be realised if teachers guide and facilitate learning by generating discourse among learners and challenging them to accept and share responsibility for their own learning based on their unique individual differences (including GESI and gifted and talented learners). **SEL:** Give responsibilities to everyone in the groups**.** As much as possible, offer all learners equitable opportunities to interact and use teaching and learning resources. **National Core Values**: • Tolerance • Friendliness • Open-mindedness

		• Patience • Hard work • Humility **Truth and Integrity:** Reward truth and honesty as strong moral principles, leading to responsible citizenship. **Tolerance:** Model tolerance among learners by creating opportunities for collaborative learning through mixed-ability grouping within differentiated classroom instruction. **Make use of socio-emotional activities such as consolidating project reports/journal writing, reading project reports aloud, doing daily consultations on projects, holding class/group meetings, and** talking about managing emotions.

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
Demonstrate the ability to relate robots to address real societal and industrial problems.	**Identify both local and global problems that can be fixed using robots and automated systems.** **Think-Pair-Share:** • Brainstorm and discuss challenges in a Ghanaian local industry. • Each member in a group identifies an industry and points out a problem or identifies an opportunity that requires automation or robot integration in the current operational processes of a local industry. • Share the identified problem or opportunity with group members • Group should discuss and prioritise the list of problems and opportunities.	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
	Learners should identify, document, and present problems in society and local industries, as well as suggest the role robots can play in solving these problems. **Project-Based Learning:** For a given local Ghanaian industry, Learners should work in groups to discuss robot-based design ideas that can be used to address the problem or opportunity. The following steps will be a good guide: • The group should adopt one of the problems or opportunities and discuss robot-based design ideas that can be used to address the problem or opportunity. • Learners Sketch out design ideas on paper and consider local and realistic components that can be sourced and used to implement the various ideas. • Group discussion and prioritisation of different concepts and the selection of the best-fit solution. • Each group should prepare to share the following 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**

	a. How did the team arrive at the final design solution? b. Is the design realistic and well proportioned? c. How did each team member contribute towards the overall design? d. Do you feel like everyone had an equal opportunity to contribute to the creative process?		
Teaching and Learning Resources	• Video Documentaries • Charts • Pictures/videos of simple physical machines,	• Field trip • Articles • Narratives	• Reports • Computers with presentation tools like PowerPoint • Flip charts

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
3.1.1.CS.2	3.1.1.LI.1	3.1.1.AS.1
Demonstrate knowledge and understanding of the high-level application of robots to address real societal problems.	**Learners prepare technical reports, including flowcharts or pseudo codes that outline the sequence of steps to solve problems**. **Talk for Learning:** Through questioning, learners share their thoughts on the meaning of technical reports and discuss examples of technical reports. **Experiential Learning:** Systematically analyse videos of industrial automation and robotic solutions and determine the Inputs, Processes and Outputs used to realise the solution. They should use algorithms, pseudocodes, and flowchart diagrams to represent the flow of input through processes to output and write a technical report on it.	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
	Peer-review and critique the technical reports presented by colleagues. **Collaborative Learning:** In small mixed-ability groups, learners develop and present technical reports from learning indicators to their classmates and receive constructive reviews and recommendations from classmates and facilitators. Learners properly document recommendations and update their reports accordingly for final submission to the facilitator for acceptance.	Level 1 Recall Level 2 Skills of conceptual understanding Level 3 Strategic reasoning **Level 4 Extended critical thinking and reasoning**
Teaching and Learning Resources	• Training workshop: Facilitators are sent to industries to observe and be educated on how robots are helping in solving societal problems. • Capacity-building workshops: Facilitators are trained on the application of robots in addressing societal problems. • Access online training material and videos on how robots are used in the industrialisation process. • Flowchart design tools • Projector or LED Screen	

	• Computers with presentation and editing tools like PowerPoint • Computers with the required installed software

