Federal Democratic Republic of Ethiopia
Ministry of Education
Special Capacity Building Training Program for Secondary School Teachers

Teaching Chemistry Trainees' Module

June, 2024
Ministry of Education
Addis Ababa

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Contributors:

Part I- Teaching Chemistry Trainees' Module

Developers:

1. Abera Gure (Ph. D., Prof, Jimma University)
2. Woldie Belachew (PhD, Addis Ababa Univesity)

Part II- Educational Technology-EdTech

1. **Developer:** Inku Fasil, *EdTech Hub ET*
2. **Reviewer:** Alemu Tesfaye, *Senior Expert in Ministry of Education-GEQIP-E*

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Part I- Teaching Chemistry

Background and Rationale

The field of education is constantly evolving, with new research, technologies, and teaching methodologies emerging regularly. To ensure that teachers are equipped with the knowledge and skills necessary to meet the needs of diverse learners and deliver high-quality instruction, ongoing professional development and training are essential. The teacher is the key factor in the process of implementing chemistry curricula. Training sessions provide teachers with multiple opportunities.

Principally, training sessions offer teachers the chance to learn new instructional strategies, assessment techniques, and classroom management skills that can enhance their teaching practices and boost student engagement and achievement. Education is dynamic, with new research, tools, and technologies influencing teaching and learning. Training sessions help teachers stay current with the latest trends and innovations in education, enabling them to adapt their practices to meet the changing needs of students. Trained teachers are better equipped to meet the diverse learning needs of students and create inclusive and supportive learning environments. Training sessions help teachers develop the skills and knowledge necessary to address the individual needs of learners and promote student success. Training opportunities provide teachers with the chance to reflect on their teaching practices, set goals for improvement, and engage in continuous professional development. By participating in training sessions, teachers can enhance their expertise, expand their skill set, and grow professionally. Such training sessions create opportunities for teachers to collaborate, share best practices, and learn from one another.

By fostering a culture of collaboration and professional learning, schools can build a supportive community of educators who work together to enhance student learning outcomes. Training sessions can help teachers align their instruction with curriculum standards, assessment requirements, and educational goals. By providing teachers with the knowledge and resources they need to effectively implement the curriculum, training sessions support the successful delivery of instruction. Training sessions can also address the social and emotional needs of teachers. The focus on teachers' training is a key strategy to achieve multiple goals indicated here.

Purpose of the Module

This Secondary School Chemistry Teachers on Job Training Module is aimed to:

- equip teachers with the knowledge, skills, and resources needed to effectively teach the subject/chemistry.
- provide teachers with up-to-date content knowledge, pedagogical strategies, and resources to create engaging and interactive learning experiences for their students.
- engage students effectively, support their learning, and help them achieve better academic results
- spark students' interest in science, technology, engineering, and mathematics (STEM) fields and encourage them to pursue further studies and careers in these areas.
- developing students' critical thinking and problem-solving abilities, which are valuable skills for success in both academic and professional settings
- improve the quality of chemistry education in secondary schools and help students develop a deeper understanding and appreciation of the subject

Pedagogical Approaches

Participatory approaches are employed throughout the module. Activities are mainly experiential in nature, and teachers are required to actively engage as participants in all of the lessons.

Reflective practice: Encouraging teachers to reflect on their teaching experiences, identify areas for improvement, and set goals for professional development can help them continuously improve their teaching skills. Reflective practice can also help teachers gain insights into their teaching practices and make adjustments based on feedback and self-assessment.

Collaborative learning: Encouraging teachers to work together in groups or pairs can promote collaboration, peer learning, and the exchange of ideas and best practices. This approach can help teachers learn from each other and develop a sense of community and support within the teaching profession.

Active learning: Engaging teachers in virtual labs, simulations, animation videos, and problem-solving tasks can help them experience firsthand the benefits of active learning strategies in the classroom. This approach can also help teachers understand how to incorporate active learning techniques into their teaching practices.

Technology integration: Providing training on how to effectively integrate technology tools and resources into chemistry instruction can help teachers enhance student engagement, facilitate personalized learning, and create interactive and dynamic learning experiences.

Differentiated instruction: Teaching teachers how to differentiate instruction to meet the diverse learning needs and preferences of students can help them create inclusive and engaging learning environments. Training on strategies such as tiered assignments, flexible grouping, and scaffolding can help teachers tailor their instruction to support all students' academic growth.

Inquiry-based learning: Introducing teachers to inquiry-based learning approaches can help them foster students' curiosity, critical thinking skills, and problem-solving abilities in the context of chemistry education. Training on designing and implementing inquiry-based activities, experiments, and projects can empower teachers to create meaningful and authentic learning experiences for their students.

Brainstorming: Teachers actively generate a broad variety of ideas about a particular topic or question. This helps teachers to generate many ideas to help solve a particular problem. Brainstorming allows student teachers to generate ideas quickly and spontaneously. It allows individual teachers' voices to become one with the group's voice. The final ideas are generally identified through consensus

Assessment Recommendations

Assessing training both sumatively and formatively is necessary to ensure that the training program is effective, meets its objectives, and provides valuable feedback for improvement. To ensure that the trainees (teachers) have acquired the relevant knowledge, skills, and attitudes or not, both formative and summative assessment techniques will be employed. Some strategies for assessing this training are:

Evaluation Surveys: At the end of the training program, distributing evaluation surveys to participants to gather feedback on the overall effectiveness of the training, relevance of content, quality of facilitation, and learning outcomes achieved is needed.

Performance Evaluations: Monitoring participants' performance in real-world classroom settings following the training to assess the application of new skills and knowledge acquired during the training program is necessary.

Observations: Conducting observations of participants during training activities or in their professional practice to assess their implementation of new strategies or techniques learned during the training is required.

Pre-Training Assessments: Conducting pre-training assessments to gauge chemistry teachers' baseline knowledge, skills, and attitudes related to the training content is essential. This information can help tailor the training to meet teachers' needs effectively.

Feedback Mechanisms: Incorporating regular feedback mechanisms throughout the training program (such as group discussions) to gather ongoing feedback from chemistry teachers on their learning experiences, challenges faced, and areas for improvement is required.

Peer Feedback: Encouraging participants to provide feedback to each other or engage in peer review activities to promote collaborative learning and self-assessment is needed.

Reflection Activities: Incorporating reflection activities into the training program where teachers can reflect on their learning progress, identify areas for improvement, and set goals for further development is crucial.

Structure of the Module

This module is prepared based on areas of difficulties identified by MoE, Ethiopia. There are nine units in this training material divided into sessions. Eight units are based on the key concepts taught at the secondary school level (Grades 9-12). One unit (the first unit) focuses on teaching learning components. This particular unit gives attention to innovative approaches to learning/teaching chemistry. Each unit of the training has a unit introduction, unit objective, Introduction of the session , session objectives, activities, Key points , implications, and takeaway resources.

Unit 1: The Learning and Teaching of Chemistry (4 h)

Introduction of the unit

This unit aims to assist chemistry teachers in understanding how to teach different chemistry concepts through innovative approaches to enhance learning, revisit their understanding of chemistry concepts, and enhance students' understanding of various topics included in the curriculum. This unit gives attention to four thematized areas. These are understanding chemistry in three levels, constructivism and misconceptions in Chemistry teaching, Inquiry-based learning in chemistry teaching, and conceptual change instruction and chemistry understanding which are important to help teachers in the implementation of the curriculum.

Different brainstorming activities are provided in each session to engage trainees in teaching the suggested topics. This will help teachers to come up with different instructional strategies while teaching chemistry.

At the end of this unit, trainees will be able to:

- Comprehend three levels of chemistry understanding
- Apply principles of knowledge construction with identification and correction of misconceptions
- Employ inquiry-based approaches in teaching chemistry
- Use the conceptual change approaches to improve understanding

Session 1.1: Understanding Chemistry in three levels: the chemistry/Jhonstone's triangle (1 h)

Session ion introduction (5 min)

This session aims to assist chemistry teachers in understanding how to consider three levels of chemistry understanding in each lesson. Teachers are expected to treat chemistry concepts at observable (macro), not observable (micro) and symbolic levels. It is important to allow teachers to reflect on the way how they treat/teach chemistry using these levels.

Session Objectives

At the end of this session, trainees will be able to:

- describe three levels of the chemistry triangle
- use three levels of chemistry triangle while teaching chemistry
- develop interest in using chemistry triangle in teaching

Brain Storming Activities (40 min)

1. What is your current understanding of the concepts of macro-level, sub-micro-level, and symbolic representation in the context of teaching chemistry? (10 min)
2. How do you currently incorporate the concepts of macro-level, sub-micro-level, and symbolic representation in your chemistry teaching? (8 min)
3. What are the benefits of using the concepts of macro-level, sub-micro-level, and symbolic representation in teaching chemistry that you have observed in your students? (7 min)
4. What challenges have you faced in implementing the concepts of macro-level, sub-micro-level, and symbolic representation in your chemistry lessons? (5 min)
5. What resources or professional development opportunities could support your growth in using the concepts of macro-level, sub-micro-level, and symbolic representation in teaching chemistry? (10 min)Section

Key points (10 min)

Several students consider chemistry perplexing to learn since the language of chemistry is intricate, dealing with abstract, indiscernible concepts and occurrences. Students are required to develop three levels of chemical representation or thinking (Johnstone, 1991). The three levels consist of macro- level, sub-level, and symbolic level (Johnstone, 1991; Russell et al., 1997).

These three levels are represented by a triangle called Johnstone's triangle/chemistry triangle by the researchers. It is a framework that categorizes chemical knowledge and understanding into three interconnected levels (Figure 1).

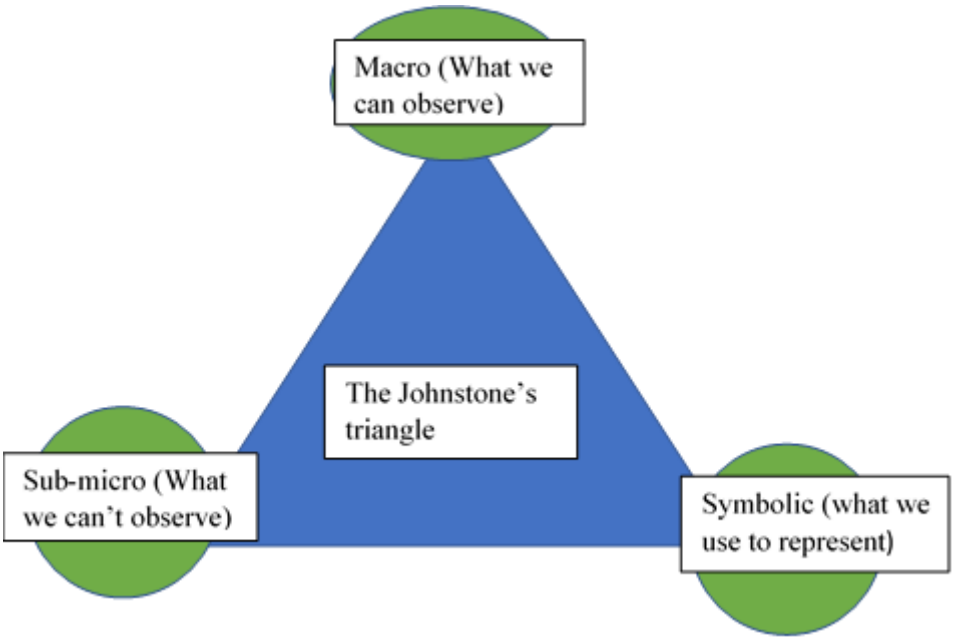


Figure 1: The Chemistry/Jhonstone's Triangle (Adapted from Johnstone, 1991)

Undeniably, matter can be observed and studied at macro level, described at the sub-microscopic level, and represented at the symbolic level. At the macro level, we can see or observe. This level focuses on macro-level observations of chemical phenomena, such as color changes, temperature variations, phase transitions, and reaction rates, providing a tangible and experiential foundation for understanding chemical processes in the laboratory and everyday life. At the sub-micro level, we focus on what we can't see. At this level, the focus is on entities that are too small to be observed. This level explores the particulate nature of substances, molecular structures, atomic interactions, and the arrangement of particles. At the symbolic level, chemists represent observable (Macro) and unobservable (sub-micro) using chemical symbols, chemical formulas, and chemical equations.

At the symbolic level, we represent what we have observed and what we haven't observed using symbols, formulas, mathematical expressions, and chemical equations.

This level uses symbolic language and notation to communicate abstract concepts, quantitative relationships, and chemical changes, facilitating the interpretation, prediction, and

manipulation of chemical phenomena. Expert chemists do not face difficulties in understanding chemical concepts at these three levels but beginners and students face difficulties (Bradley, (2014; Johnstone, 1991; Taber, 2013).

The difficulty to understanding chemistry is not the existence of these levels of representation, but the fact that chemistry teaching occurs largely at the symbolic level, the most abstract, without teachers' mindfulness of the need to address them at different times (Schettini, 2020). Johnstone's triangle helps also teachers to understand students' misconceptions/alternative conceptions occurring at all three levels (Russell et al., 1997; Schettini, 2020). When teachers consider this three levels, students can develop a holistic understanding of chemistry and make meaningful connections between observable phenomena, molecular structures, and symbolic representations of chemical reactions and properties Teaching chemistry with cognizance of Johnstone's triangle (levels of chemistry understanding) is crucial for meaningful learning. Through the module, these levels of chemistry understanding are incorporated in each section.

Implication to teaching (5 min)

- What did you learn from this session and how will you use the "chemistry triangle" in this session in your classroom teaching?
- How can you help your students benefit from the lesson in this session?

Takeaway resources/materials

- Johnstone, A. H. (1991). *Why is science difficult to learn? Things are seldom what they seem. Journal of Computer Assisted Learning, 7(2), 75–83.* doi:10.1111/j.1365-2729.1991.tb00230.x Link to down load: https://libgen.is/scimag/?q=Why+is+science+difficult+to+learn%3F+Things+are+seldom+what+they+seem
- Gilbert & D. F. Treagust (2009). *Multiple Representations in Chemical Education*. Dordecht: Springer. Book, can be downloaded from the link: file:///C:/Users/hp/Downloads/(Models%20and%20Modeling%20in%20Science%20Education%204)%20John%20K.%20Gilbert,%20David%20F.%20Treagust%20(auth.),%20Prof.%20John%20K.%20Gilbert,%20Prof.%20David%20Treagust%20(eds.)%20-%20Multiple%20Representations%20in%20Chemical%20Education-Springer%20Ne.pdf

Session **1.2: Constructivism and misconceptions in chemistry teaching (1 h)**

Introduction of the session (5 min)

This session aims to support chemistry teachers in comprehending how to consider constructivism in each lesson. Teachers are expected to consider prior knowledge while following constructivist approaches which sense the construction of meaning rather than simply accepting concepts as they are. It is essential to allow teachers to reflect on the way how they treat chemistry concepts using constructivist views during the learning/teaching process.

Session Objectives

At the end of this session, trainees will be able to:

- Explain the construction of knowledge in terms of the learning/teaching of chemistry
- Use principles of constructivism while teaching chemistry
- Develop interest in using principle of knowledge construction in the learning/teaching of chemistry

Brain storming activity (30 min)

1. How can you apply constructivist principles (active learning, prior knowledge integration, social interaction, authentic tasks, inquiry-based learning, multiple perspectives, scaffolding, and reflection and metacognition) and address misconceptions in your own teaching of chemistry? What strategies can you use to promote deeper understanding and critical thinking in your students? 15 min)
2. Suppose a teacher is reviewing for an upcoming exam on chemical reactions with students. If the same teacher provides a list of key concepts and equations for students to study, but does not offer any opportunities for students to apply their knowledge in real-world situations:
    a. How might constructivism be used to help students apply their knowledge of chemical reactions in practical scenarios? (5 min)
    b. What misconceptions might students develop about chemical reactions if they only focus on memorizing facts and equations without understanding their real-world applications? (10 min)

Key points (10 min)

The principles of constructivism which guide educators in creating dynamic and student-centered learning environments that promote active engagement, critical thinking, and the construction of meaningful knowledge include active learning, prior knowledge integration, social interaction, authentic tasks, inquiry-based learning, multiple perspectives, scaffolding, and reflection and metacognition.

If meaningful learning involves interpreting new information in terms of existing conceptual structures, the manner in which learners' ideas are related to each other is of central importance (Taber & Watts,1997:13). Learners should be allowed to integrate 'what they know' with 'what they are supposed to know' through knowledge construction, which is essential in helping students to learn effectively. Constructivism is an epistemological view of knowledge acquisition emphasizing knowledge construction through social interaction rather than knowledge transmission and the recording of information conveyed by others (Fosnot, 1996; Harland, 2003; Vygotsky, 1978). It is a learning theory that emphasizes the active construction of knowledge through meaningful learning experiences, where learners build on their existing knowledge and experiences to develop new understandings (Chiu & Lin, 2001). Bodner (1986, P.874) puts this as follows:

Anyone who has studied chemistry, or tried to teach it to others, knows that active students learn more than passive students. Chemists should therefore have a natural affinity for a model which replaces a more or less passive recipient of knowledge with an active learner. The problem with constructivism arises when one tries to look at the logical consequences of the assumption that knowledge is constructed in the mind of the learner.

The stipulation here above by Bonder (1986) is that the learner constructs knowledge continually when there is interaction and active involvement. The most important aspects of constructivism in chemistry teaching include prior knowledge activation, using conceptual change strategies, scaffolding and guided inquiry-based instruction, metacognitive reflection, and considering authentic contexts and real-world applications. Construction of new knowledge by learners starts with a starting point of the whole thing that is already known by them earlier (Bransford et al., 1999). This means, students come to school with well-established prior Knowledge. This knowledge is usually peculiar and hard to change. Some of the ideas that learners already "know" are wrong completely or in part (Wandersee et al., 1994). The literature refers to such students' self-constructed conceptions as misconceptions, alternative conceptions, preconceptions, or naive conceptions (Driver & Easley, 1978). Misconceptions or

alternative conceptions usually diverge from accepted scientific thoughts and are incomplete theories that people have developed to understand their world (Konicek-Moran & Keeley, 2015). In the context of chemistry teaching, addressing misconceptions is vital as students often hold alternative conceptions that may deter their learning and conceptual development.

By embracing constructivist approaches, teachers can help students identify and correct misconceptions, involve in hands-on activities, and build a deeper understanding of chemical concepts. Teaching chemistry with cognizance of constructivism and recognizing students' misconceptions is fundamental for meaningful learning. The module incorporates constructivism principles and students' misconceptions-related components in each section.

Implication to teaching (5 min)

- What did you learn from this session and how will you use the "constructivism principles" in this session in your classroom teaching?

Takeaway resources/materials

- Garnet, P.J. (2000). Constructivism and chemistry teaching, Link to down load: https://www.researchgate.net/publication/262373909_Constructivism_and_chemistry_teaching
- Bodner, G. M. (1986). *Constructivism: A theory of knowledge. Journal of Chemical Education, 63(10), 873.* doi:10.1021/ed063p873. Link to down load: https://libgen.is/scimag/?q=CONSTRUCTIVISM%3A+A+THEORY+OF+KNOWLEDGE

Session 1.3: Inquiry-based Learning in Chemistry Teaching (1 h)
Introduction of the session (3 min)

This session aims to support chemistry teachers in comprehending how to consider inquiry based learning (a constructivist approach) in each lesson. Teachers are expected to use inquiry based approaches to ensure students learning with understanding. It is necessary to allow teachers to reflect on the way how they include inquiry based learning while teaching chemistry.

Session Objectives
At the end of this session, trainees will be able to:

- explain inquiry based learning
- use inquiry based learning while teaching chemistry
- develop curiosity in inquiry based learning in the learning/teaching of chemistry

Brain storming activity (35 min)

1. How would you define inquiry teaching in the context of chemistry education? (5 min)
2. Reflect on your current practices in incorporating inquiry teaching in your chemistry classroom. What specific strategies or activities do you use to promote inquiry-based learning? (5 min)
3. In what ways do you believe inquiry teaching enhances students' understanding of chemistry concepts and principles? (5 min)
4. What are some of the challenges you have encountered when implementing inquiry teaching in your chemistry lessons? (5 min)
5. How do you currently assess student learning in chemistry through inquiry-based activities? Are there any assessment strategies you find particularly effective? (5 min)
6. What resources or professional development opportunities could support your growth in using inquiry teaching in chemistry education? (5 min)
7. Reflect on a successful inquiry-based experiment or project you conducted with your students. What factors contributed to its success? (5 min)

Key points (7 min)

Inquiry-based approach is an effective method for students to increase content knowledge and problem-solving skills (Domin, 1999; Gelder et al., 2015; Guo et al., 2013). It is an educational approach that underscores active exploration, investigation, and discovery

through questioning, experimentation, and problem-solving. Inquiry focuses on self-generated data to explain scientific observations, rather than simply testing knowledge (Cooper & Stowe, 2018). Inquiry-based learning is important to make learning more meaningful, transferable, and conducive to self-directed, life-long learning (Lim, 2004). Incorporation of scientific practices into a learning environment promotes the development of expert-like thinking in students and the chemistry laboratory is the ideal place for students to practice and evaluate their data (Duschl, 1990; Gao &Lloyd, 2020).

In the context of chemistry teaching, inquiry-based learning begins with posing questions that spark curiosity, provoke investigation, and guide students' exploration of chemical phenomena. It encourages students to formulate research questions, design experiments, and seek answers through scientific inquiry. It also promotes active engagement, critical thinking, and hypothesis testing in the learning process. Inquiry-based learning promotes conceptual understanding by encouraging students to ask questions, design experiments, analyze data, and draw evidence-based inferences.

With Inquiry-based learning, chemistry teachers can engage students in hands-on laboratory experiments; involve them in analyzing and interpreting data obtained from experiments to draw meaningful conclusions and construct scientific explanations; encourage them to work together, share ideas, and engage in peer discussions to address complex scientific challenges; promote reflection and revision to enable students to evaluate their hypotheses, experimental procedures, and conclusions; and foster metacognitive awareness and self-assessment skills. By fostering curiosity, inquiry skills, and scientific reasoning, teachers can allow students to construct knowledge, improve problem-solving abilities, and nurture a deeper appreciation of chemical principles.

Teaching chemistry with understanding of inquiry-based approaches is important for meaningful learning. Through the module, activities designed for teachers of chemistry are with an inquiry-based approach in mind.

Implication to teaching (4 min)

- What did you learn from this session and how will you use the “Inquiry-based approach” in this session in your classroom teaching?

Takeaway resources/materials

- Orosz, G., Nemeth, V., Kovacs, L., Somogyi, Z. and Korom, E. (2023). Guided inquiry-based learning in secondary-school chemistry classes: a case study. Chem. Educ. Res. Pract., 2023, 24, 50-70. Link to download: https://pubs.rsc.org/en/content/articlehtml/2023/rp/d2rp00110a
- Cooper M.M. & Stowe R.L. (2018). Chemistry Education Research—From Personal Empiricism to Evidence, Theory, and Informed Practice. *Chem. Rev., 118* (12), 6053-6087. DOI: 10.1021/acs.chemrev.8b00020. Link to download: https://pubs.acs.org/doi/10.1021/acs.chemrev.8b00020

Session 1.4: Conceptual change instruction and chemistry understanding (1 h)

Introduction of the session (5 min)

This session aims to support chemistry teachers in comprehending how to consider different conceptual change approaches in chemistry classes. Teachers are expected to use conceptual change approaches to ensure students' learning with meaningful understanding. It is crucial to allow teachers to reflect on the way they include conceptual change strategies to improve understanding.

Session Objectives

At the end of this session, trainees will be able to:

- Elucidate conceptual change instruction
- Employ conceptual change approaches in teaching chemistry
- Develop interest in conceptual change instructional approaches in the learning/teaching of chemistry

Brainstorming activity (35 min)

1. What are some conceptual change instructional approaches that improve students' understanding? Is reducing misconception considered improving understanding? (7 min)
2. How have you identified and addressed misconceptions in your chemistry teaching practice? (5 min)
3. Describe a hands-on activity or experiment you have used to help students understand abstract chemical concepts. (5 min)
4. In what ways do you encourage students to ask questions and engage in discussions to deepen their understanding of chemistry concepts? (5 min)
5. How do you provide opportunities for students to reflect on their learning and make connections between new and existing knowledge in your chemistry lessons? (5 min)
6. Reflect on the impact of incorporating conceptual change instruction on students' understanding of chemistry concepts in your classroom. What improvements or changes have you observed in your students' understanding of chemistry concepts? (8 min)

Key points (7 min)

Conceptual change (CC) is a learning process in which students' alternative conceptions change or renovate into the intended scientific conceptions (Beerenwinkel et al., 2010; Vosniadou, 2007).

It is a pedagogical approach that focuses on helping students restructure their existing knowledge and beliefs to develop accurate and scientifically valid understandings of complex concepts. It is an outgrowth of constructivist epistemology in which knowledge acquirement is viewed as a constructive process that involves actively generating and testing alternative propositions (Tyson et al., 1997). CC takes place when a learner makes a shift from not understanding how something works to understanding it (Mayer, 2002). CC occurs when students move from mistaken belief to scientifically accepted conceptions (Heddy et al., 2017). CC instruction is the means through which meaningful learning occurs (Mayer, 2002).

Some common CC approaches used in teaching chemistry through conceptual change approach include Socratic questioning, Concept mapping, Peer instruction, Hands-on experiments, Concept cartoons (Cartoons which include prior knowledge or misconceptions of learners, and Conceptual change texts (texts which include prior knowledge or misconceptions of learners). During CC instruction teachers identify misconceptions, engage students in activities that create cognitive conflict, provide scaffolding support and guidance, promote metacognitive monitoring and self-regulation skills, and incorporate reflective assessment tasks with constructive feedback. Gabel (1999) suggests the importance of addressing misconceptions and promoting conceptual understanding in chemistry, and he indicates different instructional strategies and approaches used to facilitate conceptual change.

In the context of chemistry education, addressing students' misconceptions and promoting conceptual change is key for fostering deep understanding, stimulating scientific literacy, and improving problem-solving skills. By involving students in reflective activities, discussions, and hands-on experiences, teachers can facilitate the process of conceptual change and support students in structuring coherent mental models of chemical phenomena.

In this module activities are experience-related, teachers are required to actively engage in reflecting on what they observed in their class, identify misconceptions they observed, use levels of chemistry understanding, and employ various conceptual change instructional approaches that can promote conceptual understanding rather than memorization. Teaching chemistry with knowledge of CC instruction through the identification of misconceptions is important for meaningful learning. Through the module, activities designed for teachers of chemistry are with the consideration of the CC approach.

Implication to teaching (3 min)

- What did you learn from this session and how will you use the "conceptual change instruction" in this session in your classroom teaching?

Takeaway resources/materials

- Beerenwinkel, A., Parchmann, I., & Gräsel, C. (2010). Conceptual change texts in chemistry teaching: A study on the particle model of matter. *International Journal of Science and Mathematics Education, 9(5), 1235–1259.* Link to down load: https://libgen.is/scimag/?q=CONCEPTUAL+CHANGE+TEXTS+IN+CHEMISTRY+TEACHING%3A+A+STUDY+ON+THE+PARTICLE+MODEL+OF+MATTER
- Gafoor, k.A. & Shilna, V. (2013). Role of concept cartoons in chemistry learning. Paper Presented in a Two Day National Seminar on Learning Science by Doing – Sciencing (December 5 & 6th 2013). Link to down load: https://files.eric.ed.gov/fulltext/ED545358.pdf

Unit 2: Atomic structure and periodic properties of the elements (10 h)

Unit introduction (5 min)

This unit of the training module aims to assist secondary school chemistry teachers in establishing a proper understanding of radioactivity, the discovery of the nucleus, the make-up of the nucleus, atomic spectra, quantum numbers, electron configurations, orbital diagrams, and the periodic classification of elements focusing on periodic properties.

Various activities are provided in each session to enhance the competencies of the trainees in teaching the suggested topics. Therefore, it is essential to motivate the trainees (teachers) to discuss either individually or in groups. This will help them come up with different instructional approaches based on their previous experiences and the discussions held on the suggested activities in each session.

Objectives

At the end of this unit, trainees will be able to:

- understand how to teach radioactivity and the makeup of the nucleus
- comprehend how the Rutherford experimental setup and observations led to the discovery of nucleus model of the atom.
- be familiar with how to teach atomic spectra and the Bohr atomic model
- understand the methods employed to teach quantum numbers in the context of electron configurations to predict the arrangement of electrons in atoms.
- realize the meaning and significance of each quantum number: principal, azimuthal, magnetic, and spin
- appreciate teaching and learning of atomic structure and periodic properties of the elements using macroscopic phenomena, submicroscopic, and symbolic representations.
- develop scientific inquiry skills: inferring, predicting, classifying, comparing and contrasting, communicating, experimenting, and making generalizations.

Session 2.1: Radioactivity and the discovery of the nucleus (1:55 h)

Introduction of the session (5 min)

This session aims to assist chemistry teachers in understanding how to teach radioactivity and the discovery of the nucleus in the classroom. Motivating the trainees (the teachers) to engage in the suggested activities either individually or in groups is essential. It is also important to encourage the trainees to brainstorm and discuss on effective methodologies for teaching this topic. The topic is taken from Grade 9 (Unit 3 and 4) as well as Grade 1 (Unit 1).

Objectives

At the end of this session, trainees will be able to:

- design different methods to teach radioactivity and the discovery of the nucleus
- describe the common types of radioactive emissions
- summarize the major contribution of Rutherford's experiment on the discovery of the nucleus
- apply available technology to teach radioactivity and the discovery of the nucleus.

Activities

Discuss in a group of 3 to 5 members on the following questions, and present your ideas to the rest

1. Describe the atomic models you are familiar with and discuss their basic differences. (10 min)
2. What misconceptions did you observe among your students while teaching radioactivity and the discovery of the nucleus? How did you address these misconceptions? (10 min)
3. How can you apply Johnston's triangle, role play, video, etc. to teach atomic models? (15 min)
4. How can technology assist you in helping learners grasp the concepts of radioactivity easily? (10 min)
5. After watching the following two videos at this link:
    - Radioactivity animation: https://www.youtube.com/watch?v=VTHQYjkCqV0
    - Rutherford's atomic model: https://www.youtube.com/watch?v=TbAa9K41PVM (20 min)
6. How can you assist learners in linking the discovery of the nucleus with radioactivity? (10 min)
7. Explain how the discoveries of the nucleus and radioactivity have contributed to our understanding of atomic structure. (10 min)
8. Discuss how you can assess your learner's understanding of radioactivity and the discovery of the nucleus in your classes? (10 min)

Key points (7 min)

While teaching the concept of radio activity and discovery of the nucleus explain these concepts briefly after getting the learners prior knowledge. Use different teaching and learning methods including Johnston's chemistry triangle, animation, videos, role plays, etc.

Radioactivity is the spontaneous emission of radiation from the nucleus of an unstable atom. It is also called **radioactive decay**. Atoms consist of a nucleus containing protons and neutrons, surrounded by electrons. When the nucleus of an atom is unstable, it can undergo radioactive decay, a process where it releases energy in the form of radiation to become more stable. There are three main types of radiation emitted during radioactive decay:

- alpha (α) radiation/particles: positively charged particles.
- beta (β) radiation/particles: high-speed electrons emitted from the nucleus.
- gamma (γ) radiation/rays: high-energy electromagnetic radiation emitted from the nucleus.

The discovery of the nucleus is a vital moment in the history of atomic theory and our understanding of the structure of the atom. Ernest Rutherford (1909) conducted the gold foil experiment in which he bombarded a thin sheet of gold foil with alpha particles. He observed that the majority of alpha particles passed straight through the foil, but some were deflected at large angles or even bounced back. This led Rutherford to propose a new model of the atom (**Nuclear Model of the Atom**). Based on the results of the gold foil experiment, Rutherford proposed that the atom consists mostly of empty space with a dense, positively charged nucleus at its center. Electrons orbit the nucleus at a distance, similar to planets orbiting the sun. Generally, the understanding of the nucleus and radioactivity has had profound implications for our understanding of the structure of matter and the behavior of atoms at the atomic level.

Implication to teaching (8 min)

- What did you learn from this session and how will you apply the methods you used to your classroom teaching?
- How can you help your students benefit from this lesson?

Takeaway resources/materials

The following resources can be used to help learners easily understand the concepts of radioactivity and the discovery of the nucleus. These resources include visual animations, simulation (using PhET interactive simulations), virtual labs, videos, etc.

- Radioactivity animation: https://www.youtube.com/watch?v=VTHQYjkCqV0
- Rutherford's model of an atom: https://www.youtube.com/watch?v=TbAa9K41PVM

Session 2.2: Make-up of the nucleus (1 h)

Introduction of the session (3 min)

This session aims to support chemistry teachers in teaching the concept of the make-up of the nucleus to secondary school students. Teaching the make-up nucleus to secondary school students requires a structured approach to ensure effective understanding. Brainstorming individually, and discussing in groups are important during this session. Motivating the trainees to engage in the suggested activities is strongly encouraged. Trainees are expected to brainstorm and discuss effective methods that can be used for teaching this concept. The topic is taken from Grade 9 (Unit 1) as well as Grade 1 (Unit 1).

Objectives

At the end of this session, trainees will be able to:

- propose different methods to teach the make-up of the nucleus
- describe the make-up of nucleus
- correlate the atomic mass with the make-up of the nucleus
- explain isotope how it relates to the make-up of nucleus
- calculate the relative atomic mass of naturally occurring isotopic elements
- use available technology to teach make-up of the nucleus concept

Activities

Individually or in groups, discuss the following questions, and present your ideas to the rest

1. How do you typically introduce the topic of the makeup of the nucleus to your students? What instructional strategies or resources do you use to explain these concepts effectively? (5 min)
2. How can you apply hands-on activities, Socratic questioning style, Interactive demonstrations video, Visual Aids (Utilize diagrams, charts, and models etc.) to teach the make-up of nucleus? (12 min)
3. How can you assist learners to easily understand the concept of isotope? (8 min)
4. Explain role of the nucleus in determining the identity of an element and how changes in the number of protons or neutrons can result in different isotopes of an element. (10 min)
5. How do you assess student understanding of the makeup of the nucleus in your classroom? What assessment tools or strategies do you use to evaluate student learning outcomes? (7 min)

Key points (7 min)

To help learners grasp the concepts of the composition of the nucleus, atomic mass, and isotopes of elements, it is crucial to build upon their existing knowledge. Many learners often have misconceptions about these concepts, making it challenging to improve their understanding. Therefore, appropriate teaching and learning approaches should be used to correct learners' misconceptions.

Learners may have the following misconceptions about the make-up of the nucleus:

- The nucleus contains both protons and electrons. In reality, the nucleus is primarily composed of protons and neutrons, while electrons orbit the nucleus in shells at a distance.
- Another misconception is that the nucleus is a solid, compact structure. However, the nucleus is a dynamic and intricate arrangement of protons and neutrons, occupying a very small volume compared to the overall size of the atom. It is also not a static entity, as it can change processes like radioactive decay.

Learners may have the following misconceptions about the atomic mass of elements:

- Atomic mass is the same as the number of protons in an atom. Atomic mass is the sum of the number of protons and neutrons in an atom. While the number of protons determines the element's identity, isotopes have different numbers of neutrons, leading to variations in atomic mass.
- Atomic mass is always a whole number. In reality, atomic mass is not always a whole number due to the presence of isotopes and their relative abundance. Atomic masses on the periodic table are averages of isotopic masses weighted by their natural abundance. The misconceptions that learners could have about isotopes of elements include:

- Isotopes are different elements. However, isotopes are forms of the same element with the same number of protons but different numbers of neutrons. Isotopes share similar chemical properties but may have different atomic masses due to varying neutron counts.
- Isotopes have different chemical properties. The reality is that isotopes of the same element have identical chemical properties since they have the same number of protons. However, they have different physical properties such as density and stability.

To effectively convey the concept of nucleus make-up, atomic mass and isotopes of elements and facilitate learners' deep understanding various teaching methods can be used. Here are some steps and tips for teaching these concepts:

- Introducing the concept of the nucleus makeup: it is the central core of an atom, composed of protons and neutrons tightly bound together by strong nuclear forces. Protons have a positive charge, while neutrons have no charge (neutral). The nucleus is very small compared to the overall size of the atom, but it contains nearly all of the atom's mass due to the relatively large mass of protons and neutrons. Visual aids like diagrams, charts, and models can be used to show the structure of the nucleus and help students' comprehension on the concept.
- Introducing the concept of atomic mass: it is the average mass of all the isotopes of an element, taking into account their relative abundance. Simple visual aids or demonstrations can help students understand this concept better.
- Introducing the concept of isotopes: they are atoms of the same element that have the same number of protons but different numbers of neutrons. Visuals or models can be used to show how isotopes of an element differ in their atomic mass due to differing neutron counts.
- Provide real-world examples of elements with isotopes and their respective atomic masses, such as C-12, C-13, and C-14.
- Engage students in interactive activities such as creating atomic models of isotopes using different numbers of colored beads to represent protons and neutrons. This hands-on approach can help them grasp the concept more effectively.
- Use problem-solving exercises by providing students with problems and questions related to calculating atomic mass from isotopic abundance. This can help reinforce their understanding and application of the concepts.
- Encourage learners to ask questions and discuss any confusion or misconceptions they may have.

Implication to teaching (8 min)

- What did you learn from this session and how will you apply the methods you used to your classroom teaching?
- How can you help your students benefit from this lesson?

Takeaway resources/materials

The following resources can be used to help learners easily understand the concepts of the makeup of the nucleus, atomic mass, and isotopes of elements.

