The Government of the Republic of the Union of Myanmar

Ministry of Education

Year 2 Semester 1

EDU2106

Curriculum and Pedagogy Studies: Mathematics

Teacher Educator Guide

PREFACE

The Myanmar Ministry of Education developed the four-year Education Degree College Curriculum, in line with the pre-service teacher education reform as specified in the National Education Strategic Plan (NESP) 2016-2021.

The Myanmar Education Degree College Curriculum consists of several components: the curriculum framework, syllabi, Student Teacher Textbooks, and Teacher Educator Guides. This curriculum for the four-year Education Degree College was designed and structured to align with the Basic Education Curriculum and to equip student teachers with the competencies needed to teach effectively in Myanmar's primary and middle school classrooms. It is based on a Teacher Competency Standards Framework (TCSF) which articulates the expectations for what a teacher should know and be able to do in the classroom.

The curriculum follows a spiral curriculum approach which means that throughout the four years, student teachers return to familiar concepts, each time deepening their knowledge and understanding. To achieve this, the four-year Education Degree College programme is divided into two cycles. The first cycle (Years 1 and 2) is repeated at a deeper level in the second cycle (Years 3 and 4) to enable student teachers to return to ideas, experiment with them, and share with their peers a wider range of practices in the classroom, with the option to follow up on specific aspects of their teaching at a deeper level.

The curriculum structure provides an integrated approach where teaching of subject knowledge and understanding educational theories are learnt through a supportive learning process of relevant preparation and practical application and experience. The focus is, therefore, not just on subject content, but also on the skills and attitudes needed to effectively apply their knowledge, skills, and attitudes in teaching and learning situations, with specific age groups. As the focus is on all components of a 'competency' – knowledge, skills, attitudes and their effective application – it is referred to as a competency-based curriculum.

Accordingly, a competency-based curriculum is learner-centred and adaptive to the changing needs of students, teachers, and society. Where new concepts are learnt, they are then applied and reflected on:

1. Learn (plan what and how to teach);
2. Apply (practise teaching and learning behaviours); and
3. Reflect (evaluate teaching practice).

Beyond the Education Degree College coursework, it is intended that student teacher graduates will be able to take and apply this cycle of 'learn, apply, and reflect' to their own teaching to effectively facilitate the learning and development of Myanmar's next generation.

The Myanmar Education Degree College Curriculum was developed by a curriculum core team, which is a Ministry of Education-appointed team of Myanmar Education Degree College teacher educators supported by the Ministry of Education, resource persons from the Universities of Education, University for the Development of National Races of the Union and a team of national and international experts. Overall guidance of the work was provided by the Department of Higher Education, Ministry of Education.

The curriculum development was also supported by the Strengthening Pre-Service Teacher Education in Myanmar project, with technical assistance from the United Nations Educational, Scientific and Cultural Organization (UNESCO) and financial contributions from Australia, Finland, and UK Governments.

TABLE OF CONTENTS

HOW TO USE THIS GUIDE

Who will use this Mathematics Teacher Educator Guide?

This teacher educator guide has been designed to help you facilitate student teachers' learning of Year 2 Mathematics. It is addressed to you, as the teacher educator, and should be used in tandem with the student teacher textbook as you teach Mathematics. This teacher educator guide contains step-by-step instructions to help you guide the student teachers in your class towards achieving the learning outcomes for each lesson and unit in the student teacher textbook.

When and where does Year 2 Mathematics take place?

A total of 66 teaching periods (Semester 1: 36 teaching periods; Semester 2: 30 teaching periods) are allotted for Year 2 Mathematics of the four-year Education Degree College programme. Classes will be held on the Education Degree College campus.

What is included in the Year 2 Mathematics teacher educator guide?

The organisation and content of both Mathematics Student Teacher Textbook and this teacher educator guide align with Mathematics subject syllabus of the four-year Education Degree College programme.

Year 2 Mathematics contains following topics:

- Introduction to Mathematics
- Problem-solving and Misconceptions
- Understanding Mathematics
- Mathematical Modelling and Representation
- How we learn and how we teach Mathematics

The Teacher Educator Guide follows the same structure as the Student Teacher Textbook. For each unit and lesson, there are **expected learning outcomes** and **competencies** that indicate what student teachers should know and be able to do by the end of the unit.

For each lesson, the Teacher Educator Guide includes:

Competencies gained: This list of competencies highlights the teacher competencies from the Teacher Competency Standard Framework (TCSF) that are focused on in that lesson.

Time: This is the total teaching minutes and number of 50-minute class periods allocated for the lesson as per the syllabus.

Learning strategies: This is an overview of all the learning strategies used during the suggested lesson learning activities.

Assessment approaches: This is an overview of all the assessment approaches suggested to be used before, during and after the lesson learning activities.

Preparation needed: This can include: guidance on what you need to know about the topic and references to subject knowledge resources; technology preparation; links to other subjects; room organisation; time management; and reference to expected answers.

Resources needed: This can include: printed media, flipchart paper, coloured paper, marker pens, URLs, video clips, low/no cost resources, and practical equipment.

Learning activities: Each lesson includes a variety of suggested learning activities designed to help student teachers achieve the expected learning outcomes within the allotted time. Each lesson should begin by activating the student teachers' prior knowledge or fostering interest in the subject. Learning activities are varied and in line with competency-based approaches to teaching and learning.

Facilitator's notes: These instruction boxes are included as an occasional 'safety net' at key points during the lesson, reminding you to quickly

check that the lesson is flowing in the direction as planned, and to check if there are any points to emphasise to ensure that student teachers are learning effectively before moving forward.

Assessment: This comes at the end of each activity. It is an explanation or recap as to how each activity can be assessed formatively in order to assess success and inform future teaching. Instructions for facilitating various types of assessment are included in the *Toolbox for assessment approaches.*

Possible student teachers' responses: These are responses that you may get from the student teachers from each learning activity's assessment.

Check student teachers' understanding: This is the lesson plenary. At the end of the lesson, revisit the learning objectives and TCSF competencies, summarise the learning outcomes and briefly assess the extent to which they have been achieved. Summarise the competencies and how they were addressed by the lesson content. Explicitly remind student teachers what they have studied and how they did so.

Extended learning activities: Some lessons in this guide include ideas on ways to adapt the learning activities to provide additional stimulus for student teachers to deepen their learning. These extended learning activities emphasise the benefits of flexibility in learning to respond to diverse needs and interests of student teachers. It is not mandatory to complete these learning activities during the class period.

Differentiated learning activities: Some lessons in this guide include ideas on ways to adapt the learning activities by considering different learning needs and interests of student teachers towards attaining the learning outcomes and TCSF competencies. These differentiated learning activities emphasise inclusive and flexible practice in teaching and learning. It is not mandatory to complete these learning activities during class period.

For each sub-unit, the Teacher Educator Guide includes:

Expected student teachers' responses for the review questions in TB: A box at the end of each sub-unit gives you the answers to the review questions in the Student Teacher Textbook. This section exists to support your knowledge as a teacher educator, and enables you to support your student teachers by confirming the answers to the questions in their Student Teacher Textbook. It is NOT part of the lesson.

Each unit of the Teacher Educator Guide ends with a **Unit Summary**, which includes:

Key messages: This is a summary of the unit, including a reminder of the key points that student teachers should take from the unit.

Unit reflection: This section is part of the student teachers' self-study material and is included in the Student Teacher Textbook. It is duplicated here to inform you of its content. Your only task here is to remind the student teachers to read it. It does not form part of any lesson. It provides the student teachers with reflection points or questions relating to the learning in the unit.

Further reading: Suggestions for additional resources are listed according to the relevant unit. You can use these resources to learn more about the topic yourself or encourage student teachers to look these up in the library, on the internet, or in your Education Degree College's e-library.

Please note that the learning activities in the Student Teacher Textbook are designed for individual self-study. At times, these individual learning activities may be incorporated into the learning activities outlined in this guide. You may also wish to assign the learning activities in the Student Teacher Textbook for homework, or encourage student teachers to do them at their own pace.

While this Teacher Educator Guide contains detailed learning activities to help you plan and deliver lessons, the instructions in this guide are only suggestions. The student teachers in your classroom will have different characteristics and learning needs. As their teacher educator, you are encouraged to come up with your own learning activities which suit these needs, interests, and ability levels. You should feel free to change and adapt the lessons as much, or as little, as needed.

What is a competency-based curriculum?

The Student Teacher Textbooks and Teacher Educator Guides for all Education Degree College programmes follow a competency-based approach. This is outlined in the Education Degree College Curriculum Framework for the four-year degree and is based on the Myanmar Teacher Competency Standard Framework (TCSF). A competency-based approach means that the teacher education curriculum does not just focus on subject content. Rather, it emphasises the development of knowledge, skills, and attitudes and their application in real-life contexts. Competency-based curriculums are learner-centred and adaptive to the evolving needs of learners, teachers, and society.

The following elements are integrated throughout this Teacher Educator Guide, in line with a competency-based approach to teacher education: [1]

- **Contextualisation:** The learning content and learning activities are based on the Myanmar context to ensure that student teachers can relate what they learn to daily life.
- **Flipped classroom:** This pedagogical concept and method replaces the standard lecture-in-class format with opportunities for student teachers to review, discuss, and investigate module content with the teacher educators in class. Student teachers are typically expected to read the learning materials before class at their own pace. Classroom time is then used to deepen understanding through discussion with peers and problem-solving activities facilitated by you, the teacher educator.
- **Collaborative learning:** This educational approach involves groups of student teachers working together to solve a problem or complete a task. Learning occurs through active engagement among peers, either face-to-face or online. The main characteristics of collaborative learning are: a common task or activity, small group learning, co-operative behaviour, interdependence, and individual responsibility and accountability (Lejeune, 2009).[2]
- **Problem-solving:** This involves the act of defining a problem; determining the cause of the problem; identifying, prioritising and selecting alternatives for a solution; and implementing a solution. The learning content and activities included in this Teacher Educator Guide provide opportunities for student teachers to apply their problem-solving skills as appropriate.

[1] Adapted from the *Glossary of curriculum terminology* (UNESCO-International Bureau of Education, 2013)
[2] Lejenue's Collaborative Learning for Educational Achievement (1999)

Course rationale and description

This course will prepare student teachers with the competencies required to teach the Mathematics subject through modelling the values and attitudes promoted in the basic education curriculum for the types of citizens and society Myanmar envisions to create. The skills fostered through this subject are relevant to the lives of everyone, particularly the ones of our students living in the rapidly changing world of the 21st century. Problem solving is a key skill, essential to have a fulfilling life as a citizen of Myanmar, fostered across different subjects and learning areas of Education Degree College curriculum and is particularly reiterated in the Mathematics subject. By making the subject more relevant to their daily lives, student teachers will develop positive perceptions towards Mathematics and become more confident in it. Through this course, student teachers will gain not only these essential skills themselves but also be able to facilitate their students' attainment of these skills. Both academic (what we teach) and pedagogical (how we teach) content and competencies are crucial and will be taught in an integrated approach. In order to address the needs of different students, student teachers will know how to create learning environments that will help middle school students learn, and develop their own teaching and learning resources, learning activities, and assessment approaches, appropriate for the age of students, for the Mathematics subject. With reference to the Educational Degree College Curriculum Framework, in Years 1 and 2, student teachers are expected to develop their fundamental knowledge of Mathematics and basic pedagogical knowledge and competencies for teaching Mathematics. In Years 3 and 4, they will further strengthen deeper understanding of Mathematics subject knowledge and gain a more systematic grasp of the effective implementation of Mathematics curriculum, instruction and assessment.

Basic Education Curriculum objectives

This subject, Mathematics, is included in the pre-service Education Degree College (EDC) curriculum to ensure that teachers are prepared to teach the Mathematics curriculum as defined for basic education in Myanmar. Middle school teachers will be trained as subject area specialist and learn about academic standard equivalent to middle and high school level in order to ensure a strong subject proficiency foundation for being effective teachers for middle school students (Education Degree College Curriculum Framework, 2018).

The objectives of Basic Education Curriculum are as follows:

a. Ensure every school-age child learn until the completion of Basic Education;

b. Generate critical thinking skills in students, progressively throughout their primary education and are hence, equipped with five strengths;

c. Engage students to become responsible and accountable individuals who abide the laws in compliance with civic, democracy and human rights standards;

d. Cultivate students with appreciation to open-mindedness, curiosity, innovation and cooperation;

e. Strengthen 'union spirit' by allowing students to appreciate and preserve the languages, literatures, cultures, arts, traditional customs and historical heritage of all national ethnic groups and hence, evolve as citizens capable to pass on those valuable assets;

f. Give rise of students who appreciate and conserve natural environment, and involve in the dissemination of knowledge and skills in respect to sustainable development;

g. Enable the quality environment for education in conformity with international standards, and strengthen the quality of learning and teaching process by integrating technology in line with today's needs;

h. Promote sound body and sportsmanship through participation in sports and physical education activities, and school health activities;

i. Develop foundational knowledge for higher education, with inclusive to technical and vocational education; and

j. Empower to become global citizens who embrace diversity as individual or group, respect and value equality, and are armed with fundamental knowledge of peace to practice in their daily lives.

Learning objectives for middle school students for Mathematics subject

- To consolidate the mathematical knowledge and skills that were developed in the primary phase of schooling in numbers, operations, geometry.
- To build further foundations of knowledge and skills in these branches (or strands and sub-strands) of Mathematics and in other new areas such as algebra, graphs and more advanced geometry.
- To develop a level of fluency in using the many algorithms and methods they are taught so that they are confident and can use this fluency and understanding to move onwards to more advanced areas of Mathematics.
- To develop the skills to think mathematically, often through teaching patterns and methods to solve problems.
- To understand how they use and could use Mathematics in their lives.
- To develop mathematical knowledge and skills to flourish in the 21st century, to explore and be creative with Mathematics.

Table A. Teacher competencies in focus: Year 2 Mathematics

Competency standard	Minimum requirement	Indicators
A1: Know how students learn	A.1.1 Demonstrate understanding of how students learn relevant to their age and developmental stage	A1.1.1 Give examples of how the students' cognitive, physical, social, emotional and moral development may affect their learning A1.1.2 Prepare learning activities to align with students' level of cognitive, linguistic, social, and physical development
	A1.2 Demonstrate understanding of how different teaching methods can meet students' individual learning needs	A1.2.1 Identify various teaching methods to help students with different backgrounds (gender, ethnicity, culture) and abilities, including special learning needs, learn better A1.2.2 Identify focused and sequenced learning activities to assist students to link new concepts with their prior knowledge and experiences
A2: Know appropriate use of educational technologies	A2.1 Demonstrate understanding of appropriate use of a variety of teaching and learning strategies and resources	A2.1.1 Plan learning experiences that provide opportunities for student collaboration, inquiry, problem-solving and creativity A2.1.2 Use teaching methods, strategies and materials as specified in the textbooks and additional low cost support materials, to support student learning

Competency standard	Minimum requirement	Indicators
	A2.2 Demonstrate understanding of appropriate use of Information and Communication Technology (ICT) in teaching and learning	A2.2.1 Describe the function and purpose of online and offline educational tools and materials to support the teaching and learning process A2.2.2 Evaluate and match available online and offline ICT tools and materials to curriculum content and pedagogical strategies, including online and offline
A4: Know the curriculum	A4.1 Demonstrate understanding of the structure, content and expected learning outcomes of the basic education curriculum	A4.1.1 Describe key concepts, content, learning objectives and outcomes of the lower secondary curriculum for the subjects and grade level/s taught A4.1.3 Describe the assessment principles underpinning the Lower Secondary curriculum
A5: Know the subject content	A5.1 Demonstrate understanding of the subject matter to teach the assigned subject/s for the specified grade level/s	A5.1.1 Describe key concepts, skills, techniques and applications for the subjects covered in the grade levels taught A5.1.2 Include in lessons accurate and relevant information, examples and exercises to support student learning of core subject content, skills and procedures A5.1.3 Link key concepts, principles and theories to real life applications to build discipline specific foundations and skills for different classes and grade levels taught
	A5.2 Demonstrate understanding of how to vary delivery of subject content to meet students' learning needs and learning context	A5.2.1 Describe ways to contextualise learning activities for the age, language, ability and culture of students to develop understanding of subject related principles, ideas and concepts A5.2.2 Explain how lessons are contextualised to include localised information and examples related to the subject content, concepts and themes A5.2.3 Describe approaches to model the use of content specific language, technical terms and skills by providing examples of use in real life contexts
B1: Teach curriculum content using various teaching strategies	B1.1 Demonstrate capacity to teach subject-related concepts clearly and engagingly	B1.1.1 Use different ways to explain the subject matter, related ideas and concepts to meet a range of learning abilities and intended learning outcomes B1.1.2 Select instructional material to link learning with students' prior knowledge, interests, daily life and local needs B1.1.3 Encourage students' awareness of their own thought processes and use of reflection to build new understanding

Competency standard	Minimum requirement	Indicators
	B1.3 Demonstrate good lesson planning and preparation in line with students' learning ability and experience	B1.3.1 Plan and structure lesson to ensure all the lesson time is used effectively B1.3.2 Provide lesson introductions to link new learning to prior learning, to engage students' interest and to motivate them in learning B1.3.3 Prepare focused and sequential learning experiences that integrate learning areas and are responsive to students' interests and experience B1.3.4 Use questioning techniques and examples, to introduce and illustrate concepts to be learnt
B2: Assess, monitor and report on students' learning	B2.1 Demonstrate capacity to monitor and assess student learning	B2.1.1 Use assessment techniques as part of lessons to support students to achieve learning outcomes B2.1.3 Use questioning and discussion techniques to check students understanding and provide feedback
	B2.2 Demonstrate capacity to keep detailed assessment records and use the assessment information to guide students' learning progress	B2.2.2 Use varied assessment practices to monitor and record students' learning progress and inform further planning of the curriculum
D1: Reflect on own teaching practice	D1.1 Regularly reflect on own teaching practice and its impact on student learning	D1.1.1 Use evidence of students learning to reflect on the impact of own teaching practice

Source: Myanmar Teacher Competency Standards Framework (TCSF), Beginning Teachers, 2020 (pp. 109 – 140)

Teaching young adult learners

The student teachers in your classroom are young adult learners. As such, evidence suggests that they will learn best when:

- The course content is related to their prior knowledge and experiences;
- There are opportunities for them to be active in their learning, both in and outside the classroom; and
- They are asked to develop their critical thinking and social skills and to take ownership of their own learning.