Subject **ROBOTICS**
Strand 1. **Principles of Robotic Systems**
Sub-Strand 2. **Robot Control Principles**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
3.1.2.LO.1		
Design and implement feedback-driven autonomous systems to improve efficiency in an identifiable local industry.	**Critical Thinking:** As learners elicit and prioritise benefits, they think critically, providing justification for each decision they make. **Technology Literacy**: As learners take sensor readings, observe defective values and calibrate sensors, they gain an experiential understanding of sensor imperfections and how to map defective sensor readings to standardised readings. **Creativity and Innovation:** Students have the opportunity to design and implement unique and creative solutions to optimise efficiency in the industry, considering factors such as safety, scalability, and compatibility. **Adaptability and Flexibility:** As students encounter challenges and complexities during the design and implementation process, they adapt their approaches, learn new skills, and adjust their solutions accordingly. **Ethical and Social Responsibility:** Students consider ethical implications, such as privacy, safety,	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and individuals to the effective management and maintenance of the home. • be sensitive to the inter-relatedness of the various aspects of life. • Value and promote justice in the home and in society.

	and the impact of autonomous systems on the workforce, as they design and implement solutions for the local industry.	**Leadership and Respect for Others' Views:** Inculcate the habit of leadership through teamwork and respect for individuals' views, beliefs, religions, and cultures. **Diversity**: Promote divergent views to ensure inclusivity in the learning environment. **Equity:** Develop fair and impartial opportunities or resources for learners devoid of unwanted segregation or discrimination among learners. **Managing Transition:** This can be realised if teachers guide and facilitate learning by generating discourse among learners and challenging them to accept and share responsibility for their own learning based on their unique individual differences (including GESI and gifted and talented learners). **SEL:** Give responsibilities to everyone in the groups**.** As much as possible, offer all learners equitable opportunities to interact and use teaching and learning resources. **National Core Values**: • Tolerance • Friendliness • Open-mindedness • Patience • Hard work

		• Humility **Truth and Integrity:** Reward truth and honesty as strong moral principles, leading to responsible citizenship. **Tolerance:** Model tolerance among learners by creating opportunities for collaborative learning through mixed-ability grouping within differentiated classroom instruction. **Make use of socio-emotional activities such as consolidating project reports/journal writing, reading project reports aloud, doing daily consultations on projects, holding class/group meetings, and** talking about managing emotions.
3.1.2.LO.2		
Demonstrate skills in reverse-engineering controls of functional autonomous robotic systems through observation and analysis.	**Critical Thinking and Problem Solving:** Reverse engineering requires students to analyse and understand the inner workings of a system, identify patterns, and troubleshoot issues. This process enhances their critical thinking and problem-solving skills as they break down complex systems and find solutions. **Collaboration and Teamwork:** Reverse-engineering projects often involve working in teams and fostering collaboration and teamwork skills. Students learn to communicate effectively, share ideas, delegate tasks, and work together towards a common goal.	**GESI:** **Gender Equality**: Students can gain awareness of the importance of equal participation and representation of all genders in the field of robotics and technology. They can explore and challenge any gender biases or stereotypes associated with robotics, promoting inclusivity and diversity in STEM fields. **Social Inclusion**: By engaging in collaborative activities and discussions, students can appreciate the value of inclusivity, respect, and acceptance of diverse perspectives, abilities,

	Creativity and Innovation: Reverse engineering encourages students to think creatively and come up with innovative solutions. They need to think outside the box to understand the control mechanisms and devise alternative approaches. **Technology Literacy:** Engaging with autonomous robotic systems exposes students to advanced technologies. They develop familiarity with robotics, sensors, actuators, and control systems, enhancing their overall technology literacy and adaptability. **Analytical Skills:** Reverse engineering involves analysing complex systems and understanding their underlying components. Students learn to collect and interpret data, make informed observations, and draw conclusions based on evidence. **Adaptability and Flexibility:** Reverse engineering requires students to adapt to unfamiliar systems and unexpected challenges. They learn to be flexible, adjust their strategies, and find alternative solutions when faced with obstacles. **Communication and Presentation Skills:** Students need to effectively communicate their findings, observations, and analysis to others. They learn to present their insights in a clear and concise manner, enhancing their communication and presentation skills.	and backgrounds. They can recognise the need to create an inclusive and supportive environment for all individuals involved in robotics and technology. **SEL:** During observation and analysis, students often work in teams, requiring effective collaboration and communication. They learn to share ideas, listen actively, and cooperate with their peers, fostering teamwork and interpersonal skills. Reverse engineering can present challenges and setbacks. Students learn the importance of perseverance, adaptability, and resilience as they encounter obstacles during the process. They develop strategies to overcome difficulties and learn from failures. **Shared National Values:** Learners recognise and appreciate the value of ingenuity in technological advancements, aligning with Ghanaian Shared National Values of promoting innovation and entrepreneurship. Working collaboratively on reverse-engineering projects reflects the Ghanaian value of communalism. Students learn to cooperate, share knowledge, and contribute to the collective learning process, embodying the spirit of togetherness and shared responsibility.