- visual aids (diagrams, charts, and models)
- Figures demonstrating isotopes of hydrogen, carbon, and chlorine (**Figure 2)**

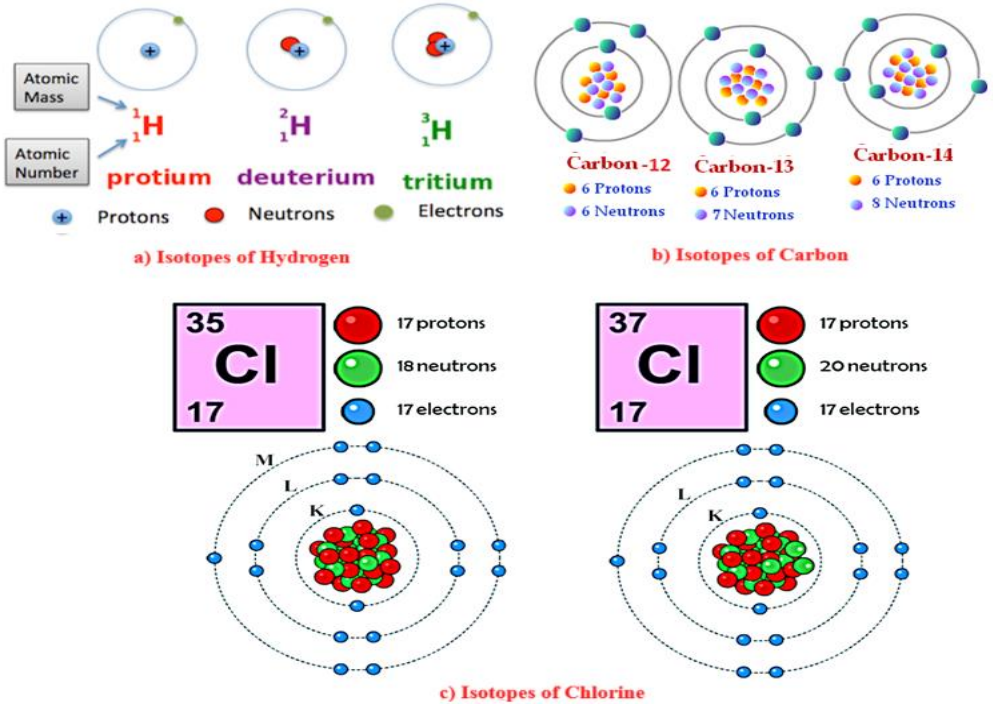


Figure 2. Isotopes of a) Hydrogen, b), Carbon, and c) Chlorine

- Hands-on activities
- Problem-solving exercises, etc.

Session 2.3: Atomic spectra (2 h)

Introduction of the session (5 min)

In this session, different methods that could help chemistry teachers teach the concept of atomic spectra to secondary school students are suggested. Teaching atomic spectra involves understanding the behavior of atoms when they absorb or emit light. To understand the concept brainstorming individually, and engaging in group discussion are important. Motivating the trainees to engage in the suggested activities is strongly encouraged. Trainees are expected to brainstorm and discuss effective methods that can be used for teaching this section.

Objectives

At the end of this session, trainees will be able to:

- design different methods for teaching atomic spectra and Bohr's atomic model

- describe how the Bohr model of the atom explains the formation of discrete atomic emission spectra
- connect atomic spectra to real-world applications, such as flame tests, firework colors, etc
- use interactive simulations or models to demonstrate the energy levels and transitions in the hydrogen atom according to the Bohr model
- use animated videos or demonstrations to visualize how electrons move between energy levels in discrete steps, emphasizing the quantization of energy levels
- explain how absorption spectra are produced and how they differ from emission spectra
- analyze and interpret spectral lines in the hydrogen spectrum to deduce information about the energy levels and transitions within an atom
- calculate the energy of transitions for different spectral lines in the hydrogen spectrum, associating with the concept of quantized energy levels
- explain why electrons in the hydrogen atom can only occupy specific energy levels and transition between them in quantized steps
- appreciate peer discussions to explain the concept to each other, supporting their learning and helping solidify their comprehension

Activities

Individually or in groups, discuss the following questions, and present your ideas to the rest

1. Watch the video of atomic spectra at this link: *https://www.youtube.com/watch?v=r9iNoM5FDQc*, and then, reflect on your observations. (15 min)
2. Watch the following two videos (Flame Test and The Science of Fireworks) at the links: *https://www.youtube.com/watch?v=TMz_XR3o5mg; and https://www.youtube.com/watch?v=dW5OBrB4MRM*, and then, reflect on your observations. (15 min)

3. What teaching methods do you use to explain that the line spectrum of a hydrogen atom demonstrates the quantized nature of the energy of its electron? (10 min)
4. Explain how absorption spectra are produced and how they differ from emission spectra. (10 min)
5. Watch the Animation of Bohr's Atomic Model at this link: *https://www.youtube.com/watch?v=r9iNoM5FDQc*, and then, reflect on your observations. (15 min)
6. How do you explain the different energy levels in the Bohr atomic model using analogy? (10 min)
7. Calculate the energy of transitions for different spectral lines in the hydrogen spectrum (n_1 to n_2, n_1 to n_3, n_1 to n_4, etc), reinforcing the concept of quantized energy levels. (20 min)
8. How can technology assist you in helping learners grasp the concepts of atomic spectra? (10 min)

Key points (5 min)

To support students' understanding of the concepts of atomic spectra composition and the Bohr atomic model, it is important to begin a session with a brainstorming activity. Learners may have misconceptions about these topics, so teachers should use different teaching methods to enhance the overall comprehension of the lesson.

Common misconceptions that learners may have about atomic spectra and Bohr's atomic model include:

- In Bohr's atomic model electrons are often thought to move in circular orbits around the nucleus. However, the reality is electrons that in Bohr's model do not move in traditional circular orbits but instead exist in quantized energy levels or shells around the nucleus. These energy levels represent distinct orbits where electrons are most likely to be found.
- All electrons in an atom emit light when they move between energy levels. In reality, only electrons transitioning between specific energy levels emit or absorb light, resulting in the observed atomic spectra. Not all electron movements result in the emission of light.
- The Bohr model is often believed to accurately describe the behavior of all atoms, it is important to note that it is most useful for explaining the atomic spectra of hydrogen-like atoms. The model has limitations when applied to larger or multi-electron atoms,

and a more accurate description of the atomic structure for complex atoms is provided by Quantum mechanics.

- It is also commonly misunderstood that electrons jump instantaneously between energy levels in Bohr's model. In reality, electron transitions between energy levels are not instantaneous but occur with the absorption or emission of photons.
- Additionally, atomic spectra are often thought to be continuous lines rather than discrete lines. However, atomic spectra consist of discrete lines or bands of light corresponding to specific electron transitions between energy levels. Each element has a unique set of spectral lines based on its electron configuration.

By addressing misconceptions and providing clear explanations about atomic spectra and Bohr's atomic model using various teaching methods, students can acquire a more accurate understanding of the lesson.

Here are some tips to guide chemistry teachers in teaching atomic spectra effectively:

- Start with the Basics, by explaining the fundamental concepts of atomic spectra, including the Bohr model, energy levels, and transitions between energy levels.
- Use interactive demonstrations, such as flame tests or fireworks to show students the emission spectra of different elements.
- Utilize visual aids like diagrams, charts, and models to illustrate atomic structure, energy levels, and transitions.
- Utilize analogies that help students understand the concept of Bohr energy levels by relating it to familiar contexts. This will make the idea of discrete energy levels within an atom easier to grasp and engage students. The analogy simplifies the abstract nature of atomic structure and energy transitions, making it easier for students to comprehend and remember the concept.
  - ✓ Musical notes analogy: compare the quantized energy levels of the hydrogen atom to musical notes on a scale, where only specific frequencies (energy levels) produce distinct sounds (spectral lines).
  - ✓ Bookshelf analogy: where each shelf represents a different energy level, and electrons can only jump between these shelves in discrete steps.
  - ✓ Building with floors analogy: where each floor represents a different energy level, and electrons can only jump between these shelves in discrete steps. In this analogy, the basement of a building represents the lowest energy level (the most

stable energy level), and the first floor of the building represents the first excited state where electrons can move when they absorb energy and jump to a higher energy level. Explain that when electrons move up to the first floor, they are in an excited state before eventually returning to the ground state.

The second floor of the building represents the second higher energy level that electrons can reach when further energy is absorbed.

- The staircase between floors serves as an analogy to the energy transition that electrons undergo when moving between energy levels.
- Energy absorption and emission are key factors to consider. When electrons climb the staircase to higher floors, they absorb energy, and when they descend, they emit energy.
- The quantized nature of this process is similar to a building with distinct floors. Electrons in atoms have fixed energy levels in which they can exist.
- Electrons can jump between energy levels but cannot occupy the space between floors, highlighting the quantized nature of electron energy levels.
- It is important to note that electrons in atoms typically return to the ground state (basement) after being excited to higher energy levels, releasing energy in the process.

- Discuss the practical applications of atomic spectra, such as identifying elements, astronomy, and x-ray analysis
- Provide hands-on activities like analyzing emission spectra, calculating wavelengths, and interpreting spectral lines to reinforce learning.
- Engage students in discussions about the significance of spectral lines, the quantization of energy, and the role of atomic spectra in scientific research.
- Incorporate simulations, online resources, and software tools to supplement classroom teaching and help students visualize atomic spectra.
- Facilitate group activities, peer discussions, and problem-solving tasks to encourage collaboration and deepen understanding.
- Provide regular assessments, quizzes, and feedback to gauge student understanding and address any misconceptions.

Implication to teaching (5 min)

- What did you learn from this session and how will you apply the methods you used to your classroom teaching?

- How can you help your students benefit from this lesson?

Takeaway resources/materials

The following methods can be used to help learners easily understand the concepts of the makeup of the nucleus, atomic mass, and isotopes of elements. These methods include

- The science of firework color: https://www.youtube.com/watch?v=dW5OBrB4MRM
- Flame test: https://www.youtube.com/watch?v=TMz_XR3o5mg
- Types of Spectra: https://www.youtube.com/watch?v=r9iNoM5FDQc
- Bohr's Atomic Model: https://www.youtube.com/watch?v=S1LDJUu4nko

Session 2.4: Quantum numbers (2 h)
Introduction of the session (5 min)

This session aims to assist chemistry teachers in understanding how to teach quantum numbers (n, l, m_l, and m_s), and the shapes of atomic orbitals in the classroom. Motivating the trainees (the teachers) to engage in the suggested activities is essential. It is also important to encourage the trainees to brainstorm and discuss effective practical strategies and approaches that facilitate understanding of the topic.

At the end of this session, trainees will be able to:

- design different methods for teaching quantum numbers
- demonstrate the ability to identify and define each of the four quantum numbers (principal quantum number (n), azimuthal quantum number (l), magnetic quantum number (m_ℓ)), and spin quantum number (m_s)) and their significance in describing electron states
- apply the four quantum numbers to describe the possible energy levels, sublevels, orbital orientations, and electron spin states within an atom
- explain the relationships among the n, l, m_ℓ, and m_s, illustrating how they define electron properties
- assign appropriate quantum numbers to electron configurations and orbital descriptions, demonstrating proficiency in determining allowed electron arrangements
- visualize electron states and orbitals based on quantum numbers, utilizing different quantum states
- predict the possible quantum numbers for electrons in specified energy levels, sublevels, and orbitals, indicating an understanding of quantum number rules
- apply the concept of quantum numbers to predict electron configurations for various elements
- solve complex problems involving quantum numbers, including determining allowed electron configurations, and orbital characteristics

Activities

Individually or in groups, discuss the following questions, and present your ideas to the rest

1. Explain the quantum numbers you know, and suggest the methods of teaching the concept. (10 min)

2. What misconceptions or alternative conceptions do students have about quantum numbers? Use your teaching experience to explain each. (10 min)
3. How can technologies assist you in helping learners grasp the concepts of quantum numbers and shapes of orbitals? (10 min)
4. How can you apply quantum number rules to determine energy levels, sublevels, and magnetic orientations for electrons? (10 min)
5. After watching the video (https://www.youtube.com/watch?v=oOVLkiBnq6o), describe all possible sets of quantum numbers of electrons in an atom, and reflect your observation from the video. (10 min)
6. Explain the relationships between the principal quantum number (n), azimuthal quantum number (l), magnetic quantum number (m_ℓ), and spin quantum number (m_s), with examples. (10 min)
7. After watching this video (https://www.youtube.com/watch?v=nNkw_0c8vY0&t=9s), deduce your understanding of the shapes of s, p & d-orbitals. Explain. (10 min)
8. Explain how quantum numbers determine the energy states of electrons in atomic orbitals. Support your explanation with examples. (10 min)
9. Discus in the group how to predict the possible quantum numbers for electrons in specified energy levels, sublevels, and orbitals, indicating an understanding of quantum number rules. Support your discussion with examples. (10 min)
10. How can you solve complex problems involving quantum numbers, including determining allowed electron configurations, and orbital characteristics? Support with at least five examples (15 min)

Key points (7 min)

Misconceptions in teaching quantum numbers (n, ℓ, m_ℓ, and m_s) and the shapes of orbitals to secondary school students are common due to the abstract and complex nature of the concepts. Teachers can effectively help secondary school students develop a thorough and accurate understanding of quantum numbers and orbital shapes in chemistry by addressing existing misconceptions through targeted instructional strategies and engaging activities. By breaking down complex concepts and providing ample opportunities for hands-on or interactive learning, learners can dispel misconceptions and promote their deep comprehension of the concepts.

Some misconceptions that students may have about quantum numbers and orbital shapes include:

- Confusion in quantum number definitions: students may confuse the roles and definitions of different quantum numbers, particularly the azimuthal quantum number (ℓ) and the magnetic quantum number (m_ℓ).
- Incorrect application of quantum numbers: students may have difficulty correctly assigning quantum numbers to electron configurations and orbital shapes, leading to misunderstandings about energy levels and orbital orientations.
- Misinterpreting orbital representations: students might have difficulty visualizing and understanding the 3D shapes of atomic orbitals based on quantum numbers, resulting in misconceptions about orbital orientations and spatial distributions.
- Equating quantum numbers with orbital shapes: there may be a misconception where students believe that each quantum number directly corresponds to a specific orbital shape, missing the nuanced relationships between quantum numbers and orbital characteristics.
- Ignoring the significance of electron spin: some students may overlook the importance of the spin quantum number (m_s) and its role in describing electron spin orientations within orbitals, leading to oversimplified explanations of electron behavior.
- Inadequate understanding of spin pairing: misconceptions can arise when students fail to grasp how electron spin dictates spin pairing rules within orbitals, affecting their understanding of magnetic properties and electron configurations.

The following strategies and activities can help to address these misconceptions:

- Use interactive simulations or physical models to demonstrate how quantum numbers relate to electron configurations and orbital shapes, clarifying misconceptions through hands-on experiences.
- Use analogies like the "building with floors" analogy for quantum numbers and shapes of orbitals to make abstract concepts more tangible and relatable to students.
- Connect quantum numbers and orbital shapes to real-world examples, such as architectural structures or molecular shapes, to illustrate practical implications and dispel misconceptions.
- Use concept maps or visual aids to outline the relationships between quantum numbers and orbital shapes, helping students see the interconnectedness of these concepts and correcting misconceptions.

- Provide clear orbital diagrams that showcase how quantum numbers dictate the size, shape, and orientation of different orbitals, aiding in visualizing orbital properties accurately.
- Use formative assessments like quizzes or concept questions to gauge students' understanding of quantum numbers and orbital shapes, identifying and addressing misconceptions promptly.
- Encourage peer discussions and feedback sessions where students can explain their reasoning behind quantum number assignments and orbital interpretations, fostering collaborative learning and correcting misconceptions.

NB: A deeper understanding of quantum numbers and orbital shapes can be achieved through the use of available technologies such as animations and simulations, virtual labs, etc Different teaching approaches including brainstorming, role play, group discussions, analogies, and real-life examples, etc can also enhance students' comprehension of the topic.

Implication to teaching (8 min)

- What did you learn from this session and how will you apply the methods in your classroom teaching?
- What analogies and real-life examples can you use to teach quantum numbers and shapes of orbitals?
- What available technologies can you use to teach quantum number concepts?
- How can you help your students benefit from this lesson?

Takeaway resources/materials

The following resources can be used to help learners easily understand the concepts of quantum numbers and orbital shapes.

- The four quantum numbers: https://www.youtube.com/watch?v=oOVLkiBnq6o
- Shapes of atomic orbitals: https://www.youtube.com/watch?v=nNkw_0c8vY0&t=9s
- Sample concept map of quantum numbers and shape of orbitals **(Figure 3)**

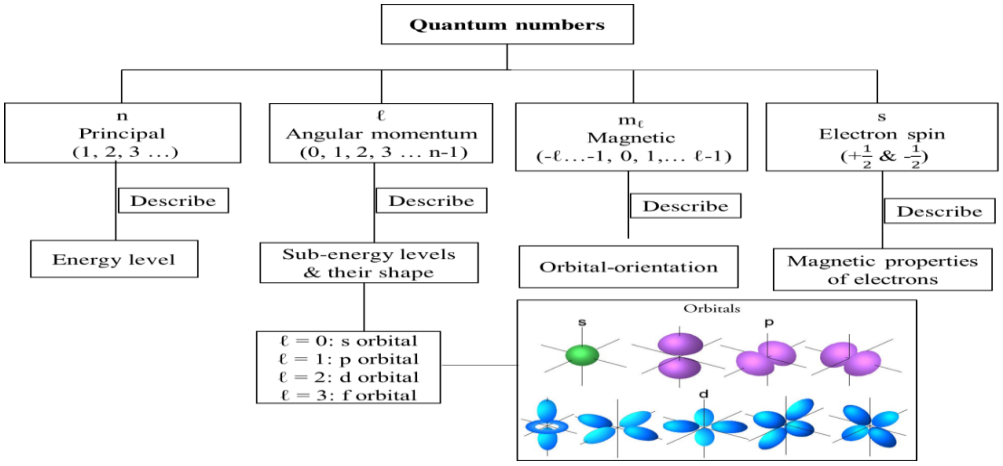


Figure 3: Concept map of quantum numbers and shape of orbitals

Session 2.5: Electron configurations and orbital diagrams (3 h)

Introduction of the session (5 min)

This session aims to assist chemistry teachers in understanding the concepts and how to teach electron configurations and orbital diagrams in the classroom. Trainees are expected to engage in the suggested activities using different learning strategies actively.

Objectives

At the end of this session, trainees will be able to:

- devise different methods for teaching electron configurations and orbital diagrams
- write electron configurations for elements up to a specified atomic number
- construct orbital diagrams to represent electron occupancy in various energy levels and sublevels
- Explain the Aufbau principle and its significance in determining the electronic structure of atoms
- practice filling orbitals with electrons based on the Pauli Exclusion Principle and Hund's rule
- interpret orbital diagrams to identify the spatial arrangement of electrons in different sublevels
- Identify common misconceptions that students may have about electron configuration and orbital diagrams
- solve complex electron configuration problems involving transition metals, ions, and unusual electronic configurations
- compare and contrast orbital diagrams for different elements, discussing how variations in electron distributions relate to atomic properties

Activities

Individually or in groups, discuss the following questions, and present your ideas to the rest

1. Discuss what you know about electron configurations and orbital diagrams, and suggest the methods of teaching these concepts. (20 min)
2. What misconceptions do learners have about electron configurations and orbital diagrams? (20 min)
3. Explain the Aufbau principle and its significance in determining the electronic structure of atoms. (20 min)
4. How can you help your learn to practice filling orbitals with electrons based on the Pauli Exclusion Principle and Hund's rule? (20 min)
5. Discuss with your peers how you can help your learners visualize electron configurations and orbital diagrams using real-life analogies. Hint: consider seating arrangements in rooms of a building as an analogy. (20 min)
6. Discus how teaching and learning methods such as role-playing, concept mapping, Problem-Solving Exercises, comparative analysis, virtual simulations, visual aids and diagrams, collaborative learning, etc. can help learners in understand how electrons are arranged in different orbitals within an atom. (40 min)
7. Explain how orbital diagrams identify the spatial arrangement of electrons in different sublevels. (20 min)

Key points (10 min)

When teaching the concepts of electron configurations and orbital diagrams you can use different strategies to address misconceptions that learners may have due to the abstract nature of atomic structure and the complex rules governing electron distribution within atoms. Before your class, try to identify the misconceptions that your students may have and select appropriate teaching methods to support their understanding of atomic structure. This will ensure accurate comprehension of electron distribution within atoms.

Learners may have the following common misconceptions when learning about electron configurations and orbital diagrams.

- Students may believe that electrons fill orbitals sequentially in a fixed order without considering the principles of the Aufbau principle, Hund's rule, and the Pauli Exclusion Principle.

- Students might misunderstand the shapes of orbitals, especially p and d orbitals, leading to confusion about how electrons are distributed spatially within these orbitals.
- Students may assume that orbitals within the same shell have the same energy level, overlooking the concept of energy sublevels within a shell.
- Students might neglect the importance of electron spin and its relationship to the Pauli Exclusion Principle, leading to errors in assigning electron spins in orbital diagrams.
- Students may wrongly associate specific quantum numbers with distinct orbital shapes, missing the concept that multiple quantum numbers collectively define an orbital's properties.
- Students could perceive electron configurations as fixed and unchangeable, missing the dynamic nature of electron rearrangements during chemical reactions and ion formation.
- Students may mistakenly assume that the number of electrons in an orbital directly correlates with its energy level, overlooking the small difference in orbital energy ordering.

To address these misconceptions teachers should use different instructional strategies and engaging activities. The following strategies and activities can help address these misconceptions:

- Clarify electron rules by emphasizing the principles of the Aufbau Principle, Hund's Rule, and the Pauli Exclusion Principle to correct misconceptions about the sequential filling of orbitals and electron spin.
- Use interactive tools, models, and simulations to demonstrate orbital shapes and electron distributions, allowing students to visually understand how electrons occupy orbitals.
- Provide sufficient practice opportunities for students to draw and interpret orbital diagrams, reinforcing the relationship between electron configurations and orbital shapes.
- Support students in understanding how quantum numbers collectively define an orbital's properties, guiding them to link quantum numbers to orbital shapes and energy levels.
- Repeatedly revise electron configuration concepts and orbital diagrams, integrating hands-on activities and discussions to support correct understanding and address misconceptions effectively.

- Connect electron configurations to chemical behaviors and properties, demonstrating how electron arrangements influence reactivity, bonding, and periodic trends.

Understanding the concepts of electron configurations and orbital diagrams can be facilitated by employing various strategies that cater to different learning styles and preferences. Here are some effective ways for learners to enhance their understanding of electron configurations and orbital diagrams:

- ✓ use visual aids such as diagrams, charts, and illustrations
- ✓ utilize interactive tools like simulations or online resources
- ✓ create concept maps to organize information
- ✓ engage in collaborative learning through peer discussions or teaching
- ✓ use of analogies or real-life comparisons, like seating arrangements in an auditorium, to make connections to familiar situations.
- ✓ take advantage of online resources, including interactive websites
- ✓ practice solving problems related to electron configurations and orbital diagrams
- ✓ assess understanding by seeking feedback on areas that need improvement and reinforcing learning

By incorporating a combination of these strategies into the learning process, learners can enhance their understanding of electron configurations and orbital diagrams. Actively practicing, engaging with visual materials, collaborating with peers, and seeking clarification when needed can help learners grasp complex concepts more effectively and build a solid foundation in chemistry.

Finally, it is important to conclude with the three rules that dictate how electrons are filled in atomic orbitals:

i. **The Aufbau principle:** states that electrons must fill atomic orbitals of a given energy level before occupying an orbital associated with a higher energy level. Electrons fill orbitals in increasing order of orbital energy level.

i. **Pauli's exclusion principle:** states that no two electrons can have equal values for all four quantum numbers. Therefore, each subshell of an orbital can accommodate a maximum of 2 electrons and these electrons must have opposite spins.

ii. **Hund's rule of maximum multiplicity**: dictates that all the subshells in an orbital must be singly occupied before any subshell is doubly occupied. Additionally, the spin of all electrons in singly occupied subshells must be the same to maximize overall spin.

Implication to teaching (5 min)

- What did you learn from this session and how will you apply these learning strategies in your classroom teaching?
- What analogies can you use to teach electron configuration and orbital diagrams?
- What available technologies can you use to teach the concepts of electron configuration and orbital diagrams?

Takeaway resources/materials

Various resources such as visual aids (utilize diagrams, charts, and illustrations), interactive tools (interactive simulations or online resources), hands-on activities, concept (mind) mapping, etc.

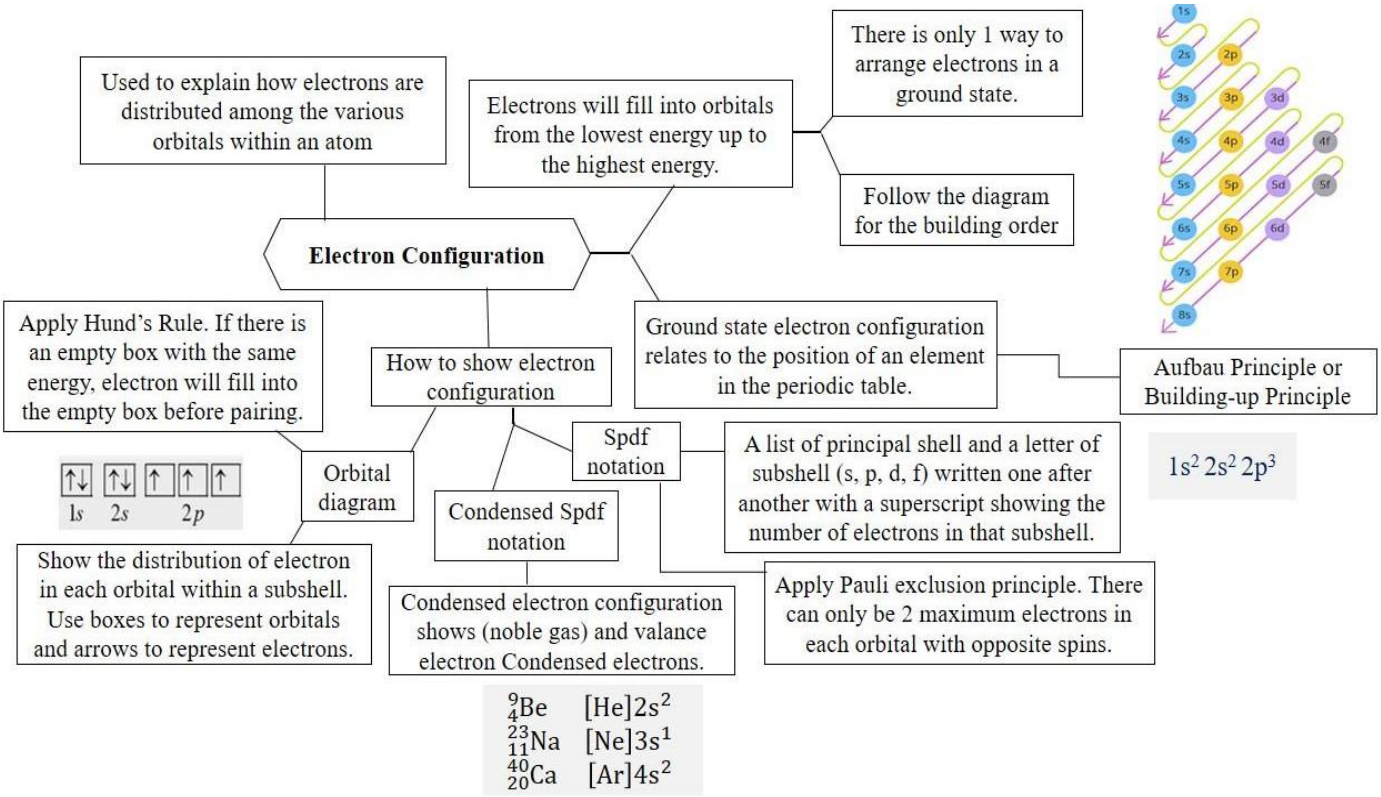


Figure 4: Mind map of electron configurations.

Session 2.6: Periodic classification of elements (2 h)
Introduction of the session (5 min)

In this session, the periodic classification of elements with a focus on the trends in the periodic properties will be addressed using different learning strategies. It is important to encourage trainees to utilize various interactive teaching and learning strategies is important while working on the suggested activities. This will help to prepare the trainees to teach the periodic classification of elements in the classroom effectively.

Objectives
At the end of this session, trainees will be able to:

- devise different methods to teaching quantum numbers
- demonstrate a thorough understanding of the organization of elements in the periodic table, including groups, periods, blocks, and the significance of atomic number and atomic mass
- explain key periodic trends such as atomic size, ionization energy, electronegativity, and electron affinity, relating these trends to element positioning on the periodic table
- analyze the properties of elements within specific groups and periods, recognizing patterns in ionization energy, electronegativity, and electron affinity, atomic size variation, and valence electron configurations
- Identify common student misconceptions related to the periodic classification of elements, such as confusion about the organization of the periodic table or the trends in properties of elements.
- apply periodic trends to explain phenomena such as the trend in electronegativity across periods, or the pattern of ionization energy within a group
- compare the properties of elements within different periods and groups

Activities

Individually or in groups, discuss the following questions, and present your ideas to the rest

1. Discuss what you know about the periodic table of elements, and design methods that can be used to teach the concept. (15 min)
2. What misconceptions do learners have about the periodic table of elements? (15 min)
3. How do you demonstrate the organization of elements in the periodic table: in groups, periods, blocks, and the significance of atomic number and atomic mass? (15 min)
4. Discus how key periodic trends such as atomic size, ionization energy, electronegativity, and electron affinity of elements vary in the periodic table. (15 min)
5. Explain how phenomena such as the trend in electronegativity across a period, and the pattern of ionization energy within a group of the periodic table vary. (15 min)
6. How do you analyze the properties of elements within specific groups and periods, recognizing patterns in ionization energy, electronegativity, electron affinity, atomic size variation, and valence electron configurations? (15 min)

7. What properties do you compare for elements within different periods and groups? (20 min)

Key points (7 min)

Teaching the periodic classification of elements focusing on periodic properties can be effectively done using various strategies that engage students and deepen their understanding of the trends in the periodic table. It is important to notice that learners may have misconceptions about the periodic classification of elements. To correct their misconceptions various teaching strategies and engaging activities should be used.

Students may have the following common misconceptions when teaching the periodic classification of elements focusing on periodic properties. These are:

- students may assume that trends in periodic properties progress uniformly across the periodic table, leading to oversimplification of complex periodic behaviors.
- Students might rely on memorization of trends without a deeper understanding of the underlying atomic and electronic structure principles that govern periodic properties.
- Students may isolate the properties of individual elements without relating them to their positions in the periodic table, missing the holistic view of trends across elements.
- Students may generalize trends across the periodic table without considering exceptions and variations that arise due to factors like electron configuration and atomic structure.
- Students might mistakenly rank elements solely based on one periodic property, overlooking the multidimensional nature of elements' properties and their interplay.

To address these misconceptions teachers should use various instruction strategies, interactive activities, and conceptual reinforcement, which can help students in developing accurate and correct understanding of periodic classification and periodic properties. The following strategies and activities can address the misconceptions:

- Comparative analysis: Encourage students to compare elements within the same group or period to understand variations in properties and clarify inconsistencies in periodic trends.
- Conceptual understanding focus: Emphasizing on the principles behind periodic trends, such as effective nuclear charge, electron shielding, and electron configuration, to foster a deeper comprehension of periodic properties.

- Real-life applications: Connect periodic properties to real-world examples like chemical reactivity, chemical bonding, and material characteristics to demonstrate the practical significance of understanding periodic trends.
- Interactive activities: Incorporating interactive exercises and simulations that allow students to manipulate elements on the periodic table, observe trends, and predict properties based on position.
- Critical thinking challenges: Present scenarios where students need to explain unexpected periodic trends or anomalies, encouraging critical thinking and exploration of underlying factors influencing periodic properties.
- Problem-based learning: Integrating problem-solving tasks that require students to apply periodic trends to explain observations or predict properties, promoting active engagement and practical application of knowledge.

Generally, teaching the periodic classification of elements focusing on periodic properties can be effectively done using various strategies that engage students and deepen their understanding of the trends in the periodic table. Some strategies for teaching periodic properties within the periodic table include interactive demonstrations (using physical models or digital simulations), periodic table activities, graphical representations (graphs and charts to visualize periodic trends), comparative analysis (comparing and contrasting elements within the same group or period to identify similarities and differences in periodic properties), hands-on group projects, role-playing scenarios, and so on.

Implication to teaching (8 min)

- What did you learn from this session and how will you apply the methods used in this session to your classroom teaching?
- What available technologies can be used to teach concepts?
- How can you help your students benefit from this lesson?

Takeaway resources/materials

Modern Periodic Table: https://www.youtube.com/watch?v=bKKJkxqIg94

Periodicity: https://www.youtube.com/watch?v=2AFPfg0Como

The Periodic Table: Atomic Radius, Ionization Energy, and Electronegativity: https://www.youtube.com/watch?v=hePb00CqvP0

Unit 3: Chemical Bonds (10 h)

Introduction (5 min)

This unit of the training module aims to assist secondary school chemistry teachers in establishing a proper understanding of chemical bonding concepts. Specifically, ionic and covalent bonds, molecular geometry concepts, valence bond theory (VBT), Hybridization, molecular orbital theory (MOT), and crystal structure concepts are given weight in this unit. Various activities are provided in each session to engage trainees. Therefore, it is essential to motivate the trainees to discuss either individually or in groups. This will help them come up with different instructional approaches based on their previous experiences and the discussions held on the suggested activities in each session. The topics are taken from Grade 9 (Unit 5) and Grade 11 Chemistry (Unit 2).

Objectives

At the end of this unit, trainees will be able to*:*

- describe chemical bonding concepts
- understand how to teach chemical bonding concepts
- comprehend ionic and covalent bonding
- know the methods to be employed to teach chemical bonding concepts.
- appreciate the bonding concepts and their application
- develop scientific inquiry skills (inferring, predicting, classifying, comparing and contrasting, communicating, experimenting and making generalizations)

Session 3.1: Classification of chemical bonds (1:55 h)

Introduction (5 min)

This session aims to support chemistry teachers in understanding how to teach chemical bonding concepts focusing on covalent and ionic bonding to secondary school students. Motivating teachers to engage in the suggested activities either individually or in groups is essential. Trainees are expected to brainstorm and discuss the effective methods they have used for teaching this topic.

Objectives

At the end of this session, trainees will be able to:

- devise different methods to teach chemical bonding concepts
- illustrate the common types of chemical bonds
- summarize the major ideas concerning chemical bonds
- use available technology to teach Chemical bonding concepts
- analyze common student misconceptions related the classification of chemical bonding concepts

Activities

Discuss in a group/brainstorm on the following questions, and present your ideas to the rest

1. Explain the chemical bonds you know, discuss their basic differences, and suggest the methods of teaching these concepts. (15 min)
2. What misconceptions or alternative conceptions do students have about chemical bonds? Use your teaching experience to explain each. (15 min)
3. How can you apply the chemistry triangle concept of Johnstone (macro, sub-micro-, and symbolic levels), use simulations, virtual labs, role play, video, etc. to teach chemical bonding concepts? (20 min)
4. How can technologies assist you in helping learners grasp the concepts of chemical bonds with ease? (10 min)
5. After watching the video of chemical bonding explained with 3D at https://www.youtube.com/watch?v=g-tE6MN-wrE, write the definition for ionic and covalent bonding, and reflect on the video you saw. (10 min)
6. How can you teach covalent and ionic bonding using analogy? (20 min)

Key points (10 min)

Facilitating learning of chemical bonding concepts is possible by considering the prior knowledge of learners. Learners usually have misconceptions that are difficult to change, but teaching through proper approaches can enhance their understanding.

Some common misconceptions related to chemical bonds include:

- chemical bonds are physical connections between atoms;
- all chemical bonds are the same
- covalent bonds involve the transfer of electrons between atoms
- all covalent bonds are equally strong
- ionic compounds only contain ionic bonds
- the number of atoms in a molecule determines the type of bond it has; and chemical bonds are always static and unchanging

To correct these misconceptions, it is important to treat chemical bonding concepts at three understanding levels of chemistry: macro, sub-micro, and symbolic levels.

- At macro level, teachers can begin by introducing students to the concept of chemical bonding using macroscopic observations like different types of materials (e.g., metals, nonmetals, ionic compounds) and discuss their physical properties related to bonding. In addition, hands-on activities or demonstrations can be conducted to illustrate bonding behavior. Allowing learners to describe and analyze macroscopic properties of substances based on their bonding types like conductivity, malleability, and solubility is important.

- At the micro or sub-micro level, it is possible to discuss the molecular and atomic structures involved in chemical bonding. This could be done by introducing concepts like valence electrons, electron configuration, and Lewis structures to explain how atoms bond to form molecules or compounds. Moreover, using molecular models or visual aids to help students visualize the arrangement of atoms and electrons in different types of bonds (covalent, ionic, metallic) is very important. Exploring the role of electronegativity, bond polarity, and bond strength in determining the nature of chemical bonds at the microscopic level is crucial.

- At the symbolic level, introducing students to symbolic representations of chemical bonds like Lewis dot structures, structural formulas, and chemical equations is very important. Teachers are expected to teach students how to write and interpret chemical formulas for compounds based on their bonding types (e.g. NaCl for sodium chloride, CO_2 for carbon dioxide). A chemical equation should be used to illustrate the bond formation and breaking in reactions, emphasizing the conservation of atoms and charge.

While teaching the covalent and ionic bonding concepts analogy can be used to clarify the basic ideas for students.

- In a covalent bond, atoms share electrons in a mutually beneficial relationship, much like how friends share and support each other. Covalent bonds can be analogized to a close friendship where individuals share responsibilities, secrets, and experiences.
- An ionic bond is a chemical bond formed between oppositely charged ions. Ionic bonds are formed when one or more electrons are transferred from one atom to another. Ionic bonds can be compared to a parent-child relationship where one party provides guidance and support while the other receives it.

A meaningful understanding of chemical bonding concepts can take place through the use of available technologies (eg. Animations and simulations) and different teaching approaches (eg brainstorming, role play, group discussions, etc)

Implication to teaching (10 min)

- What did you learn from this session and how will you apply the methods used in this session to your classroom teaching?
- What available technologies can be used to teach chemical bonding concepts?
- How can you help your students benefit from this lesson?

Takeaway resources/materials

The following resources can be used to help learners easily understand the concepts of chemical bonding. These resources include describing bonding concepts at three levels of chemistry understanding (Johnstone's Triangle), visualization, simulation, virtual labs, videos, etc.