The different types of content delivery and learning strategies proposed in this Teacher Educator Guide are based on the following 'good practice' principles of teaching adult learners:

1. **Keep it relevant.** Adults tend to be goal-oriented and practical. They want to understand how what they are learning will be important in their daily lives. This means that it is important to have clearly defined goals and objectives for what student teachers will accomplish in a lesson, and why. Student teachers need to see the relevance of what they are learning for their future jobs as teachers. You can tell them explicitly what they are learning or how individual learning activities will be useful to them as teachers.
2. **Recognise your student teachers' backgrounds.** Your student teachers are coming to you with at least 18 years of life experience. The content of your course should reflect the level of education that they have completed and the realities of their daily lives. Adult learners need to be shown respect by valuing the experience and knowledge that they bring to the class. In your lessons, you can look for places where student teachers can draw on their real-life experiences and prior knowledge to help them understand and connect to a topic.
3. **Encourage exploration.** As adult learners, your student teachers are capable of learning on their own and being self-directed. Activities that require problem-solving and collaboration can help your student teachers to connect deeply and meaningfully with the lesson content. To do this, look for ways to actively involve your student teachers through discussion groups, real-life practice and opportunities to teach others. It may help to think of yourself as a *facilitator* of learning, rather than a teacher. You can encourage the student teachers in your classes to take ownership of their learning by finding out what is interesting to them and encouraging them to pursue these things.

Guidelines for inclusive and equitable classroom practices

Inclusion is the act of ensuring that all persons are free from discrimination of any kind and enjoy equal rights. In terms of inclusion in education, a child should be able to enjoy their right to education, regardless of their gender, language, ethnicity, religion, disability, socioeconomic status and geographic location, as set forth in the 1990 UN Convention on the Rights of the Child. The vision of the Ministry of Education (MoE) is to ensure significant advancement towards adhering to the terms of the UN Convention. Its aim is also the achievement of the Sustainable Development Goal for Education, namely: SDG Goal 4: *Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.*

The achievement of SDG Goal 4 can be realised through the creation of inclusive,

learner-friendly environments at all levels of the Education *Degree* College. While teacher educators can model inclusive and equitable classroom practices to their student teachers, administrators can also contribute by creating mission and/or vision statements and policies that celebrate inclusion, including a policy against discrimination.

As a teacher educator, actively promoting inclusion and gender equality in the classroom is an essential element of your teaching. Facilitating a safe and positive environment and atmosphere where all student teachers feel that their contributions are equally valued, and have equal access to learning, requires you to be mindful of the teaching and learning strategies and resources you use.

It is your responsibility not only to ensure your student teachers have equal access to learning, but also to ensure that they understand and value the importance of inclusion and gender equality and take that knowledge with them into their own teaching practice. The skills, knowledge, values and attitudes developed in the classroom with regards to creating inclusive, learner-friendly environments, either implicitly or explicitly, can have a long-lasting impact on the future behaviour of your student teachers.

General strategies to facilitate an inclusive classroom

Teachers, as facilitators, are responsible for creating high quality, inclusive learning environments where all students are supported to experience success in their learning.

- Think about each student teacher and consider the barriers they may experience because of their gender, disability, religion, ethnicity, language, geographical context, and socio-economic situation.
- Be aware of your own biases and reflect on your actions and teaching strategies.
- Ensure that all genders are represented and recognized, be aware not to reinforce gender stereotypes.
- Be sensitive to the marginalization of different ethnic or religious groups experienced or continue to experience.
- Be aware that student teachers from ethno-linguistic groups who may not be as confident in using the language of instruction in the school. Use terms that all students would be familiar with and check for understanding throughout

the lesson. If needed, provide translations of key documents and materials for all student teachers.

- Recognise and acknowledge different religious practices and try to represent all in the class and not have a bias towards the most predominant culture or religion in the population.
- Ensure that activities and examples are accessible to student teachers from all socio-economic groups and can all participate. Use local examples relevant to the locality and materials that are easy to acquire, low-cost and are readily available.
- Provide accommodations and adapt lessons for student teachers with disabilities.
- Make sure you present the key learning points of the lesson through visual, auditory and if possible tactile cues – respond to different learning styles.
- Be flexible and offer a variety of activities for different student teachers to explore the same learning competencies and learning outcomes.
- Have high expectations of all student teachers and focus on helping each them all achieve the learning outcomes.

Ensure gender inclusivity in the classroom

Gender stereotypes are often inadvertently reinforced in the classroom through the use of language, pedagogical approaches and resources that support the preconceived culturally expected norms, roles, and responsibilities of women and men. By promoting a gender-inclusive environment in the classroom, you can support both male and female student teachers in building a healthy understanding of gender equality and further mainstreaming of this gender-sensitive and inclusive practice into basic education classrooms.

- Ensure that there is equal representation of male and female voices, names, quotes and examples.
- Ensure that illustration examples do not reinforce any existing stereotypes.
- Use equitable and gender-inclusive language and ensure that your student teachers do likewise.
- Help and encourage your students to be gender aware, highlight any perceived gender-biased attitudes and encourage your student teachers to reflect on their

own actions.

- Ensure that you interact equally with male and female student teachers, addressing and engaging them both to the same degree in your teaching, across different subjects. For example, when asking questions, asking for volunteers, selecting activity leaders, giving complements, giving eye contacts, or even remembering the names of student teachers.
- Arrange the classroom setting in a gender-sensitive and equal manner, in terms of classroom decorations, seating arrangement, and group formation/ division.

Specific guidelines to adapt a lesson according to the different needs of your student teachers:

Types of situations	Guidelines
Student teachers not interested in lesson topic	Make relevant connections between topic and their lives
	Show them practical applications of topic
	Use examples related to their interests
	Include games and activities which require the student teachers to collaborate together on the lesson content
Unmotivated student teachers to engage in activities	Provide choices within the classroom
	Increase opportunities for peer-based learning
	Ensure learning tasks is at appropriate level of difficulty
Student teachers reluctant to participate in class	Provide options for participation
	Be flexible in expectations for participation among peer partners/ small groups
	Encourage and support the participation of quieter student teachers
Student teachers who may finish their work more quickly	Develop and prepare extension activities
Student teachers who may take longer time to complete the tasks	Allow more time to complete work if they need it
Student teachers who respond better to visual input (including learners with hearing impairments)	Use objects / pictures, color-coded information for visual organisation

Types of situations	Guidelines
Student teachers who respond better to auditory input (including learners with visual impairments)	Use lecture or discussion-based learning, peer-based activities, audiobooks, text-to-speech software
Student teachers with learning or attention challenges	Use small chunk of information, frequent repetitions, multiple examples, concrete learning experiences, actual demonstration, hands on learning
Student teachers who learn better kinaesthetically	Use hands-on learning, touching objects, tactile graphics, frequent movement, project-based learning
Culturally diverse student teachers	Use culturally-relevant materials and instructional methods
Student teachers with disabilities	Group them with student teachers who can offer support and assistance, not with those who are facing difficulties
Student teachers with hearing impairments	Ask them to sit near the front of the room
	Make sure that they can see your lips to be engaged through lip-reading
	Provide written representations of what is being communicated
Student teachers with visual impairments	Ask them to sit near the blackboard
	Use large-print materials with the contrast enhanced
	Provide instructions verbally as well as visually
	Provide a variety of engaging activities engaging other senses
Student teachers who prefer expressing themselves through printed words (including students with speech difficulty)	Use journaling, fill in the blank activities, essays, stories or poems
Student teachers who are verbally expressive (including students having writing difficulties)	Include discussions in class or “reporting back” to questions
Students teachers who communicate best with drawings, diagrams (including students with speech or writing challenges)	Use visuals, poster making or other artistic formats
Student teachers who express themselves better through demonstration and movement	Use drama / skit, body movements, building models
Student teachers who need time to think before responding (including second-language learners)	Provide time for them to construct responses before sharing with you or their classmates
Student teachers who have limited mobility	If movement is required, adjust the lesson to include variations that allows the student teachers to demonstrate knowledge by using other parts of their body or wheelchair movement.
	Have them demonstrate the competency using a written or oral description.
Student teachers with complex physical disabilities	Use of scribe to support writing
Student teachers with learning/ organisational challenges	Encourage peer support
	Use sentence-starters in writing, work banks, pictures, to-do-lists, task checklists.

Inclusive, quality assessment to enhance learning

Traditional assessment strategies create barriers for many students. Inclusive assessment allows student teachers to maximise access to learning opportunities, but also considers their individual differences and contributes to improving the quality of education.

- Use formative assessments frequently. Use the data that you get from formative assessments to influence instructional decisions.
- Design and adapt tests so that they are accessible to all student teachers.
- Ensure that all instructions are clear and easy to understand, questions are at the reading level of all students, and diagrams are clear and easy to read.
- Allow student teachers with disabilities to be supported by providing assistance in writing down their answers or understanding the questions as needed (this can be a student teacher from another year group or class or a designated teaching assistant)
- Use assessment rubrics with benchmarks towards the learning goal, using a rating scale such as ‘not yet evident’, ‘beginning’, ‘developing’ and ‘independent’. The benchmarks can be adjusted depending on the lesson or individual learning goals. Other alternatives include checklists, personal feedback, student self-assessment, portfolio with selecting highlights and areas for improvement.
- Ensure that there is more than one way for you to check understanding in a lesson. Provide several options for student teachers to express learning through a variety of assessment tasks.

Accommodations for student teachers who may experience barriers in participating in assessment tasks

Type of Accommodations	Ideas
Accommodations in presentation	Provide oral reading of the assessment (either by recorded voice or adult reader)
	Use large print for the assessments
	Provide audio amplification to aid in listening (hearing aids of speakers)
	Use computerised screen readers of text
Accommodations in response	Use a computer or a scribe to help with answering of questions
	Circle answers directly in the text booklet rather than a separate book
	Use organisational devices (calculators, organisers, spell checkers, dictionaries)
Accommodations in setting	Administrate the test in a separate place to minimise distraction
	Test in a small group
	Adjust lighting in a room (more or less light for students who need it)
	Provide noise buffers (headphones, ear plugs, earphones)
Accommodations in timing	Extend time to complete a test
	Allow multiple or frequent breaks
	Change the order of a test (e.g., provide easier subjects first to decrease anxiety)
	Test over multiple days rather than one day

Enhance inclusive teaching through reflective practice

You should constantly reflect on your teaching practice to ensure that you are providing quality education that is accessible and engaging for all of your student teachers, regardless of their background. After every lesson, think about these questions for your reflection:

1. Teaching is planned with all student teachers in mind.

- Do lesson activities take account of student teachers' interests and experiences?
- Are varied teaching strategies and methods used?
- Do the student teachers understand the purposes of lesson activities?

- Does the lesson plan support the achievement of intended learning outcomes?
- What works well and what does not work well for who? Is there a better way to teach the subject?
- Have I anticipated different learning styles, preferences, abilities, and needs of student teachers and designed activities to cater to their needs?
- How have I considered student teachers' understanding and prior knowledge? How have I adapted my lesson to scaffold understanding and address a range of needs?

2. Lessons encourage the participation of all student teachers.

- Are all student teachers, regardless of gender, addressed by their name equally?
- Are there locally, culturally, and personally relevant materials that engage the interest of the student teachers?
- Do student teachers feel they are able to speak during lessons?

3. Student teachers are actively involved in their own learning.

- Are student teachers encouraged to take responsibility for their own learning?
- Does the classroom environment encourage independent learning?
- Have I designed the lesson to allow student teachers an element of choice in how they learn?

4. Student teachers are encouraged to support one another's learning.

- Do seating arrangements encourage student teachers to interact?
- Are student teachers sometimes expected to work in pairs or groups?
- Do student teachers help one another to achieve the goals of lessons?

5. Support is provided when student teachers experience difficulties.

- Am I watching out for student teachers experiencing difficulties?
- Do students feel able to ask for help?

6. Positive learning behaviour is based on mutual respect.

- Are there established rules for taking turns to speak and listen?
- Do student teachers feel that their voice is being equally heard?
- Are bullying, gender stereotyping and discriminatory biases discouraged?

7. Student teachers feel that they have somebody to speak to when they are worried or upset.

- Are the concerns of all student teachers listened to, regardless of background?
- Do I make myself available for student teachers to talk with me privately?
- Have I created an encouraging and positive learning environment?

8. Assessment contributes to the achievement of all student teachers.

- Have I used assessment to encourage learning?
- Are the assessment techniques inclusive and accessible for all student teachers?
- Are all student teachers actually learning what they are supposed to?
- Are student teachers given constructive feedback on their work?
- Have I supported student teachers for tests or examinations according to their individual needs?
- Do teachers ensure that diversity is respected, even within one united formal assessment system?

Toolbox for teaching and learning strategies

This Teacher Educator Guide includes suggested learning activities for each lesson in the Student Teacher Textbook. These learning activities are intended to help support you as you plan your lessons but they do not dictate what you must do to help student teachers develop the desired knowledge, skills and attitudes for each lesson. On the contrary, you are encouraged to come up with the lesson activities that will best help the student teachers in your classroom to learn, given their unique backgrounds and needs.

Many of the learning activities listed below are used in this Teacher Educator Guide. You can also use this list to help you plan, or further adapt, your lessons. This is not an exhaustive list of teaching and learning strategies. You may wish to brainstorm additional teaching strategies by visiting http://www.theteachertoolkit.com/index.php/tool/all-tools or other similar websites.

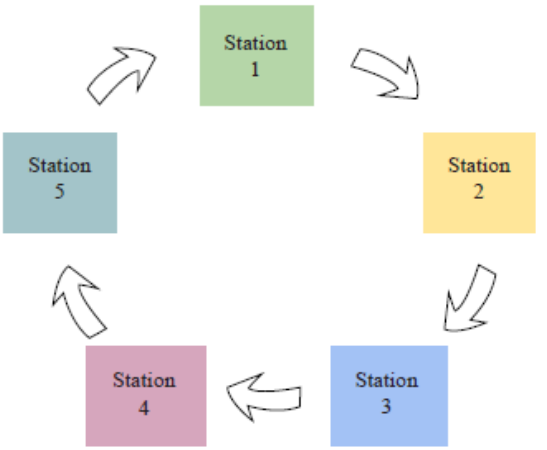
Assignments: The assignments that you give to student teachers might include formal written essays, portfolios and reflection journals. They also might be smaller, developmental tasks – for example, a short homework assignment answering questions about a reading. Assignments can help student teachers to review previously taught materials. They can also help student teachers prepare for future learning – for example, you might assign student teachers to read the Student Teacher Textbook content in advance of the next lesson.

Case studies: Working through case studies can help student teachers to develop their problem-solving and critical thinking skills as they must apply what they are learning to a scenario or story (the 'case'). To complete a case study, student teachers first read the scenario and then discuss and answer one or more open-ended questions about the scenario. Case studies often require student teachers to propose solutions to the problem presented in the scenario.

Directed activities: These are activities set by you, as the teacher educator, but carried out by the student teacher independently. For example, a directed activity might be for a student teacher to interview a basic education teacher during their Practicum school placement, or to independently research a specific teaching method. Directed activities are typically followed up in tutorials, seminars or workshops which provide an opportunity for student teachers to share about what they have learnt and to learn from their peers.

Gallery walk: In a gallery walk, student teachers work in groups to answer questions or complete a task on poster paper at various stations. They then rotate stations and add comments, questions, or further content to the poster at that station.

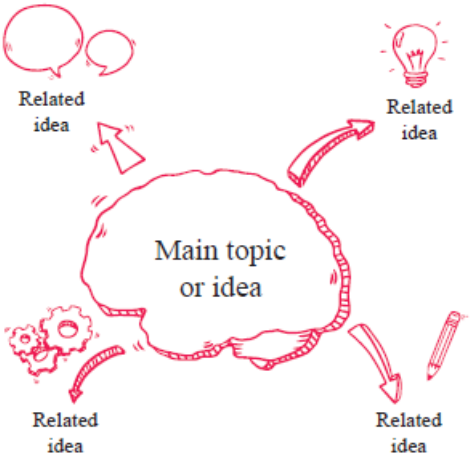
You can also use a version of the gallery walk to display student teachers' work. In this type of gallery walk, posters created during individual or group work are displayed around the room. Student teachers then circulate at their own pace to either simply view the posters, or to add their questions or comments to the poster.



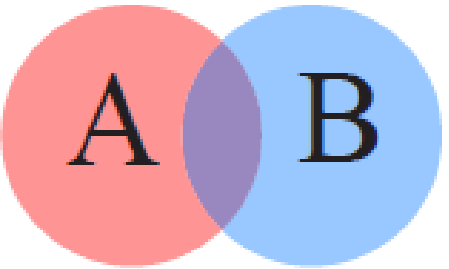
Graphic organisers: Graphic organisers are a simple and effective tool to help student teachers brainstorm and organise their thoughts and ideas in a way that makes it easier for them to understand. Graphic organisers can be used in any lesson for brainstorming, planning, problem-solving or decision-making.

Some of the most popular graphic organisers that you will see in your Teacher Educator Guides include:

- **Concept map (also called a mind map):** Concept maps, or mind maps, can be used to visually show the relationships between concepts or ideas. They are useful for brainstorming and also organising information. Concept maps can be organised in different ways and with different levels of complexity but most start with broad topics first, connected to sub-topics (or more specific concepts) to form a web of connecting ideas. The diagram below shows a very simple concept map.



- **Venn diagram:** Venn diagrams can be used to compare and contrast at least two different things or ideas (A and B). In the Venn diagram below, the overlapped area represents the characteristics belonging to both A and B and the two areas without overlap are for listing the characteristics that belong only to A and those that belong only to B.



- **KWL chart:** KWL charts can help student teachers organise information before, during and after a unit or a lesson. They can be used to engage students in a new topic, activate prior knowledge, share unit objectives and monitor student teachers' learning. KWL charts can be completed as a small group, whole class or by an individual. Before the lesson or unit, student teachers should fill in the first two columns about what they already know and what they want to know. After the lesson or unit, they can fill in the column about what they have learnt.

K What I **K**now	**W** What I **W**ant to know	**L** What I **L**earnt

- **T-chart:** T-charts can help student teachers examine two facets of a topic; for example, the advantages and disadvantages, or facts versus opinions.

Heading 1	**Heading 2**

Group work: Group work refers to any time you ask student teachers to cooperatively work together in groups on a task (for example, see the Jigsaw activity below). Group work can help motivate student teachers and encourage active learning. It requires student teachers to practise key critical thinking, communication and decision-making skills. Student teachers can work in groups to answer questions, create a presentation, write a lesson plan, analyse a case study, conduct a role-play and many more learning activities. You may wish to assign roles to group members – for example, recorder, presenter and team leader – to make sure that everyone is involved in the task.

Jigsaw: In a jigsaw activity, small groups of student teachers become experts on one component of a topic and then 'teach' that component to their peers. This gives student teachers the opportunity to work with others and to see different points of view. The jigsaw technique is especially effective because each student teacher is responsible for another's learning, and student teachers come to realise that each group member has something important to contribute to the group. In a jigsaw, student teachers must

practise using many important skills, including communication, problem-solving and critical thinking.

Lecture: Lectures are largely one-way communication between you, as a teacher educator, and a group of student teachers. They can be useful for delivering straightforward new content. Even when giving a lecture, you can involve student teachers more actively by pausing to ask and respond to questions, or by asking a student teacher to reflect or comment on the topic.

Micro-teaching: During a micro-teaching experience, a student teacher, or a small group of student teachers, teaches their peers all or part of a lesson. They then receive feedback on the mini-lesson and reflect on the experience in order to develop practical skills and apply their learning. Micro-teaching is an important opportunity to prepare for the Practicum Lesson Study and school placements. It can also provide a chance to focus on specific core teacher practices; for example, asking open-ended questions or giving students positive feedback.