	Ethical and Responsible Behaviour: Reverse-engineering projects often involve working with proprietary or patented technology. Students learn the importance of ethical behaviour, respecting intellectual property rights, and responsible use of information. **Lifelong Learning:** Engaging in reverse engineering cultivates a mindset of continuous learning. Students develop a curiosity and eagerness to explore new technologies and seek knowledge independently.	
3.1.2.LO.3		
Create test plans for testing robotic systems to uncover faults and go through an iterative fault detection and correction process to fix the defect.	**Critical Thinking:** As learners critically analyse the narratives of the performance impacts of robots in these environments. **Listening Skills:** • Learners develop the skills of listening as they listen to the facilitator and the submission of their colleagues during the revision process. • The experiential method of facilitation allows learners to embrace empathy and attain a certain level of discipline. **Critical Thinking**: Learners critically analyse and find solutions to problems and also find out if the solutions are realistic. **Information Literacy:** As learners observe and go online to observe solutions and fix them.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with each other in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • Respect individuals of different backgrounds. • Embrace diversity and practice inclusion. • Examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • Interrogate their stereotypes and biases about gender and the role men and women play in home management. • Identify injustice, especially in recognition of the contributions of different groups and individuals to the effective management and maintenance of the home.

	Critical Thinking: As learners brainstorm and find solutions to problems and fix them	• Sensitive to the inter-relatedness of the various aspects of life. • Value and promote justice in the home and in society. **Leadership and Respect for Others' Views:** Inculcate the habit of leadership through teamwork and respect for individuals' views, beliefs, religions, and cultures. **Diversity**: Promote divergent views to ensure inclusivity in the learning environment. **Equity:** Develop fair and impartial opportunities or resources for learners devoid of unwanted segregation or discrimination among learners. **Managing Transition:** This can be realised if teachers guide and facilitate learning by generating discourse among learners and challenging them to accept and share responsibility for their own learning based on their unique individual differences (including GESI and gifted and talented learners). **SEL:** Give responsibilities to everyone in the groups. As much as possible, offer all learners equitable opportunities to interact and use teaching and learning resources. **National Core Values**: • Tolerance

		• Friendliness • Open-mindedness • Patience • Hard work • Humility **Truth and Integrity:** Reward truth and honesty as strong moral principles, leading to responsible citizenship. **Tolerance:** Model tolerance among learners by creating opportunities for collaborative learning through mixed-ability grouping within differentiated classroom instruction. **Make use of socio-emotional activities such as consolidating project reports/journal writing, reading project reports aloud, doing daily consultations on projects, holding class/group meetings, and** talking about managing emotions.

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
Design feedback systems for autonomous control of prototype robotic systems	**Design a prototype feedback-driven autonomous system for efficiency improvement in an identified local industry.** **Project-Based Learning:** Work in small mixed-ability teams to explore, Identify and define a problem in any local industry and follow a Design & Engineering Process to build a prototype feedback-driven solution that addresses the defined problem. The following steps can be followed: • Brainstorm problems in a typical Ghanaian Local Industry & Ideate feedback-based solutions that address the problem a. Discuss the problems b. Discuss up to five candidate design ideas. c. Consider building components and their availability. d. Prioritise and sketch out three candidate design ideas on paper. e. Choose and justify the best design. f. Build A Prototype of the best design using robotics kits or local materials. • Discuss the following items with your team and be prepared to share them with the rest of the class. a. How did the team arrive at the final design solution? b. Is the design realistic and well proportioned? c. How did each team member contribute towards the overall design? d. Do you feel like everyone had an equal opportunity to contribute to the creative process? **NB- The Facilitator should provide feedback during each stage of learners' work and request amendments or rework where required.**	Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** **Level 4 Extended critical thinking and reasoning**
Teaching and Learning Resources	• Local materials (e.g., wood, boxes, glue, springs, etc.	