- Chemical bonding explained with 3D at: https://www.youtube.com/watch?v=g-tE6MN-wrE
- Bonding note at: https://fns.uniba.sk/fileadmin/prif/chem/kag/Bakalar/vch_noga/GEN_INORG_CHEM03-04.pdf
- Resources/materials developed during the training program

Session 3.2: Molecular geometry (3 h)

Introduction (5 min)

This session aims to help chemistry teachers understand how to effectively teach molecular geometry concepts to secondary school students. Brainstorming individually and engaging in group discussions are key components of this session. Encouraging the trainees to participate in the recommended activities, whether in groups or individually, is crucial. It is expected of the trainees to come up with ideas and discuss the best methods they have found to teach this topic.

Objectives

At the end of this session, trainees will be able to:

- apply different methods to teach molecular geometry
- produce molecular models
- describe how electron pair arrangements and shapes of molecules can be predicted from the number of electron pairs
- use available technology to teach molecular geometry

Activities

Discuss in a group/brainstorm on the following questions, and present your ideas to the rest

1. Why understanding molecular geometry is crucial in predicting the physical and chemical properties of substances? (15 min).
2. Discuss how the number of bonding pairs and lone pairs around the central atom affect the geometry and shape of molecules. (20 min)
3. Describe the geometries and shapes of some molecules with specific examples. (15 min)

4. How are you going to engage students in hands-on activities like building molecular models to visualize different geometries? (20 min)
5. What misconceptions do students have about molecular geometry? Share your experiences how you addressed the misconceptions. (20 min)
6. Design a lesson using the chemistry triangle concept (Macro, sub-micro-, and symbolic levels), role play, etc. to teach molecular geometry concepts. (20 min)
7. How can technologies assist you in helping learners grasp the concepts of molecular geometry with ease? (10 min)
8. After watching the videos of molecular geometry explained with 3D at: https://www.youtube.com/watch?v=nLhmgF81Kqo, https://www.youtube.com/watch?v=eh8wKUn41Zg, and https://www.youtube.com/watch?v=S6zU34h0_ts, reflect on what you learned concerning molecular geometry. (30 min)
9. What resources or materials can you propose to support students who need extra assistance to comprehend the molecular geometry concept? (10 min)

Key points (10 min)

Learning molecular geometry concepts is possible by considering the prior knowledge (which can be misconceptions) of learners. Learners usually have misconceptions or alternative conceptions that are difficult to alter. Improving learning through a proper approach can increase their understanding.

There are common misconceptions among students about molecular geometry concepts. These include:

- all molecules with two atoms are linear in shape
- electron geometry (arrangement of electron pairs around the central atom) is always the same as the molecular shape (actual arrangement of atoms
- molecules with the same number of atoms will always have the same geometry.

Addressing these misconceptions requires providing clear explanations, visual aids, interactive demonstrations, and practice problems that challenge students to apply their understanding of molecular geometry concepts in various situations. Teachers are expected to consider these misconceptions, so that instruction plays a role in shaping these misconceptions. Molecular geometry is a fundamental concept in chemistry that deals with the three-dimensional arrangement of atoms in a molecule. Understanding molecular geometry is crucial as it helps predict the physical and chemical properties of substances, such as polarity and, reactivity, and

biological activity. Atoms in a molecule are connected by chemical bonds, which determine the shape of the molecule. The arrangement of atoms in space influences the overall geometry of the molecule. The shape of a molecule is determined by the number of bonding pairs and lone pairs of electrons around the central atom.

Teaching these ideas at different levels of chemistry understanding (macro, sub-micro, and symbolic levels) can help students develop a comprehensive understanding.

- At the macro level, focusing on the observable properties of molecules and their shapes in three-dimensional space is important. At this level, physical models or interactive simulations can be used to demonstrate the shapes of common molecules.
- At the sub-micro level, go deep into the arrangement of atoms and electron pairs within a molecule. Using molecular models or diagrams to represent the spatial arrangement of atoms and electron pairs in different molecular geometries important. At this level, emphasis should be given to the role of electron pair repulsion in determining molecular shape and stability.
- At the symbolic level, use Lewis structures, molecular formulas, and structural diagrams to represent molecules and their geometries.

A meaningful understanding of molecular geometry concepts can take place through the use of available technologies (animations and simulations, virtual labs, etc) and different teaching approaches (brainstorming, role play, group discussions, model construction, etc).

Implication to teaching (5 min)

- What did you learn from this session and how will you apply the methods used in this session in teaching molecular geometry?
- What additional technologies can be used to teach molecular geometry concepts?
- How can you help your students benefit from this lesson?

Takeaway resources/materials

The following resources can be used to help learners easily understand the concepts of molecular geometry. These resources include describing geometry concepts at three levels of chemistry understanding (Johnstone's Triangle), visualization, simulation, virtual labs, videos, etc.

- Molecular geometry explained in 3D at: https://www.youtube.com/watch?v=nLhmgF81Kqo and https://www.youtube.com/watch?v=eh8wKUn41Zg

- Video of molecular geometry at: https://www.youtube.com/watch?v=S6zU34h0_ts,

Session 3.3: Valence bond theory and molecular orbital theory (3 h)

Introduction (5 min)

This session aims to assist chemistry teachers in understanding how to teach Valence Bond Theory (VBT) and Molecular Orbital Theory (MOT) concepts to secondary school students. It is mandatory for trainees to participate in the suggested activities, either individually or in groups. Trainees will engage in brainstorming and discussing effective teaching strategies they have used while teaching this topic.

Objectives

At the end of this session, trainees will be able to:

- apply different methods to teach VBT and MOT concepts
- use models that can help in understanding VBT and MOT concepts
- explain how the geometrical shapes of some simple molecules based on hybridization and the nature of electron pairs be predicted
- use available technologies to instruct VBT and MOT concepts.

Activities

Brainstorm/discuss in a group on the following questions, and present your ideas to the rest

1. Explain the concept of hybridization. (15 min)
2. Explore the different types of orbital overlapping (sigma, and pi) and how they contribute to the strength and polarity of covalent bonds as well as polarity of covalent molecules. How are you going to present these concepts to your students? (30 min)
3. Discuss the hybridizations involved in compounds containing multiple bonds. (15 min)
4. Which theory (VBT or MOT) perfectly explains all aspects of bonding? (15 min)
5. What misconceptions do students have about VBT and MOT concepts? (15 min)
6. How can you apply the chemistry triangle concept of Johnstone (Macro, sub-micro-, and symbolic levels), use simulations, virtual labs, role play, video, etc. to teach VBT and MOT concepts? (20 min)
7. Watch the following videos and reflect on what you learned from them. (30 min)
    - the VBT 3D at: https://www.youtube.com/watch?v=PRmYlUuDXVI
    - the Hybridization lesson at: https://www.youtube.com/watch?v=pdJeQUd2g_4,
    - MOT 3D at: https://www.youtube.com/watch?v=FMxuss0RXOU

8. How can technologies assist you in helping learners grasp the concepts of VBT and MOT with ease? (20 min)

Key points (10 min)

Students' understanding problem starts in the early phases of lessons on VBT and MOT. The basic principle of VBT is that a covalent bond forms when the orbitals of two atoms overlap and the overlap region, which is between the nuclei, is occupied by a pair of electrons. The MOT assumes that when atoms come together, their orbitals not only overlap but are also simultaneously transformed into new orbitals. Students face difficulty in understanding these ideas and teachers are expected to design strategies that can help learners. There are different student-related misconceptions about concepts in VBT and MOT. These include:

- hybridization involves the mixing of entire atomic orbitals, and always necessary for bond formation
- a single Lewis structure of molecules represents the true structure of a molecule
- bonds alone determine the strength of a molecule
- electrons in molecular orbitals are confined to the space between the nuclei of the bonded atoms
- MOT is only applicable to diatomic molecules
- all molecular orbitals have the same energy
- molecular orbitals correspond directly to specific atomic orbitals
- MOT completely replaces VBT
- all molecules exhibit pure sigma and pi bonds. Recognizing these misconceptions and looking for mechanisms to improve understanding is important.

One very important approach is considering the chemistry triangle while teaching these concepts. To effectively teach VBT and MOT concepts at micro, sub-micro, and symbolic levels of chemistry understanding, it is essential to use a variety of teaching strategies and resources.

- At the Micro Level, physical models or molecular model kits to demonstrate the three-dimensional structure of molecules can be used. Experiments or demonstrations can be conducted to illustrate the formation of covalent bonds through orbital overlap. Virtual labs, videos, or animations can be used to depict the bonding process at the atomic level.

- At the sub-micro Level (Particulate View), Lewis structures can be used to represent the arrangement of atoms and electrons in molecules. Molecular orbital diagrams can be used to show the energy levels and electron distribution in molecules.
- t the symbolic Level (Symbolic Representation), students can be encouraged to practice drawing Lewis structures and predicting molecular geometries based on valence bond theory principles. Molecular formulas and structural formulas can be used to represent different types of chemical bonds.

Understanding of VBY and MOT concepts can take place through the use of available technologies (animations and simulations) and different teaching strategies (brainstorming, role play, group discussions, models, etc).

Implication to teaching (5 min)

- What did you learn from this session and how will you apply the methods used in this session in teaching VBT and MOT?
- What available technologies can be used to teach VBT and MOT concepts?
- How can you help your students benefit from this lesson?

Takeaway resources/materials

The following resources can be used to help learners easily understand the concepts of VBT and MOT. These resources include describing VBT and MOT concepts at three levels of chemistry understanding (Johnstone's Triangle), visualization, simulation, virtual labs, videos, etc.

- VBT 3D at: https://www.youtube.com/watch?v=PRmYlUuDXVI
- Hybridization lesson at: https://www.youtube.com/watch?v=pdJeQUd2g_4
- MOT 3D at: https://www.youtube.com/watch?v=FMxuss0RXOU

Session 3.4: Types of crystals (2 h)

Introduction (5 min)

This session aims to help chemistry teachers better understand how to teach types of crystals to secondary school students. Trainees must participate in the suggested activities, either individually or in groups. Trainees are expected to engage in brainstorming and discussing the most effective methods they have used for teaching the topic of types of crystals.

Objectives

At the end of this session, trainees will be able to:

- design different methods to teach crystal concepts
- use models that can help in understanding and teaching crystal concepts
- Identify common misconceptions that students may have about types of crystals
- distinguish different types of crystals
- elucidate how crystals differ from one another
- use available technology for crystal concepts.

Activities

Brainstorm and discuss on the following questions in a group. Present your ideas on how you will use the experiences gained from this training in your chemistry classes.

1. Explain the concept of crystal structure or a crystal solid. (10 min)
2. Discuss on the types of crystals. How are you going to present these concepts to your students? (10 min)
3. Explain why ice, which is a crystalline solid, has a melting temperature of 0 °C, whereas butter, which is an amorphous solid, softens over a range of temperatures. (10 min)
4. Discuss on unit cells. How are you going to present these concepts to your students? (10 min)
5. What misconceptions do students have about crystal concepts? (10 min)
6. How can you apply the chemistry triangle concept of Johnstone (Macro, sub-micro-, and symbolic levels), Animation, Simulations, virtual labs, video, etc. to teach crystal concepts? (10 min)
7. After watching the following videos reflect what you learned about crystal structures and their types as well as crystal lattice and unit cell at: (20 min)

    - Crystal structures and their types: https://www.youtube.com/watch?v=Pm0494Eqi_c
    - https://www.youtube.com/watch?v=BjVTdZ_htu8

8. What misconceptions do students have about the types of crystals and their structures? Share your experiences how you addressed them in your classes. (10 min)
9. How can technologies assist you in helping learners grasp the concepts of crystal with ease? (10 min)

Key points (10 min)

Students often struggle to understand the concepts of crystals. Teachers are expected to design effective strategies to help students grasp these concepts easily. Additionally, students may have misconceptions about the different types of crystals because of the abstract nature of crystal structures.

Some common misconceptions related to crystal concepts and their types are:

- all crystals are perfectly ordered and symmetrical
- crystals can only be formed from inorganic substances
- all crystals have a regular geometric shape
- crystals can only be grown in a laboratory setting
- crystal structures are static and unchanging
- all crystals exhibit visible cleavage

Recognizing these misconceptions and looking for appropriate approaches to improve students 'understanding is important. To effectively teach crystal concepts at micro, sub-micro, and symbolic levels of chemistry understanding, it is essential to use a variety of teaching strategies and resources. Teaching crystal concepts at micro, sub-micro, and symbolic levels in chemistry understanding can help students to effectively grasp the abstract nature of the concepts.

- At macro level (Macroscopic level), hands-on Activities can be used. It is possible to start by introducing crystals using macroscopic examples such as salt crystals, sugar crystals, and gem-stones. While doing this, allowing students to observe and handle these crystals is necessary to understand their physical properties like shape, color, and cleavage. Physical models or crystal structure kits can also be used to demonstrate how atoms are arranged in a crystal lattice. This hands-on approach can help students visualize the 3D structure of crystals and how they pack together.
- At sub-micro level (particulate level), particle diagrams can be used to represent the arrangement of atoms or ions in a crystal lattice. It is important to show how individual atoms or ions are arranged in repeating patterns to form the crystal structure. Discussing the role of intermolecular forces in holding the particles together in a crystal lattice is also necessary.
- At the symbolic level, chemical formulas can be used to represent the composition of crystals. It is important to show how the ratio of atoms or ions in a unit cell is represented by the chemical formula of the compound. Informing students about unit

cells and how they are used to represent the repeating structure of a crystal lattice is equally important. Discussion on the different types of unit cells (cubic, tetragonal, hexagonal) and their characteristics is also helpful. Introducing students to crystal notation and how it is used to describe the orientation and arrangement of crystal faces is very important.

Comprehending Crystal concepts can take place through the use of available technologies (animations and simulations) and different teaching strategies (brainstorming, role play, group discussions, structure-related models, etc).

Implication to teaching (5 min)

- What did you learn from this session and how will you apply the methods used in this session in teaching crystal concepts?
- What additional available technologies can be used to teach crystal concepts?
- How can you help your students benefit from this lesson?

Takeaway resources/materials

The following methods can be used to help learners easily understand the concepts of crystals. These methods include describing crystal concepts at three levels of chemistry understanding, visualization, simulation, virtual labs, videos, etc.

- Crystal structures and their types at: https://www.youtube.com/watch?v=Pm0494Eqi_c
- Crystal Lattice and Unit Cell at: https://www.youtube.com/watch?v=BjVTdZ_htu8
- Additional materials prepared by the trainees during the training program.

Unit 4: Chemical changes and electrochemistry (10 h)

Introduction (5 min)

This unit of the training module is designed to help secondary school chemistry teachers establish a solid understanding of chemical changes and electrochemistry concepts, as well as teaching strategies to effectively instruct these concepts. The unit focus on energy changes in electrochemistry, oxidation-reduction reactions, electrochemical cells, quantitative aspects of electrolysis, and the industrial applications of electrolysis.

Each session includes various activities to actively involve trainees in teaching the recommended topics. It is important to motivate the trainees to engage in discussions either individually or in groups. This will enable them to develop different instructional approaches based on their prior experiences and the discussions held during the suggested activities in each session. The topic is taken from the new chemistry textbooks for Grade 10 (Unit 4) and Grade 12 (Unit 2).

Objectives

At the end of this unit, trainees will be able to:

- comprehend how to teach changes associated to electrochemistry
- be familiar with different oxidation-reduction reactions.
- know how to teach oxidation-reduction reactions
- understand the methods employed to teach electrochemical cells.
- realize the importance of quantitative aspects of electrolysis
- appreciate teaching and learning of industrial application of electrolysis.
- develop scientific inquiry skills (inferring, predicting, classifying, comparing and contrasting, communicating, experimenting and making generalizations*)*

Session 4.1: Energy changes associated to electrochemistry (2:55 h)

Introduction (5 min)

This session aims to assist chemistry teachers in understanding how to teach energy concepts related to electrochemistry to secondary school students. Trainees are expected to engage in the suggested activities either individually or in groups. They are also expected to share the effective strategies they have used for teaching this specific topic.

Objectives

At the end of this session, trainees will be able to:

- identify different methods to teach energy associated with electro chemistry
- describe principles used to identify electrochemical cells
- differentiate electrochemical cells
- interpret how galvanic cells differ from electrolytic cells
- identify common misconceptions that students may have about energy changes associated to electrochemistry
- use available technology for teaching electrochemical concepts.

Activities

Brainstorm and discuss on the following questions in a group. Present your ideas on how you will use the experiences gained from this training in your chemistry classes.

1. Discuss the key components of an electrochemical cell, including electrodes (anode and cathode), electrolyte solution, and salt bridge. (15 min)
2. Differentiate between voltaic (galvanic) cells and electrolytic cells. Which one requires an external power source to drive non-spontaneous reactions? Explain. (15 min)
3. Explain how oxidation occurs at the anode (electron donor) and reduction occurs at the cathode (electron acceptor) in redox reactions. (15 min)
4. Examine any topic or subtopic in this session and make a list of activities/experiments that can be performed by observing keenly and using local available materials. Using the locally available materials design an experiment on electrolysis of dilute sodium chloride solution. Discuss the role of the external power source in providing the necessary energy for electrolysis to occur. (20 min)
5. Highlight the diverse applications of electrochemical cells in batteries, fuel cells, corrosion prevention, electroplating, and electrolysis processes. (15 min)

6. Discuss the environmental and economic benefits of utilizing electrochemical technologies in various industries. (10 min)
7. What misconceptions or alternative conceptions do students have about electrochemical processes or cells? Use your teaching experience to explain each misconception. (20 min)
8. How can you apply the chemistry triangle concept of Johnstone (Macro, sub-micro-, and symbolic levels), Animation, Simulations, virtual labs, video, etc. to teach electrochemical processes or cells? (15 min)
9. How can technologies assist you in helping learners grasp electrochemical processes or cells with ease? (10 min)
10. Watch the following videos and reflect on what you learned from them. (20 min)
    - Voltaic cells video at: https://www.youtube.com/watch?v=Lh-J1-6ks6g, and https://www.youtube.com/watch?v=qpFC_Ecu_yQ
    - Electrolytic cells video at: https://www.youtube.com/watch?v=uzYVK7aa5oU and https://www.youtube.com/watch?v=o8auXrCo_BM

Key points (10 min)

Comprehending problems exist in electro-chemical concepts. Electrochemistry considers chemical reactions and takes apart the reactions into half-cell reactions so that chemical energy can be converted directly into electrical energy or vice versa. Chemical energy is changed into electrical and electrical to chemical energy. Students face trouble in grasping these ideas and teachers are expected to design approaches that can help learners. Misconceptions related to electrochemical concepts can occur. Misconceptions related to electrochemical cells and electrochemistry can arise from students' incomplete understanding of the underlying principles and processes involved. Some common misconceptions include:

- electrochemical cells always involve the production of electricity
- anode is always negative and cathode is always positive
- electrons flow through the electrolyte solution in an electrochemical cell
- higher voltage in an electrochemical cell always indicates a stronger battery
- all redox reactions are spontaneous and can be used to generate electricity.

Teaching electrochemical concepts at micro, sub-micro, and symbolic levels in chemistry understanding can help students grasp these concepts more effectively.

- At the macro level, it is possible to start by introducing the basic concept of an electrochemical cell as devices that convert chemical energy into electrical energy or use electrical energy to drive non-spontaneous redox reactions. It is good to explain the components of an electrochemical cell, such as electrodes, electrolyte, and salt bridge, using physical models. Demonstrate how redox reactions occur at the electrodes and how electrons flow through the external circuit to produce electricity. It is important to discuss the applications of electrochemical cells in everyday life, such as batteries and fuel cells, to show the relevance of the concept.
- At sub-micro level, dive deeper to explore the redox reactions that take place at the electrodes. Introducing the concept of oxidation and reduction reactions occurring at the anode and cathode, respectively using particle diagrams or molecular models is important.
- At symbolic level, introducing symbolic representations, such as half-cell reactions and cell notation, to represent the redox reactions occurring in electrochemical cells is necessary. Teachers are expected to teach students how to write and balance half-cell reactions for different electrode materials

Understanding of electrochemical concepts can take place through the use of available technologies (animations and simulations, etc.), connecting to real-life contexts and different teaching strategies (brainstorming, group discussions)

Implication to teaching (5 min)

- What did you learn from this session and how will you apply the methods used in this session in teaching electrochemical energy change concepts?
- What available technologies can be used to teach electro chemical energy change concepts?
- How can you help your students benefit from this lesson?

Takeaway resources/materials

The following methods can be used to help learners easily understand the electro chemical energy related changes. These methods include describing crystal concepts at three levels of chemistry understanding (Johnstone's Triangle), visualization, simulation, virtual labs, videos, etc.

- Voltaic cells videos at: https://www.youtube.com/watch?v=Lh-J1-6ks6g, and https://www.youtube.com/watch?v=qpFC_Ecu_yQ
- Electrolytic cells videos at: https://www.youtube.com/watch?v=uzYVK7aa5oU and https://www.youtube.com/watch?v=o8auXrCo_BM

Session 4.2: Reduction-oxidation reactions (2 h)

Introduction (5 min)

This session aims to support chemistry teachers how to teach energy concepts associated to oxidation-reduction reaction concepts to secondary school students. Brainstorming individually and discussions in groups on the he suggested on the suggested activities are important during this session.

Objectives

At the end of this session, trainees will be able to:

- recognize different methods to teach oxidation-reduction reactions
- use different principles to classify reactions as redox
- differentiate oxidation and reduction
- explain how oxidation differs from reduction
- employ available technology in teaching redox reactions.

Activities

Brainstorm/discuss in a group on the following questions, and present your ideas to the rest

1. Discuss the significance of redox reactions in various chemical processes, such as corrosion, combustion, and metabolism. (10 min)
2. Explore different types of redox reactions, including combination reactions, decomposition reactions, displacement reactions, and combustion reactions. (20 min)
3. Discuss the challenges students face when balancing redox equations and share strategies for effectively balancing equations. (15 min)
4. How have you integrated indigenous knowledge into your teaching of redox reactions? Which specific indigenous knowledge have you incorporated while teaching the lessons on redox reactions? What are the benefits that you have observed in your students when you incorporate indigenous knowledge into the study of redox reactions? (20 min)
5. Explore the practical applications of redox reactions in everyday life, industry, and environmental processes. (15 min)
6. Investigate redox reactions in biological systems, focusing on cellular respiration, photosynthesis, and other biochemical processes. (15 min)
7. What misconceptions or alternative conceptions do students have about redox reactions? Use your teaching experience to explain each misconception. (15 min)

8. How can you apply the chemistry triangle concept of Johnstone, Animation, Simulations, virtual labs, video, etc. to teach redox reactions? (15 min)
9. How can technologies assist you in helping learners grasp redox reactions with ease? (10 min)
10. Watch the following videos and reflect on what you learned from them. (30 min)
    - Redox reaction in our body: https://www.youtube.com/watch?v=IyZfJ-qAEsQ
    - Redox reactions related to our surroundings: https://www.youtube.com/watch?v=orI2m6IarJg and https://www.youtube.com/watch?v=cyEEEq5-FCg

Key points (5 min)

Redox reactions are difficult for students to understand. Students face difficulty in understanding these ideas and teachers are expected to design strategies that can help learners. Misconceptions related to redox reactions in chemistry can arise due to the complexity of electron transfer processes and the various ways in which redox reactions can occur. Some common misconceptions related to redox reactions include:

- only reactions involving oxygen are redox reactions
- redox reactions always involve the transfer of oxygen atoms
- oxidation always involves the addition of oxygen
- reduction always involves the addition of hydrogen
- all reactions involving metals are redox reactions
- redox reactions always involve a color change

Teaching redox reaction concepts at micro, sub-micro, and symbolic levels in chemistry understanding can help students grasp these concepts more meaningfully. Teaching redox reaction concepts at macro, sub-micro, and symbolic levels in chemistry can help students develop a comprehensive understanding of electron transfer processes.

- At the macro Level teachers can use visual Demonstrations and conduct experiments that demonstrate redox reactions. For example, the reaction between iron and copper (II) sulfate can show a clear color change from blue to green.
- At the sub-micro Level (Particulate Level), it is possible to use particle Diagrams. Particle diagrams can be used to illustrate the transfer of electrons during redox

reactions. It is possible to show how atoms or ions gain or lose electrons to change their oxidation states.

- At the symbolic level, redox notations can be used. Teachers can teach students how to write redox reactions using symbolic notation, indicating the oxidation states of elements before and after the reaction. At this level, it is important to discuss electron Configurations and the relationship between electron transfer and changes in oxidation states.

Understanding of reduction-oxidation reactions related concepts can take place through the use of available technologies (animations and simulations), connecting to real-life contexts (photosynthesis, Rusting, traditional knowledge in preventing rusting), and different teaching strategies (brainstorming, group discussions, experiments).

Implication to teaching (5 min)

- What did you learn from this session and how will you apply the methods used in this session in teaching redox reaction concepts?
- What available technologies can be used to teach redox reaction concepts?
- How can you help your students benefit from this lesson?

Takeaway resources/materials

The following methods can be used to help learners easily understand redox reactions. These methods include describing crystal concepts at three levels of chemistry understanding (Johnstone's Triangle), visualization, simulation, virtual labs, videos, etc.

- Redox reaction in our body video at: https://www.youtube.com/watch?v=IyZfJ-qAEsQ
- Redox reactions related to our surroundings video at: https://www.youtube.com/watch?v=orI2m6IarJg and https://www.youtube.com/watch?v=cyEEEq5-FCg

Session 4.3: Quantitative aspects of electrolysis (3 h)

Introduction (5 min)

This session aims to help chemistry teachers understand how to teach the quantitative aspects of electrochemistry to secondary school students. Participating in the suggested activities either individually or in groups is necessary. Trainees are also expected to reflect on the effective strategies they have been used for teaching this topic.

Objectives

At the end of this session, trainees will be able to:

- Employ different methods to teach quantitative aspects of electrolysis
- Use different principles to deal with calculations in electrolysis
- Distinguish Faradays laws
- Describe how Faraday laws can be applied in different contexts.
- Apply available technology in Quantitative Electrolysis Concepts.

Activities

Brainstorm/discuss in a group on the following questions, and present your ideas to the rest

1. Discuss the importance of understanding the relationship between charge, current, and time in electrolysis.(15 min)
2. What are the practical applications of electrolysis in various industries and technologies? (10 min)
3. Compare theoretical calculations and experimental results in electrolysis. (15 min)
4. Discuss on the role of Faraday's laws in quantifying the amount of substance produced during electrolysis. (15 min)
5. What misconceptions or alternative conceptions do students have in quantitative aspects of electrolysis? (15 min)
6. How can you apply the chemistry triangle concept of Johnstone, Animation, Simulations, virtual labs, video, etc. to teach quantitative aspects of electro chemistry? (20 min)
7. How can technologies assist you in helping learners understand quantitative aspects of electrolysis with ease? (15 min)
8. Watch the following videos and reflect on what you learned from them. (35 min)

- Quantitative aspects of electrolysis at: https://www.youtube.com/watch?v=HToLeY_lYuI and https://www.youtube.com/watch?v=OXIlrO_T8jU
- Electrolysis of water, sodium chloride solution and potassium iodide solution video at: https://www.youtube.com/watch?v=6hCC_cr0nfs

- Faradays first law and second: https://www.youtube.com/watch?v=sZ8Z54E4WXI and https://www.youtube.com/watch?v=4DK0go1_u4Y

Key points (10 min)

Quantitative aspects of electrolysis are difficult for learners or students. Learners face challenges in understanding these ideas and teachers are expected to design strategies that can help learners. Misconceptions related to the quantitative aspects of electrolysis can arise due to a lack of understanding of the underlying principles and processes involved. Some common misconceptions include:

- misunderstanding the relationship between charge, current, and time
- equating electrode size with product formation
- confusion between Faraday's laws and stoichiometry
- Overlooking factors that affect electrolysis efficiency.

Teaching the quantitative aspects of electrolysis using macro-, sub-micro, and symbolic representations in chemistry can be done effectively through a combination of visual aids, hands-on activities, and interactive discussions.

- At the macro-level, it is possible to start by focusing on the observable changes that occur during electrolysis. This can include showing students actual electrolysis experiments using electrodes and an electrolyte solution. While doing experiments, encourage students to observe and record their observations of the changes that take place during the process.
- At the sub-micro level, visual aids such as diagrams or animations can be used to show the movement of ions and electrons at the molecular level. This will help students connect the macroscopic changes they observed with the underlying chemical processes.

- At the symbolic representation level, electrolysis reactions can be described using chemical equations. Show them how to write balanced half-reactions for the oxidation and reduction processes that occur at the electrodes. Encourage students to practice writing and balancing these equations to reinforce their understanding of the chemical reactions involved in electrolysis. At this level it is possible to provide students with practice problems that involve calculating quantities such as the amount of product formed, the charge passed through the cell, or the current flowing in the circuit during electrolysis. Encourage students to use both macro and symbolic representations to solve these problems and relate them to the sub-micro level.

  Understanding of quantitative aspects of electrolysis can take place through the use of available technologies (eg. Animations and simulations), connecting to real-life contexts (eg Optimizing products related to electrochemical processes), and different teaching strategies (eg brainstorming, group discussions, experiments).

Implication to teaching (5 min)

- What did you learn from this session and how will you apply the methods used in this session in teaching quantitative aspects of electrolysis?
- What available technologies can be used to teach quantitative aspects of electrolysis?
- How can you help your students benefit from this lesson?

Takeaway resources/materials

The following resources can be used to help learners easily understand quantitative aspects of electrolysis. These resources include describing electrolysis concepts at three levels of chemistry understanding (Johnstone's Triangle), experiments, demonstrations, virtual labs, videos, etc.

- videos on quantitative aspects of electrolysis: https://www.youtube.com/watch?v=HToLeY_lYuI and https://www.youtube.com/watch?v=OXIlrO_T8jU
- Electrolysis of water, sodium chloride solution and potassium iodide solution video: https://www.youtube.com/watch?v=6hCC_cr0nfs
- Faradays first law and second law videos: https://www.youtube.com/watch?v=sZ8Z54E4WXI and https://www.youtube.com/watch?v=4DK0go1_u4Y

Session 4.4: Industrial application of electrolysis (4 h)

Introduction (5 min)

This session is intended to support chemistry teachers on how to teach the industrial application of electrochemistry (electro-refining and electroplating) to secondary school students. Teachers should engage in the suggested activities either individually or in groups. They are expected to present effective strategies they have used to instruct the topic.

Objectives

At the end of this session, trainees will be able to:

- differentiate methods to teach industrial application of electrochemistry (electro refining and electroplating
- distinguish electro refining and electroplating
- produce pure metals through electro refining
- use electroplated metals.
- apply available technology in electro refining and electroplating Concepts.

Activities

Brainstorm/discuss in a group on the following questions, and present your ideas to the rest

1. Discuss the detailed process and mechanism involved in electro-refining and electroplating. (10 min)
2. In your groups, explain why electrolytic reduction rather than chemical reduction is often used to obtain active metals from their compounds.(10 min)
3. Why are molten metal chlorides used as electrolytes rather than using other molten salts? Discuss and then reflect on the points you raised during the discussions. (20 min)
4. In your groups, discuss the purposes for which electroplating is employed or used. (10 min)
5. In your groups, discuss on the detailed Applications of electro refining and electroplating. (10 min)
6. What factors play important roles in both electroplating and electro refining in determining the quality and efficiency of the process? Discuss in detail and reflect. (15 min)

7. What misconceptions or alternative conceptions do students have in electro refining and electroplating concepts? Use your teaching experience to explain each misconception. (15 min)
8. How can you apply the chemistry triangle concept of Johnstone (Macro, sub-micro-, and symbolic levels), Animation, Simulations, virtual labs, video, etc. to teach electro refining and electroplating? (20 min)
9. How can technologies assist you in helping learners understand electro refining and electroplating with ease? (10 min)
10. Watch the following videos and reflect on what you learned from them. (40 min)
    - Electrolytic refining of metals: https://www.youtube.com/watch?v=pMEiyKZ4H4g https://www.youtube.com/watch?v=zpUIeN48A9c
    - Electrolysis production of chemicals: https://www.youtube.com/watch?v=eZ5_LAka92s
    - Electroplating: https://www.youtube.com/watch?v=qczuns50OTU https://www.youtube.com/watch?v=NClagKbLUMM

Key points (10 min)

Concepts related to the industrial application of electrochemistry are not easy for students to understand. Students misconceive industrial application-related concepts of electrolysis. Misconceptions about the industrial application of electrolysis can arise due to the complexity of the process and the variety of applications it encompasses. Some common misconceptions about the industrial application of electrolysis include:

- electrolysis is always energy-intensive and environmentally harmful, electrolysis is only used for producing hydrogen
- electrolysis has a limited practical application
- electrolysis is not cost-effective compared to other industrial processes
- electrolysis is a complex and inaccessible technology for most industries
- electrolysis has limited scalability for industrial production.

These misconceptions are common among students as well as community members. Moreover, misconceptions related to the electrolytic refining of metals can arise due to the complexity of

the process and the underlying principles of electrochemistry. Some common misconceptions that students may have include:

- electrolytic refining is the same as smelting or other metal extraction processes
- electrolytic refining can be used to extract any metal from its ore
- electrolytic refining is a simple process that only involves passing current through a metal solution
- electrolytic refining always results in 100% pure metal
- electrolytic refining is only used for a few specific metals.

Furthermore, misconceptions related to electroplating can arise due to the complexity of the process and the underlying principles of electrochemistry. Some common misconceptions that students may have include:

- electroplating is the same as painting or coating a metal surface
- electroplating can be used to change the properties of a metal permanently
- electroplating always results in a smooth and uniform coating
- electroplating is only used for decorative purposes
- electroplating is a simple process that anyone can do at home

Teaching the industrial application of electrochemistry/electrolysis at three different understanding levels of chemistry (macro, micro, and symbolic) can help students develop a comprehensive understanding of the concepts involved.

- At the macro level (Observations and Phenomena), it is possible to start by introducing students to real-world examples of industrial applications of electrochemistry. This can include electrolysis in the production of metals or electroplating in manufacturing. While doing this, it is possible to discuss the overall purpose and significance of these industrial applications in various industries, such as automotive, electronics, or pharmaceuticals.
- At the micro level (particle interactions and Mechanisms), teachers can dive deeper into the underlying principles of electrochemistry by exploring the micro-level interactions that drive these industrial processes. While doing this, teachers can discuss the movement of ions and electrons at the molecular level and how they contribute to the

overall outcome of the process. Visual aids, such as diagrams or animations can be used to help students visualize the microscopic processes taking place during electrochemical reactions.

- At the symbolic level, the overall electrolysis process can be represented by a chemical equation that shows the reactants, products, and the transfer of electrons.

Understanding of industrial application related concepts can take place through the use of available technologies (eg. Animations and simulations), connecting to real-life contexts (eg. electroplating of iron products), and different teaching strategies (eg brainstorming, group discussions, experiments).

Implication to teaching (5 min)

- What did you learn from this session and how will you apply the methods used in this session in teaching industrial application of electrolysis (refining and electroplating)?
- What available technologies can be used to teach industrial application of electrolysis (refining and electroplating)?
- How can you help your students benefit from this lesson?

Takeaway resources/materials

The following resources can be used to help learners easily understand industrial application of electrolysis. These resources include describing electro refining and electroplating related electrolysis concepts at three levels of chemistry understanding (Johnstone's Triangle), experiments, demonstrations, virtual labs, videos, etc.

- Electrolytic refining of metals at: https://www.youtube.com/watch?v=pMEiyKZ4H4g and https://www.youtube.com/watch?v=zpUIeN48A9c
- Electrolysis production of chemicals video at: https://www.youtube.com/watch?v=eZ5_LAka92s
- Electroplating videos at: https://www.youtube.com/watch?v=qczuns50OTU and https://www.youtube.com/watch?v=NClagKbLUMM

Unit 5: Chemical Kinetics and Equilibrium (12 h)

Introduction (5 min)

This unit aims to help secondary school chemistry teachers establish a thorough understanding of chemical kinetics and equilibrium concepts. Specifically, reversible and irreversible reactions, rates of reactions, factors influencing rates of chemical reactions, factors affecting chemical equilibrium, and quantitative aspects of chemical equilibrium are emphasized.

Various activities are included in each session to actively involve trainees in teaching the recommended topics. Therefore, trainees should be encouraged to reflect individually or discuss in groups regarding the instructional approaches they used, the experiences they have, and strategies suggested by the trainer. The topics are taken from grade 11 Chemistry (Units 4 and 5).

Objectives

At the end of this unit, trainees will be able to:

- Be aware of how to teach changes associated to electrochemistry
- Familiarize different chemical kinetics and equilibrium concepts.
- understand how to teach chemical kinetics and equilibrium concepts
- use the methods suggested to teach chemical kinetics and equilibrium concepts.
- comprehend the importance of chemical kinetics and equilibrium concepts
- appreciate teaching and learning of chemical kinetics and equilibrium concepts.
- improve the scientific enquiry skills.

Session 5.1: Reversible and irreversible reactions (1 h 55 min)

Introduction (5 min)

This session aims to help chemistry teachers understand how to teach reversible and irreversible reactions to secondary school students. Teachers should actively participated in discussions either individually or in groups. They are also expected to reflect on the effective approaches they used for teaching the topic.

Objectives

At the end of this session, trainees will be able to:

- differentiate methods to teach irreversible and reversible reactions
- understand how irreversible reactions are difficult to reverse
- use real world examples of irreversible and reversible reaction concepts
- apply available technology in teaching concepts related to irreversible and reversible reactions

Activities

Brainstorm/discuss in a group on the following questions, and present your ideas to the rest

1. Discuss the way how Chemical reactions occur. (10 min)
2. Discuss the directionality of reactions. (10 min)
3. What misconceptions or alternative conceptions do students have in irreversible and reversible reactions concepts? Use your teaching experience to explain each misconception. (15 min)
4. How can you apply the chemistry triangle concept of Johnstone (Macro, sub-micro-, and symbolic levels), Animation, Simulations, virtual labs, video, etc. to teach irreversible and reversible reactions? (20 min)
5. How can technologies assist you in helping learners understand irreversible and reversible reactions with ease? (10 min)
6. Watching the following videos and reflect on what you learned from them. (20 min)
    - Chemical reactions: https://www.youtube.com/watch?v=Lvbm8horG1U
    - Irreversible and irreversible reactions:
      https://www.youtube.com/watch?v=br8lKynV1Hc
      https://www.youtube.com/watch?v=5iowJs6MryI

7. How can you assist learners in understanding irreversible and reversible reactions? Explain. (10 min)

Key points (10 min)

Misconceptions about irreversible and reversible reaction can arise due to the difficulty of these reactions to students. Some common misconceptions about irreversible and reversible reactions include:

- irreversible reactions are always fast, reversible reactions are slow
- irreversible reactions are always exothermic (release heat)
- reversible reactions are always endothermic (absorb heat)

Irreversible reactions can be fast or slow, just as reversible reactions can be fast or slow. The key difference between the two types of reactions is their ability to proceed in both the forward and reverse directions. Irreversible reactions proceed in one direction only and reach completion, while reversible reactions can establish an equilibrium state where reactants and products coexist. There are many irreversible reactions, such as combustion reactions, that do release heat. Also, there are irreversible reactions that are endothermic. Similarly, reversible reactions can be exothermic or endothermic depending on the specific reaction conditions.