Modelling: Modelling is an instructional strategy in which the teacher demonstrates a new concept or approach, and students learn by observing. As a teacher educator, you may choose to demonstrate a learning activity or teaching strategy, rather than simply telling the student teachers about it – this is modelling.

Modelling may also be followed by a discussion about how you presented the activity or strategy and what impact that had on the student teachers as learners. This can highlight the role of modelling in teaching and encourage student teachers to reflect on how they might use modelling in their own teaching in the future.

Observation: Student teachers can observe a peer or expert teacher teaching, then participate in structured, reflective discussion to make sense of what was observed. You may also observe a student teacher teaching all or part of a lesson and then follow this with a discussion to explore and develop the student teachers' thinking and practice. This strategy is an excellent opportunity to make links between theory and practice, and to support student teachers in making accurate assessments of their progress.

Practicals: Practicals can include demonstrations by you as teacher educator (for example, showing how to conduct a science experiment) and those led by, or involving, student teachers (for example, having student teachers complete a

mathematical investigation and associated worksheet). This strategy can help student teachers to understand how different activities can help students learn. Practicals can also encourage student teachers to connect theory to their developing practice as teachers.

QR Codes: QR codes are a mobile friendly way to enter web addresses or check out links of specific information. Instead of clicking on links, a collection of small black squares, known as a QR code, is scanned.

First, student teachers will need to use their smartphone todownload a QR code scanner or reader from the iOS Apple Store or Google Play, using mobile data or available internet connection. After downloading the scanner, connected students can hold up their phone, point their camera, scan the code and be directed to a given location. Teachers should be encouraged to use these codes in their own classrooms and know how to generate them easily and quickly.

These QR codes can be a great tool used for the flipped classroom approach, allowing student teachers to easily access links, websites, and download worksheets. You can also use them in warm up activities, assessments, surveys and other learning activities to include VLE in the classroom.

Please note that you and your student teachers will need mobile data or internet connection for the scanner to work.

Reading groups: A reading group is a small group session focused on the analysis and interpretation of a text, most commonly an academic paper. The paper is usually issued in advance and student teachers are expected to be familiar with its contents before attending the reading group. One student teacher may be asked to present the paper to the group, followed by a discussion to which all student teachers contribute. This strategy helps to familiarise students with academic writing as well as with the ideas within papers. Discussions may focus on the content, presentation or the methodology of the papers presented.

Role-playing: Role-play is a technique that allows student teachers to explore realistic situations as they interact with people and scenarios in a simulated way to try different strategies. This can allow student teachers to work through common

challenges, or specific aspects of teaching, in a safe and supported environment.

Self-study: In a self-study, student teachers must take responsibility for their own learning, with you as a guide. This strategy can supplement face-to-face and Education *Degree* College-based learning and is important to help frame, supplement, and consolidate new learning. Self-study can take a number of forms, such as reading around topic areas and action planning. Self-study includes time to think about specific areas of education.

Seminars: Seminars are small group sessions where questions can be explored, and views can be debated and analysed. Students usually complete preparatory work or reading before the seminar. While you would lead the seminar as a teacher educator, all student teachers are expected to contribute to discussions. Seminars can be good for developing student teachers' deeper thinking about content with which they are already familiar.

Think-pair-share: Think-pair-share is a simple and collaborative strategy where learners work together to solve a problem or answer a question. To use think-pair-share in your class, you can follow these three steps:

1. Think: Begin by asking a specific question about the text. Ask student teachers to 'think' about what they know or have learnt about the topic.
2. Pair: Each student teacher should pair up with a classmate, or with a small group.
3. Share: With their partner or small group, student teachers should share and discuss their thinking about the question. You can then expand this time of sharing into a whole class discussion about the topic.

Tutorials: Tutorials are one-on-one or small group sessions between you and a student teacher. Tutorials allow for personalised, detailed discussion and exploration of ideas. They may have a pastoral or academic focus and may be used to support student teachers who are struggling with specific academic content, or who have missed out on an in-class learning experience.

Virtual Learning Environment (VLE): This widely-used tool is a teaching strategy to supplement and support learning and self-study. In VLE, activities, study skills and website links are shared with student teachers, and different tools are used to

explore understanding, such as wikis, forums and blogs. An e-library is available for student teachers to access teaching and learning resources.

Workshops: Workshops are group sessions in which student teachers engage with new content and skills in order to develop their understanding and practice. This strategy often incorporates a great deal of collaboration and discussion as well as more lecture 'teaching' by you, as teacher educator. Workshops allow for detailed discussions about a topic and for student teachers to practise applying what they are learning.

Toolbox for assessment approaches

There are many different ways you can monitor student teachers' learning before, during, and after a lesson. This Teacher Educator Guide includes many of these assessment approaches. Remember that providing feedback, either written or verbally, is an important part of formative assessment. Your feedback is what will help student teachers to learn and improve on future tasks. You can think of formative assessment as a chance for student teachers to practise before the summative assessment, where they will be asked to show what they have learnt through a larger test, exam or project.

Some of the most popular assessment methods you will see in this Teacher Educator Guide include:

Demonstration: In a demonstration, you may ask a student teacher to show you – or demonstrate – a skill that they have been learning. For example, you may ask a student teacher to demonstrate a dance technique, a step in a science experiment, or a movement in physical education. By observing the demonstration, you can monitor student teacher progress and provide suggestions for improvement. As with all formative assessment approaches, the feedback you provide on the student teacher's demonstration is what will help him or her to improve.

Homework assignments: Checking student teachers' homework assignments, which may include tasks such as reading and answering questions or looking up additional information, is a good way to monitor if they are on the right track. Depending on the homework assignment, you may wish to discuss answers as a class, check for completion, or collect and provide written feedback.

Journal log/ reflection papers: These are a detailed log of student teachers' thoughts and feelings about their professional development and growth. The journal log and reflection papers are intended to help student teachers think deeply about their own learning by reflecting on their progress towards becoming a teacher. The process of consciously reflecting on their learning will help student teachers make connections between the content they learnt in a subject and other subjects, solve problems that come up, and learn from their experiences. Teacher educators may provide advice to student teachers on the areas to focus on when preparing the journal logs and reflection papers.

Observation: Informal observation – by circulating the room, listening to groups discuss, and making eye contact – is a good way to get a general sense of whether student teachers understand the material. More formal observation would involve using a checklist or criteria that you are looking for in a student teacher's answers or presentation. You can then provide feedback on the basis of what you have observed.

Peer-assessment: If you ask student teachers to evaluate or judge, the work of their peers, this is called peer-assessment. You will need to have the appropriate peer-assessment tools – either a rubric or a checklist – so that student teachers can provide feedback to their classmates based on established criteria. When student teachers observe each other during micro-teaching and complete an observation sheet, this is a form of peer-assessment.

Presentation: A presentation may be similar to a demonstration but often involves more preparation on the part of the student teachers. Asking groups or individuals to present their work – perhaps at the end of the lesson – is an excellent opportunity to check for understanding, correct any misconceptions and provide feedback.

Projects: Projects are completed by each student teacher, either individually or collaboratively in a group. This is to demonstrate their understanding in the subject content knowledge and their competencies gained through designing, planning and developing projects. Student teachers work on a project over a certain period of time to investigate a topic or a real-life issue. Teacher educators are requested to provide instructions on completing the projects, including the rubrics of the assessment.

Question and answer: Asking student teachers both closed-ended and open-ended questions is a good way to monitor whether student teachers understand the material. During question and answer sessions, be sure to call on a variety of student teachers for their responses. While you may want to use some closed-ended questions (with

one correct answer) to check understanding, you will be able to foster better and deeper discussions through open-ended questions, which have more than one right answer and generally require more thinking on the part of the student teachers.

Quiz: You may wish to use a short quiz to test the knowledge of your student teachers. Quizzes can be graded in class as a whole class activity, or you may wish to collect and check the quizzes outside of class. Quizzes can also be seen as a way to 'practise' for a summative test or exam.

Self-assessment: In a self-assessment, student teachers evaluate their own strengths and weaknesses. This process can help them to understand their own gaps in skills or knowledge and to create a plan to address these gaps. Self-assessments are good ways to encourage student teachers take ownership of their own learning and development. As in peer-assessment, student teachers will need some coaching to understand the assessment criteria and how to apply them to their own work or skill sets.

Written examinations: Written examinations are conducted usually at the end of each semester to test the basic subject content specific knowledge and reflection of related pedagogy discussed during the course.

General tips for facilitating a lesson

Some of the teaching and learning strategies suggested here and throughout this Teacher Educator Guide may be new to you. If so, it is recommended that you spend some time carefully planning out how you will use them in your lessons so that student teachers can achieve the desired learning outcomes.

The following are some additional general tips that you can implement to help your student teachers learn.

Before teaching a class, you may wish to do the following:

- Choose a small amount of content to deliver. Keep in mind that in a given 50-minute class period, you generally do not want more than one-third of the class period should be focused on content delivery. This will enable there to be enough time for student teachers to practise their skills and deepen their understanding of the topic.

- Note down the key points you think are most important for your student teachers to learn from the lesson content. You can refer to these as you deliver the content to the class to make sure you discuss these key points.
- Make sure you are clear on how you will carry out the content delivery and the learning activities. Refer to the suggestions in this guide and discuss with other teacher educators, if needed. Always feel free to change the suggested steps so that the lesson activities work well for your specific classroom situation.
- For each learning activity, prepare clear written instructions for your student teachers describing, step-by-step, how to do the activity. The instructions could be displayed on a presentation slide, printed on a handout or written on the board. Make sure the instructions are large enough to be read by all student teachers.
- You may want to practise explaining the instructions verbally, going slowly and step-by-step. This will help you be ready to explain the instructions to your student teachers before the activity, so they will understand what to do. You can practise the explanation with a friend or colleague ahead of time and then ask them what needs to be explained more clearly.
- If time allows, prepare to model of what student teachers are expected to do during the activity. This might involve one or two teacher educators doing a short role-play, pretending they are the student teachers doing the activity. This will enable student teachers to see exactly what they should be doing.
- If student teachers are expected to produce something at the end of an activity, you may wish to prepare an example, or 'end product,' to show student teachers what they should be aiming to create during the activity.

During class, just before the content delivery or any learning activity, if applicable, it may be helpful to:

- Distribute any materials or learning supplies that student teachers will need to carry out tasks you will ask them to do. Make good use of the e-library to request student teachers to access necessary teaching and learning materials online as appropriate.
- Provide clear verbal and written instructions to student teachers about any task you would like them to do as you deliver the content.
- Model what the student teachers should do using a short role-play.

- Show the example end product to student teachers that you prepared before class.
- Ask one or more student teachers to repeat back to the class how to do the activity, using their own words, to make sure they understand the instructions.
- Tell student teachers how long they have to complete the activity.

Throughout the class, it may be helpful to:

- Look for any signs that suggest whether the student teachers understand the content you are delivering or the task they are working on. If you suspect certain points may be difficult for student teachers to understand, consider explaining the information in a different way or breaking down the information into smaller, more manageable pieces.
- Walk around to all parts of the classroom to:
    - Ensure all student teachers are on task;
    - Answer questions student teachers have;
    - Ensure student teachers have all the materials needed to do the activity; and
    - Assess student teachers' understanding by observing whether they are carrying out the activity as instructed.
- Encourage student teachers to ask questions.
- If you detect a misunderstanding, either talk directly to the student teacher to clarify, or if the whole class may benefit from the clarification, call the attention of all student teachers and explain to everyone.
- Check for **Facilitator's notes** instruction boxes for points to emphasise and to ensure that student teachers are learning effectively before moving forward.

At the end of class, it may be helpful to:

- Consider following the suggested ways to "Check student teachers' understanding" at the end of each lesson. This is an opportunity to summarise the lesson and to briefly assess the student teachers' achievement of the

learning outcomes and understanding of how the lesson addressed the Teacher Competency Standards Framework (TCSF).

- Assess student teachers' understanding by asking them to share a point from the content you delivered that they thought was particularly interesting, or that surprised them.
- Encourage student teachers to ask questions and provide comments on what you have just taught them.
- Ask one or two student teachers to share what they produced during the activity. If the activity was not designed to produce an end product, ask one or two student teachers to describe what they learnt from the activity.
- After student teachers share their work or their thoughts, choose one or two aspects of what they shared to emphasise to the class. The point you choose to emphasise should be key points that you would like all student teachers to learn and remember from the activity.

As a teacher educator, you have an important role to play in creating a classroom where all student teachers feel free to ask questions, share their reflections, and practise teaching in a safe supportive environment. It is your feedback and support that will help them grow into teachers who can foster the holistic development and learning of Myanmar's children and youth.

Table B. Year 2 Semester 1, Mathematics Content Map

Units	Sub-units	Lesson Headings	Learning Outcomes	TCSF		Periods
				Minimum Requirements	Indicators	
1. Introduction to Mathematics	1.1. Nature of Mathematics	1.1.1. Mathematics and branches of Mathematics	• Describe what Mathematics is • Identify the branches of Mathematics: algebra, geometry, statistics, etc.	A4.1 A5.1 A5.2 B1.1	A5.1.1	1
		1.1.2. Mathematics, Science and Technology	• Explain the strong connection between Mathematics, Science, and Technology • Develop ideas about how to teach middle school students to realise the connection between Mathematics, Science and Technology		A5.1.3	1
		1.1.3. Mathematical thinking	• Develop ideas how to improve mathematical thinking skills of middle school students		A5.2.3 B1.1.3	1
		1.1.4. Famous geniuses in the field of Mathematics	• Appreciate and value the mathematicians and their contributions to the fields of Mathematics that are studied in the Myanmar Mathematics curriculum: algebra, geometry, statistics, etc.		A5.1.2	1
	1.2. Mathematics in the Basic Education Curriculum	1.2.1. Objectives of teaching Mathematics in Middle School	• Explain why Mathematics is taught to middle school students • Explain how middle school students can use Mathematics in everyday life		A4.1.1	1

Units	Sub-units	Lesson Headings	Learning Outcomes	TCSF		Periods
				Minimum Requirements	Indicators	
		1.2.2. Scope and sequence of Mathematics in Middle School	• Explain the linkage between the goals of Middle School Mathematics and the features of grade-wise content of Middle School Mathematics		A5.1.1	1
	1.3. Course overview of Education Degree College Mathematics Curriculum	1.3.1. Education Degree College Year 2 Mathematics curriculum	• Express the Education Degree College Year 2 Mathematics curriculum and syllabus and component parts • Appraise the connections between the strands of the Education Degree College Mathematics syllabus and the Middle School Mathematics syllabus		A5.1.1	1
2.Problem-solving and Misconceptions	2.1. Problem-Based Learning	2.1.1. Developing thinking skills for middle school students	• Describe some of the challenges with the learning of Mathematics in the context of developing thinking skills • Reflect on these challenges and propose some teaching and learning approaches to develop thinking skills in Middle School Mathematics	A1.1 A1.2 A4.1 A5.1 B1.1 D1.1	A1.1.1 A4.1.1 B1.1.1	1
		2.1.2. Problem-based learning and mathematical thinking	• Explain steps in problem-based learning at middle school level • Develop ideas to promote the mathematical thinking of middle school students with the use of these steps		A1.1.1 A1.2.2 A4.1.1 A5.1.1	1

Units	Sub-units	Lesson Headings	Learning Outcomes	TCSF		Periods
				Minimum Requirements	Indicators	
		2.1.3.Teaching problem-based learning	• Demonstrate a lesson for problem-based learning		A1.1.1 A1.2.2 A4.1.1 A5.1.1 B1.1.1	1
	2.2. Research in Mathematics	2.2.1.Common errors and misconceptions in algebra	• Describe some common errors and misconceptions in algebra • Give examples of how common errors and misconceptions can be used as a tool for learning		A1.1.1 A4.1.1 A5.1.2 D1.1.1	1
		2.2.2. Reflecting on teaching and learning Mathematics	• Practise self-reflection based on teaching and learning		A1.1.1 A4.1.1 D1.1.1	1
	2.3. Inclusive Approach to Teaching Mathematics	2.3.1. Collaborative learning approach	• Develop ideas to facilitate collaborative learning of middle school students • Demonstrate how to promote inclusion in middle school classrooms		A1.1.1 A1.2.1 B1.1.1	1
3. Understanding Mathematics	3.1. Numbers	3.1.1. Rational and irrational numbers	• Summarise the organisation of the real number system (rational and irrational numbers) • Demonstrate practical ideas to teach the real number system (rational and irrational numbers)	A1.1 A1.2 A2.1 A4.1 A5.1 A5.2 B1.1	A1.1.2 A2.1.2 A4.1.1 A5.1.1 B1.1.1	1
		3.1.2. Factors and multiples	• Summarise the concept of highest common factor and least common multiple		A1.1.2 A2.1.2 A4.1.1 A5.1.1 B1.1.1	1

Units	Sub-units	Lesson Headings	Learning Outcomes	TCSF		Periods
				Minimum Requirements	Indicators	
			• Demonstrate practical ideas to teach highest common factor and least common multiple			
		3.1.3. Exponents and radicals	Period 1 • Explain the rules of exponents and radicals		A1.1.2 A4.1.1 A5.1.1	1
			Period 2 • Demonstrate ideas of how to teach solving exponential equation by using exponential rules of positive integers, zero and negative integers		A1.1.2 A2.1.2 A4.1.1 A5.1.1 B1.1.1	1
		3.1.4. Ratio, proportion and percentage	• Explain the concept of ratio, proportion and percentage • Explore ideas of teaching the concepts of ratio, proportion and percentage		A1.1.2 A2.1.2 A4.1.1 A5.1.1 A5.1.2 B1.1.1	1
		3.1.5. Sets	Period 1 • Describe the basic concepts of sets (subsets, finite sets, infinite sets, empty sets and equal sets)		A4.1.1 A5.1.1	1
			Period 2 • Demonstrate an understanding of how to teach set operations by using Venn diagrams and number lines		A1.1.2 A2.1.2 A4.1.1 A5.1.1 B1.1.1	1

Units	Sub-units	Lesson Headings	Learning Outcomes	TCSF		Periods
				Minimum Requirements	Indicators	
		3.1.6. Patterns and sequences	Period 1 • Explain connection between number patterns and sequences • Explain how to get n^{th} term in given sequences		A1.1.1 A4.1.1 A5.1.1	1
			Period 2 • Demonstrate an understanding of how to teach patterns, sequences and how to get n^{th} term in given sequences		A1.1.1 A1.1.2 A1.2.2 A2.1.2 A4.1.1 A5.1.1 B1.1.1	1
		3.1.7. Estimation of errors	• Explain estimation of errors • Explain how to solve problem by using estimation of errors (absolute error, relative error, and percentage error)		A4.1.1 A5.1.1	1
		3.1.8. Counting systems	Period 1 • Summarise various counting systems • Explain how to convert between denary or decimal system (base 10) and binary system (base 2)		A5.1.1	1
			Period 2 • Demonstrate an understanding of how to teach different counting systems and how to convert between denary or decimal system (base 10) and binary system (base 2)		A1.1.2 A2.1.2 A4.1.1 A5.1.1 B1.1.1	1