	• Access to robotics lab with requisite tools (e.g., screwdrivers, glue guns, pliers, multimeters, function generators, etc.), basic sensors and actuators (e.g., light sensors, ultrasonic sensors, temperature sensors, gyro sensors, servo motors, speakers, etc.)

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
3.1.2.CS.2	3.1.2.LI.1	3.1.2.AS.1
Demonstrate skills in Reverse-Engineering of controls in a robotic system.	**Observe and reverse-engineer the controls of a functional autonomous robotic system.** **Collaborative Learning:** • Learners work in groups to repair existing robots, recreate existing robots or test existing robots for errors using reverse engineering principles. The following steps may be adopted. • Collect information about the existing robot. This could mean identifying source designs, product measurements, or original device coding. • Create part-wise models or sketches of the robot being reverse engineering. Teams may use CAD tools to design 3D models of their sketches. • Disassemble the robot layer by layer and organise the parts in the order that they were taken off for easier reassembly. Analyse, measure and discuss the various parts to understand their function. • Evaluate the disassembled parts and take notes on how the parts can be improved or find any errors that need fixing. • Reassemble the robot and make adjustments where necessary.	Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** **Level 4 Extended critical thinking and reasoning**
Teaching and Learning Resources	• Pre-built robots, testing tools (E.g., multimeters, Oscilloscope, mechanical gauges, etc.), 3D printers, Computer-Aided Design (CAD) tools • Access to robotics lab with requisite tools (e.g., screwdrivers, glue guns, pliers, multimeters, etc).	

Content Standards	Learning Indicators and Pedagogical Exemplars with 21st Century Skills and Competencies, and GESI	Assessment
3.1.2.CS.3	3.1.2.LI.1	3.1.2.AS.1
Demonstrate practical skills in evaluating and improving existing robotic systems.	**Test operational robots for specified tasks and observe/document identified flaws.** **Talk for Learning:** Through questioning, discuss test methods and metrics to assess industrial robot system agility in both simulation and in reality. Discuss test methods and associated quantitative and qualitative metrics for assessing robot system efficiency and effectiveness.	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
	Identify faults in robotic systems and trace them to algorithm flaws, design flaws or coding errors. **Experiential Learning:** For a given problem and a commensurate solution either in video or reality, learners observe sample solution(s) in execution and document the following: • Outline the functional requirements of a problem • Brainstorm on whether or not the features of the solution(s) given address all the outlined functional requirements identified. • Discuss whether the designed solution is realistic, well-proportioned, and efficient. • List the solution's limitations and classify/justify them as algorithmic, design or programming flaws.	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
	Go through a series of iterations to fix the identified flaws or improve the robot's performance. **Project-Based Learning:** For a given non-functional attempted solution to a problem, learners observe the solution and fix errors. The following steps can be adopted:	Level 1 Recall Level 2 Skills of conceptual understanding

	Discuss and brainstorm on the following questions: a. What is the robot supposed to do? b. What does it actually do? c. Are the identified errors likely algorithmic, designs or programming flaws? d. Have you encountered these types of problems before? If yes, how did you fix it? e. Where and why do you think the errors occurred? **Iteratively modularise the solution and test each sub-module until all the errors have been tracked and fixed.** **Integrate and test the whole robot to see if the holistic system works.**		Level 3 Strategic reasoning **Level 4 Extended critical thinking and reasoning**
Teaching and Learning Resources	• Mechanical gauges • Multimeter • Oscilloscopes • Function generators • Videos on robotic systems	• Real object presentation • Problem narratives • Flipcharts • Non-functional robot • Problem and solution narratives	• Testing tools(E.g., multimeters, Oscilloscope, mechanical gauges, etc.) • 3D printers • Computer-aided design (CAD) tools • Access to robotics lab with requisite tools (e.g., screwdrivers, glue guns, pliers, multimeters, etc).