Teaching the concepts of irreversible and reversible reactions at different levels of understanding in chemistry can help students develop a comprehensive grasp of these fundamental principles.

- At the macro Level (Observational), it is possible to start by introducing the concept of irreversible and reversible reactions using everyday examples. For irreversible reactions, demonstrate a common example such as burning substances like magnesium ribbon where the reaction proceeds to completion and cannot be reversed. For reversible reactions, you can use examples like dissolving carbon dioxide in water.
- At the micro Level (Particle), it is good to explain how irreversible and reversible reactions involve the rearrangement of atoms and molecules. It is possible to use models or animations to illustrate how reactant molecules interact to form products in irreversible reactions. For reversible reactions, show how reactant molecules can interconvert with product molecules, leading to the establishment of an equilibrium state.

- At the symbolic Level, it is possible to introduce students to symbolic representations of irreversible and reversible reactions using chemical equations. It is important to allow students how to write balanced chemical equations for irreversible reactions, highlighting that they typically have unidirectional arrows pointing toward the products. For reversible reactions, double arrows are used in chemical equations to indicate that the reaction can proceed in both the forward and reverse directions. Involving students in calculations related to irreversible and reversible reactions can reinforce these ideas.

Implication to teaching (5 min)

- What did you learn from this session and how will you apply the methods used in this session in teaching irreversible and reversible reactions?
- What available technologies can be used to teach irreversible and reversible reactions?
- How can you help your students benefit from this lesson?

Takeaway resources/materials

The following resources can be used to help learners easily understand irreversible and reversible reactions. These resources include describing irreversible and reversible reactions related concepts at three levels of chemistry understanding (Johnstone's Triangle), experiments, animations, role plays, simulations, demonstrations, virtual labs, videos, etc.

- Chemical reactions video at: https://www.youtube.com/watch?v=Lvbm8horG1U
- Irreversible and irreversible reactions at: https://www.youtube.com/watch?v=br8lKynV1Hc and https://www.youtube.com/watch?v=5iowJs6MryI

Session 5.2: Rate of reactions (2 h)

Introduction (5 min)

This session aims to help chemistry teachers understand how to effectively teach rates of chemical reactions to secondary school students. Teachers should be motivated to engage in the suggested activities either on their own or in groups. They are also expected to share their

experiences on effective teaching strategies and assessment techniques they have used while teaching the topic of Rates of reactions.

Objectives

At the end of this session, trainees will be able to:

- distinguish methods to teach rates of reaction
- give examples of chemical reactions that take place over a variety of different periods or time durations
- describe how concentrations of reactants and products change over time during the course of a reaction
- draw graphs to show concentrations of reactants and products changing over time,
- define the term rate of reaction as the change in the concentration of the reactants and products per unit of time
- apply available technology in teaching concepts related to rates of reactions.

Activities

Brainstorm/discuss in a group on the following questions, and present your ideas to the rest

1. Discuss on rates of reactions by considering slow and fast reactions. (10 min)
2. What misconceptions or alternative conceptions do students have in relation to rates of reaction concepts? Use your teaching experience to explain each misconception. (15 min)
3. How can you apply the chemistry triangle concept of Johnstone (Macro, sub-micro-, and symbolic levels), Animation, Simulations, virtual labs, video, etc. to teach rates of reaction? (15 min)
4. How can technologies assist you in helping learners understand rates of reaction with ease? (10 min)
5. Watching the following videos and reflect on what you learned from them. (40 min)
    - Rates of reactions: https://www.youtube.com/watch?v=NhdtqnEfa9w, https://www.youtube.com/watch?v=SPXanyy3-hU, reflect on what you learned.

- Simulation and animation rates of reactions:
  https://www.youtube.com/watch?v=UmOZ5kFgeKA
  https://www.youtube.com/watch?v=0baMOc_yDlg

6. How can you assist learners in understanding rates of reaction properly? Explain. (10 min)

Key points (10 min)

Misconceptions related to rates of reaction concepts in chemistry can stem from the abstract nature of kinetic processes and the complexities involved in understanding reaction rates. Some common misconceptions about rates of reaction concepts include:

- Faster reactions always mean higher temperatures
- faster reactions always involve more reactants being used up
- the rate of a reaction is solely determined by the speed at which products are formed
- all reactions proceed at a constant rate from start to finish

Chemical reactions can take place over a range of different timescales. During a chemical reaction, the concentration of reactants decreases, while the concentration of products increases. The speed at which a chemical reaction takes place is known as the rate of reaction. The rate of a chemical reaction can be defined as the change in the concentrations of the reactants and products per unit of time

Treating rates of reaction concepts at different understanding levels of chemistry (macro, micro, and symbolic) can help students grasp the complexities of reaction kinetics from various perspectives.

- At the macro level (Observable Reactions), it is possible to use visual demonstrations, and/or conduct experiments that demonstrate varying rates of reaction using easily observable changes. For example, the reaction between magnesium and hydrochloric acid can show a visible release of hydrogen gas.
- At the micro level (Particulate View), it is possible to use particle Diagrams. Particle diagrams can be used to illustrate the collision theory of reaction rates. It is possible to show the way how reactant particles collide with sufficient energy and proper orientation for a successful reaction to occur.

- At the symbolic level (Chemical Equations), it is appropriate to teach students how to write and interpret rate laws for different types of reactions. Allow the students to explore reaction mechanisms showing the step-by-step processes involved in complex reactions.

Implication to teaching (5 min)

- What did you learn from this session and how will you apply the methods used in this session in teaching rates of reaction concepts?
- What available technologies can be used to teach rates of reaction concepts?
- How can you help your students benefit from this lesson?

Takeaway resources/materials

The following resources can be used to help learners easily understand rates of reaction concepts. These resources include describing rates of reaction concepts at three levels of chemistry understanding (Johnstone's Triangle), experiments, simulations, animations, demonstrations, virtual labs, videos, etc.

- Rates of reactions related videos at: https://www.youtube.com/watch?v=NhdtqnEfa9w, and https://www.youtube.com/watch?v=SPXanyy3-hU
- Rates of reactions related PhET Simulation, and Animation videos a: https://www.youtube.com/watch?v=UmOZ5kFgeKA and https://www.youtube.com/watch?v=0baMOc_yDlg

Session 5.3: Factors affecting rates of chemical reactions (2 h)

Introduction (5 min)

This session aims to help chemistry teachers understand how to effectively teach factors affecting rates of chemical reactions to secondary school students. Teachers should be actively participate in the suggested activities either on their own or in groups. They are also expected to share their experiences on effective teaching strategies they have used while instructing the topic.

Objectives

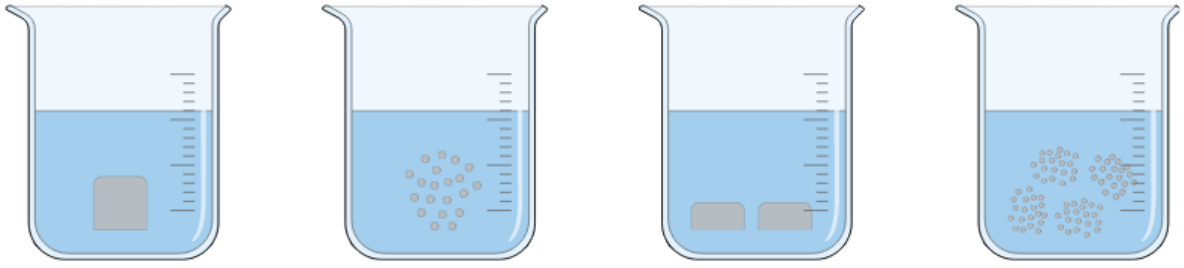
At the end of this session, trainees will be able to:

- differentiate methods to teach factors affecting rates of chemical reactions
- provide appropriate examples on factors affecting rates of chemical reactions
- explain how different factors affect rates of chemical reactions
- epply available technology in teaching factors affecting rates of chemical reactions.

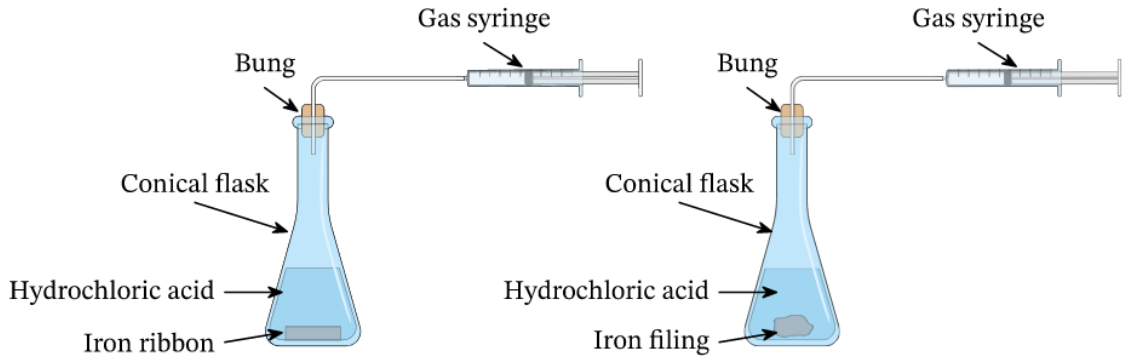
Activities

Brainstorm/discuss in a group on the following questions, and present your ideas to the rest

1. Discuss how factors like surface area, concentration, temperature, catalyst and pressure impact the likelihood of successful collisions between reactant particles to form products.(10 min)
2. Discuss how students understand increase in surface are concept. For this part of the discussion, see the diagram below showing four different reactions of a sample of metal with an acid. In which container the reaction is fast? In which container the reaction is slow? Assume the total mass of the metal, the concentration of the acid, and the temperature are the same for all reactions. Do your students understand these concepts without difficulty? Explain. (10 min)



3. An experiment can be set up as shown below. In the experiment, two conical flasks are filled with the same concentration of hydrochloric acid (HCl). An iron ribbon is put into one of the conical flasks and iron filings are put into the other. Both reactions occur at the same temperature. The gas syringe is used to measure how much hydrogen gas is produced as the iron filings or iron ribbon reacts with the hydrochloric acid.



Is the final amount of gas produced in each reaction the same or different? In which flask the gas is produced faster? Why? In which flask the gas is produced slowly? Why? Do your students understand these with easiness? Why not? Why? (10 min)

4. Why does limestone ($CaCO_3$) deteriorate more rapidly in highly polluted air than in less polluted air? Explain. Do your students understand this easily? Why not? (10 min)
5. What misconceptions or alternative conceptions do students have on factors affecting rates of reactions? Use your teaching experience to explain each misconception. (10 min)
6. How can you apply the chemistry triangle concept of Johnstone, Animation, Simulations, virtual labs, video, etc. to teach factors affecting rates of reactions? (10 min)
7. How can technologies assist you in helping learners understand factors affecting rates of reactions with ease? (10 min)
8. Watching the following videos and reflect on what you learned from them. (30 min)
   - Factors affecting rates of reactions:
     https://www.youtube.com/watch?v=ExHV_cFWYSM
     https://www.youtube.com/watch?v=6mAqX31RRJU
     https://www.youtube.com/watch?v=qIvPSuUsgJU

- Concentration and surface area: https://www.youtube.com/watch?v=jDmxbFYvQgo and https://www.youtube.com/watch?v=lukSSS9Hfaw

Key points (10 min)

There are understanding problems on factors affecting rates of reactions. Misconceptions about the factors affecting rates of reactions can hinder students' understanding of this important topic in chemistry. Some common misconceptions related to factors affecting rates of reactions are:

- increasing the concentration of reactants always speeds up a reaction
- temperature affects the rate of a reaction by changing the amount of reactants used up
- the size of reactant particles does not affect the rate of a reaction
- adding a catalyst increases the amount of product formed in a reaction
- pressure has a direct impact on the rate of a reaction.

Teaching factors affecting rates of reaction concepts at different understanding levels of chemistry (macro, micro, and symbolic) can help students grasp the complexities of how reaction rates are influenced by various factors.

- At macro Level (Observable Reactions), visual Experiments can be used. Conducting experiments that demonstrate how different factors affect reaction rates, such as using varying concentrations of reactants or different temperatures is important.
- At the micro Level (Particulate View) it is possible to use particle Simulations. Interactive simulations or animations can be utilized to show how factors like concentration and temperature affect the behavior of reactant particles at the molecular level.
- At the symbolic level (Chemical Equations), it is possible to introduce students to rate law equations that express the relationship between reaction rates and concentrations of reactants. It is possible to show how changes in reactant concentrations affect the overall rate of the reaction.

Implication to teaching (5 min)

- What did you learn from this session and how will you apply the methods used in this session in teaching factors affecting rates of reaction concepts?

- What available technologies can be used to teach factors affecting rates of reaction concepts?
- How can you help your students benefit from this lesson?

Takeaway resources/materials

The following resources can be used to help learners easily understand rates of reaction concepts. These resources include describing rates of reaction concepts at three levels of chemistry understanding (Johnstone's Triangle), experiments, simulations, animations, demonstrations, virtual labs, videos, etc.

- Factors affecting rates of reactions related videos at: https://www.youtube.com/watch?v=ExHV_cFWYSM, https://www.youtube.com/watch?v=6mAqX31RRJU and https://www.youtube.com/watch?v=qIvPSuUsgJU
- Concentration and surface area as a factor affecting rate videos at: https://www.youtube.com/watch?v=jDmxbFYvQgo and https://www.youtube.com/watch?v=lukSSS9Hfaw
- Simulation Resource: https://phet.colorado.edu/en/simulations/reactions-and-rates

Session 5.4: Quantitative aspects of chemical equilibrium (2 h)

Introduction (5 min)

This session is intended to assist chemistry teachers in comprehending and how to effectively teach the quantitative aspects of chemical equilibrium to secondary school students. Various activities that require the active involvement of the teachers are included to support them while conveying the topic. It is also expected that trainees will share their experiences on teaching strategies they have used while instructing this topic.

Objectives

At the end of this session, trainees will be able to:

- Determine methods to teach quantitative aspects of chemical equilibrium
- calculate values for equilibrium constant involving concentration
- state the relationship of Keq to the relative amounts of products and reactants in a given reaction
- write the equilibrium constant expression for chemical reactions that involve partial pressure
- calculate values for equilibrium constant involving partial pressure
- show the relationship between KC and KP
- distinguish between homogeneous and heterogeneous equilibrium reactions
- define reaction quotient
- use the equilibrium quotient to predict the direction of the reaction and the position of equilibrium
- calculate equilibrium concentrations given initial concentrations
- determine whether the reactants or products are favored in a chemical reaction given the equilibrium constant
- Develop scientific enquiry skills
- Apply available technology in teaching quantitative aspects of chemical equilibrium.

Activities

Brainstorm/discuss in a group on the following questions, and present your ideas to the rest

1. What does it mean when a reaction is described as "having reached equilibrium"? (10 min)
2. How do the forward and reverse reaction rates relate to each other at equilibrium? Discuss and reflect to your group members. (15 min)
3. Is it correct to say that the reaction has "stopped" when it reaches equilibrium? Discuss and reflect to your group members. Do your students understand this differences without difficulty? (10 min)
4. Discuss whether Q and K are the same or not. Do your students understand this differences without difficulty? (20 min)
5. Discuss practical applications of chemical equilibrium principles in industries. (20 min)
6. What misconceptions or alternative conceptions do students have on quantitative aspects of chemical equilibrium? Use your teaching experience to explain each misconception. (20 min)
7. How can you apply the chemistry triangle concept of Johnstone (Macro, sub-micro-, and symbolic levels), Animation, Simulations, virtual labs, video, etc. to teach quantitative aspects of chemical equilibrium? (20 min)
8. How can technologies assist you in helping learners understand quantitative aspects of chemical equilibrium with ease? (15 min)
9. Watching the following videos and reflect on what you learned from them. (20 min)
    - Quantitative aspects of chemical equilibrium:
      https://www.youtube.com/watch?v=dJ3NxDqxQiY
      https://www.youtube.com/watch?v=xfGlEXWDRZE,
      https://www.youtube.com/watch?v=QRou4Li5rUc r

Key points (10 min)

There are understanding problems with the quantitative aspects of equilibrium. Misconceptions related to the quantitative aspects of chemical equilibrium often arise due to the mathematical nature of equilibrium constants and reaction quotient calculations. Some common misconceptions regarding the quantitative aspects of chemical equilibrium are:

- equilibrium constant values indicate the speed of a reaction
- changing the initial concentrations of reactants will alter the value of the equilibrium constant
- equilibrium constants for reverse reactions are reciprocals of each other

The equilibrium constant is a reflection of the extent of a reaction at equilibrium, not the speed at which equilibrium is reached. A large equilibrium constant indicates that the reaction favors products at equilibrium, while a small constant indicates a greater concentration of reactants at equilibrium. A large equilibrium constant indicates a reaction has gone to completion. The equilibrium constant is a constant at a given temperature for a specific reaction. Changing initial concentrations will not change the value of the equilibrium constant; it will only alter the system's position to reach a new equilibrium. The equilibrium constant does not provide information on the extent to which a reaction has proceeded; it only indicates the ratio of product to reactant concentrations at equilibrium. Even with a large equilibrium constant, a reaction may not be completed due to limitations in reactant concentrations or reaction conditions. Equilibrium constants for the forward and reverse reactions of a reversible reaction are not necessarily reciprocals of each other. The equilibrium constant expression for the reverse reaction is derived from the equilibrium constant expression for the forward reaction.

Teaching the quantitative aspects of chemical equilibrium using three different understanding levels of chemistry (macro, sub-micro, symbolic) can help students develop a comprehensive understanding of equilibrium concepts.

- At the macro Level (Observable Reactions), it is possible to use visual Demonstrations. Teachers can conduct experiments that illustrate the concept of equilibrium using observable changes such as color changes, temperature changes, or pressure changes.
- At the sub-micro Level (Particulate View), particle Diagrams can be used. Using particle diagrams to represent the dynamic nature of equilibrium, showing how reactant and product particles are constantly interconverting at equilibrium is necessary.
- At the symbolic Level (Chemical Equations), it is possible to engage students in equilibrium Constant Calculations. Teachers are expected to teach students how to write equilibrium constant expressions for different types of reactions and calculate K values using given concentrations.

By including these strategies at the macro, sub-micro, and symbolic levels, students can develop a multi-faceted understanding of the quantitative aspects of chemical equilibrium.

Implication to teaching (5 min)

- What did you learn from this session and how will you apply the methods used in this session in teaching quantitative aspects of chemical equilibrium?
- What available technologies can be used to teach quantitative aspects of chemical equilibrium?
- How can you help your students benefit from this lesson?

Takeaway resources/materials

The following resources can be used to help learners easily understand quantitative aspects of chemical equilibrium. These resources include describing quantitative aspects of chemical equilibrium at three levels of chemistry understanding (Johnstone's Triangle), experiments, simulations, animations, demonstrations, virtual labs, videos, etc.

- Factors affecting chemical equilibrium related videos at: https://www.youtube.com/watch?v=ExHV_cFWYSM, https://www.youtube.com/watch?v=6mAqX31RRJU and https://www.youtube.com/watch?v=qIvPSuUsgJU
- PhET simulation: https://www.youtube.com/watch?v=5gF-JhJkWWA

Session 5.5: Factors affecting chemical equilibrium (2 h)

Introduction (5 min)

This session is intended to provide support to chemistry teachers in understanding the concepts of industrial applications of electrochemistry (electrorefining and electroplating) and how to teach these topics to secondary school students. Participation of the teachers in the suggested activities either individually or in groups is necessary, and they are expected to present effective strategies they have used to instruct the topic.

Objectives

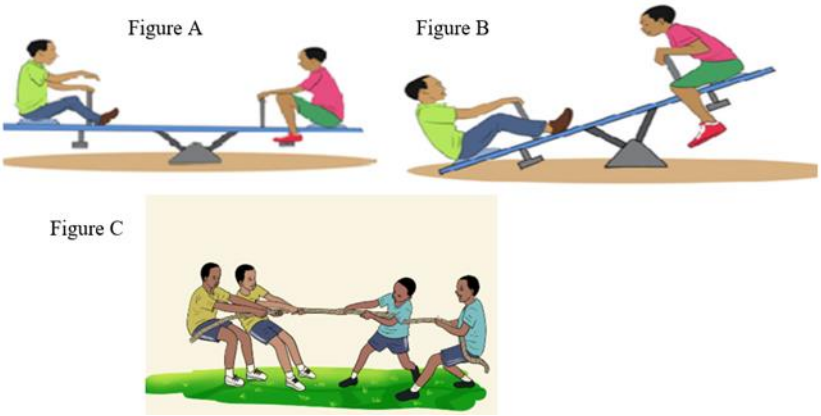
At the end of this session, trainees will be able to:

- identify methods to teach factors affecting Chemical Equilibrium
- explain the factors that affect the position of the equilibrium in a reversible reaction.
- apply Le Châtelier's principle to explain the effects of changes in the temperature, concentration and pressure on a system in equilibrium.
- explain how equilibrium principles may be applied to optimize the production of industrial chemicals (e.g., production of ammonia and sulphuric acid)
- develop scientific enquiry skills
- apply available technology in teaching factors affecting rates of chemical reactions.

Activities

Brainstorm/discuss in a group on the following questions, and present your ideas to the rest

1. After observing the figures below, answer the questions that follow: (10 min)



   i. What is the difference between Figures A and B?
   ii. What condition (s) is /are necessary for Figure B to be like Figure A?
   iii. What will happen if one person on the right side leaves his/her group in Figure C?

2. Discuss how changes in the concentration of reactants or products, pressure, and temperature can shift the equilibrium positions. Emphasize the concept of Le Chatelier's principle. Support your discussion with practical examples. (25 min)
3. What misconceptions or alternative conceptions do students have on factors affecting equilibrium? Use your teaching experience to explain each misconception. (15 min)
4. How can you apply the chemistry triangle concept of Johnstone, Animation, Simulations, virtual labs, video, etc. to teach factors affecting equilibrium? (20 min)
5. How can technologies assist you in helping learners understand factors affecting equilibrium with ease? (15 min)
6. Watching the following videos and reflect on what you learned from them. (15 min)
   - Factors affecting equilibrium:
     https://www.youtube.com/watch?v=2Dvxw-sP2WI
     https://www.youtube.com/watch?v=7zcIKkkFg1A,
     https://www.youtube.com/watch?v=W1HDDeX4cPM

Key points (10 min)

There are understanding problems about factors affecting equilibrium. Misconceptions related to factors affecting the position of equilibrium in chemical reactions can arise due to the complexity of dynamic equilibrium and the interplay of various factors that influence the equilibrium state. Some common misconceptions regarding factors affecting the position of equilibrium are:

- Increasing the concentration of products will always shift the equilibrium towards the products side
- adding a catalyst will shift the equilibrium position
- changing the pressure of a system will always shift the equilibrium in a particular direction
- increasing the temperature will always shift the equilibrium towards the endothermic side
- equilibrium means that the reaction has stopped
- reaching equilibrium means that equal amounts of reactants and products are present.

Factors affecting chemical equilibrium can be taught at three different levels of understanding.

- At the macro level, it is possible to use demonstrations or experiments to show how changes in concentration, pressure, or temperature affect the position of equilibrium. It is important to provide real-life examples such as the Haber process to illustrate the concept of chemical equilibrium.
- At the sub-micro Level, it is possible to use animations or molecular models to show the dynamic nature of chemical equilibrium at the molecular level.
- At the symbolic level, it is possible to introduce the concept of equilibrium constant (Kc) and discuss how it is affected by changes in concentration, temperature, or pressure. At this level, it is important to provide practice problems to students that can involve them in calculations of equilibrium concentrations using the equilibrium constant expression. Encouraging students to write balanced chemical equations and use Le Chatelier's principle to predict the direction of shift in equilibrium in response to changes in conditions is necessary.

Implication to teaching (5 min)

- What did you learn from this session and how will you apply the methods used in this session in teaching factors affecting chemical equilibrium?
- What available technologies can be used to teach factors affecting chemical equilibrium?

Takeaway resources/materials

The following resources can be used to help learners easily understand factors affecting chemical equilibrium. These resources include describing factors affecting chemical equilibrium at three levels of chemistry understanding (Johnstone's Triangle), experiments, simulations, animations, demonstrations, virtual labs, videos, etc.

- Factors affecting chemical equilibrium related videos at: https://www.youtube.com/watch?v=ExHV_cFWYSM, https://www.youtube.com/watch?v=6mAqX31RRJU and https://www.youtube.com/watch?v=qIvPSuUsgJU
- PhET simulation: https://www.youtube.com/watch?v=5gF-JhJkWWA

Unit 6: Introduction to Organic Compounds (10 h)

Introduction (5 min)

The primary objective of this training module unit is to help secondary school chemistry teachers develop a solid understanding of some basic organic compounds. This includes saturated and unsaturated hydrocarbons, their functional groups, names, and polymers. The focus is on the polymerization of both synthetic and natural polymers, as well as organic compounds containing oxygen like alcohols, ethers, carboxylic acids, and esters.

The unit is divided into three sessions, each containing a variety of exercises to support trainers in teaching these principles. Encouraging trainees to actively engage in these activities, either individually or in groups, is crucial. This will help trainees become familiar with various teaching and learning strategies based on their prior experiences. These topics are taken from Grade 10 (Unit 6), Grade (Unit 6) and Grade (Unit 4).

Objectives

At the end of this unit, trainees will be able to:

- understand how to teach various organic compounds
- comprehend the significance of functional groups in organic compounds
- familiarize the basic principles and concepts of organic chemistry
- know how to teach the structure, nomenclature, and functional groups of organic compounds
- use the methods suggested to teach basic principles and concepts of organic chemistry
- comprehend the importance of various organic compounds in human life
- appreciate teaching and learning of various organic chemistry concepts
- develop the scientific enquiry skills of the trainees

Session 6.1: Hydrocarbons (3 h 55 min)

Introduction of the session (5 min)

The objective of this session is to help chemistry teachers educate secondary school students about hydrocarbons, with a focus on the functional groups and nomenclature of saturated and unsaturated hydrocarbons. Throughout this training session, individuals will be encouraged to brainstorm independently and engage in group discussions. It is crucial to motivate trainees to take part in suggested activities, either individually or in teams. It is expected that trainees will explore different teaching and learning methods for this topic.

Objectives

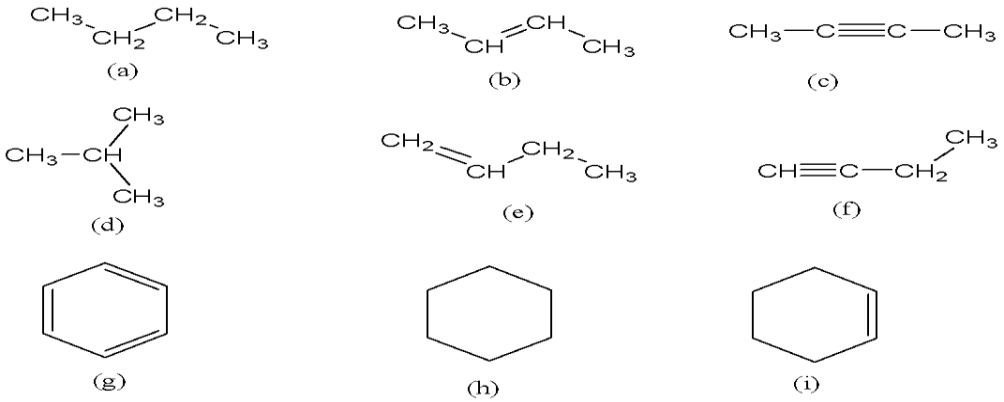
At the end of this session, trainees will be able to:

- design various methods to teach organic chemistry
- differentiate between saturated and unsaturated hydrocarbons
- Explain homologous series
- identify isomerism
- identify common functional groups found in saturated and unsaturated hydrocarbons
- explain how functional groups impact the chemical properties of hydrocarbons
- apply IUPAC nomenclature rules to systematically name various saturated and unsaturated hydrocarbons
- Evaluate and compare the physical and chemical properties of saturated and unsaturated hydrocarbons

Activities

Brainstorm/discuss in a group on the following questions, and present your ideas to the rest

1. Identify and label the functional groups of the following compounds. (20 min)



2. How can you help your students to easily grasp: (90 min)
   i. classification of hydrocarbons?
   ii. functional groups of hydrocarbons?
   iii. homologous series?
   iv. isomerism?
   v. the difference between saturated and unsaturated hydrocarbons?
   vi. systematic naming of various saturated and unsaturated hydrocarbons?
3. How can assist your students to get familiar with the naming of saturated and unsaturated hydrocarbons using the system of IUPAC nomenclature? (30 min)
4. What misconceptions do students have on saturated and unsaturated hydrocarbons: functional groups and nomenclatures? Use your teaching experience to explain each misconception. (20 min)
5. How do you assist your students to evaluate and compare the physical and chemical properties of saturated and unsaturated hydrocarbons? (30 min)
6. What technologies can you use in teaching these concepts? (20 min)

Key points (10 min)

When teaching about saturated and unsaturated hydrocarbons with a focus on functional groups and nomenclature, the following some key points should be addressed:

- Saturated hydrocarbons contain only single bonds between carbon atoms.

- Unsaturated hydrocarbons contain at least one double or triple bond between carbon atoms.
- Functional groups are specific groups of atoms within a molecule that determine its chemical properties and reactivity.
- In hydrocarbons, functional groups can include double or triple bonds, as well as other reactive groups like halogens, hydroxyl groups, carbonyl groups, and carboxyl groups
- Understanding functional groups is essential for predicting the behavior of organic compounds in various reactions.
- Functional groups in hydrocarbons can significantly influence their physical and chemical properties, affecting solubility, reactivity, and other characteristics.
- The nomenclature of hydrocarbons involves identifying the longest carbon chain (parent chain), locating and numbering substituents, and using prefixes and suffixes to indicate functional groups.
- Isomerism is the phenomenon where compounds have the same molecular formula but different structural arrangements.
- Structural isomers of hydrocarbons can arise due to different arrangements of carbon atoms or the presence of double or triple bonds in different positions.
- Understanding isomerism is crucial for recognizing the diverse structures and properties that hydrocarbons can exhibit
- Saturated hydrocarbons are less reactive compared to unsaturated hydrocarbons due to the absence of multiple bonds in saturated hydrocarbons.
- Unsaturated hydrocarbons typically have lower boiling points than their saturated counterparts due to weaker intermolecular forces.

When teaching about saturated and unsaturated hydrocarbons, it's important to be aware of common misconceptions that students may have. Some misconceptions that students have include:

- Students may assume that all hydrocarbons are saturated. This misconception can be corrected by explaining that saturated hydrocarbons contain only single bonds between carbon atoms, while unsaturated hydrocarbons contain at least one double or triple bond. Unsaturated hydrocarbons have additional reactivity due to the presence of these multiple bonds.

- Students may assume that all unsaturated hydrocarbons are alkenes. However, unsaturated hydrocarbons include both alkenes (with double bonds) and alkynes (with triple bonds). Each type of unsaturated hydrocarbon has distinct properties and reactivity based on the type of bond present.
- Students assume that functional groups in hydrocarbons only refer to double or triple bonds. Nevertheless, functional groups in hydrocarbons can also reactive groups such as halogens, hydroxyl groups, carbonyl groups, and carboxyl groups.
- Students may assume that the nomenclature of unsaturated hydrocarbons follows the same rules as saturated hydrocarbons. However, specific nomenclature rules are used for unsaturated hydrocarbons, including the use of suffixes like "-ene" for alkenes and "-yne" for alkynes to indicate the presence of double or triple bonds.

By addressing the aforementioned misconceptions and providing clear explanations, examples, and practice problems in teaching about saturated and unsaturated hydrocarbons, functional groups, and nomenclature, students can develop a more accurate and comprehensive understanding of organic chemistry concepts. Encouraging hands-on activities, visual aids, real-life examples, model building, and real-world applications can further enhance their learning experience. Relate the concepts of hydrocarbons to real-life examples, such as the types of hydrocarbons found in everyday products like gasoline, plastics, and food. Encourage students to discuss and explain the concepts to each other in small groups or pairs. Present students with scenarios or problems that require them to apply their knowledge of hydrocarbons, functional groups, and nomenclature to solve them. This can help them develop critical thinking skills and apply their knowledge in practical situations. By using a combination of these teaching methods, teachers can effectively teach secondary school students about hydrocarbons, saturated and unsaturated hydrocarbons, functional groups, and nomenclature in an engaging and interactive way.

Implication to teaching (5 min)

- What did you learn from this session and how will you apply the methods used in this session in teaching saturated and unsaturated hydrocarbons' functional groups and nomenclature?
- What available technologies can be used to teach on saturated and unsaturated hydrocarbons' functional groups and nomenclature?
- How can you help your students benefit from this lesson?

Takeaway resources/materials

Use videos, simulations, and online resources while teaching this session. Learners can also use such materials by their own to have deeper understanding about the concepts.

IUPAC nomenclature**:** https://www.youtube.com/watch?v=PYZJXWBMqBE

Session 6.2: Oxygen-containing organic compounds (3 h)

Introduction of the session (5 min)

The primary objective of this session is to provide secondary school chemistry teachers with updated knowledge on teaching organic molecules that contain oxygen, specifically alcohols, ethers, carboxylic acids, and esters. Trainees are encouraged to discuss the suggested exercises in groups, pairs, or individually, and brainstorm ideas.

Objectives

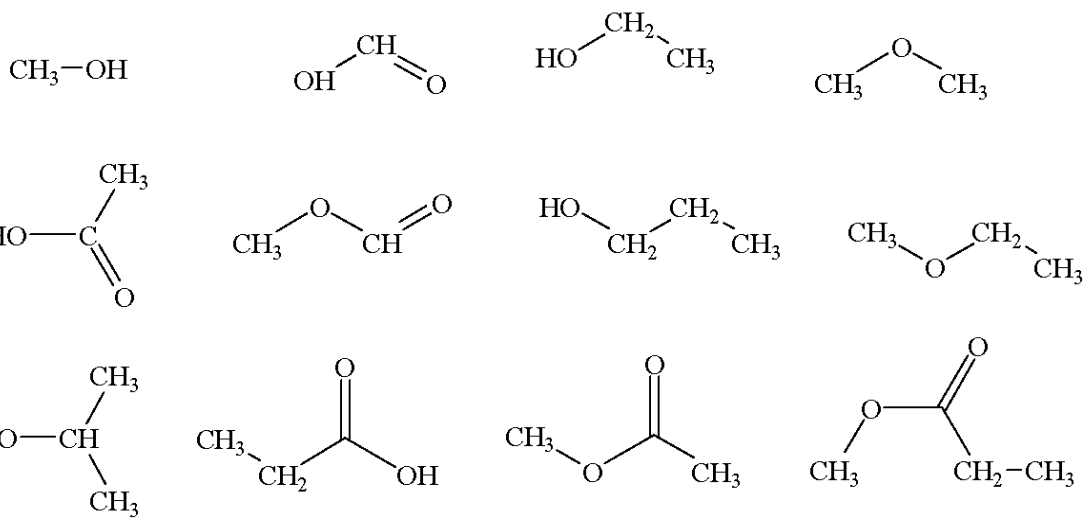
At the end of this session, trainees will be able to:

- differentiate between alcohols, ethers, carboxylic acids, and esters based on their functional groups and structural characteristics
- identify and describe the properties and reactivity of alcohols, ethers, carboxylic acids, and esters, including their solubility, boiling points, and chemical reactions
- apply IUPAC nomenclature rules to systematically name various alcohols, ethers, carboxylic acids, and esters, including identifying substituents and determining the parent chain
- analyze the structure of oxygen-containing organic compounds to predict their physical and chemical properties based on the functional groups present and the nature of their bonds.
- evaluate and compare the uses and applications of alcohols, ethers, carboxylic acids, and esters in everyday life and industrial processes based on their unique properties and reactivity

Activities

Brainstorm/discuss in a group on the following questions, and present your ideas to the rest

1. What teaching methods can you use to teach oxygen containing organic compounds? (20 min)
2. How can you help your students to learn about the following compounds? (20 min)



3. How can you help your students easily grasp the (600 min)
    i. classification of oxygen-containing organic compounds?
    ii. functional groups of oxygen containing organic compounds?
    iii. homologous series of oxygen containing organic compounds
    iv. isomerism in oxygen containing organic compounds?
    v. systematic naming of various oxygen containing organic compounds, with a focus on alcohols, ethers, carboxylic acids and esters?
4. Discuss how oxygen containing compounds are used in everyday products and industries. (20 min)
5. How can you assist your students in becoming familiar with the naming of alcohols, ethers, carboxylic acids and esters using the IUPAC nomenclature system? (20 min)
6. What misconceptions do students have about oxygen-containing organic compounds including alcohols, ethers, carboxylic acids and esters? Use your teaching experience to explain each misconception. (20 min)
7. How do you assist your students in evaluating and comparing the physical and chemical properties of alcohols, ethers, carboxylic acids and esters? (20 min)

Key points (10 min)

Teaching about oxygen-containing organic compounds with a focus on alcohols, ethers, carboxylic acids, and esters can be made engaging and effective through various strategies.

It is good to start by introducing oxygen-containing organic compounds taking alcohols, ethers, carboxylic acids, esters, etc as an example. To make the topic more relatable and interesting to students, introduction of real-life examples where alcohols, ethers, carboxylic acids, and esters are commonly found (e.g., at home, in pharmaceuticals, food flavorings, perfumes). To create a dynamic and engaging learning environment for teaching the concepts, utilization of different interactive demonstrations, visual aids, problem-solving exercises, group activities, technology integration, and assessment strategies are recommended. Application of different learning styles and encouraging active participation can help students grasp the concepts effectively and develop a deeper appreciation for concepts.