Units	Sub-units	Lesson Headings	Learning Outcomes	TCSF		Periods
				Minimum Requirements	Indicators	
	3.2. Measurement	3.2.1. Basic constructions	Period 1 • Explain how to teach basic constructions by using a pair of compasses, set squares and protractor; draw perpendicular lines and angles		A1.1.2 A2.1.2 A4.1.1 A5.1.1 B1.1.1	1
			Period 2 • Explain how to teach drawing of perpendicular bisectors and angle bisectors		A1.1.2 A2.1.2 A4.1.1 A5.1.1 B1.1.1	1
		3.2.2. Bearing angles and land dimension	Period 1 • Explain how to teach the bearing angles: normal convention of bearing, angle of elevation and depression		A1.1.2 A2.1.2 A4.1.1 A5.1.1 A5.2.3 B1.1.1	1
			Period 2 • Explain how to teach land dimension, survey, draw the form of patches		A1.1.2 A2.1.2 A4.1.1 A5.1.1 A5.2.3 B1.1.1	1
	3.3. Developing Mathematical Problem-Solving Skills	3.3.1. Language of Mathematics in Middle School	• Describe the importance of considering the language of Mathematics particularly when teaching middle school students • Explain how middle school students will gain problem-solving skills in classrooms		A1.1.1 A4.1.1 A5.1.1	1

Units	Sub-units	Lesson Headings	Learning Outcomes	TCSF		Periods
				Minimum Requirements	Indicators	
		3.3.2. Problem-solving for middle school students	Period 1 • Describe various types of problem-solving questions that are useful to enhance mathematical thinking for Grade 6 and 7 students • Explain problem-solving skills that Grade 6 and 7 students should attain		A1.1.1 A1.2.2 A4.1.1 A5.1.1	1
			Period 2 • Describe various types of problem-solving questions that are useful to enhance mathematical thinking for Grade 8 and 9 students • Explain the problem-solving skills that Grade 8 and 9 students should attain		A1.1.1 A1.2.2 A4.1.1 A5.1.1	1
	3.4. Mathematics in Everyday Life	3.4.1. Social arithmetic	Period 1 • Explore knowledge about Metric and British systems (length, weight, volume, capacity) • Describe the strategies of how to teach solving the real life problems connected with this knowledge		A5.2.1 A5.2.2 A5.2.3	1

Units	Sub-units	Lesson Headings	Learning Outcomes	TCSF		Periods
				Minimum Requirements	Indicators	
			Period 2 • Explore knowledge about purchase lists, profit and loss, stocks and shares • Describe the strategies of how to teach solving the real life problems connected with this knowledge		A1.1.2 A2.1.2 A5.2.1 A5.2.2 A5.2.3 B1.1.1	1
		3.4.2. Planning a contextualised project-based learning	Period 1 • Use the skills with Metric and British systems (length, weight, volume, capacity) to design a lesson around (e.g. playground project) • Develop similar practical lessons to demonstrate how numeracy skills and mathematical thinking are used in real life situations		A5.2.1 A5.2.2 A5.2.3	1
			Period 2 • Use the skills with purchase lists, profit and loss, stocks and shares to design a lesson around (e.g. marketing project) • Develop similar practical lessons to demonstrate how numeracy skills and mathematical thinking are used in real life situations		A5.2.1 A5.2.2 A5.2.3	1
Total Number of Periods (Semester 1)						**36**

Unit 1

Introduction to Mathematics

To begin the second year of the Mathematics course, we ask why Mathematics is a core and critical subject. This unit provides an overview of important matters such as an understanding of Mathematics and its branches and the link between Mathematics and areas of Science and Technology. Student teachers will explore why teaching mathematical thinking is critical to developing important psychological skills at middle school level. They will examine the global impact made by mathematical geniuses and look at some of the significant contributions these mathematicians have made through the ages. They will then explore how and why Mathematics is taught at middle school level. This is followed by a lesson where student teachers will get an understanding of what they will learn in the course of the Education Degree College (EDC) Mathematics curriculum.

Expected learning outcomes

By the end of this unit, student teachers will be able to:

- Describe what Mathematics is;
- Identify the branches of Mathematics: algebra, geometry, statistics etc.;
- Explain the strong connection between Mathematics, Science and Technology;
- Develop ideas about how to teach middle school students to realise the connection between Mathematics, Science and Technology;
- Develop ideas about how to improve mathematical thinking skills of middle school students;
- Appreciate and value mathematicians and their contributions to the fields of Mathematics that are studied in the Myanmar Mathematics curriculum: algebra, geometry, statistics, etc.;
- Explain why Mathematics is taught to middle school students;
- Explain how middle school students can use Mathematics in everyday life;
- Explain the linkage between the goals of Middle School Mathematics and the features of grade-wise content of Middle School Mathematics;
- Express the Education Degree College Year 2 Mathematics curriculum and syllabus and component parts; and
- Appraise the connections between the strands of the Education Degree College Mathematics syllabus and the Middle School Mathematics syllabus.

Competencies gained

A4.1 Demonstrate understanding of the structure, content and expected learning outcomes of the basic education curriculum

A5.1 Demonstrate understanding of the subject matter to teach the assigned subject/s for the specified grade level/s

A5.2 Demonstrate understanding of how to vary delivery of subject content to meet students' learning needs and learning context

B1.1 Demonstrate capacity to teach subject-related concepts clearly and engagingly

1.1. Nature of Mathematics

A series of four lessons is included here. The first explores the branches of Mathematics and the links between topics on these branches. The second draws links between Mathematics, Science and Technology. The third explores various ideas on how to encourage mathematical thinking and the fourth looks at the contribution of some important geniuses to Mathematics throughout history.

1.1.1. Mathematics and branches of Mathematics

Expected learning outcomes

By the end of this lesson, student teachers will be able to:

- Describe what Mathematics is; and
- Identify the branches of Mathematics: algebra, geometry, statistics, etc.

Competency gained

A5.1.1 Describe key concepts, skills, techniques and applications for the subjects covered in the grade levels taught

Time: One period of 50 minutes

Learning strategies: Link to prior knowledge, group work, pair work, whole class discussion, video viewing (if available)

Assessment approaches: Observation, question and answer, peer-assessment. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read Lesson 1.1.1. in the Student Teacher Textbook. If possible, preview the video mentioned in the extended learning activity.

Resources needed: Flipchart paper and pens, the curriculum for Mathematics in middle school

Learning activity 1. Group work: What is Mathematics? (10 minutes)

Ask the student teachers:

1. To sit in groups of four or five.
2. First in pairs or groups of three (if the group is an odd number), then with their whole group, they should discuss what they think Mathematics is, referring to their notes from Learning activity 1 of Lesson 1.1.1. in the Student Teacher Textbook.
3. They should take notes on this, which they will need for Learning activity 2.

Assessment

Walk around the class and monitor each group. Facilitate their discussion, if necessary, and try to stimulate equal contribution of all student teachers to the discussion. Ask a few groups to explain what they think Mathematics is.

Possible student teachers' responses

Accept any answers that reflect the discussions that took place in the groups. This can include the study of numbers, shapes and space, patterns and mathematical modelling.

Learning activity 2. Link to prior knowledge: The four branches of of Mathematics (35 minutes)

Tell the student teachers:

1. To continue working in their groups.
2. By the end of this learning activity they have to create a poster that shows:

    a. The branches of Mathematics in middle school.

    b. As many topics of the Mathematics curriculum as they can think of, fitted within these branches. They might find that some topics belong to more than one branch. In that case, they should show that these are connected. They can also use the curriculum for inspiration.

    c. How the aspects of 'What is Mathematics' that they considered in Learning activity 1, fit with the branches and topics of Mathematics.

3. They have to think carefully about how they are going to represent these ideas in one poster. They have 25 minutes to do this.
4. At the end, they will be able to view each other's posters and peer-assess them.
5. After 25 minutes, ask the groups to display their poster clearly and neatly on their desks. Then they should go and look at least three other posters, peer-assess and leave their written constructive comments next to the poster they peer-assessed.

    Peer-assessment questions:

    a. Is the information this group wants to share clearly organised and presented?

    b. Can you see the connections the group is trying to make clear?

    c. Write down two things you like about the poster and one thing that could be improved.

6. If there is time left, ask the groups to make improvements to their posters, addressing the comments of the peer-assessments.

Assessment

Use the peer-assessment mentioned above as assessment.

Facilitator's notes

Make sure that student teachers are objective and fair in doing peer-assessment.

Possible student teachers' responses

Accept any answers that address the peer review questions. Challenge any comments that are not written in a constructive way.

Extended learning activity. Group work: The four branches of Mathematics (15 minutes)

If the class has access to the internet, tell the student teachers to work in their groups and to:

1. Watch the video of Professor Jo Boaler from Stanford University (Youcubed, 2017).
2. Discuss in your groups: why is it important for middle school students to recognise the connection between topics in Mathematics?
3. Discuss your ideas in a whole class discussion or with other groups who also watched the video.

Check student teachers' understanding (5 minutes)

Ask student teachers to turn to their partner and to explain what Mathematics means to them.

- Remind student teachers of the learning outcomes of this lesson.
- Remind student teachers that they explored the nature of Mathematics and that they will use this when teaching as qualified teachers.

Facilitator's notes

Reflect on your own teaching: how could this lesson be improved to make sure all student teachers feel included? What could you have done differently to make all student teachers' learning more effective?

1.1.2. Mathematics, Science and Technology

Expected Learning Outcomes

By the end of this lesson, student teachers will be able to:

- Explain the strong connection between Mathematics, Science and Technology; and
- Develop ideas about how to teach middle school students to realise the connection between Mathematics, Science and Technology.

Competency gained

A5.1.3 Link key concepts, principles and theories to real life applications to build discipline specific foundations and skills for different classes and grade levels taught

Time : One period of 50 minutes

Learning strategies : Group work, whole class discussion, critical thinking

Assessment approaches: Question and answer. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read Lesson 1.1.2. in the Student Teacher Textbook. If possible, preview the video mentioned in the extended learning activity.

Resources needed: If possible, bring a story or article from a newspaper/ magazine that you think shows a link between Mathematics, Science and Technology (student teachers have been asked to bring this, but just in case there are not enough stories for all of the groups).

Learning activity. Research: The connection between Mathematics, Science and Technology (45 minutes)

1. Have a whole class discussion about the connection between Mathematics, Science and Technology. Can the student teachers see an application of this around them; for example, here in college or on their journey to college? Invite a variety of ideas.
2. Ask the student teachers to work in groups of four or five.
3. In their groups, they should examine the articles and stories they selected and brought in as instructed in the learning activity in the Student Teacher Textbook.
4. For each article and story, although they might not have time to examine them all, they should identify the Mathematics, Science and Technology involved.
5. Then they should explore how these three subject areas are interconnected.
6. They should make notes on their findings.

Facilitator's notes

If there are note-takers during group work, make sure both women and men serve as note-takers.

7. Then they have to exchange their ideas with one other group.
8. Ask the student teachers to reflect: how did having a choice in this activity help your learning? Would having a choice help all middle school students?

Assessment

Ask two or three groups to explain what they found for one of their stories or articles. Prompt the other student teachers to ask questions for clarification if needed.

Possible student teachers' responses

Accept any answers that reflect the discussions that took place in the groups.

Extended learning activity. Research: The connection between Mathematics, Science and Technology (20 minutes)

If the class has access to the internet, ask the student teachers to:

1. Work in groups of three or four.
2. Watch the documentary 'Cyclone shield: Breathing new life into Myanmar's mangroves' (Al Jazeera English, 2018).
3. One of the groups writes down, while watching, evidence of the Mathematics they hear in the documentary; another one does this for Science, the third one for any reference to Technology that they hear in the story.
4. Then they should discuss their findings with each other and explore how Mathematics, Science and Technology are connected in this story.

Check student teachers' understanding (5 minutes)

Ask student teachers to turn to their partner and to give one example from real life where Mathematics, Science and Technology are connected.

- Remind student teachers of the learning outcomes of this lesson.
- Remind student teachers that they explored the nature of Mathematics and that they will use this when teaching as qualified teachers.

1.1.3. Mathematical thinking

Expected learning outcome

By the end of this lesson, student teachers will be able to:

- Develop ideas about how to improve the mathematical thinking skills of middle school students.

Competencies gained

A5.2.3 Describe approaches to model the use of content specific language, technical terms and skills by providing examples of use in real life contexts

B1.1.3 Encourage students' awareness of their own though processes and use of reflection to build new understanding

Time: One period of 50 minutes

Learning strategies: Assignment, think-group-share, whole class discussion, assignment

Assessment approaches: Question and answer. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read Lesson 1.1.3. in the Student Teacher Textbook.

Resources needed: Mathematics textbooks for middle school

Learning activity. Assignment: Encouraging mathematical thinking by asking questions (45 minutes)

1. Write the following two multiplication sums on the board: 123 x 45 and 103 x 4.5.
2. Invite two student teachers to come and write the solutions on the board.
3. Then ask these student teachers the following questions (the same as in the Student Teacher Textbook), one question at a time:

    a. What is the same and what is different between these two multiplication sums?

    b. Can you explain your method?

    c. Why does that method work?

    Possible answers:

    a. The first multiplication sum only uses integers, the second one includes a decimal number.

    b. Invite as many different methods as possible, as long as it gives the correct answer. For example, I calculated the multiplication sum 123 x 45 mentally, I did: 123 x 100, then divided the answer by 2—giving the answer for 123 x 50 as 6,150. I then divided that answer by ten, giving the answer for 123 x 5 as 615. I then subtracted 615 from 6,150, giving me the answer 5,535.

    c. Invite as many different explanations as possible, as long as it gives the correct answer.

Facilitator's notes

Enhance the equal participation of all student teachers regardless of their background or gender by asking various student teachers for their answers, ensuring everyone feels equally invited to share their answers.

4. Ask the whole class to reflect: which thinking process happened as a result of having to answer these questions? Invite the student teachers to share their ideas.
5. Now ask the student teachers to work in pairs, find some mathematical problems in the Mathematics textbooks and solve these.
6. Then they should follow up by answering any of the questions that are listed in their Student Teacher Textbook to promote mathematical thinking.
7. They should then reflect and make a note of their ideas: which thinking process happened as a result of having to answer these questions?
8. In their pairs, they should then write a briefing note to parents of middle school students, explaining why they would be using such questions to promote mathematical thinking in their teaching.
9. Invite a few pairs to read out their briefing note and discuss these with the class:

    a. Are the briefing notes clear? Will the parents be able to understand why their child is having to answer questions that promote mathematical thinking?

    b. Any suggestions for improvement of the briefing note?

Assessment

Ask two student teachers who did not belong to the pairs to read out their briefing note. This is to summarise the reasons for using questions that promote mathematical thinking in the teaching of middle school Mathematics.

Possible student teachers' responses

Accept any answers that reflect the discussion that took place as part of the learning activity.

Extended learning activity. Pair work: Encouraging mathematical thinking by asking questions (5 minutes)

1. Ask the student teachers to look again at the questions that promote mathematical thinking in their Student Teacher Textbook.
2. Do they think these would need adjusting if they are working with a student that is visually or hearing impaired?

Check student teachers' understanding (5 minutes)

Ask student teachers to turn to their partner and to give one reason why mathematical thinking is important.

- Remind student teachers of the learning outcome of this lesson.
- Remind student teachers that they explored the nature of Mathematics and that they will use this when teaching as qualified teachers.

1.1.4. Famous geniuses in the field of Mathematics

Expected learning outcome

By the end of this lesson, student teachers will be able to:

- Appreciate and value mathematicians and their contributions to the fields of Mathematics that are studied in the Myanmar Mathematics curriculum: algebra, geometry, statistics, etc.

Competency gained

A5.1.2 Include in lessons accurate and relevant information, examples and exercises to support student learning of core subject content, skills and procedures

Time: One period of 50 minutes

Learning strategies: Group work, active learning, presentations

Assessment approaches: Peer-assessment. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read Lesson 1.1.4. in the Student Teacher Textbook.

Resources needed: Student Teacher Textbook, internet access (if possible) for the extended learning activity

Facilitator's notes

- Asking student teachers to prepare interview questions and then pretending to interview the famous mathematician is an alternative to asking student teachers to make posters and then look at each other's posters. This way, they will learn about other famous mathematicians without having to explore these themselves in detail.
- Make sure all of the three mathematicians mentioned in the Student Teacher Textbook are explored by at least one group.
- Make sure all of the three famous mathematicians are 'interviewed' for the whole class. Allow sufficient time for the 'interviews' and the peer-assessment.

Learning activity. Active learning: Some famous mathematicians (45 minutes)

1. Ask the students to work in groups of four or five.
2. Tell them that today each group will explore the lives and works of one of the famous mathematicians mentioned in their Student Teacher Textbook. They can decide which mathematician themselves.
3. They are to pretend they work for Myanmar television and they will be interviewing their chosen famous mathematician.
4. First, they have to prepare a set of interesting interview questions that they will later ask the famous mathematician. They should include a question on how the inventions of the famous mathematician are relevant to life today or to the middle school level Mathematics curriculum. They can use the texts in their Student Teacher Textbooks to help them with this.
5. They should also prepare a set of answers to those questions.
6. Then they have to decide who will pretend to be the journalist that will ask the questions, and who will pretend to be the famous mathematician that answers the questions. They should practise this interview in their groups.

Facilitator's notes

Keep inclusive education in mind: make sure the group leaders are from different backgrounds and genders.

7. Tell them that after about 25 minutes a few groups will be asked to conduct their interview in front of the class. Explain that the other student teachers will peer-assess this interview against the following criteria:

   Peer-assessment questions:

   a. Is the 'interview' conducted in a way that is understandable?
   b. Did you find the questions that were asked interesting?
   c. Did the famous mathematician answer the questions well?
   d. Did you learn more about the life and work of this famous mathematician?

8. After about 25 minutes, invite at least three groups that have explored different famous mathematicians, to come and do their 'TV interview' in front of the class. Ask the other student teachers to give feedback by using the peer-assessment questions mentioned above.
9. Ask the student teachers to reflect: how did having the opportunity to talk and discuss your ideas help your learning? Would it help all middle school students?

Assessment

Use the peer-assessment mentioned above as assessment.

Possible student teachers' responses

Accept any answers that address the peer review questions. Challenge any comments that are not constructive.

Extended learning activity. Group work: Some famous mathematicians (15 minutes)

If the class has access to the internet, ask the student teachers to search for information about any of these other famous mathematicians:

- Euclid
- Hypatia
- Sophie Germain
- Maryam Mirzakhani
- Pythagoras
- Terry Tao
- Benjamin Banneker.

If the students do not have internet access, suggest they look in the library for books on famous mathematicians.

Check student teachers' understanding (5 minutes)

- Ask student teachers to turn to their partner and to name one famous mathematician and their contribution to Mathematics.
- Remind student teachers of the learning outcome of this lesson.
- Remind student teachers that they explored the nature of Mathematics and that they will use this when teaching as qualified teachers.