Subject **ROBOTICS**
Strand 1. **Principles of Robotic Systems**
Sub-Strand 3. **Sensors & Actuators**

Learning Outcomes	21st Century Skills and Competencies	GESI, SEL and Shared National Values
3.1.3.LO.1		
Observe and explain the underlying STEM concepts of functional automated system processes and recommend feasible automation designs for unautomated industrial processes.	**Collaboration:** As learners listen and contribute to the discussion initiated by the facilitator, they learn to embrace one another's views. **Critical Thinking:** As learners discuss and make meaningful discussions **Collaboration:** Learners work in groups to analyse the typical operational processes of an unautomated local industry. **Critical Thinking**: Learners analyse and find new ways to replace the manual processes of the local industry with some digital electronic components.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and individuals to the effective management and maintenance of the home. • be sensitive to the inter-relatedness of the various aspects of life. • value and promote justice in the home and in society. **Leadership and Respect for Others' Views:** Inculcate the habit of leadership

		through teamwork and respect for individuals' views, beliefs, religions, and cultures. **Diversity**: Promote divergent views to ensure inclusivity in the learning environment. **Equity:** Develop fair and impartial opportunities or resources for learners devoid of unwanted segregation or discrimination among learners. **Managing Transition:** This can be realised if teachers guide and facilitate learning by generating discourse among learners and challenging them to accept and share responsibility for their own learning based on their unique individual differences (including GESI and gifted and talented learners). **SEL:** Give responsibilities to everyone in the groups**.** As much as possible, offer all learners equitable opportunities to interact and use teaching and learning resources. **National Core Values**: • Tolerance • Friendliness • Open-mindedness • Patience • Hard work • Humility

		Truth and Integrity: reward truth and honesty as strong moral principles, leading to responsible citizenship. **Tolerance:** Model tolerance among learners by creating opportunities for collaborative learning through mixed-ability grouping within differentiated classroom instruction. **Make use of socio-emotional activities such as consolidating project reports/journal writing, reading project reports aloud, doing daily consultations on projects, holding class/group meetings, and** talking about managing emotions.

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
Demonstrate analytical skills in the selection of final control elements for industrial control solutions.	**Analyse the operating principles and use of advanced industry-based actuators (valves, hydraulic-based actuators, contactors, relays, etc.)** **Initiating Talk for Learning:** Drive discussions of industrial actuators and their use cases. The discussion should include the following category of actuators: • Hydraulic Actuators: • Pneumatic actuators: • Relays • Stepper and Servo Motors • Solenoid Valves In different task groups, learners work on one category per group and share findings 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
	3.1.3.LI.2	3.1.3.AS.2
	Evaluate an industrial control requirement and recommend final control actuators with appropriate justification. **Project-Based Learning:** Learners work in small groups to analyse the typical operation processes of any unautomated local industry. Learners should come up with sensor and actuation requirement specifications to automate the processes involved in the operations of the local industry. Learners recommend and justify actuator combinations that can be used to replace the manual processes of the local industry and sketch actuation designs for the automation of the processes identified. **Learners discuss the following items in groups and share them with the rest of the class.** • How did the team arrive at the final design solution?	Level 1 Recall Level 2 Skills of conceptual understanding Level 3 Strategic reasoning **Level 4 Extended critical thinking and reasoning**

	• Is the design realistic and well-proportioned? • How did each team member contribute towards the overall design? • Do you feel like everyone had an equal opportunity to contribute to the creative process?		
Teaching and Learning Resources	• Real actuators • Online resources, including pictures	• Videos of actuators in operation • Online resources and videos	• Internet • Field trips (where applicable)

Subject **ROBOTICS**
Strand 2. **Robot Design Methodologies**
Sub-Strand 1. **Digital and Analogue System Design**

Learning Outcomes	**21st Century Skills and Competencies**	**GESI, SEL and Shared National Values**
3.2.1.LO.1		
Reverse engineer an existing combinational circuit and implement similar circuits or improved versions.	**Collaboration:** Learners work in groups to recreate existing combinational circuits. **Critical Thinking:** As learners work in groups to evaluate the disassembled components and take note of how the circuit can be improved **Information Literacy:** As learners go online searching for information to design combinational circuits. **Critical Thinking:** As Learners discuss design, evaluate the designs and make changes when necessary **Listening Skills:** learners acquire good listening skills as they listen to critiques from peers and teachers. Their listening skills are measurable in their final work if traces of comments and feedback can be seen in the modifications that are effected in the final presented work.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and individuals to the effective management and maintenance of the home.