When teaching students about oxygen-containing organic compounds, it is important to address the following key points to ensure a comprehensive understanding of these compounds.

- Functional groups alcohols, ethers, carboxylic acids, and esters
- Basic difference between alcohols and ethers, as well as carboxylic acids, and esters
- General formula, structure, and naming conventions (nomenclature and naming rules)
- Physical properties such as boiling points, solubility, and odor of the compounds
- Chemical reactions that these compounds can undergo
- Method for synthesis and preparations of alcohols, ethers, carboxylic acids, and esters,
- Their applications and use in various industrial, pharmaceutical, and everyday life, etc.

It is also important to be aware of common misconceptions that students may have while teaching oxygen-containing organic compounds, arising from the complex nature of the concept and the variety of functional groups involved. Some common misconceptions that students may encounter in learning about these compounds are

- Treating alcohols as simple compounds without considering their diverse structures, properties, and reactivity beyond just being associated with alcoholic beverages.
- Believing ethers are chemically inert and solely used as solvents, overlooking their potential reactivity and functional group properties.

- Assuming all carboxylic acids are strong acids due to the presence of the carboxyl group, without understanding variations in acidity strengths within this functional group.
- Viewing esters primarily as fragrant compounds found in perfumes and fruit flavors, neglecting their broader significance in organic synthesis and chemical applications.
- Equating different functional groups such as alcohols, carboxylic acids, and esters solely based on their oxygen content, without recognizing distinct structural and chemical differences between them.
- Confusion in naming and identifying oxygen-containing functional groups like alcohols and carboxylic acids in organic compounds, leading to errors in compound categorization.

Therefore, teachers should address these misconceptions through targeted instruction, practical examples, and interactive activities, to help students overcome misunderstandings and develop a correct understanding of oxygen-containing organic compounds.

Implication to teaching (5 min)

- What did you learn from this session and how will you apply the methods used in this session in teaching organic molecules that include oxygen, particularly alcohols, ethers, carboxylic acids, and esters?
- What available technologies can be used to teach these concepts?

Takeaway resources/materials

You can use videos, simulations, and online resources while teaching this session or advise your students to use such materials by their own to have deeper understanding about the concepts. IUPAC nomenclature**:** https://www.youtube.com/watch?v=PYZJXWBMqBE

Session 6.3: Polymers (synthetic and natural) (3 h)

Introduction of the session (5 min)

This session aims to support secondary school teachers in teaching about polymers (including the polymerization of synthetic and natural polymers) by presenting a variety of activities that utilize mixed learning and teaching methodologies. As a result, trainees should engage in group or pair discussions about the recommended activities or brainstorm ideas on their own.

Objectives At the end of this session, trainees will be able to:

- propose various methods of teaching polymers
- define polymers
- describe their structure, and properties
- differentiate the difference between homopolymers and copolymers
- classify polymers based on their composition and origin (synthetic vs natural).
- explain polymerization process
- analyze the chemical structure of polymers
- predict physical properties polymers
- appreciate the role of polymers in various industries

Activities Brainstorm/discuss in a group on the following questions, and present your ideas to the rest

1. How do you assist your students in learning about polymers? (20 min)
2. What makes polymers different from other organic compounds? (20 min)
3. What criteria determine the classification of polymers as synthetic or natural? (25 min)
4. Discuss the basic differences between homopolymers and copolymers. (20 min)
5. In what ways can technology help you in teaching about polymers? (20 min)
6. How can you guide your students in analyzing the structure of polymers? (20 min)
7. Discuss how these compounds are used in everyday life and industries. (25 min)

Key points (12 min)

When teaching students about polymers, it is important to address the following key points to ensure a comprehensive understanding of these compounds. It is good to start with introduction of the concept of polymers as large molecules composed of repeating subunits called monomers. This process can occur through polymerization, such as addition polymerization, condensation polymerization, or ring-opening polymerization.

Polymers can be classified into synthetic polymers, which are man-made through chemical processes, and natural polymers, which occur in nature and can be extracted from plants, animals, or other sources. There are various types of synthetic polymers which commonly used in everyday products, such as plastics, synthetic fibers, and rubber. Whereas, natural polymers include proteins, carbohydrates, and nucleic acids.

Polymerization reactions can be controlled by adjusting factors like temperature, pressure, reaction time, and the presence of specific catalysts or initiators. The properties of the resulting polymers, such as molecular weight, chain structure, and physical characteristics, can be tailored by manipulating these reaction parameters. Polymerization plays a crucial role in the production of a wide range of materials, including plastics, synthetic fibers, rubbers, adhesives, coatings, and composites. Understanding the principles of polymerization is essential for designing new materials with desired properties and applications in various industries.

There are some common misunderstanding in polymerization concepts. Misconceptions about polymerization reactions include:

- polymerization is always a condensation reaction
- all polymers are plastics
- polymers are always synthetic
- polymers are always amorphous
- polymerization reactions are always irreversible
- all polymers are strong and durable
- polymers are always non-biodegradable
- polymerization reactions are always exothermic
- polymers are always high molecular weight
- polymerization reactions are always complex and difficult to control.

These misconceptions can be corrected by varying instructional strategies. To teach about polymers teachers can use various teaching methods including, interactive demonstrations, visual aids, real-world examples, group projects, etc.

Implication to teaching (8 min)

- What did you learn from this session and how will you apply the methods used in this session in teaching organic molecules that include oxygen, particularly alcohols, ethers, carboxylic acids, and esters?
- What available technologies can be used to teach these concepts?
- How can you help your students benefit from this lesson?

Takeaway resources/materials

You can use videos, simulations, and online resources while teaching this session or advise your students to use such materials by their own to have deeper understanding about the concepts.

Polymers - Basic Introduction: https://www.youtube.com/watch?v=PYZJXWBMqBE

Unit 7: Acid-Base Concepts (12 h)

Introduction (5 min)

This unit of the training module aims to assist secondary school chemistry teachers in establishing a proper understanding of acid-base concepts. It focuses on Arrhenius and Bronsted-lowery acid-base theories, acid-base equilibria, Buffer solutions, hydrolysis, and acid-base indicators.

The unit consists of five sessions, each containing engaging activities designed to help trainees to comprehend the suggested concepts. It is essential to motivate trainees to participate individually or in groups to address these activities actively. This will help them become aware of and familiarize themselves with different teaching and learning methods based on their previous experiences and the discussions on activities designed in each session.

Objectives

At the end of this unit, trainees will be able to:

- understand how to teach various acid-base concepts
- Familiarize with the Arrhenius and Bronsted-lowery acid-base theories
- comprehend acid-base equilibria
- discuss the buffer solutions, hydrolysis of salts, and acid-base indicators
- explain how buffering action affects our daily lives using examples
- comprehend the importance of acid-base concepts in human life
- develop the scientific enquiry skills of the trainees

Session 7.1: Acid-base theories (2 h)

Introduction of the session (5 min)

With a focus on the Arrhenius and Bronsted-Lowery theories, this session offers a variety of approaches to teaching and learning about acid-base theories. Participation in group or peer conversations and individual brainstorming is highly recommended for trainees.

Objectives

At the end of this session, trainees will be able to:

- propose various methods of teaching acid-base concepts
- define acid and bases by the Arrhenius and Bronsted-Lowry concepts
- give examples of Arrhenius and Bronsted-Lowry acids and bases
- explain what conjugate acids and conjugate bases are
- identify the acid-base conjugate pairs from the given reaction
- calculate pH from $[H^+]$ and $[H^+]$ from pH

Activities

Brainstorm/discuss in a group on the following questions, and present your ideas to the rest

1. Take a few minutes to brainstorm individually what you know about acids and bases. (10 min)
2. How can you identify and differentiate between acids and bases according to the Arrhenius and Brønsted-Lowry theories? (15 min)
3. Watch the following video: https://www.youtube.com/watch?v=2dwQu32Pq3Q, and then reflect on your observation. (15 min)
4. How do you assist your students in learning about acid-base theories? (15 min)
5. How can you guide your students in analyzing acids and bases? (15 min)
6. Discuss how acids and bases are used in everyday life and industries. (20 min)
7. What technologies can you use to teach these concepts? (15 min)

Key points (7 min)

When teaching students about acids and bases, it is important to address the following key points to ensure a comprehensive understanding of these compounds.

- Define acids and bases according to the Arrhenius theory (acids release H^+ ions, bases release OH^- ions) and the Brønsted-Lowry theory (acids donate protons, bases accept protons).
- Discuss the key properties of acids (sour taste, ability to turn blue litmus paper red, react with metals to produce hydrogen gas) and bases (bitter taste, ability to turn red litmus paper blue, slippery feel).
- Explain how acid-base reactions occur according to the Arrhenius theory (H^+ ions from acids react with OH^- ions from bases to form water) and the Brønsted-Lowry theory (proton transfer from acid to base).
- Present the concept of conjugate acid-base pairs, where an acid donates a proton to become its conjugate base, and a base accepts a proton to become its conjugate acid.
- Discuss how equilibrium is established in acid-base reactions, and how the concentration of reactants and products can be calculated using the principles of the Arrhenius and Brønsted-Lowry theories.
- Highlight the differences between the two theories in terms of their definitions of acids and bases, and discuss the strengths and limitations of each theory.
- Provide examples of acid-base reactions in everyday life, such as in the human body (stomach acid neutralizing food) or in environmental processes (acid rain).
- Explore how the Arrhenius and Brønsted-Lowry theories relate to other acid-base theories, such as the Lewis theory (which defines acids as electron pair acceptors and bases as electron pair donors).
- Engage students in solving acid-base equilibrium problems using the principles of the Arrhenius and Brønsted-Lowry theories to reinforce understanding.
- Encourage students to actively participate in discussions, ask questions, and articulate their understanding of acid-base theories through presentations or group activities.

Various teaching/learning methods including, interactive demonstrations (conduct hands-on experiments or demonstrations), visual aids (diagrams, charts, and models), real-world examples (analogies and real-life examples), group discussions and peer teaching, Problem-solving exercises, technology integration (simulations, interactive apps, or online resources),

inquiry-based learning (ask questions, conduct research, and explore acid-base reactions on their own), use of assessments such as quizzes, or class, etc can be used for teaching/learning acid and base concepts.

Implication to teaching (5 min)

- What did you learn from this session and how will you apply the methods used in this session in your classroom?
- What available technologies can be used to teach these concepts?
- How can you help your students benefit from this lesson?

Takeaway resources/materials

When instructing this session, use a variety of interactive teaching techniques. To help them grasp the concepts more thoroughly, you might also suggest that they use a variety of online resources, reference books, and independent practice problems.

Polymers - Basic Introduction: https://www.youtube.com/watch?v=PYZJXWBMqBE

- Experiment (to study the properties of acids and bases): https://www.youtube.com/watch?v=2dwQu32Pq3Q
- Properties of acids and bases:https://www.youtube.com/watch?v=yzoceTAN3Eg

Session 7.2: Acid-base equilibria (3 h)

Introduction of the session (5 min)

This session presents a range of activities for teaching and learning about acid-base equilibria, with an emphasis on the weak acids. It is highly recommended that trainees participate in peer or group discussions on the proposed activities in addition to individual brainstorming.

Objectives

At the end of this session, trainees will be able to:

- design methods of teaching acid-base ionic equilibria
- explain the dissociation of weak acids
- describe the concept of equilibrium constant (Ka)
- identify and calculate the pH of weak acid solutions
- relate the values of Ka to the strength of weak acids
- identify the factors that affect the degree of ionization, such as concentration, temperature, and the presence of common ions
- relate acid-base equilibria to real-life applications
- appreciate technologies that support teaching and learning of chemistry

Activities

Brainstorm/discuss in a group on the following questions, and present your ideas to the rest

1. Take a few minutes to individually brainstorm what you know about strong acids and weak acids. (15 min)
2. What makes weak acids different from strong acids? Provide examples to support your discussion. (15 min)
3. Discuss how you can help your students in applying the concept of equilibrium constant (Ka) to calculate the degree of ionization and pH of weak acid solutions. (20 min)
4. How can you guide your students in analyzing the relationship between the concentration and degree of ionization of weak acids? Discuss how Le Chatelier's principle is applicable to acid-base equilibria. (30 min)
5. How could you help your students in determining the factors that affect the degree of ionization, such as concentration and the presence of common ions? (30 min)

6. Discuss how weak acids are used in everyday life and industries. (15 min)
7. Give examples that can assist the problem-solving skills of your students focusing on weak acid equilibria. (15 min)
8. What technologies can you use to teach acid-base equilibria concepts?(20 min)

Key points (7 min)

The following key points should be covered while teaching acid-base equilibria, with a focus on weak acids:

- Acids that only dissociate partially in water, leaving the undissociated acid and its ions in equilibrium, are known to as weak acids.
- The ability of weak acids to ionize in water distinguishes them from strong acids.
- It is important to clarify the concepts of acid dissociation equilibrium and the equilibrium constant (Ka), highlighting the fact that a weak acid's strength is determined by how much dissociation has occurred.
- The idea of pH, how it relates to the amount of hydronium ions (H_3O^+) in a solution, and how to compute the pH of a weak acid solution by utilizing the dissociation constant (Ka) and the concentration of the undissociated acid
- Examples should be used to illustrate the idea of pH, its relationship to the concentration of hydronium ions (H_3O^+) in a solution, and how to determine the pH of a weak acid solution using the concentration of the undissociated acid and the dissociation constant (Ka).
- The pH of a solution can be calculated using the following formula: $pH = -\log[H_3O^+]$.
- Examples should be used to illustrate how concentration and the presence of common ions affect the degree of ionization of weak acids.
- the significance of weak acids in daily life, including biological systems (blood pH regulation and enzyme function), household goods (cleaning agents and cosmetics), and industrial processes (chemical manufacture and food preservation).

By addressing these key points, students will develop a solid understanding of acid-base equilibria, specifically focusing on weak acids, and be equipped to apply their knowledge to various situations and problem-solving activities.

Various teaching/learning methods including, interactive demonstrations (conduct hands-on experiments or demonstrations), visual aids (diagrams, charts, and models), providing real-life examples of weak acids and their equilibrium reactions, Engaging students in problem-solving

activities related to weak acids and equilibrium reactions, group discussions, technology integration (simulations, interactive apps, or online resources), inquiry-based learning (ask questions, conduct research, and explore weak acid equilibria on their own), use of assessments such as quizzes, or class, etc can be used for teaching/learning acid-base equilibria, with a focus on weak acids concepts.

Implication to teaching (8 min)

- What did you learn from this session and how will you apply the methods used in this session in your classroom?
- What available technologies can be used to teach these concepts?
- How can you help your students benefit from this lesson?

Takeaway resources/materials

When instructing this session, use a variety of interactive teaching techniques. To help them grasp the concepts more thoroughly, you might also suggest that they use a variety of online resources, reference books, and independent practice problems.

- Weak acid equilibria: https://www.khanacademy.org/science/ap-chemistry-beta/x2eef969c74e0d802:acids-and-bases/x2eef969c74e0d802:weak-acid-and-base-equilibria/v/weak-acid-equilibria
- Worked example: https://www.khanacademy.org/science/ap-chemistry-beta/x2eef969c74e0d802:acids-and-bases/x2eef969c74e0d802:weak-acid-and-base-equilibria/v/worked-example-finding-the-percent-ionization-of-a-weak-acid

Session 7.3: Buffer solutions (3 h)

Introduction of the session (5 min)

This session includes a variety of teaching and learning exercises about buffer solutions, with an emphasis on acidic buffers. It is strongly advised that trainees engage in independent brainstorming about the suggested activities as well as group or peer discussions.

Objectives

At the end of this session, trainees will be able to:

- propose methods of teaching buffer solution
- define the buffer solutions
- explain the components of acidic buffer solutions
- give some examples of acidic buffer solutions
- evaluate the action of buffer solutions and its importance in chemical processes
- calculate the pH of acidic buffer solutions
- demonstrate the acidic buffer action with examples
- relate buffer solutions to real-life applications
- appreciate technologies that support teaching buffer solutions

Activities

Brainstorm/discuss in a group on the following questions, and present your ideas to the rest

1. Take a few minutes to individually brainstorm what you know about buffer solutions. (15 min)
2. Discuss with a group or peer how you can help your learners understand: (20 min)
    a. What buffer solutions are?
    b. How do they function to resist changes in pH?
3. What are the components of acidic buffer solutions? Explain how these components work together to neutralize added acids or bases and maintain a relatively constant pH. (20 min)
4. How can you assist your students in determining the pH of acidic buffer solutions, and predicting the effect of adding acids or bases to a buffer system? (20 min)

5. Discuss practical applications of acidic buffer solutions in fields such as biology, chemistry, and environmental science. (20 min)
6. Give examples that can assist the problem solving skills of your students focusing on acidic buffer solution. (20 min)
7. Discuss in groups or with your peers, how you can assist your learners by providing hands-on activities to prepare and test acidic buffer solutions in the laboratory. Focus on accurate measurement, mixing techniques, pH adjustments, and data analysis to enhance practical skills. (25 min)
8. What technologies can you use to teach buffer solution concepts? (20 min)

Key points (7 min)

When teaching about buffer solutions, specifically acidic buffer solutions, it is important to address the following key points:

- Define a buffer solution as a solution that resists changes in pH when an acid or base is added to it.
- Buffers are composed of a weak acid and its conjugate base (or a weak base and its conjugate acid), which work together to maintain the solution's pH within a relatively narrow range.
- Buffer solution that contain weak acid and its conjugate base in known as acidic buffer.
- Buffers are important in various chemical, biological, and environmental processes where maintaining a stable pH is crucial.
- Buffer capacity refers to the ability of a buffer solution to resist changes in pH, which is affected by the concentration of the weak acid and its conjugate base
- Henderson-Hasselbalch equation, which is used to calculate the pH of a buffer solution should be addressed, and apply the equation to determine the pH of certain buffer solutions.
- It is good to provide hands-on experience in preparing and testing acidic buffer solutions in the laboratory, focusing on accurate measurement, mixing techniques, pH adjustments, and data analysis to enhance practical skills.
- Encouraging collaboration among learners to design and conduct experiments related to preparation of buffer solutions is recommended.

Various teaching/learning methods including, interactive demonstrations (conduct hands-on experiments or demonstrations), visual aids (diagrams, charts, and models), providing real-life examples of buffer solution, Engaging students in problem-solving activities related to buffer solution, group discussions, technology integration (simulations, interactive apps, or online resources), inquiry-based learning (ask questions, conduct research, and explore buffer solutions on their own), use of assessments such as quizzes, tests, asking questions, etc can be used for teaching/learning the concepts of buffer solutions.

Implication to teaching (8 min)

- What did you learn from this session and how will you apply the methods used in this session in your classroom?
- What available technologies can be used to teach these concepts?
- How can you help your students benefit from this lesson?

Takeaway resources/materials

When instructing this session, use a variety of interactive teaching techniques. To help them grasp the concepts more thoroughly, you might also suggest that they use a variety of online resources, reference books, and independent practice problems.

Session 7.4: Hydrolysis of salts (2 h)

Introduction of the session (5 min)

This session contains a range of teaching and learning exercises on hydrolysis of salts, focusing specifically on salts of strong bases and weak acids. Trainees are encouraged to participate in independent brainstorming on the suggested activities and group or peer discussions.

Objectives

At the end of this session, trainees will be able to:

- plan methods of teaching hydrolysis of salts
- define hydrolysis of salts
- demonstrate haw hydrolysis of salts
- classify salts as acidic, basic, or neutral based on the nature of the cation and anion originating from the hydrolysis of salts
- explain why a salt of strong base and weak acid gives a basic solution
- apply knowledge of ion product constants and equilibrium reactions in acid-base system to calculate the pH of hydrolyzed salt solutions
- appreciate technologies that support teaching hydrolysis of salts

Activities

Brainstorm/discuss in a group on the following questions, and present your ideas to the rest

1. Individually brainstorm what you know about hydrolysis for a few minutes. (5 min)
2. Discuss with a group or peer how you can help your learners understand: (10 min)
    a. What hydrolysis of salts are?
    b. How are they classified?
3. What are the components of salt solutions? Explain how these components work and the hydrolysis of different types of salts. (15 min)
4. How can you assist your students in determining the pH of salt solutions, considering a salt of strong base and weak acid as an example? (20 min)
5. Give examples that can assist the problem solving skills of your students focusing on hydrolysis of salts of a strong base and weak acid. (15 min)
6. Discuss in groups or with your peers, how you can assist your learners by providing hands-on activities to prepare and test the pH of salts solutions in the laboratory. Focus

on accurate measurement, mixing techniques, pH determination, and data analysis to enhance practical skills. (20 min)

7. What technologies can you use to teach hydrolysis of salts concepts? (10 min)

Key points (7 min)

While teaching about hydrolysis of salts, specifically salts of a strong base and weak acid, it is important to address the following key points:

- hydrolysis is a chemical reaction in which a compound reacts with water to form two or more products.
- hydrolysis of salts of weak acids and strong bases results in the formation of a basic solution.
- Hydrolysis of salts varies based on the interaction between cations and anions in aqueous solutions.
- the general equation for the hydrolysis of salts of weak acids and strong bases is:

  Salt (cation) + Water ⇌ Hydroxide ion + Acid (anion)
- the pH of the salt solution is determined by the relative strengths of the acid and base components in the salt.
- the equilibrium constant (K_a or K_b) is important in determining the extent of hydrolysis and the pH of the solution.
- hydrolysis reactions are important in various contexts, such as in environmental science, biology, and industrial processes.
- solving problems related to the hydrolysis of salts can support understanding of the topic.

Generally, when teaching students about the hydrolysis of salts, particularly focusing on salts of strong bases and weak acids, interactive activities can enhance their understanding of acid-base reactions and pH changes in solution. By engaging students in diverse activities focused on the hydrolysis of salts, teachers can promote active learning, critical thinking, and application of theoretical concepts in practical contexts, promote a deeper understanding of acid-base reactions and pH changes in salt solution.

Implication to teaching (8 min)

- What did you learn from this session and how will you apply the methods used in this session in your classroom?
- What available technologies can be used to teach these concepts?
- How can you help your students benefit from this lesson?

Takeaway resources/materials

When instructing this session, use a variety of interactive teaching techniques. To help them grasp the concepts more thoroughly, you might also suggest that they use a variety of online resources, reference books, and independent practice problems.

Session 7.5: Acid-base indicators (2 h)

Introduction of the session (5 min)

This session include variety of teaching and learning exercises on acid-base indicators. Trainees are encouraged to engage in independent brainstorming on the suggested activities and group or peer discussions.

Objectives

At the end of this session, trainees will be able to:

- plan methods of teaching acid-base indicators
- define acid-base indicators
- prepare acid-base natural indicators from plants
- explain the role acid-base indicators are used in determining the endpoint of a titration
- describe the principle behind the color change of acid-base indicators
- give examples of common acid-base indicators and their color changes at different pH ranges
- demonstrate how to prepare natural acid-base indicators from plants
- appreciate technologies that support teaching acid-base indicators

Activities

Brainstorm/discuss in a group on the following questions, and present your ideas to the rest

1. Individually brainstorm what you know about indicators for a few minutes. (10 min)
2. Discuss how you can help your learners to understand: (20 min)
    b. what indicators are?
    c. how they are classified?
3. Discuss how you can prepare acid-base natural indicators from plants. (15 min)
4. Watch the following video: https://www.youtube.com/watch?v=2DmbnhZDqYI, and then, present what you have observed from the video. (10 min)
5. How can you assist your students in determining the pH range within which the acid-base indicators change their colors? Support your discussion by examples. (15 min)
6. Discuss in groups or with your peers, how you can assist your learners by providing hands-on activities to prepare and test the acid-base indicators in the laboratory. (15 min)
7. What technologies can you use to teach indicator concepts? (15 min)

Key points (7 min)

While teaching about hydrolysis of salts, specifically salts of a strong base and weak acid, it is important to address the following key points:

- Acid-base indicators are substances that change color in response to changes in pH, indicating the presence of acids or bases.
- Acid-base indicators can be classified into synthetic indicators, such as phenolphthalein and methyl orange and natural indicators, such as red cabbage juice, Rose petal, and onion
- Indicators change color in acidic and basic solutions. For example, phenolphthalein is colorless in acidic solutions and pink in basic solutions.
- Each indicator changes color over a certain pH range, and thus, some indicators are more suitable for measuring specific pH ranges.
- Acid-base indicators are used in laboratory for determining the end points of titrations, and for qualitative analysis
- Experimental activities using acid-base indicators can help them understand the concept and observe color changes.

- Provide real-life examples from everyday items requiring utilization of acid-base indicators, such as litmus paper used to test the pH of soil, lemon juice, or swimming pool water.

Generally, when teaching students about the acid-base indicators, interactive activities can enhance their understanding of the concepts of acid-base indicators. Visual aids (visual aids such as diagrams, charts, and videos) to help students visualize the concept of acid-base indicators and understand how they work. By engaging students in diverse activities focused on use of acid-base indicators, teachers can promote active learning, critical thinking, and application of theoretical concepts in practical contexts, promote a deeper understanding of acid-base indicators concepts.

Implication to teaching (8 min)

- What did you learn from this session?
- How will you apply the methods used in this session in your classroom?
- What available technologies can be used to teach these concepts?
- How can you help your students benefit from this lesson?

Takeaway resources/materials

When instructing this session, use a variety of interactive teaching techniques. To help them grasp the concepts more thoroughly, you might also suggest that students' use a variety of online resources, reference books, and independent practice problems.

- Acid-bases indicator test: https://www.youtube.com/watch?v=2DmbnhZDqYI
- Preparation of natural acid-base indicators from:
- Rose Petals: https://www.youtube.com/watch?v=kbh5hPtI06M&t=86s
- Red Cabbage: https://www.youtube.com/watch?v=oG-pNRVHsc4
- Beetroot: https://www.youtube.com/watch?v=aHx33L2Nlls
- Common flower: https://www.youtube.com/watch?v=zmRhXmFCpFU&t=35s
- Onion: https://www.youtube.com/watch?v=a_tP_PFbvxg&list=TLPQMDIwNDIwMjT46Z681Qcm9Q&index=9

Unit 8: Industrial Chemistry (8 h)

Introduction (5 min)

This unit of the training module is designed to assist secondary school chemistry teachers in developing a deeper understanding of industrial chemistry. The unit focuses on natural resources and industries, manufacturing valuable products such as fertilizers, pesticides, or sulfuric acid, as well as exploring some chemical industries in Ethiopia like glass, sugar, soap, and detergent.

The unit is divided into three sessions, each containing engaging activities aimed at helping trainees effectively teach the suggested concepts. It is important to encourage trainees to actively participate, either individually or in groups, to solve the activities. This will help them become familiar with different teaching and learning methods based on their prior experiences and the discussions held during each session's activities. This unit is taken from Grade 12 (Unit 3).

Objectives

At the end of this unit, trainees will be able to:

- comprehend how to teach various industrial chemistry concepts
- familiarize with the natural resources and industry
- understand how manufacturing valuable products such as fertilizers, pesticides or sulfuric acid are produced in the industry
- identify some chemical industries in Ethiopia
- comprehend the importance of industrial chemistry to human life
- develop the scientific enquiry skills of the trainees

Session 8.1: Natural resource and industry (1:55 h)

Introduction of the session (5 min)

This session includes a variety of teaching and learning exercises on natural resources. Trainees are encouraged to engage in independent brainstorming on the suggested activities and group or pair discussions.

Objectives

At the end of this session, trainees will be able to:

- propose methods of teaching natural resources and industry
- define natural resources
- identify different types of natural resources
- classify chemical industries based on the raw materials they are using
- classify chemical industries based on the type of product they manufactured
- describe the applications of minerals in industry
- apply technologies that support teaching natural resources and industry

Activities

Brainstorm/discuss in a group on the following questions, and present your ideas to the rest

1. Write in your notebook at least five things that you know about natural resources. (15 min)
2. Discuss with a group or pair how you can help your learners understand the classification of natural resources. (20 min)
3. Discuss how your students understand the chemical industry, its classification, and the raw materials used for producing required products. (20 min)
4. Watch the following video at https://www.youtube.com/watch?v=CXCT2R1K6Ts, and then, share your observations from the video. (20 min)
5. What technologies can be used to teach natural resource and industry concepts? (20 min)

Key points (7 min)

When teaching the concepts of natural resources and industry, it is important to address the following key points:

- Natural resources are materials or substances that occur in nature and can be used for economic gain or to meet human needs.

- Natural resources are classified into two: renewable (e.g., solar energy, wind power, timber) and non-renewable (e.g., fossil fuels, minerals) resources.
- Industry is a type of economic activity that converts raw materials into usable products.
- Industries rely on natural resources as raw materials for manufacturing products and providing services.
- Different industries such as agriculture, mining, forestry, energy, and manufacturing sectors utilize natural resources to produce goods and generate economic growth.
- Balancing industrial development with environmental conservation is crucial to prevent resource depletion, pollution, and ecosystem degradation.
- The extraction and utilization of natural resources can lead to environmental degradation, habitat destruction, and climate change.
- Learning about natural resources and industries can inspire students to explore their career paths in environmental science, conservation, renewable energy, sustainable agriculture, forestry, and green technology sectors.

While teaching natural resource and industry concepts teachers can allow their students define natural resources and industry; explore types of natural resources; discuss the importance of natural resources; explain the impact of industry on natural resources; introduce different industries, analyze the interdependence of natural resources and industry; explore case studies (case studies can help students understand real-world challenges and solutions), engage students in projects and foster critical thinking and problem-solving.

Implication to teaching (8 min)

- What did you learn from this session?
- How will you apply the methods used in this session in your classroom?
- What available technologies can be used to teach these concepts?
- How can you help your students benefit from this lesson?

Takeaway resources/materials

When instructing this session, use a variety of interactive teaching techniques. To help them grasp the concepts more thoroughly, you might also suggest that students use a variety of online resources, reference books, and independent practice problems.

- Types of Natural Resources: https://www.youtube.com/watch?v=CXCT2R1K6Ts

Session 8.2: Some chemical industries valuable products (fertilizers) (3 h)

Introduction of the session (5 min)

This session includes a variety of teaching and learning exercises on manufacturing valuable products focusing on nitrogen fertilizers and natural compost. Trainees are encouraged to engage in independent brainstorming on the suggested activities and group or peer discussions.

Objectives

At the end of this session, trainees will be able to:

- propose methods of teaching manufacturing valuable products in industry
- explain the methods and chemical processes involved in manufacturing fertilizers
- describe the properties, compositions, and formulations of common nitrogen fertilizers
- analyze how nitrogen fertilizers contribute to crop yield increase, plant growth promotion, and soil nutrient replenishment
- apply Indigenous knowledge to produce natural compost
- apply technologies that support teaching manufacturing valuable products

Activities

Brainstorm/discuss in a group on the following questions, and present your ideas to the rest

1. List chemical industries that you know of in your area or Ethiopia. (25 min)
2. Discuss how you can help your learners to understand methods and chemical processes used in the manufacture of nitrogen fertilizer. (25 min)
3. Discuss the properties, formulations, classifications, and the raw materials used for the production of required products. (20 min)
4. Explain how nitrogen fertilizers provide the essential nutrient for plant growth. (20 min)
5. Discuss the role of nitrifying bacteria in the reaction of nitrogen-based fertilizers. (20 min)
6. Watch the video at https://www.youtube.com/watch?v=eFlhYS-_tpY, share your observation to your peers. (20 min)

7. What technologies can you use to teach fertilizer concepts? (20 min)

Key points (10 min)

When teaching the concepts of manufacturing valuable products focusing on nitrogen fertilizers and natural compost, it is important to address the following key points:

- Nitrogenous fertilizers comprises anhydrous ammonia, urea, urea-ammonium nitrate (UAN) solutions and diammonium monohydrogen Phosphate $(NH_4)_2HPO4$ (DAP)
- Nitrogenous fertilizer influences crop growth in many ways. It encourages the development of foliage, imparts a green color to leaves. In cereals, it tends to produce lumpiness in seeds and it tends to produce succulence or tenderness in the plant.
- Natural compost is formed by the natural decomposition process of organic matter to produce nutrient-rich soil conditioner.
- Natural compost is advantageous in improving soil structure, enhancing water retention, and providing essential nutrients for plant growth.
- Conversion of food scraps and yard waste from landfills to compost can play a great role in management of wastes.

Learning about manufacturing valuable products focusing on nitrogen fertilizers and natural compost can inspire students to gain a comprehensive understanding of the agricultural practices, and sustainable approaches involved in producing valuable products for soil fertility and plant nutrition. teachers are expected to allow students define nitrogen fertilizers and natural compost; explain the importance of nitrogen for plant growth; describe the manufacturing process of nitrogen fertilizers; explain the production of natural compost; compare the benefits of nitrogen fertilizers and natural compost; emphasize the environmental concerns associated with excessive nitrogen fertilizer use, such as water pollution and greenhouse gas emissions; explore case studies (eg case studies on the use of natural compost in organic farming and gardening); and engage students in projects (eg conduct experiments to demonstrate the effects of nitrogen fertilizers and natural compost on plant growth) and foster critical thinking and problem-solving (encourage students to evaluate the pros and cons of nitrogen fertilizers and natural compost).

Implication to teaching (10 min)

- How will you apply the methods used in this session in your classroom?
- What available technologies can be used to teach these concepts?

Takeaway resources/materials

To help them grasp the concepts more thoroughly, you can suggest that students' use a variety of online resources, reference books, and independent practice problems.

- Make kitchen waste compost easily at home: https://www.youtube.com/watch?v=eFlhYS-_tpY

Session 8.3: Some chemical industries in Ethiopia (3 h)

Introduction of the session (5 min)

This session includes a variety of teaching and learning exercises on some chemical industries in Ethiopia, focusing on soap and detergents. Trainees are encouraged to engage in independent brainstorming on the suggested activities and group or peer discussions.

Objectives At the end of this session, trainees will be able to:

- list some manufacturing industries in Ethiopia
- describe terms such as soap, detergent, saponification, hard soap and soft soap.
- explain the difference between soap and detergents
- outline the important steps in the production of soaps and detergents
- identify the materials which are required for the preparation of soaps and detergents
- write an equation to represent the formation of a soap
- develop the skill of preparation of soaps and detergents
- apply technologies that support teaching preparation of soaps and detergents

Activities

Brainstorm/discuss in a group on the following questions, and present your ideas to the rest

1. Take a few minutes to brainstorm what you know about soap and detergents, and then, share your idea with your peers. (20 min)
2. Discuss how you can help your learners understand terms like *soap*, detergent, saponification, hard soap and soft soap. (30 min)
3. Discuss how your students understand the important steps in the production of soaps and detergents. (30 min)
4. How could you help students to understand the difference between soaps and detergents? (20 min)
5. After watching the following videos at: https://www.youtube.com/watch?v=Nxkjn-XhgE0, and https://www.youtube.com/watch?v=5gjWtGDjDX8, Share your observation to your peers. (30 min)
6. What technologies can you use to teach these concepts? (20 min)

Key points (15 min)

Soap and detergent concepts are difficult for students to understand. Some common misconceptions on soap and detergent concepts are:

- soap and detergent are the same thing
- soap can be used in any water
- more soap or detergent is better
- all soaps and detergents are biodegradable
- all soap and detergent kill bacteria
- soap and detergent are safe for all fabrics
- all soaps and detergents are equally effective

When teaching the concepts of some chemical industries in Ethiopia focusing soap and detergent, it is important to address the following key points:

- **Soaps and detergents are substances** that, when dissolved in water possess the ability to remove dirty from surfaces such as the human skin, textiles, and other solids.
- Soaps are the potassium or sodium salts of long-chain fatty acids and detergents are generally alkyl benzene sulfonates.
- Soaps are potassium or sodium salts of a carboxylic acid having a long aliphatic chain attached to it.
- Soaps are generally prepared via the saponification of fats and oils.
- The carboxylate end of the soap molecule is hydrophilic whereas the hydrocarbon tail is hydrophobic.
- Detergents are the potassium or sodium salts of a long alkyl chain ending with a sulfonate group. They are soluble in hard water
- Soap is produced industrially in four basic steps, including

  Step 1: Saponification: a mixture of tallow (animal fat) and coconut oil is mixed with sodium hydroxide and heated. The soap produced is the salt of a long chain carboxylic acid.

  $$\text{Fat} + 3\text{NaOH} \rightarrow \text{glycerine} + 3\ \text{soap}$$

  Step 2: Glycerine removal: glycerine is more valuable than soap, so most of it is removed. Some is left in the soap to help make it soft and smooth. Soap is not very soluble in salt water, whereas glycerine is, so salt is added to the wet soap causing it to separate out into soap and glycerine in salt water.

  Step 3: Soap purification: any remaining sodium hydroxide is neutralized with a weak acid such as citric acid and two thirds of the remaining water removed.

  Step 4: Finishing: Additives such as preservatives, colour and perfume are added and mixed in with the soap and it is shaped into bars for sale.
- Depending upon the nature of alkali used in the production of soap, they are classified into two types.

  Hard soap: sodium salt of long chain fatty acid. It is difficult to dissolve in water.

  Soft soap: potassium salt of long chain fatty acid is known as soft soap, as it produces
- A soap molecule consists of two parts: a long chain hydrocarbon tail and an hydrophilic dead
- Cleansing action of soaps: when soap is added to an oily or greasy part of cloth, the hydrocarbon part of soap dissolves in oil, keeping the head away from the oil. Big

molecules of oil and soap break by rubbing into small emulsified oil droplets in water, which are washed away by stream of water. The soap molecules which form micelles assist in dissolving the dirt in water, thus, we can wash our clothes

Generally, when teaching students about the manufacturing of soap and detergent, interactive activities can enhance their understanding of the concepts of manufacturing of soap and detergent. Visual aids (visual aids such as diagrams, charts, and videos) to help students visualize the concept. By engaging students in diverse activities focused on use of soap and detergent preparation, teachers can promote active learning, critical thinking, and application of theoretical concepts in practical contexts, promote a deeper understanding of soap and detergent concepts.

Implication to teaching (10 min)

- How will you apply the methods used in this session in your classroom?
- What available technologies can be used to teach these concepts?
- How can you help your students benefit from this lesson?