Expected student teachers' responses for the review questions in TB

Question 1: What are some of the questions that make you think mathematically?

Answers may include: *What is the same and what is different? How do you know? How do you know this is correct? Can you give another example and another and another and another? Is this always, sometimes or never true? Can you explain why...? Can you show me an example of...? Can you explain your method? Why does that method work?*

Question 2: What are the four branches of Mathematics?

Answer: *The four branches are arithmetic, algebra, geometry and probability and statistics.*

Question 3: How is Mathematics beneficial to other Science subjects?

Answer: *Mathematics is involved in every scientific activity and technical solution; however, this is often not obvious. Mathematics, and often quite advanced mathematics, is used to make science and technology applications such as electricity provision, building techniques, computer programming and environmental solutions possible.*

1.2. Mathematics in the Basic Education Curriculum

In the following sequence of two lessons, student teachers will first explore why we teach Mathematics to students at middle school level. Then, to get a good basic grasp of what is taught in the Mathematics curriculum, student teachers will examine the scope and sequences of the curriculum and how these topics are covered in the textbooks for grades 6 to 9 in Myanmar schools.

1.2.1. Objectives of teaching Mathematics in Middle School

Expected learning outcomes

By the end of this lesson, student teachers will be able to:

- Explain why Mathematics is taught to middle school students; and
- Explain how middle school students can use Mathematics in everyday life.

Competency gained

A4.1.1 Describe key concepts, content, learning objectives and outcomes of the lower secondary curriculum for the subjects and grade level/s taught

Time: One period of 50 minutes

Learning strategies: Link to prior knowledge, group work, whole class discussion

Assessment approaches: Question and answer, teacher assessment. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read Lesson 1.2.1. in the Student Teacher Textbook. If possible, preview the video mentioned in the extended learning activity.

Resources needed: The middle school curriculum for Mathematics, internet access (if possible) to view the video for the extended learning activity

Learning activity 1. Link to prior knowledge: Teaching Mathematics to middle school students (25 minutes)

Tell the student teachers to:

1. Work in groups of three or four.
2. Read again the aims of teaching Mathematics at middle school level in their Student Teacher Textbooks.
3. Have a short whole class discussion to make sure everyone understands these aims.
4. In their groups, ask them to decide the most important and the least important of these aims.
5. Rank the aims in terms of importance and add reasons why they put them in that order.
6. Ask a few groups to read out the first three most important aims according to them and their reasons for this. Allow other student teachers to make comments and share their views.
7. Ask a few groups to read out the two least important aims according to them and their reasons for this. Allow other student teachers to make comments and share their views.

Facilitator's notes

There are no right or wrong answers to the ranking of the aims. The importance of this activity is the discussion and student teachers being aware of the reasons why Mathematics is taught to middle school students.

Assessment

Ask three student teachers to each say two reasons why Mathematics is taught to middle school students.

Possible student teachers' responses

Any of the following: *Consolidation of mathematical knowledge and skills; building further foundations of knowledge and skills; developing a level of fluency; thinking mathematically; applying mathematics to real life; developing 21st century skills.*

Learning activity 2. Link to prior knowledge: Mathematics and developing 21st century skills (20 minutes)

Ask the student teachers:

1. For any examples they came up with for Learning activity 2 in their Student Teacher Textbook: 'Think of some examples where you felt you did think about connections between ideas and concepts and were curious'.
2. In groups of three or four, to then explore their examples in more detail: what was the mathematical topic? What had they been asked to do?

Facilitator's notes

Make sure that everyone has the opportunity to lead discussions.

3. To now look at the middle school Mathematics curriculum and identify where developing 21st century skills, that is working on seeing connections, being

creative and curious, would fit well in the curriculum.

4. They should write a short briefing note for the advisory group for Mathematics in Myanmar with their ideas.
5. Ask a few groups to read out their briefing note. Give constructive feedback.

Assessment

Ask a few student teachers to explain why the aims of teaching Mathematics have changed.

Possible student teachers' responses

Accept any answers that reflect the discussions that took place during the learning activity. One of the responses that should be included is the introduction of computers into our lives.

Extended learning activity. Mathematics and developing 21st century skills (30 minutes)

If the student teachers have access to the internet, tell them to:

1. Work in groups of three or four.
2. Watch the conversation between Professor Jo Boaler, mathematics educator, and mathematician Dr Keith Devlin, both from Stanford University in the USA, about 21st century mathematics and learning (Youcubed, 2019). The video is quite lengthy, so they can skip parts of it if they want to.
3. What has changed since the 1980s in Mathematics?
4. What do they think of the suggestions made in the video for teaching Mathematics differently?

Check student teachers' understanding (5 minutes)

- Ask student teachers to turn to their partner and to explain why teaching Mathematics should also include developing 21st century skills.
- Remind student teachers of the learning outcomes of this lesson.
- Remind student teachers that they explored Mathematics in the Basic Education Curriculum and that they will use this when teaching as qualified teachers.

1.2.2. Scope and sequence of Mathematics in Middle School

Expected learning outcome

By the end of this lesson, student teachers will be able to:

- Explain the linkage between the goals of Middle School Mathematics and the features of the grade-wise content of Middle School Mathematics.

Competency gained

A5.1.1 Describe key concepts, skills, techniques and applications for the subjects covered in the grade levels taught

Time: One period of 50 minutes

Learning strategies: Group work, whole class discussion, posters

Assessment approaches: Peer-assessment. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read Lesson 1.2.2. in the Student Teacher Textbook.

Resources needed: The middle school Mathematics curriculum, poster paper and pens

Learning activity. Research: The grade-wise content and goals of middle school Mathematics (45 minutes)

1. Use question and answer to remind the student teachers about the aims or goals of teaching Mathematics to middle school students. They should not forget to include developing 21st century skills in their summing up. They can refer to their notes from the previous lesson, Lesson 1.2.1.
2. Tell the student teachers to look at the curriculum for Mathematics at middle school level.
3. Discuss with the whole class some of the scope and sequences (the grade-wise progressions of a topic) in the curriculum so that everyone is clear what this is and where to find it.
4. Tell the student teachers to work in groups of four or five.
5. In this lesson, they are to design a poster that shows the linkage between the goals of middle school Mathematics and the features of the grade-wise content of middle school Mathematics. They have 25 minutes to do this.
6. They should do this for two sub-units of the curriculum. They are free to choose these sub-units; however, the sub-unit should have learning outcomes in at least three of the four grades. For example, ‘algebraic expressions’ is acceptable, but ‘number patterns and sequences’ is not.
7. At the end, they will be able to view each other’s posters and peer-assess them.
8. After 25 minutes, ask the groups to display their poster clearly and neatly on their desks. Then they should go and see at least three other posters, peer-assess and leave their written constructive comments next to the poster they peer-assessed.

Peer assessment questions:

a. Is the information this group wants to share clearly organised?

b. Can you see the connections the group is trying to make?

c. Write down two things you like about the poster and one thing that could be improved.

9. If there is time left, ask the groups to make improvements to their posters, addressing the comments of the peer-assessments.

Assessment

Use the peer-assessment mentioned above as assessment.

Possible student teachers' responses

Accept any answers that address the peer review questions. Challenge any comments that are not written in a constructive way.

Extended learning activity. The grade-wise content and goals of middle school Mathematics (10 minutes)

Ask the student teachers to peer review some more posters on sub-units they have not considered so far.

Check student teachers' understanding (5 minutes)

- Ask student teachers to turn to their partner and to explain how the curriculum for Mathematics is organised.
- Remind student teachers of the learning outcome of this lesson.

- Remind student teachers that they explored Mathematics in the Basic Education Curriculum and that they will use this when teaching as qualified teachers.

Expected student teachers' responses for the review questions in TB

Question 1: What is the meaning of 'the scope of the curriculum'?

Answer: *The scope is the detailed description of all the topics that need to be covered in each of the four years from Grade 6 to Grade 9. This tells the teachers which details they need to cover.*

Question 2: What are the goals or aims of teaching Mathematics at middle school level?

Answer: *The goals or aims include: consolidation of mathematical knowledge and skills, building further foundations of knowledge and skills, developing a level of fluency, thinking mathematically, applying mathematics to real life and developing 21st century skills.*

1.3. Course Overview of Education Degree College Mathematics Curriculum

In this sub-unit you will learn what student teachers will study in the Education Degree College Mathematics curriculum in Year 2. Student teachers will also explore the links between this curriculum and the grade-wise curriculum for Mathematics for Grades 6 to 9.

1.3.1. Education Degree College Year 2 Mathematics curriculum

Expected learning outcomes

By the end of this lesson, student teachers will be able to:

- Express the Education Degree College Year 2 Mathematics curriculum and syllabus and component parts; and
- Appraise the connections between the strands of the Education Degree College Mathematics syllabus and the Middle School Mathematics syllabus.

Competency gained

A5.1.1 Describe key concepts, skills, techniques and applications for the subjects covered in the grade levels taught

Time: One period of 50 minutes

Learning strategies: Link to prior knowledge, group work, whole class discussion, posters

Assessment approaches: Question and answer, presentation, peer-assessment. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read Lesson 1.3.1. in the Student Teacher Textbook.

Resources needed: The middle school Mathematics curriculum, the Education Degree College Mathematics curriculum for Year 2, its syllabus and component parts, flipchart paper and pens

Learning activity 1. Link to prior knowledge: The Education Degree College Mathematics Year 2 curriculum (10 minutes)

Tell the student teachers:

1. To work in groups of five or six.
2. By the end of this lesson, they should have prepared a poster for their group. A few groups will be asked to present their poster to the whole class, but they will not know beforehand which groups, so all groups should be ready to present.
3. In this learning activity they will be asked to examine the Education Degree College Mathematics Year 2 curriculum and its content. In the next learning activity they will be asked to add the connections between the Education Degree College Mathematics and the middle school Mathematics curriculum.
4. Remind the student teachers that they can get a good overview of the Education Degree College Mathematics Year 2 curriculum from examining the table of contents at the beginning of their Student Teacher Textbook.

Facilitator's notes

It is important that the student teachers know what to expect from these two learning activities so that they can bear this in mind when designing their poster.

5. Tell the groups to note any patterns in the structure of the course. Why do they think it is organised like this?
6. Now ask them to look at the sub-units. Note any patterns in the structure of the sub-units.
7. Is there anything that surprises them?

Assessment

Ask five student teachers to each name one unit from the Education Degree College Year 2 Mathematics curriculum.

Possible student teachers' responses

Introduction to Mathematics; Problem-solving and misconceptions; Understanding Mathematics; Mathematical modelling and representation; How we learn and teach Mathematics.

Learning activity 2. Link to prior knowledge: Connections between the Education Degree College Mathematics and the Middle School Mathematics curriculum (35 minutes)

Tell the student teachers to:

1. Continue working in their groups.
2. Look at the Middle School Mathematics curriculum and examine the units, sub-units and lessons of the Education Degree College Year 2 curriculum.

3. Compare and contrast the Middle School Mathematics curriculum and examine the units, sub-units and lessons of the Education Degree College Year 2 curriculum. They should bear in mind that the Education Degree College course aims to address three aspects: deepen subject knowledge, learn about effective teaching strategies on how to teach Mathematics topics at middle school level, and practise teaching some of these topics through micro-teaching.

Facilitator's notes

'Compare' means examining what is the same. 'Contrast' means examining what is different.

4. Identify where and how the Education Degree College curriculum is connected to the middle school curriculum for Mathematics.
5. Add their findings to their poster and make sure any connections are clear.

Assessment

Ask three groups to present their posters to the whole class. Invite other student teachers to give constructive feedback.

Possible student teachers' responses

Accept any answers that reflect the discussion of the activity and that show how the Education Degree College curriculum is connected to the middle school curriculum for Mathematics.

Extended learning activity. The Education Degree College Year 2 Mathematics curriculum (10 minutes)

Ask the student teachers to examine the Education Degree College Year 2 Mathematics curriculum and identify where aspects of inclusion are addressed. They can add this to their posters.

Check student teachers' understanding (5 minutes)

- Ask student teachers to turn to their partner and to give two examples of how the Education Degree College curriculum is connected to the middle school curriculum for Mathematics.
- Remind student teachers of the learning outcomes of this lesson.
- Remind student teachers that they explored Education Degree College Mathematics curriculum in Year 2 and that they will use this when teaching as qualified teachers.

Expected student teachers' responses for the review questions in TB

Question 1: What are the five units of the Education Degree College Mathematics Year 2 curriculum?

Answer: *The five units are: Introduction to Mathematics; Problem-solving and misconceptions; Understanding Mathematics; Mathematical modelling and representation; How we learn and how we teach Mathematics.*

Question 2: In which units of the Education Degree College Mathematics Year 2 curriculum will you examine and learn more about the structure of the Mathematics curriculum for middle school students?

Answer: *Learning about the structure of the Mathematics curriculum for middle school students is addressed in Unit 1 'Introduction to Mathematics' and in Unit 5 'How we learn and how we teach Mathematics'.*

Unit Summary

Key messages

- The key objective of teaching Mathematics to students in the middle school phase is to prepare them with mathematical knowledge and thinking skills to help them function effectively in the 21st century world. Teachers must be able to encourage curiosity and interest.
- Middle school students have an increased interest and understanding of mathematics if they are able to make the links between the various units of Mathematics. It is the role of student teachers to help their students to do this.
- Students are more likely to be motivated and to see the value of learning mathematics if they have an understanding of the links between mathematics, science and technology. Lessons that draw these links can also be used to help develop critical mathematical thinking skills.
- In order to be effectively prepared to teach Mathematics to middle school students, student teachers need to have a good understanding of the details of the scope and sequence of the Mathematics curriculum in this phase.

Unit reflection

- How can thinking about what Mathematics is and considering its branches help student teachers and their students to understand mathematics?
- Why do you think it is important to make the connection between Mathematics and other subjects such as science and technology?

Further reading

Clifford, A., & Ji-Won Son. (2018). Complete the what? The Mathematics Teacher, 112, 218-225.

Khin Maung Swe. (2012). *နှစ်ဆယ်ရာစုခေတ်ဦးထူးခြားသချိုင်္ဘာဖန်တီးရှင်များ* [The creators of distinctive mathematics in the early twentieth century]. Yangon, Myanmar: ZinYaTaNaSaw sarpay.

Robinson, K. (2010). Changing education paradigms [Video file]. Retrieved from *https://www.ted.com/*

Tekkatho Maung Thinchar. (2013). *သချိုင်္ဘာအခြေခံအယူအဆသဘောများနှင့်မိတ်ဆက်ခြင်း* [Introducing the fundamental concepts of mathematics]. Yangon, Myanmar: ZinYaTaNaSaw sarpay.

Youcubed. (2018, September 25). Excerpt of Jo from 'The importance of struggle' [Video file]. Retrieved from *https://www.youcubed.org/*

Unit 2

Problem-Solving and Misconceptions

This unit explores aspects and approaches to problem-solving and common misconceptions in algebra at the middle school level in Myanmar. Both are very important parts in the learning of mathematics. It also discusses why working collaboratively in the Mathematics lesson can help student teachers and their students' progress in their learning and support inclusivity in the classroom.

Expected learning outcomes

By the end of this unit, student teachers will be able to:

- Describe some of the challenges with the learning of Mathematics in the context of developing thinking skills;
- Reflect on these challenges and propose some teaching and learning approaches to develop thinking skills in Middle School Mathematics;
- Explain steps in problem-based learning at middle school level;

- Develop ideas to promote the mathematical thinking of middle school students with the use of these steps;
- Demonstrate a lesson for problem-based learning;
- Describe some common errors and misconceptions in algebra;
- Give examples of how common errors and misconceptions can be used as a tool for learning;
- Practise self-reflection based on teaching and learning;
- Develop ideas to facilitate collaborative learning of middle school students; and
- Demonstrate how to promote inclusion in middle school classrooms.

Competencies gained

A1.1 Demonstrate understanding of how students learn relevant to their age and developmental stage

A1.2 Demonstrate understanding of how different teaching methods can meet students' individual learning needs

A4.1 Demonstrate understanding of the structure, content and expected learning outcomes of the basic education curriculum

A5.1 Demonstrate understanding of the subject matter to teach the assigned subject/s for the specified grade level/s

B1.1 Demonstrate capacity to teach subject-related concepts clearly and engagingly

D1.1 Regularly reflect on own teaching practice and its impact on student learning

2.1. Problem-Based Learning

Problem-based learning is very important in Mathematics. It requires the student to reason with, to use and to apply mathematical concepts and techniques that they have learned. Sometimes the problems are set out in a well-structured and clear way. At other times, the problems are more open and allow different approaches to solving the problem. Students have to learn how to solve these problems and how to bring structure into an open problem so they can solve these.

2.1.1. Developing thinking skills for middle school students

Expected learning outcomes

By the end of this lesson, student teachers will be able to:

- Describe some of the challenges with the learning of Mathematics in the context of developing thinking skills; and
- Reflect on these challenges and propose some teaching and learning approaches to develop thinking skills in Middle School Mathematics.

Competencies gained

A1.1.1 Give examples of how the students' cognitive, physical, social, emotional and moral development may affect their learning

A4.1.1 Describe key concepts, content, learning objectives and outcomes of the lower secondary curriculum for the subjects and grade level/s taught

B1.1.1 Use different ways to explain the subject matter, related ideas and concepts to meet a range of learning abilities and intended learning outcomes

Time: One period of 50 minutes

Learning strategies: Active learning, group work, posters, whole class discussion

Assessment approaches: Observation, presentation, question and answer. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read the text for Lesson 2.1.1. in the Student Teacher Textbook. Decide how you will organise the groups. Select some problem-solving learning activities that you normally use to teach this topic. Write these on the board or write a reference to where the student teachers can find these, such as 'name of the textbook + pages'. An example of a problem-solving activity is: *It takes Myat 18 minutes to finish reading 4 pages of a book. How long does it take for her to finish reading 30 pages?*

Resources needed: Student Teacher Textbook, flipchart paper, marker pens

Learning activity. Active learning: Identifying difficulties and solutions for problem-based learning in Mathematics (45 minutes)

Part A. Group work: Brainstorming ideas in groups (10 minutes)

1. Ask the student teachers to work in small groups.
2. Point to the examples of problem-solving learning activities you have written on the board or ask the student teachers to look these up.
3. Give the student teachers two minutes to discuss the below question in their groups. They can refer to the text in their Student Teacher Textbook.

   What possible difficulties can students encounter when asked to use and

apply their mathematical knowledge and thinking skills for problem-solving in Mathematics?

4. Give student teachers two minutes to discuss this question in their groups:

   Do you have any similar difficulties in your own current experiences or when you were younger? Give examples.

5. Ask each group to write their ideas as a list on the board simultaneously.
6. Tell the student teacher, in their groups, to brainstorm any solutions they can think of that might help students overcome these issues. Give them two minutes.
7. Ask student teachers to add their ideas to the board.

Facilitator's notes

Allow sufficient time for students to answer questions—especially student teachers who may be less confident or afraid to express themselves.