		• be sensitive to the inter-relatedness of the various aspects of life. • value and promote justice at home and in society. **Leadership and Respect for Others' Views:** Inculcate the habit of leadership through teamwork and respect for individuals' views, beliefs, religions, and cultures. **Diversity**: Promote divergent views to ensure inclusivity in the learning environment. **Equity:** Develop fair and impartial opportunities or resources for learners devoid of unwanted segregation or discrimination among learners. **Managing Transition:** This can be realised if teachers guide and facilitate learning by generating discourse among learners and challenging them to accept and share responsibility for their own learning based on their unique individual differences (including GESI and gifted and talented learners). **SEL:** Give responsibilities to everyone in the groups**.** As much as possible, offer all learners equitable opportunities to interact and use teaching and learning resources. **National Core Values**:

		• Tolerance • Friendliness • Open-mindedness • Patience • Hard work • Humility **Truth and Integrity:** Reward truth and honesty as strong moral principles, leading to responsible citizenship. **Tolerance:** Model tolerance among learners by creating opportunities for collaborative learning through mixed-ability grouping within differentiated classroom instruction. **Make use of socio-emotional activities such as consolidating project reports/journal writing, reading project reports aloud, doing daily consultations on projects, holding class/group meetings, and** talking about managing emotions.

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 practical skills in the design and implementation of combinational digital systems that solve actual problems.	**Observe the input/output pairs of combinational circuit black boxes and reverse-engineer the circuit.** **Project-Based Learning:** Learners work in small mixed-ability/ gender groups to recreate existing combinational circuits. The following steps may be adopted: • Collect information about the existing circuit. This could mean identifying and analysing source designs and schematics, monitoring input/output pairs with oscilloscopes, etc. • Create partwise circuit designs where the circuit looks too complete. • Where necessary, disassemble the circuit layer by layer and organise the parts in the order that they were taken off for easier reassembly. • Analyse, measure and discuss the various parts to understand their function. • Evaluate the disassembled components and take notes on how the circuit can be improved. • Follow combinational circuit design principles to create a replica or improved version of the analysed circuit.	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
	Analyse a given real-world scenario and build a circuit that uses a number of inputs to control a given number of outputs. **Project-Based Learning**: Work in groups to design combinational circuits for given use cases. The following steps may be adopted: • Gather and document the functional requirements of the circuit and determine the inputs as well as the outputs. • Discuss how the inputs route to or drive the outputs and present your discussion in a Truth table. For complex circuits, try breaking the design into modules or sub-circuits.	Level 1 Recall Level 2 Skills of conceptual understanding **Level 3 Strategic reasoning** Level 4 Extended critical thinking and reasoning

	• Use a simplification approach of your choice to optimise the circuit(s). • Evaluate designs and make changes where necessary. • Build and test the final design and troubleshoot where necessary.		
Teaching and Learning Resources	• Oscilloscope, virtual laboratory with required software installed • Flow charts • Design narratives	• Online resources • Pictures	• Circuit and breadboards • Access to the lab with requisite tools (multimeters, soldering iron, glue guns, screwdrivers, etc.)