Takeaway resources/materials

When instructing this session, use a variety of interactive teaching techniques. To help them grasp the concepts more thoroughly, you might also suggest that students' use a variety of online resources, reference books, and independent practice problems.

Online resources

- Saponification of fats and oils; soaps and detergents: https://chem.libretexts.org/Courses/Brevard_College/CHE_301_Biochemistry/03%3A_Lipids/3.06%3A_Saponification_of_Fats_and_Oils_Soaps_and_Detergents
- Difference between soap and detergent:https://byjus.com/chemistry/difference-between-soap-and-detergent/

Videos

- Saponification: https://www.youtube.com/watch?v=Tu_sWoHULtY
- Cleansing action of soap: https://www.youtube.com/watch?v=Nxkjn-XhgE0
- Cleansing action of soaps and detergents: https://www.youtube.com/watch?v=5gjWtGDjDX8

Unit 9: Introduction to Environmental Chemistry (8 h)

Introduction (5 min)

This unit of the training module aims to assist secondary school chemistry teachers establish a proper understanding of environmental chemistry concepts. Specifically, is focuses on environmental pollution, global warming and climate change, green chemistry and cleaner production.

Various activities are provided in each session to engage trainees in teaching the suggested topics. It is essential to motivate the trainees (teachers) to discuss either individually or in groups. This will help them develop different instructional approaches based on their previous experiences and the discussions held on the suggested activities in each session. The topic is taken from grade 12 Chemistry (unit 5).

Objectives

At the end of this unit, trainees will be able to:

- be familiar with ways of teaching environmental chemistry concepts
- understand environmental chemistry
- comprehend the components that make the environment
- be familiar with environmental pollution
- comprehend global warming and climate change
- describe the principle of green chemistry and cleaner production
- appreciate teaching and learning of environmental chemistry concepts.
- develop the scientific enquiry skills.

Session 9.1: Environmental pollution-focus on air, water and land/soil pollution (2:55 h)

Introduction (5 min)

This session aims to support secondary school teachers in teaching about environmental pollution by presenting a variety of activities that utilize mixed learning and teaching methodologies. As a result, trainees should engage in group or pair discussions about the recommended activities or brainstorm ideas on their own.

Objectives

At the end of this session, trainees will be able to:

- use different methods to teach environmental pollution h
- explain environmental pollution
- explain causes of air, water and land pollution.
- describe some of the methods used to reduce air, water and land pollution
- propose safe method of disposing non-biodegradable wastes
- recommend method of preventing pollution caused by over use of fertilizers
- describe how pollutants can affect human health
- develop scientific enquiry skills
- use available technology in teaching pollution concepts.

Activities

Brainstorm/discuss in a group on the following questions, and present your ideas to the rest

1. Discuss on the causes of air pollution in detail and reflect on the points you raised. (20 min)
2. What are the principal sources of contamination of surface water and groundwater? (20 min)
3. Discuss on the causes of water pollution in detail and reflect on the points you raised. (15 min)
4. Discuss on the causes of soil/land pollution in detail and reflect on the points you raised. What should be your responsibility in solving the land pollution problems? (20 min)
5. What misconceptions or alternative conceptions do students have on pollution (air, water and soil)? (15 min)
6. How can you apply the chemistry triangle concept of Johnstone, Animation, Simulations, virtual labs, video, etc. to teach pollution (air, water and soil)? (15 min)
7. How can technologies assist you in helping learners understand pollution (air, water and soil) with ease? (20 min)

8. After watching pollution (air, water and soil) videos at: https://www.youtube.com/watch?v=TXSK7Qvmlps, https://www.youtube.com/watch?v=Zk1J2EW-nmQ https://www.youtube.com/watch?v=Cy6W5fHPBLg, reflect on what you learned. (20 min)
9. How do you assess and help your students' understanding on pollution (air, water and soil) properly? (10 min)

Key points (10 min)

Air, water, and land pollution concepts are not easy to comprehend. Misconceptions about air, water, and soil/land pollution include:

- air pollution is only a problem in urban areas
- air pollution is only caused by visible sources like factories and vehicles
- air pollution is a localized problem that only affects those living near pollution sources
- air pollution only affects the respiratory system
- air pollution only affects outdoor air quality
- water pollution only affects aquatic life
- water pollution is only caused by industrial sources
- water pollution is only a problem in developing countries
- water pollution is easily reversible
- water pollution only impacts surface water bodies like rivers and lakes
- land pollution is only caused by littering and dumping waste
- land pollution only affects the appearance of the environment
- land pollution is a localized problem that does not have global impacts
- land pollution can be easily remediated or reversed
- land pollution only affects rural areas or industrial sites.

Teaching air, water, and land pollution concepts at three levels of chemistry understanding (macro, sub-micro, and symbolic) can help students develop a comprehensive understanding.

- At the macro level, it is possible to focus on the observable properties and behaviors of substances in the environment. For air pollution, students can investigate the effects of

pollutants on air quality by measuring particulate matter, gases, and pollutants in the atmosphere using sensors or monitoring devices. For water pollution, students can analyze water samples from different sources (e.g., rivers, lakes, tap water) to identify contaminants such as heavy metals, and pesticides. For land pollution, students can study soil samples from polluted sites to observe changes in soil texture, color, and composition due to contaminants.

- At the sub-Micro Level, it is possible to explore the interactions and transformations of particles and molecules at the molecular and atomic scale.
- At the symbolic Level, it is possible to use chemical symbols, equations, and models to represent chemical reactions and processes. For air pollution, students can write balanced chemical equations for combustion reactions that produce air pollutants like carbon monoxide, sulfur dioxide, and nitrogen oxides. For water pollution, students can create chemical equations to illustrate the transformation of contaminants in water, such as the hydrolysis of pesticides or the oxidation of organic pollutants by ozone. For land pollution, students can use chemical formulas to represent the structure of common pollutants like heavy metals, persistent organic pollutants, and industrial chemicals found in contaminated soil.

Implication to teaching (5 min)

- What did you learn from this session and how will you apply the methods used in this session in teaching factors affecting chemical equilibrium?
- What available technologies can be used to teach factors affecting chemical equilibrium?
- How can you help your students benefit from this lesson?

Takeaway resources/materials

Different resources can be used to help learners easily understand Pollution concepts. These resources include describing factors affecting chemical equilibrium at three levels of chemistry understanding, experiments, simulations, animations, demonstrations, virtual labs, videos, etc.

- Pollution (air, water and soil) videos at:

https://www.youtube.com/watch?v=TXSK7Qvmlps,
https://www.youtube.com/watch?v=Zk1J2EW-nmQ, and
https://www.youtube.com/watch?v=Cy6W5fHPBLg**Session 9.2: Global warming and climate change (3 h)**

Introduction (5 min)

This session is designed to help chemistry teachers understand how to teach secondary school students about global warming and climate change. It is crucial to encourage teachers to engage in the proposed activities, either individually or in groups. Participants are encouraged to brainstorm and discuss effective teaching methods for this topic.

Objectives

At the end of this session, trainees will be able to:

- use different methods to teach global warming and climate change
- describe global warming and climate change from the perspective of chemistry
- list the common greenhouse gases
- explain greenhouse gases and greenhouse effect
- discuss about the chemistry of greenhouse gases related to global warming
- develop scientific inquiry skills
- use available technology in teaching pollution concepts.

Activities

Brainstorm/discuss in a group on the following questions, and present your ideas to the rest

1. Explain the difference between global warming and climate change. How are they related? (10 min)
2. How do human activities and industrial byproducts contribute to global warming and climate change? Provide examples of specific actions that lead to these phenomena. (10 min)
3. What are the potential consequences of global warming and climate change on ecosystems, wildlife, and human populations? (10 min)
4. How can individuals alleviate the effects of global warming and climate change in their daily lives? (15 min)

5. What role do governments and international organizations play in addressing global warming and climate change? Are current policies and initiatives effective in combating these issues? (15 min)
6. In recent years in Ethiopia, the Green legacy has been practiced in the country. What is the relationship between the Green legacy, Global warming and climate change? What other methods are used to capture CO_2 from the atmosphere? (20 min)
7. How can advancements in technology and innovation help combat global warming and climate change? Provide examples of sustainable solutions. (15 min)
8. What misconceptions or alternative conceptions do students have on global warming and climate change? Use your teaching experience to explain each misconception. (20 min)
9. How can you apply the chemistry triangle concept, Animation, Simulations, virtual labs, video, etc. to teach global warming and climate change? (20 min)
10. How can technologies assist you in helping learners understand global warming and climate change with ease? (10 min)
11. After watching global warming and climate change videos at: https://www.youtube.com/watch?v=Z_b2A-d5hGY https://www.youtube.com/watch?v=3ojaDMadZXU, reflect on what you learned. (15 min)

Key points (10 min)

There are understanding problems on global warming and climate change concepts. Students may have various misconceptions regarding global warming and climate change due to the complex and multifaceted nature of these environmental issues. Some common misconceptions include:

- global warming and climate change are the same thing
- climate change is a natural phenomenon and not influenced by human activities
- individual actions don't matter to address climate change
- climate change will only result in warmer temperatures
- the Earth has always experienced climate change, so the current changes are not concerning
- technology alone can solve global warming.

The chemistry triangle concept of Johnstone, which emphasizes the interconnectedness of macro, sub-micro, and symbolic representations in teaching chemistry, can be effectively applied to teach global warming and climate change.

- At the macro-level, it is possible to start by introducing students to the macroscopic manifestations of global warming and climate change, such as rising global temperatures, melting ice caps, extreme weather events, and shifting ecosystems. Also, it is possible to use real-world examples and visual aids to help students understand the observable impacts of these phenomena on the environment and society.
- At the sub-micro, it is possible to go deeper (using diagrams, and models) into the sub-microscopic level to explore the underlying science behind global warming and climate change.
- At the symbolic level, it is possible to connect the macro and sub-micro levels through symbolic representations, such as chemical equations. Using symbols and formulas to illustrate key concepts, such as the carbon cycle, the greenhouse effect, and the mechanisms of climate change is necessary.

Implication to teaching (5 min)

- What did you learn from this session and how will you apply the methods used in this session in teaching global warming and climate change?
- What available technologies can be used to teach global warming and climate change?

Takeaway resources/materials

Different resources can be used to help learners easily understand global warming and climate change concepts. These resources include describing global warming and climate change at three levels of chemistry understanding, experiments, simulations, animations, demonstrations, virtual labs, videos, etc.

- global warming and climate change videos at: https://www.youtube.com/watch?v=Z_b2A-d5hGY, https://www.youtube.com/watch?v=3ojaDMadZXU

Session 9.3: Green chemistry and cleaner production (2 h)

Introduction (5min)

This session aims to help chemistry teachers understand how to teach *green chemistry and cleaner production* concepts to secondary school students. It is important to motivate the teachers to engage in the suggested activities either individually or in groups. Trainees are expected to brainstorm and discuss effective methods they have used for teaching this topic.

Objectives

At the end of this session, trainees will be able to:

- employ different methods to teach environmental pollution
- explain the terms green chemistry and cleaner production
- discuss on the major principles of green chemistry and cleaner production
- elucidate the importance of cleaner production
- explain atom economy
- calculate the atom economy based on the given chemical reaction
- apply green chemistry principles while doing laboratory activities
- apply the atom economy principle during designing chemical reactions
- develop scientific enquiry skills
- use available technology in teaching green chemistry and cleaner production concepts.

Activities

Brainstorm/discuss in a group on the following questions, and present your ideas to the rest

1. Give examples of a green chemistry solution that involve safer chemicals.(10 min)
2. Explain what cleaner production means. Which principle of green chemistry best explains in cleaner production? Discuss the concept of green chemistry principles and how they influence the design and optimization of cleaner production processes. Reflect on the points you raised during the discussion. (15 min)
3. Discuss or debate on the importance of cleaner production in addressing global environmental challenges. Reflect on the points you raised during the discussion or debate. (10 min)
4. What misconceptions or alternative conceptions do students have on *green chemistry and cleaner production* concepts? Use your teaching experience to explain each misconception. (13min)

5. How can you apply the chemistry triangle concept of Johnstone (Macro, sub-micro-, and symbolic levels), Animation, Simulations, virtual labs, video, etc. to teach *green chemistry and cleaner production* concepts? (12 min)
6. How can technologies assist you in helping learners understand *green chemistry and cleaner production* concepts with ease? (10 min)
7. After watching *green chemistry and cleaner production* concepts videos at:https://www.youtube.com/watch?v=k3bdjfdjy1c&list=PLSzaGxYuUEf63gvQkT0JUmltCSzQwBrKn&index=2, https://www.youtube.com/watch?v=2M1XBJeY7ak&list=PLSzaGxYuUEf63gvQkT0JUmltCSzQwBrKn&index=3, https://www.youtube.com/watch?v=I-I02nSXfXs&list=PLSzaGxYuUEf63gvQkT0JUmltCSzQwBrKn&index=4, https://www.youtube.com/watch?v=IFpd7J63WDk, https://www.youtube.com/watch?v=xNBu-a0-Nic and https://www.youtube.com/watch?v=b0MHNxxWQjM reflect on what you learned. (20 min)
8. How can you assist learners in understanding *green chemistry and cleaner production* concepts properly? Explain. (10 min)

Key points (10 min)

There are understanding problems in green chemistry and cleaner production concepts. Misconceptions about green chemistry and cleaner production include:

- green chemistry is only about using green-colored chemicals
- green chemistry is only for scientists and chemists
- green chemistry is not important for everyday life
- green chemistry is not relevant to career opportunities
- green chemistry is only about using natural products
- cleaner production is only relevant for large industries
- green chemistry and cleaner production are costly and not economically viable
- green chemistry and cleaner production are only relevant to chemical industries.

Teaching green chemistry and cleaner production concepts at three levels of chemistry understanding (macro, sub-micro, and symbolic) can help students develop a comprehensive understanding.

- At the macro level (Observable Phenomena), it is possible to conduct hands-on experiments that demonstrate the principles of green chemistry, such as recycling, energy efficiency, and waste reduction. It is possible to organize field trips to environmentally friendly facilities or laboratories to showcase sustainable practices in action. Multimedia resources, such as videos or simulations, can be used to illustrate how cleaner production processes impact the environment and society on a larger scale.
- At the sub-micro Level (Molecular Level), it is possible to use molecular models to illustrate the structure of chemicals and how they interact in green chemistry processes. It is necessary to discuss the properties of green solvents, catalysts, and renewable materials at the molecular level to emphasize their environmental benefits.
- At the symbolic Level (Chemical Equations and Symbols), it is possible to introduce students to green chemistry principles through chemical equations that highlight efficient reactions, minimal waste generation, and non-toxic products. Engaging students in creating their own symbolic models or flowcharts to illustrate the steps involved in implementing cleaner production strategies is necessary to increase their understanding.

Implication to teaching (5 min)

- What did you learn from this session and how will you apply the methods used in this session in teaching green chemistry and cleaner production?
- What available technologies can be used to teach green chemistry and cleaner production?

- How can you help your students benefit from this lesson?

Takeaway resources/materials

Different methods can be used to help learners easily understand green chemistry and cleaner production concepts. These methods include describing green chemistry and cleaner production concepts at three levels of chemistry understanding, experiments, simulations, animations, demonstrations, virtual labs, videos, etc.

Green chemistry and cleaner production concepts videos at:

- https://www.youtube.com/watch?v=X9GHBdyYcyo&list=PLSzaGxYuUEf63gvQkT0JUmltCSzQwBrKn
- https://www.youtube.com/watch?v=k3bdjfdjy1c&list=PLSzaGxYuUEf63gvQkT0JUmltCSzQwBrKn&index=2
- https://www.youtube.com/watch?v=2M1XBJeY7ak&list=PLSzaGxYuUEf63gvQkT0JUmltCSzQwBrKn&index=3, https://www.youtube.com/watch?v=I-I02nSXfXs&list=PLSzaGxYuUEf63gvQkT0JUmltCSzQwBrKn&index=4
- https://www.youtube.com/watch?v=IFpd7J63WDk, https://www.youtube.com/watch?v=xNBu-a0-Nic, https://www.youtube.com/watch?v=b0MHNxxWQjM , https://www.youtube.com/watch?v=j-7amZS4etQ

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Part II – Educational Technology

Part II – Educational Technology

Introduction

This Educational Technology training manual is developed by EdTech Hub ET in collaboration with the Ministry of Education (MOE) to empower general education teachers to leverage technology effectively in their teaching and learning practices. Built upon the UNESCO ICT Competency Framework for Teachers (2018), MoE Digital Competency Framework and the TPACK model of technology integration as its conceptual framework, the manual provides practical guide on how to integrate technology in secondary school teachings. Further contextual factors have been considered, and several consultative workshops were conducted to develop the material.

This professional development resource aims at entrenching digital literacy in teaching and learning, equipping teachers, and learners with ICT skills, and enhancing their capacity to use technology in their day-to-day activities. Above all, it helps teachers to consider and use any locally available technologies for teaching and learning purposes.

The manual helps teachers and practitioners in secondary schools to practice creative use of technology in their classrooms. However, the material is not a comprehensive how-to guide, rather it provides initial possible strategies and practical exercises for schools to consider integrating technology in their lessons. Teachers are encouraged to further explore on EdTech subjects to have a detailed knowledge and skills in their efforts to leverage technology in their lessons through participating in continuous professional development activities.

The first unit of the material details educational technology related concepts, locally available digital resources and their practical implication at the school level. The second unit looks at the basic digital skills needed in our daily life which encompasses through navigating computer and smartphones, connecting to the internet, using the worldwide and web and google educational apps. The subsequent units' contents (units three through five) are intended to help teachers explore various digital tools and resources that will assist them in incorporating technology into their lessons. The emphasis has been on how to help teachers improve both subject knowledge and digital literacy simultaneously. Each unit's sessions feature practical suggestions for the classroom and out-of-school practices, as well as explorations of free web-based resources and activities for preparing. The final unit focuses on the safety and security procedures that should be implemented when using digital resources and working online to preserve teacher data and safety.

The module is suitable for both new and experienced general education teachers, offering comprehensive coverage of essential topics such as an introduction to educational technology, digital technology tools, open educational resources, and digital citizenship. To fully grasp the material, participants can expect to invest approximately two full days in face-to-face setting or two weeks of online teaching in completing the course.

Pedagogical Approach

The pedagogical approach employed in developing this module aligns with the experiential learning model**.** Learners actively engage with new information through a variety of interactive methods, including discussions, demonstrations, question-and-answer sessions, and other activities. These experiences serve as the foundation for their learning journey, providing concrete encounters that facilitate understanding.

After these initial experiences, learners enter a reflective phase. During this stage, they contemplate their encounters, draw connections to existing knowledge, and conceptualize the newly acquired concepts. Often, this reflective process leads to the understanding of the educational implication and development of novel ideas based on their experiences. Finally, learners are encouraged to engage in a self-assessment to measure and test their understanding and skills within their own context, reinforcing the learning process.

The sessions within this module are thoughtfully organized. They include a brief introduction to the topic, expected learning outcomes, specific activities, key ideas, implications for learning, and takeaways. Teachers are prompted to respond to key questions and note down activity points for future reference. Consider recording these insights in your portfolio using the provided handout. This structured approach serves as a quick reference for understanding digital literacy and its practical application in teaching and learning. The key ideas highlight essential information related to the topic, enabling educators to apply their learning effectively. Additionally, supplementary reading resources are provided for offline activities and further practice. Overall, this process reflects the experiential model of learning.

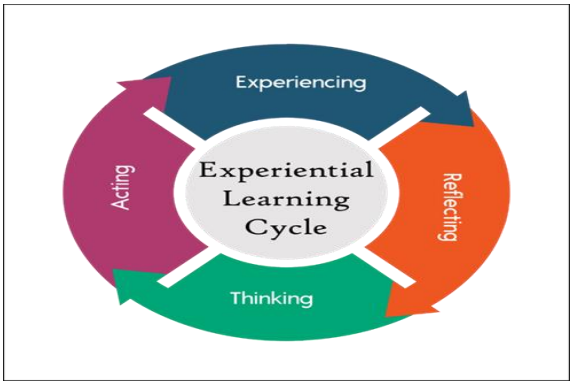


Figure 1: Experiential Learning Cycle; Source: Bing

Training Delivery Methods

In this digital skills training, we leverage a variety of online platforms to facilitate our sessions. Engaging in numerous activities across these platforms offers dual advantages. Firstly, it enhances the interactivity and user-friendliness of our training sessions. Secondly, it grants participants hands-on experience with diverse educational tools, which they can then seamlessly integrate into their teaching practices upon returning to their respective schools. Facilitators are advised to familiarize themselves with these digital tools in advance, ensuring a smooth guidance process for the participants. Facilitators are also required to complete the online EdTech course in advance as it enables them practice with different online training tools and the content of the training. A link to the online training is provided in unit five of this material.

Materials needed to during the Training

As a trainee, you'll require a copy of the trainees' guide (this document), a general lesson plan for each day and an accompanying PowerPoint slideshow to deliver this course. During the training, refer to the relevant slides in the manual. Many of the notes from the manual are also included directly in the slides. Ensure that participants have access to an internet connection for optimal course delivery. Some parts of the course will require participants to use a computer (PC or laptop) with a slideshow program and internet access. Encourage participants to bring tablets or smartphones. Ideally, all participants should have smartphones, but if not, at least one internet-connected tablet or smartphone should be available in each group setting, as practical exercises are an integral part of the course.

Before starting the course, create a working Telegram Group among participants. The group page will serve as our online dashboard for sharing documents and information. We strongly recommend utilizing all available digital resources during course delivery and minimizing paper use.

Learning Outcomes

After completing this module, you will be able to:

- Explain importance of educational technology and its applications their subjects.
- Design technology enhanced lesson plans that can address specific learning objectives.
- Take advantage of locally available digital tools to increase student engagement and active participation.

- Engage in different online and offline educational tools to enhance students' learning outcomes and professional development.
- Use digital resources safely and securely to ensure operational efficiency and data security.

Total Allotted Time to Each Unit (Face-to-Face)

S/N	Unit	Content	Number of Sessions	Allotted Time	Remark
1	One	Understanding Educational Technology	Two	1hr 5'	
2	Two	Basic Digital Skills	Two	1hr 10'	
3	Three	The use of social media for Education Purpose	One	1hr 25'	With practice
4	Four	Online Educational Tools	Three	3hr 20'	With practice
5	Five	Accessing and Creating Digital Content	Three	3hr 50'	With Practice
6	Six	Digital Citizenship	Two	1hr 10'	

UNIT ONE: UNDERSTANDING EDUCATIONAL TECHNOLOGY

Introduction

This unit provides you with a set of activities designed to explore the concept of educational technologies and digital literacy. It supports you to understand digital literacy in light of its implications for classroom teaching and learning. You will delve into the concept of educational technology and discuss its impact on how students learn and how you can teach. In addition, you will also explore any possible technologies available in their local areas. Further, it will enable you to explore the concept of Teaching and Larning Using Locally Available Resource (TALULAR) as a framework for identifying technology-based learning resources. This includes digital resources within your schools and towns, tech-savvy colleagues, and even relevant institutions. Think of this session as a springboard for seamlessly integrating technology into your learning environments.

Learning Objectives

At the end of this unit, you will be able to:

- Explore digital resources in your school and consider their use for teaching and learning activities.
- Explain the concept of educational technology and its application in teaching and learning practices.
- Identify key digital literacy skills and its implication for teaching and learning.

Key Topics

Session One: Locally available digital resources and their function

Session Two: The concept of educational technology and digital literacy

Session One: Locally available digital resources and their function.

Introduction

This session contains activities that are designed to provide you with an opportunity to explore any possible technologies available in your school and local areas. It will provide a useful starting point to think of using locally available digital resources in your classroom instruction and professional development. They will further explore the concept of TALULAR for technology-related learning resources. TALULAR is an acronym that stands for Teaching and

Learning Using Locally Available Resources. There are different technological resources available in your local context that can be used for teaching and learning. These resources might include any digital resource in your schools.

Activity 1.1. Individual Task (10 minutes)

Individually, list down all digital resources you might know and their possible uses in our daily lives. Consider how technologies are being used in your town, country, and the world at large.

NB: Use Slido/Menti.com to respond (your facilitator will give you a link to Slido.com or Menti.com). After all your peers share their answers on a link shared by your trainer a word cloud will be created as shown figure 1.

Facilitator Notes

Generate a link to https://www.slido.com/ or https://www.mentimeter.com/ and distribute it to participants. Then direct them to submit their responses via the chosen platform. They will also learn how to create word clouds and use the platforms by doing so. In the event of offline sessions or connectivity issues, provide participants with sticky notes to jot down their responses.

You can create a word cloud like the below one through different online tools like menti.com, kahoot.it, and other related apps. Step-by-step guidelines have been provided in the digital tools' session.

Figure 2: Word Cloud

Activity 1.2. Group Discussion on your digital experience (15 minutes)

In groups of four to six, share your experience of using digital content or resource in your classroom or elsewhere for teaching and learning purpose.

- What was the topic of your lesson?
- How you use digital content or digital resource?
- How do you prepare or from where did you get the content or the resource?

NB: Share your response to the wider team (whole class) through one of the interactive online tools or use a flipchart to share your group discussion.

Facilitator Notes

Provide participants with a link to an online collaboration dashboard, such as Padlet or Jamboard, and instruct them to post their group discussions on the platform. In cases of connectivity issues, participants may use a flipchart to present their discussions. However, they are encouraged to utilize digital platforms for their presentations to foster creativity. Emphasizing the educational benefits of technology, such as reducing paper usage, encourages participants to employ all available digital resources to disseminate their discussion outcomes. For instance, they could photograph their discussion and upload it to the Telegram group page. The facilitator can then display these images via a projector for the entire class to view.

Activity 1.3. Explore Digital Experience of a Teacher (15 minutes)

Case Story 1

At Sendafa Secondary School, Mr. Menberu, a dedicated physics teacher, sought to enhance student engagement through interactive learning. Despite resource constraints, his ambition to incorporate technology into his teaching led him to utilize locally available digital tools. Mr. Menberu identified several underused assets within the school, including desktop computers, plasma TVs, tablets, and his personal smartphone. Conversations with the school principal, Mr. Aman, and the ICT teacher, Mr. Naol, revealed that these tools could be effectively employed for educational purposes with minimal maintenance. Recognizing Mr. Menberu's enthusiasm, the school also provided him with complimentary Wi-Fi access to facilitate the use of online educational resources. To Mr. Menberu's surprise, he discovered that many students had access to smartphones and TVs at home. After assessing all available digital resources, he collaborated with Mr. Naol and his department colleagues to devise strategies for leveraging these technologies to make physics more engaging and understandable. Mr. Menberu's initiatives included:

- ✓ ***Establishing a Telegram group for his class to distribute educational content and maintain communication with students and parents.***
- ✓ ***Offering downloadable video lectures for students to view on any accessible device.***
- ✓ ***Encouraging students to engage with educational TV programs, providing them with specific channel recommendations.***
- ✓ ***Introducing students to physics simulations via the PhET app in the school's digital hub.***
- ✓ ***Utilizing the classroom's plasma TVs to display images and videos that complemented his lessons.***
- ✓ ***Creating PowerPoint presentations to further enrich his teaching materials.***

Mr. Menberu's Educational Technology use not only revitalized his physics lessons but also ignited a newfound appreciation for the subject among his students. The positive shift in student performance was evident, and his classroom soon became an exemplar for

fellow educators, inspiring them to harness the power of technology in their teaching practices.

Read case story 1 and reflect on the following questions based on Mr. Menberu's experiences:

- What did you learn from his approach to digital integration in his teaching?
- Identify the types of digital content/tools he discovered to aid his students' learning?
- What are the effects of Mr. Memberu's using of digital resources in his classroom?
- How can you apply his experience to your own teaching and learning context within your subject areas?

Session Two: The Concept of Educational Technology

Introduction

In this session, you will investigate various definitions of educational technology and interpret the concept through practices. You will also explore what does not constitute Educational Technology and address common misconceptions within the educational context. They will formulate their personalized definition of educational technology, having examined different concepts in the area. Finally, they will explore key concepts of digital literacy and their implication for teaching and learning.

Activity 2.1. Individual activity on myths about Educational Technology (10 minutes)

This activity helps trainees to identify and explore what is commonly referred to as digital literacy or educational technology but in actual teaching and learning, they are not. Post agree and disagree signs on the wall and read aloud the below sentences then ask participants whether they agree or not. Then, ask them why they agree or disagree.

Facilitator Notes

Read out the below statements one at a time and ask participants to agree or disagree giving reason for their choice. Alternatively, you can attach 'agree' and 'disagree' signs on the opposite walls and conduct the activity in groups. Participants need to have a clear understanding of the various concepts of educational technology particularly as they relate to teaching and learning practices.

Educational Technology

- Educational Technology is merely the ability to use digital technologies (disagree)

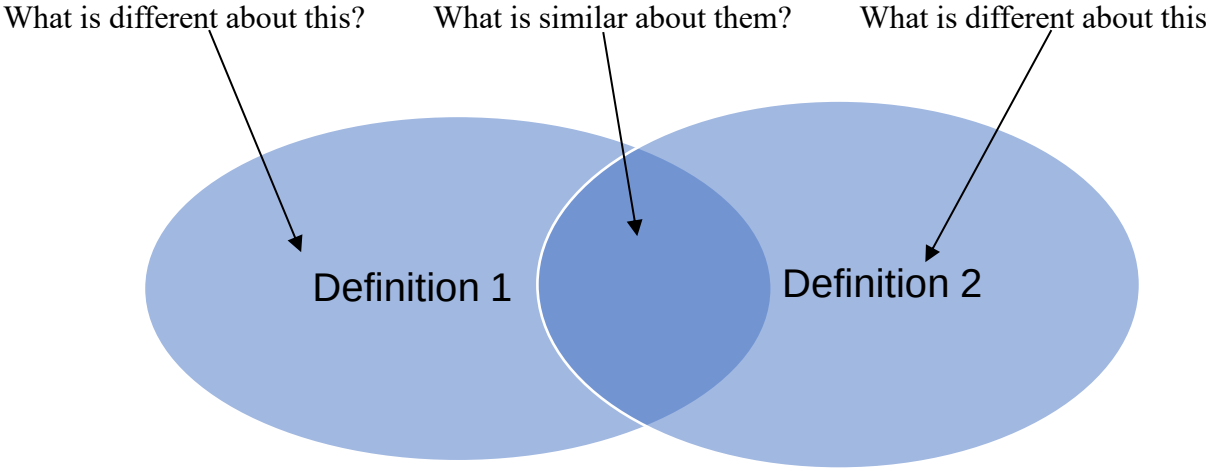
- Being able to understand how a tool works do not tell us how effect it is being used, or the value or purpose for which it is being used.

- Educational Technology is just a set of basic computer skills related to the use of hardware, software, and online resources (disagree). EdTech is the use of hardware, software, and online resources to improve students learning outcomes.
- Digital literacy includes the ability to use digital technology safely and securely (agree). But, while e-safety and security are essential aspects of digital literacy, this is far from the whole picture; it also encompasses the use of technology as methodology, assessment tools, classroom management and to access to digital contents.

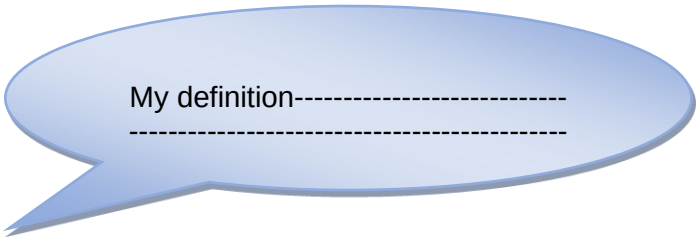
- The ultimate purpose of Educational Technology practices is to use different online and offline educational resources (disagree). The ultimate purpose of EdTech is to improve students' learning outcomes through using any available technology. We use technology not for the sake of using it, but only to improve learning outcomes.

Activity 2.2. Define Educational Technology (**Individual task 10 minutes)**

Individually go to the list of definitions in the 'key ideas' below, then choose two of the definitions provided, the one you are most drawn to and the one which you think is more related to teaching and learning. Then, compare the two definitions. Take the parts of each definition that make the most sense to you and write your definition of educational technology. Share your definition on https://jamboard.google.com/. A specific link to Jamboard will be provided by the facilitator. You might also share your definitions on Telegram group page.



Take the parts of each definition that make the most sense to you and write your own definition of educational technology.



Facilitator Notes

This activity provides practitioners with several definitions of educational technology and supports them to identify common futures among the definitions. They will review the definitions considering their usefulness in teaching and learning. Finally, they will develop their definition of digital literacy.

Key Ideas

In today's digital age, educators have access to a variety of resources, but it's essential to recognize that not all schools or educational settings have equal access to high-tech gadgets or sophisticated digital tools. In many cases, locally available resources play a crucial role in enhancing the teaching and learning experience. Traditional media such as television and radio remain relevant even in the digital era. For instance, Plazma TVs allow teachers to display visual content by project educational videos, animations, or slideshows to enhance explanations and engage students. Again, almost every teacher carries a smartphone these days, even including students. Teachers can use their phones to look up information on the spot, for capturing photos or videos during field trips or experiments and other activities as well. Besides, teachers might also consider using radios for audio-based learning and access to educational broadcast programmes. Similarly, teachers might consider using other digital resources to improve their teaching and learning practices. let's not overlook the value of familiar tools like TVs, radios, and mobile devices. By thoughtfully harnessing these resources, teachers can create dynamic and engaging learning environments that benefit all students.

Definitions of Educational Technologies

- Educational Technology is the use of technology in the instructional processes to enhance both teaching and learning.
- Educational Technology is the use of multimedia to create engaging, effective learning experiences.

- Educational technology is the use of available technological tools for pedagogical purposes and motivation.
- Educational technology is the l use of technology, such as computers, digital technology, and networked digital devices as well as theories for educational purpose in ethical way.
- Educational technology is the use of digital technology in teaching and learning as methodologies, classroom management, formative assessments, teachers' training, etc tools.

Implication to Teaching

Record your responses to the following questions as your key learning areas and future consideration on your handout.

- What did you learn about Educational Technology and how are you going to apply it in your practice?
- What digital resources are easily available in your school and how are you going to use them next year?
- What adjustment you would do to your practice to integrate technology into your lesson based on the above activities?

Self-Assessment (Unit One)

1. What is the acronym TALULAR and how does it relate to technology-based learning resources?
   A. Teaching And Learning Using Locally Available Resources; it helps identify technology-based learning resources
   B. Technology And Learning Using Local Applications; it focuses on digital literacy skills
   C. Teaching And Learning Using Advanced Resources; it emphasizes online educational resources
   D. Technology And Learning Using Global Tools; it highlights the use of international digital resources

2. What is the importance of digital literacy in navigating the digital landscape?
   A. It equips individuals to evaluate information critically
   B. It focuses on technical proficiency only
   C. It enhances personal and professional development
   D. It is a luxury rather than a necessity

3. How can teachers leverage digital literacy skills to enhance their teaching and learning activities?
   A. By accessing a vast library of online content

B. By collaborating with students on digital platforms
C. By sharing engaging resources
D. All of the above

4. What is the role of technology in our daily life?
   A. Technology is irrelevant in our daily routines
   B. Technology enhances connectivity and productivity
   C. We can live without technology
   D. Technology benefits only specific group of people

5. One of the following is very important to integrate technology into lesson?
   A. Level of advance of technology
   B. Availability of online resources
   C. Learning outcomes
   D. None of the above

Reference Materials

Type	Resources
Read	Making Teaching from Locally available resources
Read	We are Teachers online Resources
Read	Definition of Educational Technology
Watch	What is Digital Literacy?
Watch	Why Digital Literacy matters?

UNIT TWO: BASIC DIGITAL SKILLS

Introduction

This unit delves into basic digital skills such as basic organisation of computers, connecting to the intermate, using search engines, and email account creation. The sessions in this unit provides you an overview of the fundamental components of a computer followed by bridging the gap between your computer and the vast world of information. Mastering internet connectivity helps you to access a universe of resources at your fingertips. No exploration of the digital world is complete without harnessing the power of search engines. Here, you'll gain the expertise to navigate these powerful tools effectively, allowing you to locate information with precision and efficiency.

Finally, you will build the skills to create and manage email accounts, transforming them into valuable tools for communication with students, colleagues, and anyone in your professional network. You will also explore the role of email as a tool for teaching and learning.

Learning Objectives

At the end of this chapter, you will be able to:

- Identify different parts of computers and their functions.
- Use the Internet, the World Wide Web, and search engines.
- Create your own personal email account and start using it to improve your teaching and learning practices.
- Exercise using Google Educational Apps for classroom instruction.

Key Topics

Session One: Computers and Smartphones

Session two: Using Web Browser and Email

Session Three: Google Educational Apps

Session One: Computers and Smartphones

Both computers and smartphones are powerful tools that have revolutionized the way we live, work, and communicate. However, they have distinct differences in terms of functionality, portability, and

processing power. In this session, you will explore different parts of a computer and its function. Computers, including desktops and laptops, offer greater processing power and storage capacity compared to smartphones. They are ideal for demanding tasks like video editing, gaming, and running complex software.

Smartphones on the other hand, are small, portable devices that offer a wide range of features, including communication, entertainment, and productivity tools. They are powered by mobile operating systems like Android and iOS, and their processing power has significantly increased in recent years.

Activity 1. 1. Navigating Computer (Peer work – 15 minutes)

Take a moment to observe the computer or laptop you are currently using at school or plan to use in the future. Answer the following questions by discussing with your peer.

- What are the different parts of your computer/laptop/desktop? Categorize the hardware parts of the computer into input, process, and output devices.
- What do you do with your computer (Desktop or laptop) you bring with you or find at your schools?
- Are you using computers as teaching and learning tools in your teaching and learning? For what purpose did you use them in teaching and learning?

Activity 1.2. Navigating your phone (Think Pair Share – 10 minutes)

Mobile phones are emerging to be strong learning tools if used appropriately. Still, some educators believe that using cell phones might be a distraction in schools and classrooms as students might use them inappropriately. While still, this remains true, educators and teachers found that phones can be turned into learning tools by putting in place good school rules and policies. Phones have evolved over the years into powerful teaching aids that, when used appropriately, can improve learning outcomes.