Part B. Group work: Writing posters (15 minutes)

1. Tell the student teachers to continue to work in their groups.
2. Tell them to now produce a poster on the difficulties of problem-solving in mathematics and any solutions that might help students overcome these issues. This should include practical ideas on how to do this when teaching problem-solving learning activities with their own students in the future.
3. Discuss with all the groups how they are addressing this task.

Facilitator's notes

Encourage the student teachers to choose their own method for doing this task. If possible, ask the different groups their methods so plenty of ideas and approaches are shared.

4. Monitor the work of the student teachers and ask for any clarification if what they are writing is not clear.

Part C. Group work: Presenting posters and learning from each other (20 minutes)

1. Tell the student teachers the focus of this part of the activity is to learn from each other. Because of the number of groups there will probably not be enough time to ask each group to present what they have found and many groups will have similar ideas.
2. Identify two or three groups that have some different ideas and approaches on their poster. Ask these groups to quickly present their posters. The other student teachers should listen carefully and then be ready to suggest more ideas and ask for clarification if necessary.
3. Ask one male and one female student teacher to work together and to summarise the findings and ideas that have arisen from the poster presentations and the discussions.

Assessment

Ask a few student teachers sitting in the back of the classroom to each say one difficulty for students in using their mathematical thinking skills in Mathematics and one solution that might help students overcome that difficulty. Ask the student teachers to also explain why the solution would work.

Possible student teachers' responses

Accept any answers that reflect the discussion and presentation of the activity.

Extended learning activity. Writing posters (15 minutes)

Tell groups to now consider whether the barriers and the solutions they are suggesting would be the same for students with disabilities: how can they adjust their suggestions to take this into account?

- Ask one group to consider this for students with visual impairment.
- Ask another group to consider this for students with dyslexia.
- Ask another group to consider this for students with a hearing impairment.

Check student teachers' understanding (5 minutes)

- Ask student teachers to turn to their partner and to explain how one of the proposed solutions might help them in their own learning of mathematics.
- Remind student teachers of the learning outcomes of this lesson.
- Remind student teachers that they explored issues around developing mathematical thinking skills and that they will use this when teaching as qualified teachers.

2.1.2. Problem-based learning and mathematical thinking

Expected learning outcomes

By the end of this lesson, student teachers will be able to:

- Explain steps in problem-based learning at middle school level; and
- Develop ideas to promote the mathematical thinking of middle school students with the use of these steps.

Competencies gained

A1.1.1 Give examples of how the students' cognitive, physical, social, emotional and moral development may affect their learning

A1.2.2 Identify focused and sequenced learning activities to assist students to link new concepts with their prior knowledge and experiences

A4.1.1 Describe key concepts, content, learning objectives and outcomes of the lower secondary curriculum for the subjects and grade level/s taught

A5.1.1 Describe key concepts, skills, techniques and applications for the subjects covered in the grade levels taught

Time: One period of 50 minutes

Learning strategies: Flipped learning, collaborative learning, group work, whole class discussion

Assessment approaches: Monitoring, whole class question and answer, peer-assessment. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read the text for Lesson 2.1.2. in the Student Teacher Textbook. Decide how you will organise the groups. Select five to eight problem-based learning activities that you normally use to teach this topic. Choose those that are relevant to middle school Mathematics and the Mathematics topics that are relevant to your class. Write these on the board or write a reference to where the student teachers can find these; for example, 'name of the textbook + pages'. You can use the examples from the previous lesson.

Resources needed: Student Teacher Textbook

Learning activity. Collaborative learning: Mathematical thinking in problem-solving (45 minutes)

Part A. Group work: Applying Polya's four steps (20 minutes)

Tell the student teachers:

1. To work in groups of four or five.
2. In their groups, they have to solve the problems you selected using Polya's four steps. Remind them that Polya considered mathematical thinking as a central goal of mathematics education: mathematics education should teach young people to think. He developed this system of four steps for problem-solving that is part of the curriculum for Mathematics in Myanmar.
3. If the student teachers have different views of what a step would be in one of the given problems, they should discuss and make a note of this.
4. After 10 minutes, discuss with the whole class any issues or different views they have about using the four steps and how to solve these problems. Address any misconceptions.
5. Give the student teachers 10 more minutes to check the work they have already done, make changes if applicable and continue solving the remaining problems.

Assessment

Check the answers to the problems by asking some student teachers to give the answers.

Possible student teachers' responses

The answers to the problems should be correct.

Part B. Group work: Developing 'habits of mind' (25 minutes)

Tell the student teachers:

1. To continue to work in their groups.
2. In their groups, they have to read the text under 'Mathematical thinking' in Lesson 2.1.2. of the Student Teacher Textbook and discuss the different 'habits of mind'.
3. The student teachers then share and discuss the examples they came up with for the learning activity in Lesson 2.1.2.:

   Read the list of 'habits of mind' again. Think of some examples of learning activities that you could plan for students in Grade 7 that would allow them to use these habits of mind. For example, for 'pattern sniffers' you could take the students outside of the classroom in the school grounds to look for patterns in buildings, fences, plants or objects and ask them to describe these to each other. Be imaginative!
4. They select two of the examples per group that they liked best, then share with the whole class. They should make sure they can argue why these are good examples for developing 'habits of mind'. Support and encourage both female and male student teachers to be leaders of group activities.
5. Ask as many groups as possible within the time to share their examples with the whole class. Ask the other student teachers to give constructive feedback: two aspects they like about the example and one aspect that could be improved.

Assessment

Ask two or three student teachers to explain why some habits of mind, such as 'guessers' and 'pattern sniffers' are examples of thinking mathematically as a mathematician-in-training.

Possible student teachers' responses

Accept any answer that explains that these 'habits of mind' describe the thinking that professional mathematicians do, with explanations as given in Lesson 2.1.2. of the Student Teacher Textbook. For example: 'guessers' is about starting with a

possible solution to a problem and working backwards or just checking your guesses. Mathematicians use guessing as a research strategy to uncover new insights and approaches, which are then addressed more rigorously than just guessing.

Differentiated learning activity. Developing habits of mind (10 minutes)

Ask the student teachers to discuss and identify in their groups which 'habits of mind' may be challenging for students with a hearing impairment and how they could help these students. They should use the pyramid model to do so. The pyramid model is a way to approach a topic/discussion in stages:

1. What is happening?
2. Why is it happening?
3. What can you do?
4. Think about strategies.
5. Make an action plan.

Check student teachers' understanding (5 minutes)

- Ask the student teachers to write down three things that will help them to teach mathematical thinking and to tell this to their partner.
- Remind student teachers of the learning outcomes of this lesson.
- Remind student teachers that they explored issues around mathematical thinking in problem-solving and that they will use this when teaching as qualified teachers.

2.1.3. Teaching problem-based learning

Expected learning outcome

By the end of this lesson, student teachers will be able to:

- Demonstrate a lesson for problem-based learning.

Competencies gained

A1.1.1 Give examples of how the students' cognitive, physical, social, emotional and moral development may affect their learning

A1.2.2 Identify focused and sequenced learning activities to assist students to link new concepts with their prior knowledge and experiences

A4.1.1 Describe key concepts, content, learning objectives and outcomes of the lower secondary curriculum for the subjects and grade level/s taught

A5.1.1 Describe key concepts, skills, techniques and applications for the subjects covered in the grade levels taught

B1.1.1 Use different ways to explain the subject matter, related ideas and concepts to meet a range of learning abilities and intended learning outcomes

Time: One period of 50 minutes

Learning strategies: Active learning, pair work, group work, micro-teaching

Assessment approaches: Monitoring, peer-assessment. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: None

Resources needed: Student teachers should have their lesson notes from the previous lesson and their Student Teacher Textbook

Learning activity. Active learning: Developing learning activities (45 minutes)

Tell the student teachers:

1. To work in groups of five or six.
2. Say: Today you will be teaching a short learning activity that involves problem-based learning in middle school to your student teacher colleagues in your group who will pretend to be middle school students.
3. They can do this as a team-teaching activity in pairs. They should refer back to their notes from the previous lesson and their Student Teacher Textbook. They can use the learning activities they did in the previous lesson as they are, adapt them or develop or find new learning activities. However, they should always use Polya's four steps for problem-solving, along with collaborative learning: working in pairs or groups. Ideally, their colleague student teachers would also be able to practise some of the 'habits of mind'.
4. They should plan a short teaching activity (maximum five minutes) in pairs. They only have about 10 minutes to prepare this.
5. Pairs in turn teach their short learning activity. The others in the group pretend to be middle school students. In their groups, they should give each other constructive feedback.
6. Ask the student teachers to reflect: what would the barriers be for middle school students who have difficulty with the topic? Have you helped to remove these barriers for these middle school students?

Assessment

Use peer-assessment: ask the student teachers to peer-assess the learning activity that

was developed in the mini-teach session.

Peer-assessment questions:

- Did the micro-teach lesson use Polya's four steps approach to problem-solving?
- Did it involve collaborative learning?
- Did it give an opportunity for the students to practise their 'habits of mind'?

Possible student teachers' responses

Look out for responses that are constructive and that talk about the mathematics that could be learned from using Polya's four steps approach and collaborative learning. For example: *The four-step approach was clearly present and helped to organise the thinking that was required to solve the problem; the working in groups helped to give more confidence in solving the problem because you could ask your peer for help or clarification and exchange ideas.*

Extended learning activity. Micro-teaching problem-based learning to middle school students (10 minutes)

Ask student teachers to work in their groups and to adapt their short teaching activities so they would also be suitable for students with visual impairment.

Check student teachers' understanding (5 minutes)

- Ask student teachers to summarise the constructive feedback that has been given in their groups. What did they do well and what can be improved?
- Remind student teachers of the learning outcome of this lesson.
- Remind student teachers that they explored issues around teaching problem-based learning and that they will use this when teaching as qualified teachers.

Expected student teachers' responses for the review questions in TB

Question 1: List Polya's four steps for problem-solving.

Answer: *Polya's four steps for problem-solving are:*

1. *Understand the problem*
2. *Devise a plan*
3. *Carry out the plan*
4. *Look back*

Question 2: Give three reasons why students can find problem-based mathematics solving activities hard to do.

Answer:

- *Students have not developed their mathematical thinking skills because they have been taught Mathematics by memorisation or rote learning.*
- *Students are unsure about how to structure their approach for solving a mathematical problem.*
- *Students have not practised any of the 'habits of mind' to act as a mathematician-in-training.*

Question 3: Give three possible solutions for helping students to get better at problem-based learning.

Answer:

- *Use more problem-solving activities in the lessons that require students to develop their mathematical thinking skills.*
- *Use less memorisation or rote learning.*
- *Remind students every time when they are doing problem-solving activities to use Polya's four steps to help them structure their approach for solving a mathematical problem.*
- *Regularly use short learning activities that require students to practise their 'habits of mind' to act as a mathematician-in-training.*

2.2. Research in Mathematics

Using and conducting your own research is an important aspect of the professional life of a teacher. Using research can help student teachers discover information on teaching approaches that have been tested and evaluated. Conducting their own research starts with reflecting on their own teaching and learning practise in a structured manner. Both can help student teachers to improve their teaching and learning practises. In this sub-unit they will first consider common errors and misconceptions in algebra and then practise self-reflection based on teaching and learning.

2.2.1. Common errors and misconceptions in algebra

Expected learning outcomes

By the end of this lesson, student teachers will be able to:

- Describe some common errors and misconceptions in algebra; and
- Give examples of how common errors and misconceptions can be used as a tool for learning.

Competencies gained

A1.1.1 Give examples of how the students' cognitive, physical, social, emotional and moral development may affect their learning

A4.1.1 Describe key concepts, content, learning objectives and outcomes of the lower secondary curriculum for the subjects and grade level/s taught

A5.1.2 Include in lessons accurate and relevant information, examples and exercises to support student learning of core subject content, skills and procedures

D1.1.1 Use evidence of students learning to reflect on the impact of own teaching practice

Time: One period of 50 minutes

Learning strategies: Reading, group work, whole class discussion

Assessment approaches: Monitoring, whole class question and answer, teacher assessment. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read the text for Lesson 2.2.1. in the Student Teacher Textbook. Use the following: 'Learning from the mistakes of fictitious students' as written under Learning activity 1 Part B, or adapt this to the topic you would like to address in this lesson. Write this on the board.

Resources needed: Student teachers should have their Student Teacher Textbook and the notes on Learning activity 2 of Lesson 2.2.1. from their Student Teacher Textbook.

Learning activity 1. Reading and reflection: Using common errors and misconceptions as a tool for learning (20 minutes)[3]

Part A

1. Discuss with the student teachers what they learned from the text 'Using common errors and misconceptions as a tool for learning' in Lesson 2.2.1. in the Student Teacher Textbook.
2. Ask for ideas and opinions from the student teachers on why learning from mistakes can be a valuable tool for learning.
3. Exchange ideas on how to establish a classroom ethos that would help this.

[3] Adapted from Teacher Education through School-based Support-India (n.d.-a).

Part B

1. Tell the student teachers to work in pairs.
2. Tell the student teachers that students Aung, Thuta and Htet were asked to simplify the following:

$$\frac{3x^3 - x}{x}$$

Aung did it like this:	Thuta thought this was what should be done:	Htet was sure this was the method:
$\frac{3x^3 - x}{x}$ $= 3x^3 - 1$	$\frac{3x^3 - x}{x}$ $= 3x^2 - x$	$\frac{3x^3 - x}{x}$ $= \frac{x(3x^2 - 1)}{x}$ $= 3x^2 - 1$

Example of fictitious students' work

3. Tell the student teachers to discuss each of these methods with their partner:
   a. Are they mathematically correct, incorrect or partly correct? Why?
   b. How do you know?
   c. Describe what the common error or misconception is in each case.
4. Ask a few pairs of student teachers to share their responses. Ask the other student teachers if they agree or disagree and why.

Assessment

Ask a few student teachers to explain why developing a classroom ethos that welcomes learning from mistakes is important. Make sure you ask an even number of male and female student teachers.

Possible student teachers' responses

Accept answers that reflect the discussion from Learning activity 1. This could include the need for feeling safe and not being laughed at when making mistakes.

Learning activity 2. Reading and reflection: Identifying common errors and misconceptions (25 minutes)[4]

1. Tell the student teachers to work in groups of four or five.
2. They should now compare and examine in their groups all the examples they prepared for Learning activity 2 of Lesson 2.2.1. in their Student Teacher Textbook: 'Identifying common errors and misconceptions'.
3. They should discuss in their groups:

    a. Are these good examples? If not, can they amend them so they become good examples?

    b. Can they find examples for more misconceptions and common errors in algebra?

    c. Can they find new and different misconceptions or common errors in algebra to add to the list?
4. Ask a few groups to share the main points of their discussion and any new and different misconceptions or common errors in algebra to add to the list.
5. Ask the student teachers to reflect: how did having a choice in this activity help your learning? Would it help all middle school students?

Assessment

Ask a few student teachers to explain why using common errors and misconceptions from work of fictitious students can be an effective teaching strategy.

[4] Adapted from Teacher Education through School-based Support-India (n.d.-a).

Possible student teachers' responses

Accept answers that reflect the discussions of this lesson. This could include: *Using work from fictitious students often works well in exposing possible misconceptions, because it avoids emotional reactions and feelings of embarrassment.*

Differentiated learning activity. Identifying common errors and misconceptions (15 minutes)

Ask the student teachers to work in pairs or groups of four to discuss how they could use the teaching strategy of using common errors and misconceptions as a tool to assess prior knowledge of the students at the start of a new topic. They should use the pyramid model to do so. The pyramid model is a way to approach a topic/discussion in stages:

1. What is happening?
2. Why is it happening?
3. What can you do?
4. Think about strategies.
5. Make an action plan.

Check student teachers' understanding (5 minutes)

- Ask the student teachers to turn to their partner and to explain how using common errors and misconceptions can be an effective teaching strategy for the learning of mathematics.
- Remind student teachers of the learning outcomes of this lesson.
- Remind student teachers that they explored issues around teaching algebra to improve their teaching and learning and that they will use this when teaching as qualified teachers.

2.2.2. Reflecting on teaching and learning Mathematics

Expected learning outcome

By the end of this lesson, student teachers will be able to:

- Practise self-reflection based on teaching and learning.

Competencies gained

A1.1.1 Give examples of how the students' cognitive, physical, social, emotional and moral development may affect their learning

A4.1.1 Describe key concepts, content, learning objectives and outcomes of the lower secondary curriculum for the subjects and grade level/s taught

D1.1.1 Use evidence of students learning to reflect on the impact of own teaching practice

Time: One period of 50 minutes

Learning strategies: Flipped learning, pair work, think-pair-share, group work, whole class discussion

Assessment approaches: Monitoring, whole class question and answer, self-assessment. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read the text for Lesson 2.2.2. in the Student Teacher Textbook. Use the problem-based learning activities you selected for Lesson 2.1.3. Write these on the board or write a reference to where the student teachers can find these; for example, 'name of the textbook + pages'.

Resources needed: Student teachers should have their lesson notes from Lesson 2.2.1., their Student Teacher Textbook and notes from the Learning activity in Lesson 2.2.2. from their Student Teacher Textbook.

Learning activity. Flipped learning: Developing your own reflection questions (45 minutes)

Part A. Introduction (10 minutes)

1. Read the text 'Reflecting about teaching and learning Mathematics' in Lesson 2.2.2. in the Student Teacher Textbook aloud with the whole class.
2. Discuss what reflection is and why it is an important aspect of being a professional teacher and how to complete a good reflection. The student teachers should also be encouraged to share insights about the role of reflection from their other courses.

Part B. Using reflection questions to reflect on teaching and learning Mathematics (35 minutes)

Tell the student teachers:

1. To work in pairs.
2. Taking turns, they should use the reflection questions they prepared for this lesson to reflect on their own learning of mathematics they did in Lesson 2.1.2. They can refer to the notes they made during that lesson and to their Student Teacher Textbook.
3. Next, they should use the reflection questions they prepared for this lesson to reflect on their teaching of mathematics they did in Lesson 2.1.3. They can refer to the notes they made during that lesson and to their Student Teacher Textbook.
4. As a pair, they should evaluate the effectiveness of their reflection questions:

   (a) Do the reflection questions help them to reflect on their teaching and learning of Mathematics so they can improve their teaching and learning of Mathematics?

5. Ask them to change, refine their reflection questions or write some new ones. They should make a note of these in their journals.
6. Ask a few student teachers to share their reflection questions on learning and on teaching Mathematics with the whole class.

Facilitator's notes

Support and encourage both female and male student teachers to be presenters for their pairs.

7. Discuss with the whole class how they can help reflection and lead to improving the teaching and learning of Mathematics. Invite as many contributions to this discussion as is feasible within the time.

Assessment

Ask a few student teachers to explain why being a reflective practitioner is important. Ask a few student teachers to explain any differences between reflecting on teaching and reflecting on learning.

Possible student teachers' responses

Accept answers that explain that reflecting on teaching practise helps them to improve their teaching skills further; reflecting on their own learning helps them to get better at learning.