Subject **ROBOTICS**
Strand 3. **Robot Construction & Programming**
Sub-Strand 2. **Robot Construction**

Learning Outcomes	**21st Century Skills and Competencies**	**GESI, SEL and Shared National Values**
3.3.2.LO.1		
Create robots using fabricated robotic materials or local materials to implement basic mechanics.	**Listening Skills:** Good listening skills are acquired as they listen to their peers during brainstorming sessions as well as during instructor-facilitated discussions. Learners also demonstrate their listening skills if traces of comments and feedback can be seen in the modifications effected in the finally presented work. **Critical Thinking:** As learners brainstorm ideas and find solutions to given problems.	**GESI:** Learners having experienced a teaching approach that ensures gender equality and social inclusion, where they work with one another in an inclusive way; cross-sharing knowledge and understanding among groups and individuals lead them to: • respect individuals of different backgrounds. • embrace diversity and practice inclusion. • examine and dispel misconceptions/ myths about gender as they relate to home management and human development. • interrogate their stereotypes and biases about gender and the role men and women play in home management. • identify injustice, especially in recognition of the contributions of different groups and individuals to the effective management and maintenance of the home.

		• be sensitive to the inter-relatedness of the various aspects of life. • value and promote justice at home and in society. **Leadership and Respect for Others' Views:** Inculcate the habit of leadership through teamwork and respect for individuals' views, beliefs, religions, and cultures. **Diversity**: Promote divergent views to ensure inclusivity in the learning environment. **Equity:** Develop fair and impartial opportunities or resources for learners devoid of unwanted segregation or discrimination among learners. **Managing Transition:** This can be realised if teachers guide and facilitate learning by generating discourse among learners and challenging them to accept and share responsibility for their own learning based on their unique individual differences (including GESI and gifted and talented learners). **SEL:** Give responsibilities to everyone in the groups**.** As much as possible, offer all learners equitable opportunities to interact and use teaching and learning resources.

		National Core Values: • Tolerance • Friendliness • Open-mindedness • Patience • Hard work • Humility **Truth and Integrity:** Reward truth and honesty as strong moral principles, leading to responsible citizenship. **Tolerance:** Model tolerance among learners by creating opportunities for collaborative learning through mixed-ability grouping within differentiated classroom instruction. **Make use of socio-emotional activities such as consolidating project reports/journal writing, reading project reports aloud, doing daily consultations on projects, holding class/group meetings, and** talking about managing emotions.

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
Final Year project Demonstrate ability to create fully functional prototypes of robotic systems that address an identified glocal issue.	**Create robots using robotic kits and/or local materials to implement basic mechanics for actuations that make use of the following:** **Gears** Transmitting Rotation with rubber bands or chains Transmitting Rotation over long distances Off-centre axes of rotation Changeover mechanism using rotational Direction Universal Joints **Vehicles** Suspended Wheels Steering Mechanisms **Moving Without Tires** Moving through vibrations **Arms, Wings & Others** Using attachments to change motion Changing the angle of rotation freely **Talk for Learning:** Leads a discussion on how the arrangement and combination of different gears can be used to realise Transmitting Rotation with rubber bands or chains, Transmitting Rotation over long distances, Off-centre axes of rotation, Changeover mechanism using rotational Direction and Universal Joints in control systems.	Level 1 Recall Level 2 Skills of conceptual understanding Level 3 Strategic reasoning **Level 4 Extended critical thinking and reasoning**

	Experiential Learning: • Use cases for problems that will require the use of gears for achieving Transmitting Rotation with rubber bands or chains, Transmitting Rotation over long distances, Off-centre axes of rotation, Changeover mechanism using rotational Direction and Universal Joints in control systems. Learners will work in groups to build fully functional robotic subsystems for the actuation of controls that satisfy conditions in the given use cases. The following steps should be adapted for this activity: a. Learners brainstorm Ideas & Solutions for the given Use Case b. Learners discuss the brainstormed design ideas. c. Learners consider building components needed and available. d. Choose the best design. e. Sketch out their design ideas on paper. f. Learners build a prototype of the best design using robotics kits or local material • Discuss the following items with your team and be prepared to share them with the rest of the class. a. How did the team arrive at the final design solution? b. Is the design realistic and well proportioned? c. How did each team member contribute towards the overall design? d. Do you feel like everyone had an equal opportunity to contribute to the creative process?	
Teaching and Learning Resources	• Video, online resources • Laboratory • Robotics kits • Electronic components and Local materials (e.g., wood, boxes, glue, springs, etc.), Access to robotics lab with requisite tools (e.g., screwdrivers, glue guns, pliers, multimeters, function generators, etc.)	