Take a time to observe your phone's functions. Consider how you could use your cell phone to assist your students learn better in class. (Consider your local environment) What types of tasks can you complete with your phone as a teacher? Pair your answer with your peer sitting next to you, then share with the whole class what you both have discussed and matched.

Session Two: Using Web Browsers

In this session, you will explore the internet and its use to connect you with a global network which allows for communication and resource sharing across the world. World Wide Web, also known as the web, is a system which contains resources that are accessed through the internet.

The World Wide Web uses website sites to create virtual spaces on the internet where videos, files, images, and other digital resources are stored so that you can view, store and retrieve them.

Activity 2.1. Connecting to the Internet (Individual Practice – 5 minutes)

- How would you connect to the internet through your phone or computer?
- Using any digital device you have on your hand, please connect to the internet, and do something. And then show it to your friend or Facilitator?

Facilitator Note:

Conclude the discussion by mentioning that we can connect to the internet in different ways including through data on your phone, WIFI or cables. Wi-Fi is a wireless technology that enables electronic devices with wireless adapters such as laptops, mobile phones, TVs, and tablets to connect to the internet.

Activity 2.2. Using a Web Browser (Group discussion – 15 minutes)

In a group of four to six, engage in a discussion about the following questions:

Figure 3: Different Browsers

- What is a web browser?
- Which web browsers do you typically use?
- How have you utilized web browsers to enhance your teaching and learning processes?

NB: Share your response to the wider team (whole class) through one of the interactive online tools or use a flipchart to share your group discussion.

Activity 2.3. Use of Emails (Group Discussion – 10 minutes)

This activity introduces participants to email ultimately aiming at helping them use email as a communication tool.

Group Discussion (10 minutes)

In groups of four to six, discuss the following questions.

- What is email and how does it function?
- What are the benefits of using email in educational settings?

Figure 4:Email; Source@pixabay

- What are your current email habits and challenges? How often do you check your emails?
- With whom do you usually use emails and for what purposes?
- How can teachers use email for teaching and learning?

Activity 2.4. Create your email (Demonstration - 25 minutes)

Click on this (How to create a gmail account) and watch the video about email creation and then create your email. You can also follow the steps provided in the box below as you create your email. Once, you watch the demonstration, create at least two email accounts on Gmail and Outlook email platforms.

What to do:
To create gmail account follow the following steps.

- **Go to the Google Account sign in page.**
- **Click Create account.**
- **Enter your name.**
- **In the "Username" field, enter a username.**
- **Enter a secured password and confirm your password.**

What to do:
To create an Outlook email account, you need to follow these steps.

- Go to the Microsoft Outlook website and select Create free account.
- Click Get a new email address. You can choose between @outlook.com or @hotmail.com as your domain name.
- Choose a username that is unique and easy to remember. If your username is already taken, you will need to pick another one.
- Create a password that is strong and secure. You can use a combination of letters, numbers, and symbols.
- Enter your personal information, such as your name, birthdate, and country or region.

- Verify your account by entering the code that is sent to your phone number or alternate email address.

Activity 2.5. Send email messages (Individual Task - 15 minutes)

Now you have already created an email account, please send a message to at least five participants including your facilitator. Then in a group, reflect on the following questions:

- How do you find your experience? Was it difficult or easy?
- What are the common features you saw on the email page? List down all the features on the email page?

Facilitator Notes

Following participants reflection, please show them the main features on email page such as new email (compose new email), inbox, outbox, sent items, delete, etc.

Activity 2.6. Accessing and Navigating Google workspace

Google Workspace for Education provides free educational apps for students and educators. These tools cover various learning needs and include popular options like Google Docs, Sheets, and Slides for collaborative document creation; Google Classroom for managing online classes, Google Search for finding information, and Google Scholar for academic resources. In this activity, you'll learn how to access these tools easily. Later, we'll explore the use of some of these tools in more detail.

Figure 5: Google Apps

Open the Google Chrome website (Google website) and explore the page. Specifically, open the nine dots you see in the top right corner of the Google Chrome browser which represent the app launcher or app grid. When you click on these dots, it opens a menu that provides access to various Google apps. You can find shortcuts

to apps like Gmail, Google Drive, Google Form, and more. This is a convenient way to quickly access your favourite Google tools.

Demonstration- 20 Minutes

Use the following what to instruction and access different google apps using the app grid, Navigate the app, list different apps you accessed and state their function. Practice adding and removing different apps into the app launcher.

What to do:

Follow the below guide to access different Google apps either on your computer or phone.

- **Make sure you have a Google account: If you use Gmail, YouTube, or other Google services, you already have one.**
- **Open Chrome browser and go to a Google website.**
- **Log in to your Google account (if not already signed in)**
- **Look for the App Launcher icon: It's a grid of nine small squares, usually located in the top right corner of the webpage.**
- **Click on the App Launcher icon. This will display a list of various Google Apps you can access.**
- **Choose the Google App you want to use: Click on the icon for the desired app (like Docs, Sheets, Slides, Classroom, etc.) to launch it within the Chrome browser window.**

Facilitator Note (Optional): *Show participants a five-minute video taken from the reference section. Then ask participants to access google apps through app launcher or app grid on chrome/google website either through their phone or laptop. Give them some time (10 minutes) to do this.*

Key Ideas

Computers

Figure 6; Source @Google Image

A computer, typically positioned on a desk, is specifically crafted for individual use. It comprises various interconnected components, functioning as a cohesive unit. Computer hardware parts are categorised into three parts:

- Input Devices: These are the tools that allow you to interact with your computer. Think keyboards, mice, touchscreens, webcams, and microphones. How do you use these to provide instructions and information to your computer?
- Processing Unit: Imagine this as the brain of your computer. It receives your instructions from the input devices, processes them, and generates the desired results.
- Output Devices: These are the components that display the results of your computer's work. Monitors, printers, and speakers fall into this category. How do they translate the computer's calculations into a form you can understand and interact with?

Computers can be powerful tools that can revolutionize teaching and learning, offering a range of benefits for both students and educators. From providing access to information to fostering collaboration and developing digital skills, computers have become an integral part of the modern educational landscape.

Smartphones

Smartphones serve as powerful educational tools, providing a portable repository of information and interactive learning possibilities. Smartphones can be utilized both in the classroom and for personal learning for the following activities:

- Access to Information: Students and teachers can instantly tap into the vast internet resources for research, answering questions, and exploring new topics.
- Educational Apps: Numerous subject-specific apps cater to various age groups and learning styles. These apps offer interactive exercises, simulations, and engaging games.
- Collaboration Tools: Communication apps allow students to form study groups, collaborate on projects, and share ideas beyond the classroom.
- Creative Learning: Teachers can use smartphones to create educational videos, presentations, or podcasts, reinforcing their understanding and showcasing their learning.

World Wide Web and Browsers

The World Wide Web, commonly known as the web, is a vast system that houses resources accessible through the internet. Websites create virtual spaces on the web where videos, files, images, and other digital content are stored. As users, we can view, store, and retrieve these resources. Connecting to the internet via Wi-Fi, data, or cable allows our electronic devices such as laptops, mobile phones, TVs, and tablets to access this wealth of information.

As educators, the internet provides us access to information on nearly any subject matter. Whether you're researching, learning, or exploring, the web is a treasure trove of knowledge. Beyond information, the internet enhances our ability to communicate and collaborate with people worldwide.

Web Browsers

A web browser is application software that enables you to access resources and websites on the World Wide Web. Several popular browsers include Google Chrome, Mozilla Firefox, Apple Safari, and Microsoft Edge. These browsers operate similarly and share common controls. Once you master one browser, you'll find it easier to navigate others as well.

Email

Email (electronic mail) is the exchange of computer-stored messages from one user to one or more recipients via the internet. Emails are a fast, inexpensive and accessible way to communicate for business or personal use. Users can send emails from anywhere as long as they have an internet connection. Emails are a great way to communicate with colleagues, students, and parents, as well as to share information, resources, and feedback.

Besides communication, you need an email to access and use the majority of educational tools. Therefore, it is advisable for teachers to have two email accounts: one on Gmail and one on Microsoft. The Gmail account allows you to use Google's free products, while the Microsoft account enables you to access Microsoft's products.

Implication to Teaching

Please note down your reflections on the following prompts, which will serve as key takeaways and future action points:

- Reflect on the insights gained from the session, including any new abilities and knowledge acquired. How do you intend to integrate these into your teaching methods?

- Share your discoveries about the use of email. How do you foresee implementing email communication moving forward?
- List down at least five educational applications provided by Google.
- How would you intend to use different web browsers for educational purposes?

Self-Assessment

1. How does a monitor help you interact with your computer?
   A. It translates calculations into a visual form.
   B. It allows you to type instructions.
   C. It processes information.
   D. It stores data.
2. Smartphones can be used for educational purposes by:
   A. Restricting access to certain websites.
   B. Downloading social media apps.
   C. Providing access to educational apps and the internet.
   D. Making phone calls.

3. Web browsers allow you to access:
   A. Your computer's files
   B. Websites on the World Wide Web
   C. Only educational resources
   D. Video games

4. Which of the following is NOT a popular web browser in Ethiopia?
   A. Google Chrome
   B. Mozilla Firefox
   C. Microsoft Edge
   D. None of the above

5. Email is primarily used for:
   A. Storing documents online
   B. Sending messages electronically
   C. Playing games
   D. Watching videos

6. Why might a teacher need two email accounts (Gmail and Microsoft)?
    A. To separate personal and professional emails.
    B. To access specific educational tools.
    C. Because Gmail is free and Microsoft is not.
    D. There is no specific reason; one account is sufficient.

Reference Materials

Type	Resources
Watch	Components of Computer System
Watch	Usage of Smartphones
Read	Computer Organisation and Design Books
Read	Set up Google Workspace on an Android device - Google Workspace Learning Center
Read	Microsoft Support
Watch	What is Web Browser?
Watch	How to create email account on Outlook?
Watch	Google Workspace Beginner Guide

UNIT THREE: THE USE OF SOCIAL MEDIA FOR EDUCATIONAL PURPOSES

Introduction

In this unit, you will explore the possibility of leveraging social media platforms, specifically Telegram and Facebook, for educational purposes. These platforms offer a myriad of possibilities for enhancing teaching and learning experiences. By harnessing their features, educators can engage with students, foster collaborative learning environments, share resources, and facilitate discussions. Whether it's creating study groups, disseminating course materials, or encouraging peer interaction, these social media channels hold immense potential to enrich educational practices. Participants will explore strategies, best practices, and activities that demonstrate how these platforms can be effectively integrated into the teaching and learning process, ultimately contributing to improved learning outcomes.

Learning Objectives

At the end of this chapter, you will be able to:

- Explore the use of social media for educational purposes.
- Utilize social media platforms such as Telegram and Facebook to improve your teaching and learning practices.

Session One: Social Media for Educational Purpose

Introduction

In this session, we will explore the use of social media like Facebook and Telegram to facilitate communication between teachers, students, and parents. Using such platforms facilitate discussions, Q&A sessions, and announcements.

Social media can also liven up learning with interactive features like polls and quizzes, while sharing educational resources like videos and articles keeps students engaged. By integrating social media strategically in their teaching and learning, teachers can create a dynamic and engaging learning environment that fosters collaboration, critical thinking, and engagement

Activity 1.1. Using Telegram as Educational Tool (Group work – 10 minutes)

Figure 7;Source@Google Image

In group of four to six, discuss on the following questions.

- What are the benefits of using Telegram in educational settings?
- How can teachers use Telegram for teaching and learning?

Demonstration (20 minutes)

Use the following Instruction and create a Telegram group. Add your peers or contacts from you address book as a member. Please practice sharing questions, videos and create poll in your telegram group.

What to do:

Step 1: Create Telegram Account

- **Connect to the Internet/Turn on mobile phone data.**
- **Click on play store/App store.**
- **Download Telegram on your phone Step.**
- **Install Telegram application.**

Step 2: Form Telegram Group

- **Launch Telegram application.**
- **Select new group.**
- **Add your students by selecting from phone book.**
- **Name the group.**
- **Start posting learning materials in the form of images, documents or texts to the group.**

Facilitator Note

Create a group of four participants (group them by subject matter) and take them through the telegram app. Assist them to create group, post assignment, videos, create poll and complete other functionalities on the app.

Optional: Show them the five-minute video on the use of the Telegram app and then ask participants to create group, post assignment, videos, create poll and complete other functionalities on the app.

Activity 1.2. Using Facebook for educational purposes (Group Work - 10 minutes)

Facebook can be utilized for educational objectives in various ways, enhancing interaction, involvement, and a sense of community beyond the traditional classroom setting. By establishing private groups for your classes, you can encourage ongoing discussions, host question-and-answer sessions, and share educational materials outside of regular school hours.

Figure 8;Source Google Image

In groups of four to six discuss on the following questions:

- Do you have Facebook account? What is your experience of using Facebook?
- Have you used it for educational purposes? How Facebook will be used for educational purposes?

Demonstration (10 minutes)

Demonstrate how to create private groups on Facebook and then support your trainees to do the same in groups. Follow the below steps as you create closed group on Facebook.

Activity 1.3. Creating Group or Page on Facebook (Group Work - 30 minutes)

Use the following instruction and create a Facebook Group Page in your specific subject matter expertise and share relevant resources, initiate chat among your students, run live Facebook videos and complete other activities which you might think are relevant for your teaching and learning.

What to do:

- **Make sure you have a personal Facebook account.**
- **On your Facebook homepage, navigate to the "Groups" section if you want to open Facebook group or navigate to the “pages” section if you want to open Facebook page on the left-hand menu and click the ‘create group’ button on the page.**

- **Group Name: Choose a clear and appropriate name that reflects the class or subject.**

- **Privacy: Select "Closed" from the privacy options. This ensures only approved members can see the group's content.**

- **Description (Optional): Provide a brief description outlining the group's purpose and intended audience (e.g., students enrolled in Biology class).**

- **Start by inviting your students who have Facebook accounts (with parental permission if necessary). You can search for them by name or email address.**

- **As the group admin, you can approve membership requests, monitor discussions, pin important announcements, and manage content within the group.**

Key Ideas

Telegram

Telegram is a software used for communication and instant messaging and offers many possibilities such as sending various media files, in addition to making voice or video calls. The Telegram program can be used in education in many ways and means, some of which can be mentioned as follows:

- Send assignments, reading materials and tasks by students to the teacher.
- Create groups and channels for classroom.
- Create polls and quizzes
- Communicate with students from other school.
- Parents communicate with teachers to follow their children performance
- Provide e-content for the home side in the reverse learning strategy.
- Make video, audio and text announcement, lecture, and resources, etc.

Facebook

Teachers might also consider using Facebook for educational purposes in several ways, fostering communication, engagement, and community outside the classroom. You can create

private groups for your students to facilitate discussions, Q&A sessions, and sharing of resources beyond classroom hours. Through private group on Facebook, we will encourage the following activities among students.

- Collaborative Projects: Encourage students to work together on projects by using Facebook groups for brainstorming, sharing research findings, and coordinating tasks.
- Sharing Learning Resources: Post links to educational websites, articles, videos, or even create online document folders within the group for students to access relevant materials.
- Polls and Quizzes (informal): Conduct quick polls or quizzes (using third-party apps within Facebook) to gauge student understanding or gather feedback on topics.
- Announcements and Reminders: Share important updates, homework reminders, or upcoming events with the entire group or specific students through private messages.
- Virtual Field Trips and Events: Utilize Facebook Live or pre-recorded videos to share virtual tours of museums, historical sites, or connect with guest speakers remotely.
- Digital Citizenship Lessons: Facebook provides real-world context for teaching online etiquette, responsible content sharing, and critical thinking about information found online.

Important Considerations:

- Privacy is Key: Ensure groups are private and only accessible to students and parents/guardians with permission.

- Set Clear Guidelines: Establish ground rules for respectful communication and appropriate content sharing within the group.

- Parental Involvement: Keep parents informed about the group's purpose and encourage their involvement if necessary.

Additional Tips to create a Closed Facebook Group for educational purposes.

- Consider creating a separate Facebook account specifically for educational purposes, keeping it separate from your personal profile.

- Encourage students to add their full names for easier identification.

- Regularly post relevant resources and discussions to keep the group active and engaging.

Implication to Teaching

Please note down your reflections on the following prompts, which will serve as key takeaways and future action points:

- Reflect on the insights gained from the session, including any new abilities and knowledge acquired. How do you intend to integrate these into your teaching methods?
- Identify the features of Telegram that could be beneficial for educational activities?
- Outline your strategy for utilizing social media platforms like Facebook and Telegram to enhance educational experiences in the forthcoming period?

Self-Assessment

1. Telegram Group Engagement Task: Post a welcoming message on your previously created Telegram group page or channel. Here's a suggested greeting: "Welcome, students! This is our dedicated space for learning and growth. Let's embark on this educational journey together with enthusiasm and curiosity." Share the Telegram link with your facilitator and peers.
2. Facebook Interaction Task: Initiate a discussion on your Facebook page by posting a topic related to your subject discipline.

Reference Materials

Read	Social Media in Education
Watch	The Use of Telegram for Educational Purposes
Watch	The Use of Facebook for instruction
Watch	Social Media in Education

UNIT FOUR: ONLINE EDUCATIONAL TOOLS

Introduction

This chapter will empower teachers to leverage technology in their classrooms. You will explore a variety of online educational tools that are suited for diverse subjects and learners. The session in this unit will help you to develop the ability to select the most appropriate platforms and resources for specific learning objectives. Teachers practice how the tools might be used appropriately and incorporated into teaching and learning in a way that supports students in developing both subject knowledge and digital literacy. You will need internet access to practice these tools. But you are encouraged to critically analyse the tools in terms of developing critical thinking, problem-solving, analytical skills, etc among students. As you review each tool, please think about how possibly you apply them in your classrooms or outside all aims at improving learning outcomes.

Learning Objectives

By the end of this chapter, you will be able to:

- Identify different types of online educational technology tools that suits for teaching and learning.
- Select appropriate online tools and platforms for different purposes and audiences.
- Utilize communication, assessment and creative tools in their teaching and learning.
- Participate in online learning communities that foster digital skills among teachers, and other stakeholders.
- Utilize artificial intelligence tools during the preparation of lesson plans, assessments, and instructional materials.

Key Topics

Session One: Communication and Collaboration Tools

Session Two: Assessment Tools

Session Three. Creative Tools

Session One: Virtual Communication and Collaboration Tools

In this session, you will explore different communication and collaboration tools that help you facilitate online discussion and collaboration among students. These tools provide you with various functionalities such as live meetings, document sharing, collaborative works and many more tasks. In addition, you will explore possibilities of creating and managing your groups, and channels, share files and documents, and communicating with students.

Activity 1.1. Using Google Meet

Google Meet allows educators to easily connect and collaborate with students through links or codes, making it perfect for both planned lessons and quick discussions. This fosters remote learning by enabling online classes and virtual tutoring, regardless of location. Engagement is boosted through features like screen sharing and presentations. Google meet is accessible from both web browsers and mobile apps.

Figure 9. Google Meet; Source @Google Image

Question and Answer (5 Minute)

Could you share your experience and familiarity with Google Meet? Have you used it before or observed others using it? Have you participated in online meetings organized through the Google Meet platform? What was your experience?

Facilitator Notes:

Encourage participants to discuss their experiences with Google Meet. While it's not essential to pose every question listed previously, consider using them to guide the conversation and extract detailed insights regarding the participants' usage of Google Meet.

Demonstration (25 minutes)

Use the following instruction and demonstrate how to organize and schedule online meetings using Google Meet. Once you completed the demonstration, create your own instant meeting using Google Meet. Then allow share the meeting link with others/your peers and allow them to join the meeting and practice how you would potentially run an online meeting.

What to do: Starting a Google Meet Meeting:

There are two ways to start a Google Meet meeting:

1. **From the Google Meet website:**

- **Go to https://meet.google.com/.**
- **Click "New meeting."**
- **Choose an option:**
  - **Create a meeting for later: Get a meeting link to share and schedule the meeting for a specific time (optional).**
  - **Start an instant meeting: Join a meeting directly without needing a link beforehand.**
    - **You'll be the host of the meeting, and others can join using the meeting link or code.**

2. **From Google Calendar (if integrated):**

- **If Google Meet is integrated with your Google Calendar, you can schedule a meeting directly within Calendar.**
- **Create a new event or edit an existing one.**
- **Click "Add video conferencing" and choose "Google Meet."**
- **A meeting link will be automatically added to the event details.**
- **Invite participants to the event, and they can join the meeting using the link at the scheduled time.**

3. **Basic Controls During a Google Meet Meeting:**

- **Microphone: Mute or unmute your microphone by clicking the microphone icon.**
- **Camera: Turn your camera on or off by clicking the camera icon.**

- **Chat: Send text messages to other participants in the chat window.**
- **Screen share: Share your entire screen or a specific window with other participants.**
- **Presentation: Present content from your computer (slides, documents, etc.).**
- **Leave meeting: End the meeting for yourself (if you're the host) or leave the meeting as a participant.**

Additional Tips:

- **You can adjust your meeting settings (background blur, captions, etc.) by clicking on the three dots in the bottom right corner.**
- **Google Meet works on most web browsers and also has mobile apps for Android and iOS.**

Facilitator Notes

Please take few minutes to discuss about Google Meet and how to access the app with participants. While the trainees are trying to demonstrate and create an instance meeting or schedule using google meet please round about and assist them.

Activity 1.2. Group Discussion about your Google Meet Experiences (15 minutes)

Discuss the following questions with your group members.

- What are your thoughts on the app?
- In what ways do you intend to integrate Google Meet into your educational practices?
- Could you share your experiences with setting up and conducting an online session? Do you find Google Meet user-friendly?
- Would you be willing to take a lead in organizing concurrent online meetings via Google Meet within your department to facilitate the exchange of experiences and collaborative learning among your friends?

Activity 1.3. Exploring Padlet (Question and Answer - 10 minutes)

Padlet is a digital dashboard tool designed for online collaboration and information sharing. It works like a virtual wall where users can post various content, making it an asset in the educational landscape.

Figure 10;Padelt; Source @Google Image

- What is your experience of using Padlet as a teacher? Have you used the app before or seen others use the app for educational purposes?
- How can teachers use Padlet to foster collaborative and engaging learning experiences?
- What tasks are well-suited for an online tool like Padlet in educational settings or during instructional processes?

Facilitator Notes:

Encourage participants to discuss their experiences with Padlet. After the discussion, summarize the session with the below information about the use of Padlet for instructional purposes. Demonstrate how to set up a free padlet account and share the link with your trainees. Then ask each participant to write two personal goals on the link provided. Setting personal learning goals is an important way to guide your progress and set expectations for yourself throughout this course. write two personal goals you hope to achieve while taking this course. (Click on the + sign to write your personal goals)

Example of Personal Goals:

1. Learn about education technology and its use in classrooms

2. Practice different online educational tools

Activity 1.4. Practising using Padlet (Individual Task 15 minutes)

Using your mobile phone, create free Padlet account and use the Padlet as online presentation board to discuss a topic or assignment from your specific subject area (If your mobile phone is not functional; please work in pairs or groups).

What to do:

- **Go to https://padlet.com/ and create a free account with your email address or sign in if you already have one.**
- **Click on "Create a Padlet" button.**

- **Choose a layout for your Padlet (Wall, List, Stream, etc.) based on your content and purpose.**
- **Give your Padlet a title and description (optional).**
- **Click "Create Padlet."**
- **Click the "+" button on your Padlet to add content.**
- **Choose how you want to add content:**
  - **Text: Write directly on the Padlet.**
  - **File: Upload an image, document, or other file.**
  - **Link: Include a link to a website or resource.**
  - **Video/Audio: Embed a video or audio clip from YouTube, Vimeo, etc.**
- **Add a title and description to your content (optional).**
- **Click "Save" or press "Enter" to add the content to your Padlet board.**
- **Click the "Share" button in the top right corner.**
- **Choose a sharing method:**
  - **Copy Link: Share the link with anyone who has access.**
  - **Embed Code: Embed the Padlet on a website or learning management system.**
  - **Social Media: Share the Padlet on social media platforms.**
  - **Set privacy options for your Padlet (public, private, password-protected).**

Session Two: Assessment Tools

Introduction

In this session, we delve into a variety of online assessment tools designed to support teachers in the development of both formative and summative assessment questions for your classroom. Specifically, you will gain an understanding of diverse assessment tools and articulate their applications within an educational context. You'll also get hands-on practice with these tools, integrating them into your lesson planning. Additionally, you'll be guided through the process of creating accounts to access and utilize these various assessment tools effectively.

Activity 2.1. The use of Quizizz (Question and Answer - 5 minutes)

Figure 11;Source @Google Image

Quizizz is an online interactive tool to assign homework and provide feedback, present quizzes in the form of games and have a real-time understanding of students' academic progress.

- What is your experience of using QUIZIZZ as a teacher?
- Have you use the app before or seen others use the app for educational purpose or in a training setting?

Activity 2.2. Online live activity using QUIZIZZ (20 minutes)

How much do you know about Educational Technology? Run the below assessment using Quizizz platform (https://quizizz.com/admin/quiz/6403b3ddfe08dd001db7681d?source=quiz_share)

Facilitator Notes

During the session, ensure to comprehensively demonstrate the app's functionalities, including its ability to generate complete graded reports for each student and how to access and edit premade questions from Quizizz library. Additionally, acquaint participants with the various modes of conducting the session, such as the 'assignment' feature and the paper mode, to provide a thorough understanding of the app's functionality in different contexts.

Activity 2.3. Create your personal free QUIZIZZ account (Individual task - 15 minutes)

Use your mobile phone to create a free quizizz account and explore resources in your subject area (If your mobile phone is not functional; please work in pairs or groups). You can also download the app from Play Store or App Store for optimal use of the app.

What to do:

- **Go to https://quizizz.com and log in, or if you are a new user, click 'Get started' and create a new account by using your email address.**
- **To use an existing quiz, select the 'Search for quizzes' box and browse. If you want to create your own quiz, select 'Create a new quiz', enter a name for the quiz, and choose the relevant subjects. Choose a type of question and fill in the question, as well as answers.**
- **Add a title image if desired. Select the appropriate language and grade range and add tags to make it easier to search for.**

- **Either select 'Play live' or 'Assign HW' and choose the desired attributes. Then share the quiz with your students by sending them the link and 6-digit code.**
- **Students can go to https://quizizz.com/join, click 'Join a game', and type in the 6-digit code to participate in the live quiz or complete it at homework. Once the students are finished, the teacher can refresh the page to view the results.**
- **You can also access to several quizzes and assignments in the library. You just need to review the questions and use for yourself.**

Activity 2.4. Introducing Slido (Question and answer – 5 minutes)

Slido is the ultimate Q&A and polling platform for live and virtual meetings and events. It offers interactive Q&A, live polls and insights during your meetings/events. What is your experience in using slide for educational purpose or in any other setting?

Activity 2.5. Create free slido account (Demonstration - 15 minutes)

Using the following what to do instruction and create a free slido account and explore the different functionality of the app. Then, support trainees to create their accounts. After participants create their account ask them to design audience questions and provide answer links with their groups.

What to do:

- **To create slido account follow the below easy steps:**
- **Go to https://www.slido.com/Links to an external site.**
- **Sign up for free**
- **Start using slido**

Activity 2.6. Exploring Survey Collection Tools (Google Form)

From time to time, educators engage in research or action research to enhance their teaching methods and contribute to educational progress. Google Forms provides a convenient platform for creating online forms and surveys, complete with various question types. You can easily share these forms with your audience. Additionally, Google Forms facilitates result analysis, allowing you to gain insights from your audience's responses. Furthermore, it's a useful tool for preparing quizzes for your classroom.

Question and answer (5 minutes)

Have you used Google Form before? When did you use it and for what purpose? What was your experience in using Google Forms?

Create survey or quiz with Google Form (Demonstration - 20 minutes)

Follow what to do instruction given below and please demonstrate how to create a survey or quiz using Google Forms or you can show participants a demonstration video. Once you completed the demonstration, ask participants to do the following:

- work in pairs and prepare a quiz using Google Forms; share it with at least 10 participants and present the result of your survey with your group members.
- Prepare a short survey using Google Forms and share it with your facilitator and students, then present the result of the survey to whole class (As you prepare the survey refer your specific learning area or subject matter).

What to do:

- **Go to https://docs.google.com/forms in your web browser. You'll need a Google account to access it (same as Gmail or YouTube).**
- **Click the "+" button or choose "Blank form" to start from scratch.**
- **You can also choose a template for specific purposes like event registration or contact forms.**

- **Click on the "Untitled Question" box and type your question.**
- **Select the question type from the dropdown menu (multiple choice, short answer, checkbox, etc.).**
- **Customize the question further by adding answer choices, making it mandatory, or shuffling options.**
- **Drag and drop questions to rearrange their order.**
- **Add sections with titles to categorize related questions.**
- **Use images, videos, or descriptions to provide additional context.**
- **Click on the "Settings" tab to configure options like:**
  - **Who can access: Choose whether anyone can submit the form or require a Google account.**
  - **Collecting responses: Decide how to collect responses (one response per person or allow multiple submissions).**
  - **Quiz settings (if applicable): Set grading options, time limits, and feedback for quizzes.**
- **Click on the "Send" button to share your form. You can:**
  - **Copy and paste the link to share anywhere.**
  - **Embed the form directly on a website.**
  - **Send the form via email with a personalized message.**
- **All responses to your form are automatically collected in a Google Sheet.**
- **Access the sheet by clicking the "Responses" tab.**
- **You can view individual responses, analyze data with charts and graphs, and even export the data to other formats.**

Facilitator Notes

Support participants as they create their own survey/quiz. Encourage them also to share the form through varies platforms like Facebook and Telegram pages.

Activity 2.7. Practicing Using EvalBee Application

EvalBee apk.

1. Assume a mathematics teacher who teaches three sections of grade ten and two sections of grade eleven, for a total of five sections with an average of 45 students in each class. How long will it take the teacher to check a student answer sheet in an examination that encompasses 40 objective-type questions out of 50?

2.Using your smart phone download the Eval Bee android app from the Play Store, create account and Sign in. Then using the Instruction below practice using EvalBee Optical mark readers App.

What to do:

- **Go to google play or app store on your smartphone and download Evalbee apk or https://evalbee.com on web browser and create an account.**

Steps to create optical mark reader or recognition (omr)

- **Decide the roll number digits (Make it 2)**
- **Insert an exam set (exam codes).**
- **Decide Exam Sets (Codes) and**
- **The number of subjects Make it 1**
- **Write the subject name in the subject box**
- **Decide the number of types of items on the section box**
- **Insert type of the item in sections 1,2 and 3**

***Section 1* :- Replace it with I. True or False**

- **True or False items in section 1**
  - ✓ **Decide number of questions for True or False items**
  - ✓ **Decide possible options from question type box**
- **You can allow partial marks (if necessary)**

***Section 2* :- Replace it with II. Matching**

- **Decide number of matching items**
- **Decide possible options**
- **You can allow partial marks**

***Section 3*:- Replace it as III. Multiple Choice**

- **Decide number of matching items**
- **Decide possible options**

- **You can allow partial marks**
- **SAVE**
  - **Write class name e.g Grade 10**
  - **Exam Name:- Mathematics**
  - **Select Exam Date It is mandatory**
  - **Finally SAVE.**
  - **Once you set answer sheet click on exam**
  - **Go to Exam management**
  - **Click on Answer Key and set it**
  - **Finally Save it**
  - **Download and print the answer sheet**
  - **Administer the Exam**
  - **Scan each answer sheet**
  - **Go to report**
  - **Record the each student result**

Session Three: Creative Tools (Artificial Intelligence)

Introduction

Artificial Intelligence (AI) is a branch of computer science that deals with the creation of intelligent agents, which are systems that can reason, learn, and act autonomously. AI research has been highly successful in developing effective techniques for solving a wide range of problems, from game playing through enhancing services in varies sectors such as education, agriculture and health.

Activity 3.1. Understanding AI (Question and Answer -10 minutes)

- What is Artificial intelligence?
- Have you used it so far or seen while others use it for different purpose including teaching and learning?

Facilitator Notes

Show them AI videos on power point slides and provide highlight of the current development of AI globally. AI is bringing exciting possibilities to classrooms around the world. There are various AI tools available to help teachers with their tasks. We will explore some of the commonly used AIs in the below activity. As conclusion show the AI video on the power point.

Activity 3.2. Stream your task through AI (Gemini and Bing) Lecture – 5 minutes

Copilot/Bing and Bard/Gemini are the two popular apps easily accessible in Ethiopia for varies tasks. Copilot/Bing is developed by Microsoft and Bard is created by Google AI respectively. Both AIs focuses on generating text, translating languages, and answering questions in an informative way.

These AI tools can be a game-changer for teachers by:

- Simplifying lesson planning: Generate ideas, find relevant resources, and outline learning objectives with AI assistance.
- Crafting engaging assignments: Design interactive exercises, propose different question types, and personalize learning pathways for each student.
- Exploring innovative teaching methods: Discover new approaches to explain concepts, spark creativity in activities, and create a dynamic learning environment.
- Provide Educational resources such as images and videos for your lesson and other activities.

By harnessing the power of AI tools like Copilot and Bard, teachers can free up valuable time and focus their expertise on what matters most: guiding their students and fostering a love of learning.

Activity 3.3. Demonstrate how AI works for schools/teachers - 10 minutes

Demonstrate the use of Bing and Bard through performing the following activities:

- Prepare lesson plans, assessment questions and instructional resources for one of the subject matters using Bard?

- Prepare instructional resources for the above topic using Bing AI – ask the AI to provide you with pictures or simulation activities for the above topic?

Facilitator Notes

As you showcase the capabilities of AI, emphasize that it's incredibly user-friendly. Teachers can conveniently access the service via a mobile app, making it even more accessible. Encourage them to download the Bing app on their phones for future use.

Activity 3.4. Practicing the use of AI (Individual Activity - 20 minutes)

Go to Edge or Chrome browsers and use either Bing or Bard as you prepare your next week plan, please generate the following and share it with your group members.

- Lesson Plan for your next week classes.
- Assessment Questions for your next week classes.
- Ask Advise for Methodologies and Teaching aids you might use in your class.

Key Ideas

Communication and Collaboration Tools

Virtual classrooms can be transformed by online communication and collaboration tools, fostering richer educational experiences for students. Platforms like Google Meet, Microsoft Teams, and Zoom create virtual meeting spaces for live video sessions, real-time interaction, screen sharing, and even breakout rooms for focused group discussions.

These tools empower educators to conduct engaging lectures and discussions, address student queries, and facilitate collaborative projects where students can work together on assignments, share ideas, and develop teamwork skills. Additionally, inviting guest speakers from various fields becomes a possibility, enriching students' learning with diverse perspectives. Virtual field trips further broaden horizons, allowing students to explore museums, historical sites, or natural wonders from anywhere in the world. Assessment is also streamlined, with online quizzes, tests, and even oral exams conducted effectively.

Beyond video conferencing platforms, online tools like Padlet offer a dynamic digital canvas. Imagine a virtual bulletin board where students can brainstorm ideas, organize thoughts, create mind maps, share research findings, project summaries, and creative works. It's a space for

collaboration, visual presentations, and receiving peer feedback or reflecting on learning experiences.

Similarly, Jamboard, Google's interactive whiteboard tool, fosters a collaborative environment for drawing, writing, and brainstorming. Students can use it to visualize complex concepts, problem-solve across various subjects, dissect scientific phenomena through visual aids, or even create engaging storyboards. From brainstorming sessions to collaborative problem-solving and visual storytelling, these online tools unlock new possibilities for enriching virtual classrooms. Below are easy guide on how to use some of these tools.

Assessment Tools

Interactive tools like Quizizz gamify quizzes, transforming them into game shows with competition and immediate feedback. Google Forms offer versatility, allowing the creation of quizzes, surveys, polls, and even short-answer assessments, with easy data analysis for personalized learning. Slido and Mentimeter prioritize real-time participation. Students can submit questions, participate in polls, and contribute to word clouds, keeping them engaged in lectures and presentations. Finally, Kahoot! takes gamification a step further, turning assessments into fast-paced game shows where students compete for the top spot. These are just a few options that can create a more engaging and data-rich learning environment, fostering interactive assessment platforms.

Artificial Intelligence

The ultimate purpose of using AI in education should be to improve student learning outcomes. AI can be a powerful tool in this journey, but it's crucial to use it wisely. Here are some key points for teachers:

- **Supportive Partner, not a Substitute:** AI can assist with various tasks, from crafting lesson plans and designing exams to assessing student work and managing records. However, it shouldn't replace teacher expertise. Review and adapt AI-generated materials to fit your specific classroom context.

- **Combating Plagiarism:** Simply submitting student work generated by AI can lead to plagiarism. If you suspect AI use, consider using AI plagiarism detection tools to verify the originality of student responses.

- **Empowerment, not Automation:** AI is here to enhance, not replace, teachers. Be creative! Explore AI-powered apps to streamline grading and free up valuable time. This allows you to focus on what matters most: guiding your students and fostering a love of learning.

- **Strategic use of AI:** By using AI strategically and maintaining a critical eye, educators can leverage its potential to personalize learning, streamline processes, and ultimately, improve student outcomes.

- The Eval Bee application is designed to help teachers create and scan Optical Mark Recognition (OMR) answer sheets for objective types of examinations such as True or False, Matching, and Multiple Choice and generate result reports in real time by scanning the OMR sheet using their phone's camera. It is an Efficient App for Teachers that makes assessment Easy & Effective in No time. Creating answer sheet design in a few clicks, Scan answer sheets in real-time. Using Eval Bee allows the error-free scan and evaluation of printed OMR answer sheets through pre-trained AI and machine learning-based algorithms in real-time. This saves a lot of time and energy for teachers and makes it easy for students and parents to get quick evaluation results.

Implication for Teaching

Record your responses to the following questions as your key learning and future considerations on your handouts.

- What did you learn about communication and collaboration tools?
- What is your plan to communication and collaboration tools in your teaching and learning or any other related task in your school?
- What did you learn about online assessment tools?
- What did you learn about Artificial Intelligence?
- What is your plan to use AI like Bard and Bing in your teaching and learning or any other related task in your school?
- What new skills, experience, knowledge have you got?
- How would you like to apply the new skills in your subject teaching learning activities (consider also exploring anything you took as a learning apart from the platform)?