Extended learning activity. Using reflection questions to reflect on teaching and learning mathematics (5 minutes)

Ask the student teachers to work in pairs and consider how they would adapt their reflection questions on teaching when they have students with motor skills issues that prevent them from writing well in their class.

Check student teachers' understanding (5 minutes)

- Ask student teachers to turn to their partner and to explain how self-reflection can help them in their own learning of mathematics.
- Remind student teachers of the learning outcome of this lesson.
- Remind student teachers that they explored issues around reflection to improve their teaching and learning and that they will use this when teaching as qualified teachers.

Expected student teachers' responses for the review questions in TB

Question 1: List some common errors students make when learning algebra.

Answer: *Anything from the following list:*

- *Student treats coefficients as addition rather than multiplication.*
- *Student makes mistakes when applying properties or order of operations.*
- *Student uses the same operation instead of the inverse operation to try to solve the equation.*
- *Student makes mistakes when using substitution.*
- *Student does not include the unknown in their equation.*
- *Student writes an expression instead of an equation.*
- *Student writes the equation terms in the order that they are mentioned in the problem.*

Question 2: List some common misconceptions students have about algebra.

Answer*: Anything from the following list:*

- *Student thinks that an unknown or variable can only stand for one value (in other words, all unknowns or variables are the same value).*
- *Student thinks that two unknowns or variables cannot be equivalent values.*
- *Student thinks that an unknown or variable represents an object rather than a number.*
- *Students think they can ignore letters. (For example, 3a to be taken as 3.)*
- *Student thinks they have to follow the rules of order of operations (BODMAS/BIDMAS) when solving equations.*

- *Student thinks that the x unknown or variable is the multiplication sign.*
- *Student thinks that simplified algebraic expressions should be a single term. For example, student does not see 7x + 4 as a complete simplification because there is an action (addition) between two terms.*
- Student thinks that constants are the same as variables.

Question 3: Why is it a good idea to use reflection questions?

Answer: *Reflection questions can be helpful to support you to practise good reflection. They can develop, refine or be changed over time.*

2.3. Inclusive Approach to Teaching Mathematics

When teaching Mathematics, it is very important to make sure all students are actively involved and included in the learning. This can be particularly challenging for student teachers when teaching and learning in large classrooms with many students, or when they address the needs of different abilities in one class. One tool to encourage an inclusive approach to teaching mathematics is using collaborative learning through group or pair work.

2.3.1. Collaborative learning approach

Expected learning outcomes

By the end of this lesson, student teachers will be able to:

- Develop ideas to facilitate collaborative learning of middle school students; and
- Demonstrate how to promote inclusion in middle school classrooms.

Competencies gained

A1.1.1 Give examples of how the students' cognitive, physical, social, emotional and moral development may affect their learning

A1.2.1 Identify various teaching methods to help students with different backgrounds (gender, ethnicity, culture) and abilities, including special learning needs, learn better

B1.1.1 Use different ways to explain the subject matter, related ideas and concepts to meet a range of learning abilities and intended learning outcomes

Time: One period of 50 minutes

Learning strategies: Active learning, pair work, micro-teaching, group work

Assessment approaches: Monitoring, peer-assessment. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: None

Resources needed: Student teachers should have their lesson notes from Lesson 2.1.3. 'Teaching problem-based learning', the learning activity they did in preparation for this lesson and their Student Teacher Textbook.

Learning activity. Micro-teaching: Preparing to teach collaborative and inclusive learning activities (45 minutes)

Tell the student teachers:

1. To work in groups of five or six.
2. Say: Today you will be teaching a short learning activity that involves collaborative learning and is inclusive for all students, to your student teacher colleagues in your group, who will pretend to be middle school students.
3. They can do this as a team-teaching activity in pairs.
4. They should refer back to the notes on the learning activity in their Student Teacher Textbook that they completed in preparation for this lesson.
5. They should first discuss their ideas for adapting the lesson plan of Lesson 2.1.3. and agree within their groups on the changes they want to make.
6. They should prepare to teach a short collaborative and inclusive teaching activity (maximum five minutes) in pairs. They only have about 10 minutes to prepare this.

7. Pairs in turn teach their short learning activity. The others in the group pretend to be middle school students. In their groups, they should give each other constructive feedback.

Assessment

Use peer-assessment: ask the student teachers to peer-assess the learning activity that was developed in the micro-teach session. Make sure that student teachers are objective and fair in doing peer-assessment.

Peer-assessment questions:

- Did the micro-teach session use good collaborative learning that was also inclusive?
- Did it include suggestions made in their Student Teacher Textbook?

Possible student teachers' responses

Look out for responses that are constructive and that focus on collaborative and inclusive learning and teaching in mathematics. For example, some of the techniques mentioned in the text in their Student Teacher Textbooks were used, such as asking the question, 'What is the same, what is different?' and being accessible to students with mobility problems.

Extended learning activity. Micro-teaching collaborative and inclusive learning activities (10 minutes)

Ask the student teachers to continue working in their groups. Ask them to adapt their short teaching activities so they would also be suitable for students who are autistic.

Then they should discuss in their group: how could you approach this task differently?

Check student teachers' understanding (5 minutes)

- Ask student teachers to summarise the constructive feedback that has been given in their groups. What did they do well and what can be improved?
- Remind student teachers of the learning outcomes of this lesson.
- Remind student teachers that they explored issues around teaching in an inclusive classroom and that they will use this when teaching as qualified teachers.

Expected student teachers' responses for the review questions in TB

Question 1: What is meant by 'inclusive education'?

Answer: *Inclusive education is based on the fundamental right of all students to participate in quality education. It is a continuous process of making the school more welcoming, child-centred and beneficial for all students. Inclusive education is about restructuring education cultures, policies and practises, so that they can respond to a diverse range of students. It involves changing school cultures and processes so that it accommodates all students. This means it does not attempt to change students to fit in existing education structures.*

Question 2: What are the four main reasons why research has shown that collaborative learning is "one of the greatest success stories in the history of modern research" (Slavin, Hurley, & Chamberlain, 2003, p. 177)?

Answer:

- Motivation
- Social cohesion
- Personalisation
- Cognitive elaboration.

Unit Summary

Key messages

- In this unit, student teachers have explored aspects and approaches to problem-solving and some of the common misconceptions in algebra in middle school. It is very important that student teachers are aware of student misconceptions, as they can hinder understanding and thus progress.
- Working in groups or pairs can help middle school students feel more confident when doing problem-based learning activities as they can support each other through challenges.
- Another approach is to consider mathematical thinking as a series of 'habits of mind' which can be taught in the classroom.
- To become and remain an excellent professional teacher, student teachers should be learning through reflection of their teaching experiences. To help them in their reflections, they should use reflection questions that they develop themselves and that work for them.
- In this unit, student teachers learned to use and develop specific reflection questions that work well for them to support them to practise good reflection. They can develop, refine or change these themselves over time.
- Student teachers also learned more about collaborative learning in Mathematics as an effective teaching strategy and as a way to support inclusivity in the classroom.
- To teach effectively student teachers have to be aware of common misconceptions and errors that students make so they can address these in their teaching. One teaching strategy that they explored in this unit to do so, was the use of incorrect mathematics work of fictitious students.
- Collaborative learning is an effective teaching strategy because it helps with motivation, social cohesion, personalisation and cognitive elaboration.

Unit reflection

- What have student teachers learnt that was new about reflection? How did it help them?
- What teaching strategies did student teachers learn about in this unit? When would they like to use them?
- Would more collaborative learning help them with their learning of mathematics? Why?
- As a teacher educator, how would you help student teachers to make their classroom inclusive?

Further reading

CAST. (2018). *Universal design for learning guidelines version* 2.2. Retrieved from http://udlguidelines.cast.org

Hall, T. E., Meyer, A., & Rose, D. H. (Eds.). (2012). *Universal design for learning in the classroom: Practical applications.* New York, NY: Guilford Press.

Kappiya Paysi. (2014). *သခ်ၤာေရာင္စဥ္နင့္ လူ႔ကမၻာ [Spectrum of mathematics and social world]*. Yangon, Myanmar: ZinYaTaNaSaw sarpay.

Khin Maung Swe. (2011). *သခ်ၤာအျမင္သခ်ၤာအေတြး [Mathematical view and mathematical thought].* Yangon, Myanmar: ZinYaTaNaSaw sarpay.

Mason, J. H. (1988) *Learning and doing mathematics.* London, England: Macmillan Education.

Perkins, D. N. (2010). *Making learning whole: How seven principles of teaching can transform education.* San Francisco, CA: Jossey-Bass.

Schacter, J. (2000). Does individual tutoring produce optimal learning? *American Educational Research Journal,* 37, 801-829.

Sharma, U., Forlin, C., Deppeler, J., & Yang, G. (2013). Reforming teacher education for inclusion in developing countries in the Asia Pacific region. *Asian Journal of Inclusive Education,* 1, 3-16.

Slavin, R. E., Hurley, E. A., & Chamberlain, A. (2003). Cooperative learning and achievement in W. M. Reynolds & G. E. Miller (Eds.), *Handbook of Psychology: Volume 7 Educational Psychology* (pp. 178-198). Hoboken, NJ: John Wiley & Sons.

United Nations Educational, Scientific and Cultural Organization. (2017). *A guide for ensuring inclusion and equity in education.* Paris, France: United Nations Educational, Scientific and Cultural Organization.

Unit 3

Understanding Mathematics

This unit describes many of the Mathematics topics that are covered in the middle school curriculum for grades 6 to 9 in Myanmar, including those related to basic number concepts, geometry and measurement. Student teachers will identify and practise some strategies for teaching these topics to middle school students. They will then explore the language of mathematics and how to use problem-solving questions in a middle school classroom. Finally, they will explore the many ways that we use mathematical thinking in our everyday lives and activities. They will develop ideas about how to link the mathematical skills that students learn in the curriculum to everyday situations through project-based learning

Expected learning outcomes

By the end of this unit, student teachers will be able to:

- Summarise the organisation of the real number system (rational and irrational numbers);
- Demonstrate practical ideas to teach the real number system (rational and irrational numbers;

- Summarise the concept of highest common factor and least common multiple ;
- Demonstrate practical ideas to teach highest common factor and least common multiple;
- Explain the rules of exponents and radicals;
- Demonstrate ideas of how to teach solving exponential equations by using exponential rules of positive integers, zero and negative integers;
- Explain the concepts of ratio, proportion and percentage;
- Explore ideas of teaching the concepts of ratio, proportion and percentage;
- Describe the basic concepts of sets (subsets, finite sets, infinite sets, empty sets and equal sets);
- Demonstrate an understanding of how to teach set operations by using Venn diagrams and number lines;
- Explain the connection between number patterns and sequences;
- Explain how to get n^{th} term in given sequences;
- Demonstrate an understanding of how to teach patterns, sequences and how to get n^{th} term in given sequences;
- Explain about estimation of errors;
- Explain how to solve problems by using estimation of errors (absolute error, relative error and percentage error);
- Summarise various counting systems;
- Explain how to convert between the denary or decimal system (base 10) and the binary system (base 2);
- Demonstrate an understanding of how to teach different counting systems and how to convert between the denary or decimal system (base 10) and the binary system (base 2);
- Explain how to teach basic constructions by using a pair of compasses, set squares and a protractor; draw perpendicular lines and angles;
- Explain how to teach drawing of perpendicular lines and angles;

- Explain how to teach drawing of perpendicular bisectors and angle bisectors;
- Explain how to teach the bearing angles: normal convention of bearing, angle of elevation and depression;
- Explain how to teach land dimension, survey, draw the form of patches;
- Describe the importance of considering the language of Mathematics, particularly when teaching middle school students;
- Explain how middle school students will gain problem-solving skills in classrooms;
- Describe the kinds of problem-solving questions that are useful to enhance mathematical thinking for Grade 6 and 7 students;
- Explain the problem-solving skills that Grade 6 and 7 students should attain;
- Describe various types of problem-solving questions that are useful to enhance mathematical thinking for Grade 8 and 9 students;
- Explain the problem-solving skills that Grade 8 and 9 students should attain;
- Explore knowledge about Metric and British systems (length, weight, volume and capacity);
- Describe the strategies of how to teach solving the real-life problems connected with this knowledge;
- Explore knowledge about purchase lists, profit and loss, stocks and shares;
- Describe the strategies of how to teach solving real-life problems connected with this knowledge;
- Use the skills with Metric and British systems (length, weight, volume, capacity) to design a lesson around (e.g. playground project);
- Develop similar practical lessons to demonstrate how numeracy skills and mathematical thinking are used in real-life situations;
- Use the skills with purchase lists, profit and loss, stocks and shares to design a lesson around (e.g. marketing project); and

- Develop similar practical lessons to demonstrate how numeracy skills and mathematical thinking are used in real-life situations.

Competencies gained

A1.1 Demonstrate understanding of how students learn relevant to their age and developmental stage

A1.2 Demonstrate understanding of how different teaching methods can meet students' individual learning needs

A2.1 Demonstrate understanding of appropriate use of a variety of teaching and learning strategies and resources

A4.1 Demonstrate understanding of the structure, content and expected learning outcomes of the basic education curriculum

A5.1 Demonstrate understanding of the subject matter to teach the assigned stubject/s for the specified grade level/s

A5.2 Demonstrate understanding of how to vary delivery of subject content to meet students' learning needs and learning context

B1.1 Demonstrate capacity to teach subject-related concepts clearly and engagingly

3.1. Numbers

This sub-unit focuses on number systems and how these topics feature in the curriculum for grades 6 through 9. Student teachers will explore the content of these Mathematics topics and how they build at each grade level in the middle school curriculum. They will identify some teaching strategies and design their own learning activities on these topics.

3.1.1. Rational and irrational numbers

Expected learning outcomes

By the end of this lesson, student teachers will be able to:

- Summarise the organisation of the real number system (rational and irrational numbers); and
- Demonstrate practical ideas to teach the real number system (rational and irrational numbers).

Competencies gained

A1.1.2 Prepare learning activities to align with students' level of cognitive, linguistic, social and physical development

A2.1.2 Use teaching methods, strategies and materials as specified in the textbooks and additional low cost support materials, to support student learning

A4.1.1 Describe key concepts, content, learning objectives and outcomes of the lower secondary curriculum for the subjects and grade level/s taught

A5.1.1 Describe key concepts, skills, techniques and applications for the subjects covered in the grade levels taught

B1.1.1 Use different ways to explain the subject matter, related ideas and concepts to meet a range of learning abilities and intended learning outcomes

Time: One period of 50 minutes

Learning strategies: Flipped learning, lecture, whole class discussion, pair work, group work, micro-teaching

Assessment approaches: Observation, peer-assessment, question and answer. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read the text for Lesson 3.1.1. in the Student Teacher Textbook. Read or try out the learning activities before you teach these.

Resources needed: Student Teacher Textbook

Learning activity 1. Flipped learning: Introduction to rational and irrational numbers (15 minutes)

1. Introduce the topic of rational and irrational numbers (based on Lesson 3.1.1. in the Student Teacher Textbook).
2. Ask student teachers to work in pairs. Tell them to carry out the following steps:
   a. Draw a number line from –5 to 5.
   b. Plot the following numbers exactly on a number line: ¼, –3, π, 4.2, $\sqrt{2}$
   c. Discuss with your partner:
      i Are you happy with the results?
      ii Were you able to plot them in exactly the right place?

iii Were some numbers easier to plot than others?

iv How could you use this activity to demonstrate rational and irrational numbers to your students?

3. Invite a few pairs to share what they discussed with the class. Select an equal number of male and female student teachers to share.
4. Lead a question and answer session about rational and irrational numbers using the questions in the assessment section below.

Assessment

Check for students' understanding of the real number system using a question and answer session after the pair work activity.

Questions**:**

- Were some numbers easier to plot than others? If so, why?
- How can you tell where to plot a *rational* number precisely?
- How can you tell where to plot an *irrational* number precisely?
- How could you use this activity to demonstrate rational and irrational numbers to students?

Possible student teachers' responses

Accept any responses that show an understanding of rational and irrational numbers and how to teach them. These are example responses for the above questions:

- *Rational numbers are easier to plot because their precise value is known.*
- *Rational numbers can be written as whole numbers, fractions or terminating decimals and their exact location pinpointed on a number line.*
- *It is not possible to pinpoint an irrational number in its precise location, but its approximate location can be found using a calculator.*
- *This could give students the understanding that irrational numbers cannot be pinpointed exactly because they are decimal numbers that continue on forever, but that they can be approximated.*

Facilitator's notes

Make sure that student teachers are able to draw conclusions about the nature of rational and irrational numbers from the number line activity. Walk around to listen to their conversations in pairs and help them make these connections as needed.

Learning activity 2. Flipped learning: Teaching rational and irrational numbers (30 minutes)

1. Ask the student teachers to work in small groups.
2. Tell them that they will design a short learning activity (maximum five minutes) about rational and irrational numbers for middle school students.
3. Ask student teachers to form pairs in their groups. They will work with one other person to plan the short learning activity. Give them about 10 minutes to prepare this.
4. Ask one student teacher from each pair to lead their small group to do their short learning activity. The student teacher will act as a teacher, while others in the group act as students. After each short learning activity, the group members give constructive feedback using the questions below.

   Peer-assessment questions:

   a. Did the 'teacher' give clear instructions and explanations?

   b. Would students develop a good understanding of the real number system based on this activity?

   c. What is one thing that went well? What is one thing that could be improved?

Assessment

Use observation to assess the student teachers. Move around the room and listen to them as they present their learning activities in their groups and give each other feedback.

Facilitator's notes

Make sure that student teachers are objective and fair in doing peer-assessment.

Possible student teachers' responses

During student teachers' presentations, check for the following:

- They demonstrate a good understanding of rational and irrational numbers.
- They are able to explain the learning activity and rational/irrational numbers clearly.
- Their learning activity would give students a better understanding of rational/irrational numbers.

As student teachers do peer-assessment after each activity, make sure that feedback is constructive. You may also provide feedback to student teachers based on what you have heard or observed.

Extended learning activity. Adapting learning activities for all middle school students (10 minutes)

For groups that finish their teaching practise early, ask them to discuss how they could adapt their learning activities for middle school students with visual impairments or hearing impairments.

Check student teachers' understanding (5 minutes)

- Ask student teachers to turn to their partner and to explain how to identify if a number is rational or irrational.
- Remind student teachers of the learning outcomes of this lesson.

- Remind student teachers that they explored the teaching of rational and irrational numbers and that they will use this when teaching as qualified teachers.

Facilitator's notes

After teaching this lesson, reflect on your own work as a teacher educator. Did all student teachers in your class benefit from the lesson? How could you change or improve this lesson to make student teachers' learning more effective?

3.1.2. Factors and multiples

Expected learning outcomes

By the end of this lesson, student teachers will be able to:

- Summarise the concept of highest common factor and least common multiple; and
- Demonstrate practical ideas to teach highest common factor and least common multiple.