Self-Assessment

1. Which of the following is NOT a benefit of using online communication and collaboration tools in virtual classrooms?
   A. Streamlined assessment through online quizzes and tests
   B. Increased difficulty for students to brainstorm ideas
   C. Enhanced real-time interaction with teachers and classmates
   D. Broader learning experiences with virtual field trips
2. Platforms like Google Meet and Zoom primarily enable:
   A. Individual research and writing assignments
   B. Collaborative brainstorming and project work
   C. Accessing and reading online textbooks
   D. Taking timed multiple-choice quizzes
3. Jamboard, an interactive whiteboard tool, is most useful for:
   A. Conducting live video sessions with guest speakers
   B. Administering online polls and surveys
   C. Visualizing complex concepts and problem-solving collaboratively
   D. Providing individual feedback on written assignments

4. Which of the following statements accurately describes Quizizz?
   A. It's a tool for creating traditional written quizzes.
   B. It offers a game-show style format for assessments with immediate feedback.
   C. It's primarily used for conducting online surveys.
   D. It requires students to write code to answer questions.

5. Google Forms allows teachers to create all of the following EXCEPT:
   A. Multiple-choice quizzes
   B. Open-ended essay questions
   C. Live word cloud activities
   D. Short answer response assessments

6. The primary benefit of using tools like Slido and Mentimeter in the classroom is:
   A. To assign homework for students to complete independently.
   B. To facilitate real-time interaction and participation during lectures.
   C. To provide in-depth feedback on written assignments.
   D. To create static presentations for students to view at their own pace.

7. Which one of the following is true about Artificial Intelligence (AI) in education?
   A. AI will replace teachers altogether in the future classroom.
   B. AI tools like Gemini and Copilot will provide additional support to educators.
   C. AI is not currently relevant to the field of education.
   D. Students should be trained in AI development as the primary learning objective.

8. 8. Which one the following is not true about Eval Bee?
   A. It generates error free or 100% accurate reports
   B. Saves a lot of teachers time and Energy
   C. It has room for various fractional markings
   D. It has very limited contribution on avoid exam cheating

Reference Materials

Watch	Using Google Meet
Watch	Online Educational Communication Tools
Watch	The use of padlet for educational purposes
Watch	Online Assessment Tools for Teachers
Watch	The use of Quizziz for teaching and learning
Watch	AI for Educational Purposes
Watch	(690) HOW TO MAKE ANSWER SHEET IN EVALBEE - YouTube

UNIT FIVE: CREATE AND ACCESS TO DIGITAL CONTENTS

Introduction

In this chapter you will discuss on how to access, use, and create digital resources and contents for your teaching and learning. Digital contents can be accessed either online or through hard disks like CDs or flash cards. You will also cover different subject specific Open Educational Resources (OERs) and Ministry of Education digital library portals.

Learning Objectives

By the end of this chapter, you will be able to:

- Create engaging digital content using different platforms for your lesson.
- Explore basic Word and PowerPoint processers functions.
- Learn how to navigate the Ministry of Education's online library and find subject-specific digital resources that will enrich your teaching.
- Explore innovative ways to integrate digital content both for classroom and remote teaching.
- Access different subject specific Open Educational Resources (OERs) for their classes.

Key Topics

Session one: Create Digital Contents

Session Two: Access Digital Contents

Session Three: Ministry of Education Digital Libraries

Session Four: Open Educational Resources (OERs)

Session One: Digital Contents

In this session, you will comprehend about digital content and explore your digital content experience on how to access authenticated resources from online sources.

Activity 1.1. What is Digital Content? (Question and Answer - 10 minutes)

Discuss with the whole class on the following questions:

- What is digital content?
- Give examples of digital contents?

Facilitator Notes

Ask participants the above questions; the objective of this activity is to provide some general understanding of digital content among participants. Finally, conclude the session by mentioning that digital contents can be produced and accessed in various ways and it encompasses materials published, distributed, and stored in electronic formats, including text, voice recordings, video clips, photographs, and animations.

Activity 1.2. Exploring your digital content experience (Group discussion - 15 minutes)

In group of four to six, discuss the following questions:

- Share your experience of using digital content in your classroom?
- What was the topic of your lesson? How you used the digital content?
- Where did you get the content (source)?

Activity 1.3. A Teacher's Journey

Case Scenario 2: Enhancing Learning with Digital Content (20 minutes)

Scenario: Mrs. Almaz's Biology Class

Mrs. Almaz, an experienced biology teacher, is passionate about creating engaging and effective lessons for her students. She believes that integrating digital content can enhance learning experiences and foster student engagement. Here's how she approaches this:

Mrs. Almaz starts by identifying the learning objectives for her lesson. She considers why the topic is important for her students and how digital content can support those objectives. She selects digital materials that align with the curriculum and provide relevant information. For example, she might use interactive maps, videos, or online simulations to illustrate cell concepts from MoE digital Library or authenticated open educational resources such as Khan

Acadamy. Mrs. Almaz evaluates the quality and accuracy of the digital resources. She checks the credibility of the sources, ensuring that the information is up-to-date and reliable. Mrs. Almaz believes that active student participation is crucial. She chooses digital materials that encourage interaction, such as quizzes, polls, or virtual field trips.

She ensures that the chosen digital content is accessible to all students. She considers factors like internet connectivity, device compatibility, and any necessary accommodations. She provides alternative formats (e.g., transcripts for videos) to accommodate diverse learning needs. After the lesson, Mrs. Almaz seeks feedback from her students. Did the digital content enhance their understanding? Was it engaging?

In small group, discuss about the criteria Mrs. Almaz took into account when selecting digital contents for her lesson? List down all the consideration she has made.

Facilitator Notes:

During the discussion on factors to be considered during digital content selection, inform participants to refer to a similar exercise in Chapter one. As you conclude the discussion, emphasize that teachers need to assess digital content based on at least the following criteria:

- *Accessibility: Ensure that the content is accessible to all students.*
- *Relevance: Consider whether the content aligns with the learning objectives.*
- *Interactivity: Evaluate the level of engagement and interaction among students.*
- *Production Quality: Check for high-quality visuals, audio, and overall presentation.*
- *License Information: Be aware of the content's licensing terms.*

Session Two: Creating Digital Contents

Digital content can be considered as any type of media that exists in the form of digital data, including text, images, audio, video, and more. It can be accessed and distributed through electronic devices and online platforms. In this session you will learn different mechanism to create digital contents for your classroom instruction.

Activity 2.1. Preparing PowerPoint Slideshow

Slideshows are very good way to present information in a visually engaging way. They can be used for anything from showcasing visual display of teaching and learning materials to delivering a compelling presentation at work. In education, we don't use slideshow for only sake of presenting

information, rather the goal is to enhance the learning experience, not to overwhelm students with too much information or distract them with overly complex slides.

Questions and Answers (5 minutes)

What is your experience of using slides for teaching and learning? When did you use it? For what purpose? What was the challenge?

Lecture (10 minute)

Present the development of an educational slideshow (PPT). Creating a slideshow for teaching and learning purposes involves several key steps to ensure that the presentation is effective and engaging. Here's a guide to help you create an educational slideshow.

- Define the Objectives: Set clear learning goals for your presentation.
- Know the context: Understand the strengths, weaknesses, and needs of your students. Consider their age, language skills, accessibility and ability to interpret concepts.
- Plan Your Content: Think of what you want to put on your slide - tables, charts, diagrams, or timelines, etc.
- Design the Slides: Use a clean and simple design. Use your placeholder wisely.

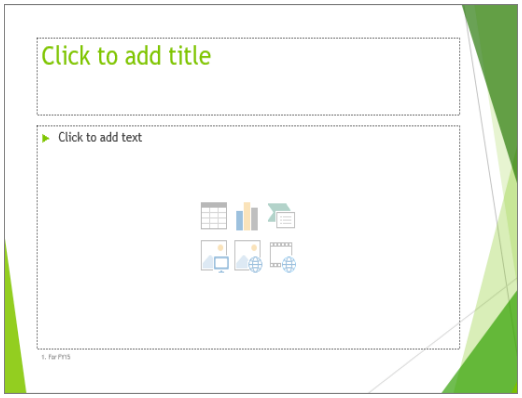


Figure 12. Placeholder

- Make It Interactive: Engage your students by incorporating questions, discussions, or problems to solve.
- Make it short: Don't overwhelm students with too much information or distract them with overly complex slides; use the general rule of 5/5/5. 5 words in each line, 5 lines in each slide, 5 text heavy slide on a subject.
- Practice and Delivery: Rehearse your presentation to ensure smooth delivery.

Demonstration (20 minute)

Demonstrate what you have explained. Open your slideshow, select a topic and create PowerPoint presentation; find an image and paste it as well. Add a caption to your image too. If you have time and think they are ready for it, you could show animation, design options and

other functionality for the power point at this point too. Design options on PowerPoint will suggest designs for your slide given what you have put on it already. Alternatively, you can also show participants a five-minute video.

Once you completed demonstration, ask participants to create their slideshow with text and images. They should make no more than 3-4 slides here. Give them some time (10 minutes) to do this. Additionally, please ask participants to **record** themselves while presenting the slideshow. After recording, they should share the recordings with their respective groups.

Activity 2.2. Using Google Slide to Create a Presentation (10 minutes)

If you don't have access to a laptop or desktop; you can create PowerPoint using Google Slides with your phone. Follow the following steps to download and create PowerPoint using Google slide.

Creating a PowerPoint presentation using Google Slides on your phone is a convenient option when you don't have access to a laptop or desktop. Here's a simple guide to get you started:

- Go to your phone's app store (Google Play Store for Android or App Store for iOS).
- Search for "Google Slides".
- Download and install the app.
- Open the Google Slides app.
- Sign in with your Google account. If you don't have one, you'll need to create it.
- Tap on the "+" icon, usually located at the bottom right of the screen.
- Select "New Presentation" to start creating your slides.
- Google Slides will offer you a variety of themes to choose from.
- Select one that suits the style and purpose of your presentation.
- Tap on the slide where you want to add content.
- Use the toolbar to insert text, images, shapes, and more.
- You can add new slides by tapping on the "+" icon near the slides preview.
- Your presentation will be automatically saved to your Google Drive.
- You can share it with others by tapping on the "Share" icon and entering their email addresses.

Activity 2.3: Using Word Processing (Question and Answer – 5 minutes)

Word processing software is a powerful tool used for creating, formatting, and editing various types of documents. Whether you're jotting down thoughts, taking meeting notes, drafting emails, or writing standard operating procedures word offer much more than the typewriters of old.

- How comfortable are you with word processing programs?
- How often do you use them?

Activity 2.4: Practice using Word (20 minutes)

Go to this link Basic Function of Word and explore how to create a text document. Then using a Microsoft word prepare a text document based on the guidance on the resource. Align your document with your subject discipline.

NB: As they create their worksheet, don't forget to practice using features like select, copy, paste, and other functions of the Word.

Activity 2.5: Using Google Docs to create a Word document (20 minutes)

Google Docs is an online word processor that lets you create and format documents and work with other people using Google Docs. On your computer or phone open Google Docs. You can access Google Docs through the nine dots on Chrome browser (Please refer accessing Google Apps in unit two).

Activity 2.3. Accessing Image for your instruction (Group Discussion - 10 minutes)

This activity focus on how to find and copy images from the internet to use in your teaching as a resource. This can be a valuable way to enhance your lessons and engage students. In group of four to six, discuss on the following questions:

- Where did we get images for our worksheets? Or when we need images for different instructional purpose?
- How do we copy images?
- Do we need to consider anything as we copied images?

Figure 13;Free Source of Images; Source @Google Image

Facilitator Notes:

Ask if participants have ever downloaded an image from the internet and where they sourced it from, with Google Images likely being a common response. Educate them on various platforms where teachers can access free and legal images, emphasizing the importance of looking for images with a

Creative Commons (CC) license. Mention that search engines like Google Images and Bing Images allow users to filter for CC images.

Highlight that platforms such as Pixabay and Unsplash specialize in providing free images. Additionally, introduce the Noun Project as a valuable resource offering free icons for various purposes, particularly beneficial for educators creating worksheets or presentations.

Guide participants on how to search for legally usable images on search engines like Google by navigating to the Usage Rights menu and selecting Creative Commons Licenses. This filter ensures that only images with the CC license are displayed.

Demonstration (15 minutes)

Do an example with Google Images, Unsplash, Pixabay and Noun Project. Take participants through the steps of copying images and use on a working document.

Group Work (15 minutes)

In group of four to six, ask participants to access images from one of the above sources for a lesson in their specific subject area. Let groups work on different source of image such as Bing AI image, Google Images, Unsplash, Pixabay and Noun Project at a time. Finally, allow them to present their result to the whole class. Ask them also to reflect on their experience.

Session Three: Open Educational Resources

Open Educational Resources (OERs) are teaching, learning and research materials in any medium that can be found in the public domain or have been released under an open license that permits no-cost access, use, adaptation, and redistribution by others with no or limited restrictions. Below are some educational resources for your consideration:

Subject specific open educational resources (OER) are learning materials that are tailored to a particular subject or discipline, such as mathematics, history, or engineering. They can include full courses, course materials, modules, textbooks, videos, tests, softwares, etc. Subject specific OER can help teachers and learners to find relevant and quality resources for their teaching and learning needs.

Some examples of platforms that offer subject specific OER are:

- https://oercommons.org/: A public digital library of OER that allows users to search and browse OER from various sources and subjects. Users can also create and publish their own OER using the Open Author tool.
- https://merlot.org/merlot/.A curated collection of free and open online teaching, learning, and faculty development services contributed and used by an international education community. Users can search for OER by discipline, material type, audience, language, and more.
- https://phet.colorado.edu/: Simulations and animations for STEM subjects.
- https://literacy.concordia.ca/en/: Resources for English Language.

Activity 3.1. How to Use OERs (Presentation/Lecture/ -10 minutes)

When we use resources from OERs, it is very important to ask ourselves the following questions:

- How does the content related to my learning outcomes?
- Who created the content? who is using the content?
- When was last updated?

It is also important to apply the 5R activities: retain, reuse, revise, remix, and redistribute as you plan to use contents from open educational resources.

- Retain a copy of an OER on your device or cloud storage for future use.
- Reuse an OER in its original form for your lesson, such as showing a video or assigning a reading.
- Revise an OER by modifying it to suit your needs, such as adding annotations, comments, questions, or feedback.
- Remix two or more OER by combining them to create a new resource, such as integrating a text with an image or a quiz.
- Redistribute an OER by sharing it with others, such as your students, colleagues, or online.

Group Discussion (20 minutes)

In small groups, review one of the examples of open educational resources provided in previous pages and explain on how to apply the 5R principles as you select content for your lesson.

Activity 3.1. Exploring Ministry of Education e-library Resources

Ministry of Education Ethiopia has established e-library for teachers and students to access relevant educational resources online through cloud technology. The e-library enable teaching and learning resources to be available online through computers and smart phones. Through this platform teachers and students will have access to approved resources for teaching and learning use.

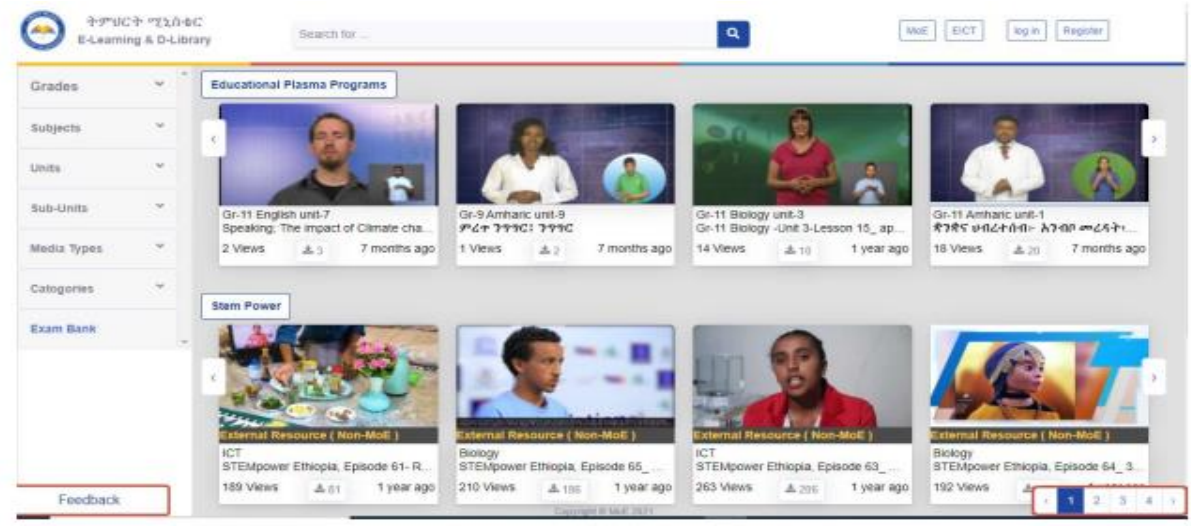


Figure 14. MoE Digital Library

Group Discussion (15 minutes)

In groups of four to six, discuss on the following questions:

- Have you ever utilized digital content from the MoE digital library portal?
- What specific topic or subject was covered in the lesson where you used digital content from the portal?
- Describe how you incorporated the digital content into your teaching.
- Was the content beneficial for enhancing your lesson?
- When selecting content from the portal, what criteria did you consider?

Demonstration (20 minutes)

Use the following what to do Instruction and Demonstrate how to access digital content from MoE Digital Library. Please select contents which are relevant to your subject matter area and describe to your colleagues on how you would use it in your lesson?

What to do:

Step 1: Go to: http://elearn.moe.gov.et.

Step 2: Select content of your choice based on grades, subjects, units, media types, and categories on the left side of the page.

Step 3: Use selected content for the work at hand.

Activity 3.3. MoE Learn English Platform (https://learn-english.moe.gov.et/)

MoE learn English platform is a free of charge or **zero rate** site for learning English language and skills. It offers various resources and activities for different levels of learners, from grade KG to grade 12. You can find videos, podcasts, and quizzes on topics such as grammar, vocabulary, pronunciation, listening, writing, and more. You can also create an account to access the site and track your progress. The site is developed by Ministry of Education Ethiopia in partnership with ethiotelecom. The site is updated regularly with new content and features.

Figure 15. MoE Learn English Website

Group Work – Review MoE Learn English Website (20 minutes)

In group of four to six, review MoE Learn English Website (https://learn-english.moe.gov.et/)

- What are your impressions of the site?
- Does it use zero rating or charge you for data usage?
- Are the contents useful and relevant for your teaching and learning?

Activity 3.4. Review Khan Academy Resources (https://www.khanacademy.org/)

Khan Academy is one of the examples of open educational resources that deliver high-quality educational content across multiple disciplines. This platform provides on its website, or on the Khan Academy's YouTube™ channel, an advanced learning analytics module with useful visualizations. The Khan Academy platform enables online courses in which lessons are produced in the form of videos, interactive activities, and challenges.

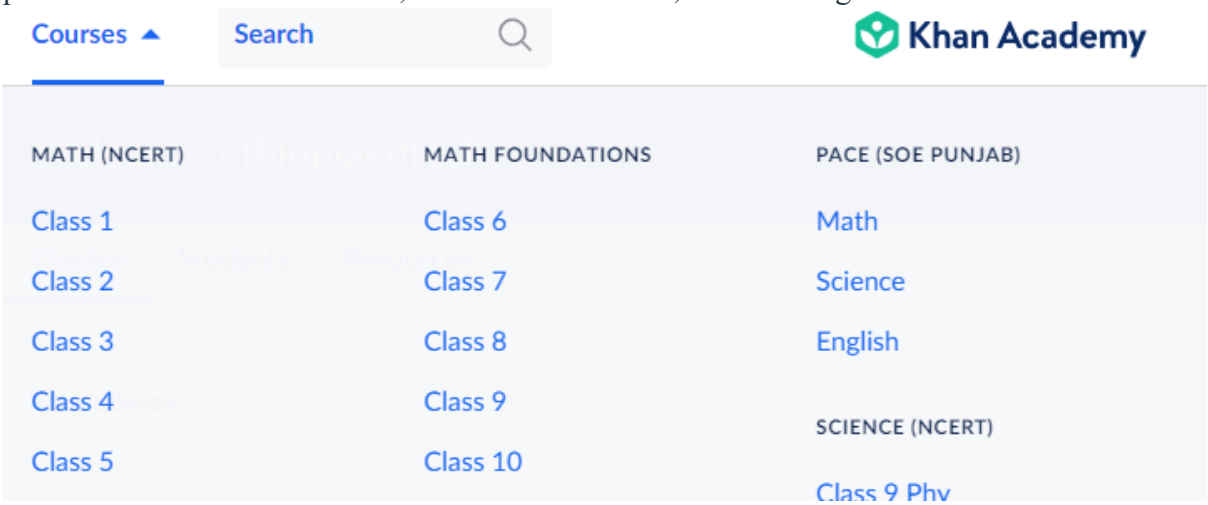


Figure 16. Khan Academy

Students can watch videos and solve supplementary practice exercises to understand various lessons and concepts more easily. Also, teachers can make use of Khan Academy to supplement the teaching process and provide extra content to learners to enhance learning.

Individual Task (15 minutes)

Go to https://www.khanacademy.org/ and identify content related to your subject area. Which content do you identified? How are you going to use the content to enhance learninig outcomes among students? How do you explain the whole experiences of accessing content from Khan Academy?

Activity 3.5. YouTube as Source of Educational Contents

YouTube is not open educational resources, but it can be a powerful tool for teachers to enhance their lessons and cater to different learning styles. Here are some ways teachers can leverage YouTube for educational purposes:

- Finding educational content: YouTube offers a vast library of educational videos on almost any subject imaginable. Teachers can find documentaries, lectures, experiments, simulations, and instructional videos created by educators or educational institutions.

- Visualizing complex concepts: Scientific phenomena, historical events, or abstract ideas can be brought to life through engaging and informative videos. This can be particularly helpful for students who learn better visually.

- Introducing new topics: A captivating and well-made video can spark students' curiosity and introduce a new topic in a stimulating way.

- Flipped classroom approach: Teachers can use YouTube videos for students to watch at home, freeing up classroom time for discussions, activities, and deeper exploration of concepts.

Additional tips for teachers using YouTube for Educational Purpose:

- Carefully curate content: Since not all YouTube content is created equal, teachers need to preview videos and choose those that are accurate, age-appropriate, and meet learning objectives.
- Consider copyright: Copyright laws apply to YouTube videos. Teachers should be familiar with fair use guidelines to ensure they are using content legally.
- Engage students with the video: Simply showing a video isn't enough. Teachers should prepare discussion questions or activities to help students process the information and connect it to the lesson.

Individual Task (15 minutes)

Go to YouTube and identify content in your subject matter for any topic you might think to explore further. Which content do you identified? How are you going to use the content to enhance learning outcomes among students? How do you explain the whole experience of accessing content from YouTube?

Activity 3.6. Exploring Digital Skills Training for Educators (EdTech 101 online course)

The EdTech 101 Course has been thoughtfully prepared as a complement to the face-to-face digital training. Its primary purpose is to allow educators (teachers, principals and supervisors)

to continue practising the use of digital tools and platforms once they return to school. In addition to the content covered during in-person sessions, this online course provides additional insights on how to seamlessly integrate digital technologies into teaching and learning practices.

The course is suitable for both new and experienced teachers, offering comprehensive coverage of essential topics. Participants will explore an introduction to educational technology, delve into various digital platforms, discover open educational resources (OER), and gain an understanding of digital citizenship. To fully grasp the material, participants can expect to invest approximately two weeks in completing the course. However, the flexibility of the course allows educators to take it at their own pace, anytime and anywhere that suits them. Based on their choice, teachers can also choose to focus on specific sections that interest them once they joined the course.

Join the training on Canvas with the following steps:

- **Open a Browser and Go to: https://canvas.instructure.com/enroll/CX4AC8**
- **Complete the Request Form**: Fill in the required information:
  - New user details (if applicable).
  - Full name.
  - Email address.
  - Agree to the terms of use.
  - If there's a Captcha form, complete it as well.
  - After submitting the form, you'll be directed to the course dashboard.
  - Here, you'll find information related to the training course.
- **Activate Your Account via Email**:
  - Check your email inbox for an activation email from Canvas.
  - Click the activation link provided in the email.
  - You'll be taken to a page where you can set your password.
- **Access the Course**:
  - Now that your account is activated, you can log in to Canvas using your email and the password you just set.
- **Mobile Access**:

- For convenience, you can also download the Canvas Student App from the App Store or Google Play Store on your phone.
- Use the app to attend the course on the go.

Individual task (45 minutes)

Get registered yourself on the course. Please follow the link provided to register for the course. Explore the course features, check your email, and activate your account using the activation email. Your facilitator will guide you through the registration process.

Key Ideas

Digital Content

Digital content can be a useful tool if teachers use it appropriately in improving learning outcomes among students. Digital tools might be employed in diverse ways to enhance learning experiences. One significant advantage of using digital content is its capacity to explain complex concepts in a more captivating manner. Teachers leverage interactive tools, simulations, and educational games to simplify the topic under discussion. Moreover, digital content facilitates differentiation, catering to students with varying learning styles and paces. Learners can revisit lessons and access supplementary resources online, fostering a self-directed learning environment. Additionally, digital content streamlines tasks for teachers—pre-made materials, online assessments, and grading software save valuable time, allowing personalized feedback to students.

Below are some of the factors we might consider as we select digital resources for our lesson.

- Learning outcomes: What knowledge, skills and attitudes do you want the learners to achieve? In fact, technology should not drive learning but rather the set learning outcomes.
- Age of learners: the technology tools to be used should consider learner development stage and their readiness to use it.
- Access to technology: What technology is available for use in the teaching and learning process.
- Learner centeredness: Does the technology chosen allow the learners to learn collaboratively on their own and can they be able to use it without depending on the teacher.
- Creativity and innovation: does the technology arouse creativity and innovation in the learners? Can the learners suggest other ways in which they can use the technology?
- Safety of learners: This should be a paramount importance especially when learners are expected to use online tools and resources.

- Teacher competence: How the teacher use the technology with confidence as he facilitates learning.
- Inclusiveness: technology instructional design should be accessible to all learners including those with special needs.

Images

Using visuals such as images play a crucial role in enhancing both teaching and learning. They capture students' attention, simplify complex ideas, and act as translators for abstract concepts. Thought-provoking images also stimulate discussions and critical thinking. For younger learners and those acquiring a new language, pictures bridge the gap between words and their meanings, reinforcing vocabulary acquisition. By incorporating a variety of visuals, teachers create an inclusive learning environment that fosters deeper understanding and a lifelong love of learning.

Power Points

Teachers and educators often utilize presentation tools like PowerPoint and Google Slides to create educational content for their students. These platforms allow them to save time and seamlessly incorporate various resources into their materials. Additionally, some educators choose to record their presentations using PowerPoint's recording feature, making it convenient to share with students for future reference.

Ministry of Education e-Library

Ministry of Education e-Library provides a wealth of educational content, most of them verified and approved. Access a variety of engaging formats to suit your learning style, including educational videos, audiobooks, and textbooks. Follow the below steps to access resources from MoE e-Library.

Open Educational Resources (OERs)

Open educational resources (OERs) are transforming classrooms by offering teachers a treasure of free and adaptable learning materials. These resources, which can include digital textbooks, interactive exercises, and multimedia content, empower teachers in several ways. Firstly, OERs tackle the issue of cost. By incorporating them, teachers can reduce the financial burden on students who might otherwise struggle to afford traditional textbooks. Secondly, OERs are incredibly flexible. Many come with open licenses, allowing teachers to modify and tailor them to their specific curriculum and student needs. This fosters a more personalized learning

experience. Additionally, OERs can tap into the power of collaboration. Teachers can share and adapt resources developed by colleagues around the world, promoting innovation and the exchange of best practices. Ultimately, OERs empower teachers to create dynamic and engaging lessons that cater to diverse learning styles, all while promoting a more equitable and accessible learning environment for all students.

Implication for teaching

Record your responses to the following questions as your key learning and future considerations on your handouts.

- What did you learn about digital content and how are you planning to use them in the future?

- What is your plan to use images from different sources for your teaching and learning or any other related task in your school?
- What is your plan to use slideshow presentations in your teaching and learning or any other related task in your school?
- What did you learn about MoE e-Libraries and Learn English platforms?
- What are Open Educational Resources and How are going to use them going forward?
- What is your plan to use MoE Digital Library and Learn English Platform for your teaching and learning or any other related task in your school?
- How are you going to encourage your students to access the MoE digital libraries and other OERs?
- What did you learn about Khan Academy and YouTube?
- How are you going to encourage your students to access digital content from YouTube and Khan Academy Sources?

Self-Assessment

1. What is one significant advantage of using digital content in education?

   A. It saves teachers time by automating grading.
   B. It fosters self-directed learning among students.
   C. It replaces traditional textbooks entirely.
   D. It simplifies complex ideas through interactive tools.

2. How do images enhance teaching and learning?

   A. By providing pre-made materials for teachers.
   B. By bridging the gap between words and meanings.

C. By automating assessments.

D. By replacing traditional textbooks.

3. Which presentation tools are commonly used by educators?

   A. Google Sheets and Excel

   B. PowerPoint and Google Slides

   C. Word and Notepad

   D. Prezi and Keynote

4. How can teachers create a PowerPoint presentation using Google Slides on their phones?

   A. By downloading the Google Slides app and signing in with their Google account.

   B. By using a laptop or desktop computer.

   C. By searching for "Google Slides" in the app store.

   D. By selecting a theme from a variety of options.

5. What does the Ministry of Education e-Library provide?

   A. Free laptops for students

   B. Educational videos, audiobooks, and textbooks

   C. Online assessments

   D. Grading software

Reference Materials

Read	Importance of Using PowerPoints and Word as a Teacher
Read	The Basics of Word
Read	The Basics of PowerPoints
Watch	How to use Google Docs and Slides
Watch	Creating Quality Digital Contents
Read	Best Practice for Teaching with Digital Content
Read	How to use image effectively in your lesson
Read	Why Should I use OERs?
Watch	Impactful use of OER
Read/Watch	http://elearn.moe.gov.et.
Watch	https://learn-english.moe.gov.et/
Read	How to join online course on Canvas

UNIT SIX: DIGITAL CITIZENSHIP

Introduction

In this chapter, you will discuss about safe use of technologies such as mobile phone, computers, tablet, and the internet. Specifically, you will discuss on risks in connection with internet use and safety measures.

Learning Objectives

By the end of this chapter, you will be able to:

- Explore safe and responsible behaviour in using internet and communication technologies.
- Explain the risks associated with using the internet and communication technologies.
- Contextualize e-safety rules and guidelines for their schools.

Key Topics

Session One: Internet Risks and e-Safety

Session Two: Computer and Smartphones Safety

Session One: Internet Risks and e-Safety

Activity 1.1: Exploring the concept of e-Safety. Think Pair Share (10 minutes)

What is e-Safety? With what concept or term does e-Safety connected?

e-Safety is often synonymous with online, or internet safety and it is concerned with being safe and appropriate use of technologies without compromising personal security and safety.

Activity 1.2: Unpacking Risks Associated with Internet

Group Discussion (15 minutes)

Students are often unaware of the potential danger in relation to internet and are susceptible to unsafe online behaviour. Now, in group of four to six, discuss on potential e-Safety risks. After you finish your discussion, share with your facilitator on any convenient platform for you.

Activity 1.3: Exploring e-safety risks.

Group Discussion (15 minutes)

In small groups, discuss on the following potential e-safety risks. (Each group might discuss at least on two of the risks mentioned below). Then, prepare online presentation using Google Slides or any convenient platform and present for the whole class.

1. Social Networking Risks
2. Age restrictions
3. Sharing Online profiles/Security risk
4. Publishing content
5. Uploading Photos and Videos
6. Cyberbullying
7. Copyright
8. Exposure to inappropriate online content
9. Excessive time online

Activity 1.4: Fake News

Being online exposes children to number of fake news and unverified information which put them and even others to risks of different kind.

Whole class discussion (5 minutes)

- What is fake news? what is news?
- Give examples of fake news on digital platforms?

Facilitator Notes

- ***News*** *is factual information about a recent event that is new to people and will be of interest to them.*
- ***Fake news*** *is lies and/or propaganda told for a political or commercial purpose and influence millions of people. It's often deploying through digital technology, social media, news networks to go viral and reach people very quickly.*

Activity 1.5: Fact, Opinion and Fake news

Whole class discussion (10 minutes)

- What is the difference between facts and opinion?
- Give some examples of facts, opinion and fake information on the similar topic?

- How can we help students to differentiate between facts, opinions, and fake information?

Example of Fact and Opinion

- **Fact:** Ethiopia is one of the Country in East Africa.
- **Opinion:** Ethiopia will soon become middle income Country.
- **Fact:** Abebech Gobena has provided education opportunity for many Ethiopians through her NGO.
- **Opinion:** Abebech Gobena is a well-remembered person in Ethiopian philanthropy work. Fact: Addis Ababa is the capital of Ethiopia.
- **Opinion:** Pollution is the main problem facing Addis Ababa.

Media Detection questions

Always encourage your students to ask themselves the following questions as they come across media contents.

Figure 17. Media detection questions

Activity 1.6: Adopting e-Safety rules for your school

Group Discussion (15 minutes)

Do you have e-safety rules at your school? In small group discuss on possible e-Safety rules for students and teachers in your school. Then, post your answers with your group name on top of it on one of interactive platforms.

Facilitator Notes: Basic e-safety rules

Social networking poses little risk if students follow basic e-safety 'rules' such as:

- *keeping personal information private*
- *respecting the rights and feelings of others*
- *Stick to the given assignment (importance of providing specific links)*
- *thinking about the long-term consequences of what you post online*
- *reading and adhering to the terms and conditions of use*

Session Two: Computer and Smartphone safety

Activity 2.1. Using Computer and smartphones safely (15 minutes)

Make a group of four to six members and discuss on the following issues.

1. How do you give care and protect your devices from malfunctioning and break?

2. What safety measures due you take to protect and secure your devices from an allowed users, virus and cyber-attacks?

Key Ideas

Internet Risks

The following are common internet risks that we should be aware of and also educate our students.

- ***Social Networking Risks:***
  - Social media platforms can expose users to cyberbullying, inappropriate content, and privacy breaches.
  - Discuss how to manage privacy settings, avoid sharing personal information publicly, and recognize fake profiles.
- ***Age Restrictions****:*
  - Many online services have age restrictions to protect children from inappropriate content.
  - Explore the importance of adhering to age limits and the risks associated with underage access.
- ***Sharing Online Profiles/Security Risk***:
  - Sharing personal information online can lead to identity theft, phishing attacks, and stalking.
  - Highlight the need for cautious profile sharing and strong passwords.
- ***Publishing Content****:*

- Posting content online (blogs, videos, etc.) can have unintended consequences.
- Discuss responsible content creation, copyright awareness, and avoiding harmful material.

- ***Uploading Photos and Videos****:*
  - Sharing images and videos can lead to privacy breaches or misuse.
  - Talk about consent, geotagging, and the impact of sharing visual content.
- ***Cyberbullying****:*
  - Online harassment affects mental health and well-being.
  - Address strategies to prevent and respond to cyberbullying.
- ***Copyright****:*
  - Using copyrighted material without permission can lead to legal issues.
  - Educate about fair use, Creative Commons licenses, and proper attribution.
- ***Exposure to Inappropriate Online Content****:*
  - Children may accidentally encounter harmful or explicit material.
  - Discuss safe browsing habits and parental controls.
- ***Excessive Time Online***
  - Spending too much time online can impact physical health, sleep, and social interactions.
  - Explore healthy screen time practices and digital balance.

Safe Use of Computers and Smartphone

Maintaining clean digital devices is crucial for both the longevity of the devices and our own well-being. Let's explore some reasons why it's essential to keep your electronic equipment clean:

1. **Device Performance and Longevity**:
- Regular cleaning helps prevent dust buildup and clogged fans, which can lead to overheating and damage to internal components.
- Clean devices run more smoothly, ensuring optimal performance and extending their lifespan.
2. **Improved Appearance**:
- A clean device looks better and is more pleasant to use.
- Considering how much time we spend interacting with our devices, an improved appearance positively impacts our daily experience.
3. **Health Protection**:
- Think about all the surfaces you touch throughout the day. Now imagine transferring that to your devices—keyboards, screens, and touchpads.
- If you don't clean your devices, they can harbour bacteria and germs, posing health risks when you touch your face or hands.
- Safe use of devices helps your eye from being damage due to inappropriate use.
4. **Avoiding Constant Replacements**:
- Regular cleaning reduces wear and tear, preventing premature device failure.
- Frequent replacements are inconvenient and costly, so maintaining your devices can save you time and money.

Implication for Teaching

Record your responses to the following questions as your takeaway and future consideration on your handouts.

- What did you learn e-safety?
- What are the potential risks in using digital technologies (internet)?
- What new skills, experience, knowledge have you got?

- How would you like to apply the new skills in your subject teaching learning activities?

Self Assessment

1. **What is the difference between facts and opinions?**

A. Facts are subjective statements, while opinions are objective.
B. Facts are based on evidence and can be verified, while opinions are personal beliefs.
C. Facts and opinions are interchangeable.
D. Opinions are always accurate, while facts can be misleading.

2. **Which of the following statements is an opinion?**

A. Ethiopia is one of the countries in East Africa.
B. Addis Ababa is the capital of Ethiopia."
C. Abebech Gobena has provided education opportunities for many Ethiopians through her NGO.
D. Ethiopia will soon become a middle-income country.

3. **What risks are associated with social networking platforms?**

A. Exposure to cyberbullying and inappropriate content
B. Increased privacy and security
C. Enhanced communication skills
D. Improved mental health

4. **Why is it important to keep digital devices clean and in good working order?**

A. To prevent identity theft
B. To avoid copyright infringement
C. For the health of the device and the user
D. To enhance internet speed

Reference Materials

Read	Smart Phone Use Safety Tips
Read	Parental Guide to Smartphone Safety
Read	How to secure your devices
Read	e-Safety Tips
Watch	Safe Online
Watch	Digital Footprint

Watch	Four Reasons to care about your digital footprint
Watch	How Fake News Spread
Watch	Fact vs Fake

Well done! You've made it to the end of the Module! We hope you've found it useful, and you'll join us Canvas Online Digital Skills Training.