Competencies gained

A1.1.2 Prepare learning activities to align with students' level of cognitive, linguistic, social and physical development

A2.1.2 Use teaching methods, strategies and materials as specified in the textbooks and additional low cost support materials, to support student learning

A4.1.1 Describe key concepts, content, learning objectives and outcomes of the lower secondary curriculum for the subjects and grade level/s taught

A5.1.1 Describe key concepts, skills, techniques and applications for the subjects covered in the grade levels taught

B1.1.1 Use different ways to explain the subject matter, related ideas and concepts to meet a range of learning abilities and intended learning outcomes

Time: One period of 50 minutes

Learning strategies: Flipped learning, lecture, pair work, group work

Assessment approaches: Observation, peer-assessment, question and answer. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read the text for Lesson 3.1.2. in the Student Teacher Textbook. Read or try out the learning activities before you teach these.

Resources needed: Student Teacher Textbook

Learning activity 1. Flipped learning: Introduction to HCF and LCM (20 minutes)

1. Introduce the topics of highest common factor (HCF) and least common multiple (LCM), based on Lesson 3.1.2. in the Student Teacher Textbook.
2. Ask student teachers to work in pairs to solve the following word problems (allow them to use any method):
    a. Ma Ma goes to the market every 4 days and Maung Maung goes to the market every 6 days. They both went to the market today. How many days will it be until they go to the market on the same day again?
    b. A carpenter has two strips of wood. One piece is 32 inches long and the other piece is 48 inches long. She wants to cut both pieces into strips of

equal length, making them as long as possible. How long should the strips be?

3. Lead a question and answer session to check for student teachers' understanding of HCF and LCM, using the assessment questions below. Select an equal number of male and female student teachers to share.

Assessment

Check for student teachers' understanding of HCF and LCM using a question and answer session. Lead a discussion using the following questions:

- What mathematics skills did you use to solve the word problems?
- Did you use LCM or HCF? If not, how could you have used LCM or HCF?
- Explain HCF and LCM in your own words.
- What difficulties do you think middle school students may have in understanding and calculating HCF/LCM?
- How would you address these difficulties as a teacher?

Possible student teachers' responses

Accept any responses that show an understanding of HCF and LCM. These are example responses for each of the above questions:

- *Student teachers may use HCF/LCM or any other method, such as counting or operations.*
- *LCM can be used to solve the first problem; the LCM of 4 and 6 is 12, which means that Ma Ma and Maung Maung will go to the market on the same day every 12 days. HCF can be used to solve the second problem; the HCF of 32 and 48 is 16, so if the carpenter cuts the pieces of wood into strips of 16 inches each, she will maximise the length of the strips.*
- *HCF is the largest factor that two or more numbers share. LCM is the smallest multiple that two or more numbers have in common.*
- *There are several terms and concepts they must learn and they must be able to distinguish the different processes for calculating HCF and LCM.*

- *Help students to understand the nature of factors and multiples and how they apply in everyday situations, so that they are not relying on rote memorisation to solve problems.*

Facilitator's notes

If student teachers do not show a good understanding of HCF and LCM, spend a few more minutes to review using the content in the Student Teacher Textbook. You may ask volunteers to solve some examples on the board to review.

Learning activity 2. Flipped learning: Teaching HCF and LCM (25 minutes)

1. Ask the student teachers to work in small groups.
2. Tell them that they will each write a word problem about HCF or LCM, then they will solve and discuss them in their groups.
3. Give student teachers five minutes to write their word problem.
4. Student teachers should solve each word problem written by their group members. After solving each problem, they should do a brief peer-assessment. They should use the following discussion questions to give each other constructive feedback.

   Peer-assessment questions:

   a. Was the word problem clear and easy to understand?

   b. Could the problem be solved using either HCF or LCM?

   c. Would students develop a good understanding of HCF or LCM based on this word problem?

Assessment

Use observation to assess the student teachers. Move around the room to read the word problems they write and listen to them as they discuss and give each other feedback.

Facilitator's notes

Make sure that the student teachers are objective and fair in doing peer-assessment.

Possible student teachers' responses

As you observe and listen to the student teachers, check for the following:

- Their word problem is clear and easy to understand.
- Their word problem is an application of HCF or LCM.
- They are able to solve each other's word problems using HCF or LCM.
- They give each other positive and useful feedback.

You may also provide feedback to student teachers based on what you have heard or observed.

Extended learning activity. Solving word problems with different methods (10 minutes)

If student teachers finish the activity early, ask them to try solving the same word problems using different methods. Remind student teachers that there are often different paths to the correct answer and creativity in problem-solving should be encouraged in a Mathematics classroom.

Check student teachers' understanding (5 minutes)

- Ask student teachers to turn to their partner and to explain how to calculate HCF or LCM (one partner should explain each).
- Remind student teachers of the learning outcomes of this lesson.
- Remind student teachers that they explored factors and multiples and that they will use this when teaching as qualified teachers.

3.1.3. Exponents and radicals-Period 1

Expected learning outcome

By the end of this lesson, student teachers will be able to:

- Explain the rules of exponents and radicals.

Competencies gained

A1.1.2 Prepare learning activities to align with students' level of cognitive, linguistic, social and physical development

A4.1.1 Describe key concepts, content, learning objectives and outcomes of the lower secondary curriculum for the subjects and grade level/s taught

A5.1.1 Describe key concepts, skills, techniques and applications for the subjects covered in the grade levels taught

Time: One period of 50 minutes

Learning strategies: Flipped learning, lecture, think-pair-share, active learning, group work, micro-teaching

Assessment approaches: Observation, peer-assessment, question and answer. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read the text for Lesson 3.1.3. Period 1 in the Student Teacher Textbook. Read or try out the learning activities before you teach these.

Resources needed: Student Teacher Textbook

Learning activity 1. Flipped learning: Introduction to exponents and radicals (20 minutes)

1. Introduce the topics of exponents and radicals (based on Lesson 3.1.3. Period 1 in the Student Teacher Textbook).
2. Ask student teachers to work with a partner to complete a think-pair-share activity. Present them with the problem:

   How many different ways can you represent the number 16 using exponents or radicals? Write down as many different ways as you can think of.
3. Student teachers should think about the problem on their own for two to three minutes before sharing ideas with their partner.
4. Ask student teachers to share their responses with the class. Ask them to write their ideas on a board or flipchart paper to form a collection of expressions equivalent to 16. (Example answers: 2^4; 4^2; $2^2 \times 2^2$; $\frac{2^9}{2^5}$; $(2^2)^2$; $(256)^{1/2}$; $\sqrt[3]{4,096}$)
5. As student teachers share their responses with the class (or afterward), ask them to identify which rules of exponents and radicals they applied.
6. Lead a discussion about exponents and radicals using the assessment questions below.

Assessment

Check for student teachers' understanding of exponents and radicals using a question and answer session. Lead a discussion using the following questions:

- How are exponents and radicals related to each other?
- Do you think this think-pair-share activity would be useful to students in your own classroom? Why or why not?
- What difficulty do you think middle school students may have in working with exponents and radicals?
- How would you address these difficulties?

Use observation to assess student teachers' understanding of exponents and radicals

as they are working in pairs. Move around the room to check whether they correctly apply the rules for radicals and exponents to write expressions and are able to express their ideas clearly to their partner.

Possible student teachers' responses

For the question and answer session, accept any responses that show an understanding of exponents and radicals. These are example responses for each of the above questions:

- *Radicals are expressions with fractional exponents ($\sqrt[n]{x} = x^{\frac{1}{n}}$). Radicals and exponents are opposite operations that 'undo' each other.*
- *It would be helpful because it encourages students to explore radicals and exponents and the relationship between them.*
- *There are many rules for exponents and radicals, so students may find it challenging to remember all of these and apply them at the appropriate times.*
- *Students will become comfortable with the rules and gain procedural fluency in applying them through practise with different types of problems.*

Facilitator's notes

If student teachers do not show a good understanding of exponents and radicals, spend a few more minutes to review using the content in the Student Teacher Textbook.

Learning activity 2. Active learning: Explaining the rules of exponents and radicals (25 minutes)

1. Ask the student teachers to work in small groups.
2. Tell them that they will design a short explanation of one of the rules of exponents or radicals (maximum three minutes).
3. Ask student teachers to form pairs in their groups. Each pair of student teachers should choose a different rule for exponents or radicals. Give them about 10 minutes to prepare their explanation. It should be in the style of a short and engaging classroom lecture or discussion.

4. Ask one student teacher from each pair to give their explanation to their group. The student teacher will act as a teacher, while others in the group act as students. After each explanation, the group members give constructive feedback using the questions below.

   Peer-assessment questions:

   a. Did the 'teacher' give clear instructions and explanations?

   b. Would students develop a good understanding of the rule based on this explanation?

   c. What is one thing that went well? What is one thing that could be improved?

Assessment

Use observation to assess the student teachers. Move around the room and listen to them as they give their explanations in their groups and give each other feedback.

Facilitator's notes

Make sure that student teachers are objective and fair in doing peer-assessment.

Possible student teachers' responses

During student teachers' presentations, check for the following:

- They demonstrate a good understanding of the rules of exponents and/or radicals and explain them clearly.
- They use appropriate examples to demonstrate the rules.
- The presentation would give students a better understanding of exponents and/or radicals.

As student teachers do peer-assessment after each activity, make sure that feedback is constructive. You may also provide feedback to student teachers based on what you have heard or observed.

Extended learning activity. Adapting learning activities for all middle school students (10 minutes)

For groups that finish their teaching practise early, ask them to discuss how they could explain the rules of exponents and radicals to a middle school student with a visual impairment.

Check student teachers' understanding (5 minutes)

- Ask student teachers to turn to their partner and to explain one method of teaching exponents/radicals that they will try in their own classroom.
- Remind student teachers of the learning outcome of this lesson.
- Remind student teachers that they explored how to teach exponents and radicals and that they will use this when teaching as qualified teachers.

3.1.3. Exponents and radicals-Period 2

Expected learning outcome

By the end of this lesson, student teachers will be able to:

- Demonstrate ideas of how to teach solving exponential equations by using exponential rules of positive integers, zero and negative integers.

Competencies gained

A1.1.2 Prepare learning activities to align with students' level of cognitive, linguistic, social and physical development

A2.1.2 Use teaching methods, strategies and materials as specified in the textbooks and additional low cost support materials, to support student learning

A4.1.1 Describe key concepts, content, learning objectives and outcomes of the lower secondary curriculum for the subjects and grade level/s taught

A5.1.1 Describe key concepts, skills, techniques and applications for the subjects covered in the grade levels taught

B1.1.1 Use different ways to explain the subject matter, related ideas and concepts to meet a range of learning abilities and intended learning outcomes

Time: One period of 50 minutes

Learning strategies: Flipped learning, lecture, whole class discussion, group work, micro-teaching

Assessment approaches: Observation, peer-assessment, question and answer. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read the text for Lesson 3.1.3. Period 2 in the *Student Teacher Textbook*. Read or try out the learning activities before you teach these.

Resources needed: Student Teacher Textbook

Learning activity 1. Flipped learning: Introduction to exponential equations (10 minutes)

1. Introduce the topics of exponential equations (based on Lesson 3.1.3. Period 2 in the Student Teacher Textbook).
2. Lead a discussion about exponential equations using the assessment questions below. Select an equal number of male and female student teachers to share.

Assessment

Check for student teachers' understanding of exponents and radicals using a question and answer session. Lead a discussion using the following questions:

- What is an exponential equation?
- At what grade level do exponential equations feature in the curriculum?
- What skills should students already have before they learn exponential equations?
- What challenges do you think students will have in solving exponential equations?
- How would you address these challenges?

Possible student teachers' responses

Accept any responses that show an understanding of exponential equations and the curriculum. These are example responses for each of the above questions:

- *An exponential equation is one with a variable in the exponent, such as* $2^x = 8$.
- *Exponential equations are covered in Grade 9.*
- *Students should understand the rules for exponents and be able to apply them to positive and negative integers.*
- *Students may have difficulty in applying the rules of exponents to rewrite both sides of an equation as an exponent with the same base.*
- *These challenges could be addressed by reviewing the rules and assigning problems that strategically build up to become more difficult and apply different rules of exponents to solve equations.*

Learning activity 2. Active learning: Solving exponential equations (35 minutes)

1. Ask student teachers to work in small groups.
2. Explain that they will work *independently* to each solve *one* of the exponential

equations in the problem bank below. They should justify each step using one of the rules of exponents. They should be prepared to demonstrate how to solve the problem. Give student teachers five minutes to solve their exponential equations.

Problem bank

$3^x = 27$

$2^x \times 2^3 = 2^{12}$

$3^{(x-1)} = 81$

$8^x = \frac{1}{64}$

$(-2)^x = -8$

$4^{3x-1} = \left(\frac{1}{2}\right)^{x-1}$

3. Ask student teachers to demonstrate their solutions to their group. They should explain each step of the solution clearly and justify the step using rules of exponents.
4. After each demonstration, the group members give constructive feedback using the questions below.

   Peer-assessment questions:

   a. Is each step correct and clearly justified with a rule of exponents?

   b. Was the explanation clear or could it be improved?

   c. Would students develop a good understanding of how to solve an exponential equation based on this solution and explanation?

Assessment

Use observation to assess the student teachers during group work. Move around the room and listen to them as they present their solutions in their groups and give each other feedback.

Facilitator's notes

Make sure that the student teachers are objective and fair in doing peer-assessment.

Possible student teachers' responses

During student teachers' presentations, check for the following:

- Each step is correct and they justify it clearly with one of the rules of exponents.
- Their explanation is clear and easy to understand.
- The presentation would give students a better understanding of how to solve exponential equations.

As student teachers do peer-assessment after each activity, make sure that feedback is constructive. You may also provide feedback to student teachers based on what you have heard or observed.

Extended learning activity. Exponential equation poster (10 minutes)

For groups that finish their teaching practise early, ask them to prepare a poster that shows effective teaching strategies to help middle school students understand exponential equations.

Check student teachers' understanding (5 minutes)

- Ask student teachers to turn to their partner and to explain the mathematical skills that students apply in solving exponential equations.
- Remind student teachers of the learning outcome of this lesson.
- Remind student teachers that they explored how to teach solving exponential equations and that they will use this when teaching as qualified teachers.

3.1.4. Ratio, proportion and percentage

Expected learning outcomes

By the end of this lesson, student teachers will be able to:

- Explain the concepts of ratio, proportion and percentage; and
- Explore ideas of teaching the concepts of ratio, proportion and percentage.

Competencies gained

A1.1.2 Prepare learning activities to align with students' level of cognitive, linguistic, social and physical development

A2.1.2 Use teaching methods, strategies and materials as specified in the textbooks and additional low cost support materials, to support student learning

A4.1.1 Describe key concepts, content, learning objectives and outcomes of the lower secondary curriculum for the subjects and grade level/s taught

A5.1.1 Describe key concepts, skills, techniques and applications for the subjects covered in the grade levels taught

B.1.1.1 Use different ways to explain the subject matter, related ideas

and concepts to meet a range of learning abilities and intended learning outcomes

Time: One period of 50 minutes

Learning strategies: Flipped learning, lecture, pair work, group work, micro-teaching

Assessment approaches: Question and answer, observation, peer-assessment. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read Lesson 3.1.4. in the Student Teacher Textbook. Read or try out the learning activities before you teach these. Bring measuring tools (rulers, measuring tapes, etc.) for Learning activity 1 if they are available. If they are not available, student teachers may use estimated measurements.

Resources needed: Student Teacher Textbook, measuring tools

Learning activity 1. Flipped learning: Introduction to ratio, proportion and percentage (20 minutes)

1. Introduce the topics of ratio, proportion and percentage (based on Lesson 3.1.4. in the Student Teacher Textbook).
2. Ask student teachers to work with a partner to complete a pair work activity.[5] Present the problem below and ask student teachers to solve it with their partner. Allow them to use measuring tools (rulers, measuring tape, etc.) if they are available.

   Measure your height and then the length of your feet. Make a note of this. Now, the largest pair of shoes in the world is 5.29 metres long. How tall do you think the person wearing this shoe would be?

[5] Activity adapted from Teacher Education through School-based Support-India (n.d.-b).

The largest pair of shoes in the world[6]

Facilitator's notes

There is no right or wrong answer. Do not tell students how to solve the problem, but allow them to explore and experiment. The example answer below shows one possible solution, but there are many possible paths and answers to this problem.

3. Ask student teachers to share their responses with the class. You may ask them to show their solutions on the board.

[6] Teacher Education through School-based Support-India (n.d.-b).

Example answer: *A student teacher sets up a proportion using their height and foot length. A person 1.7 metres tall with a foot 0.25 metres long could solve the following proportion:*

$$\frac{actual\ height}{actual\ foot\ length} = \frac{giant\ height}{giant\ shoe\ length}$$

$$\frac{1.7}{0.25} = \frac{giant\ height}{5.29}$$

Giant height $= (1.7 \times 5.29) \div 0.25 \approx 36.0\ m$

4. Lead a discussion about ratio, proportion and percentage using the assessment questions below. Select an equal number of male and female student teachers to share.

Assessment

Use observation to assess student teachers' understanding of proportion as they are working in pairs. Move around the room to check whether they correctly apply proportions and are able to express their ideas clearly to their partner.

Monitor each group to facilitate their discussion if necessary and stimulate equal contribution of all student teachers to the group work.

Check for student teachers' understanding of ratio, proportion and percentage using a question and answer session. Lead a discussion using the following questions:

- Do you think this activity would be useful to students in your own classroom? Why or why not?
- How are ratio, proportion and percentage related to each other?
- Why do you think it is important for students to understand these topics?
- What difficulties do you think students may have in working with ratio, proportion and percentage?
- How would you address these difficulties?

Possible student teachers' responses

Accept any responses that show an understanding of ratio, proportion and percentage. These are example responses for each of the above questions:

1. *The activity would be useful because it encourages students to explore.*
2. *A proportion is the statement of the equality of two ratios. A percentage is a part-to-whole ratio where the 'whole' is 100. Percentages can be used in proportions.*
3. *Ratios and proportions are used in many aspects of life; students are already using them to solve everyday problems, whether they are aware of this or not. Formalising this knowledge builds problem-solving skills that are useful both in and out of the Mathematics classroom.*
4. *If students lack the basic concepts and skills, they will likely struggle in grades 8 and 9 when they work with direct and inverse proportion and variation.*
5. *Teachers could use real-world examples that students would be familiar with; for example, interpreting the scale of a map.*

Extended learning activity. Advanced example (15 minutes)

This is a more advanced version of the problem presented in Learning activity 1, that involves a giant shoe. You may ask student teachers to solve this version of the problem instead of the above problem or in addition to the above problem.

Problem: *The largest pair of shoes in the world is 5.29 metres long and 2.37 metres wide. It is said to be equivalent to a shoe size of 753. If this was your shoe, how tall would you be?*

Example answers: Student teachers may set up various proportions using their height, shoe size, length of width of their shoe. An example solution is given below. The example answer given above with height and foot length also applies here.

$$\frac{actual\ height}{actual\ shoe\ size} = \frac{giant\ height}{giant\ shoe\ size}$$

$$\frac{1.7}{39} = \frac{giant\ height}{753}$$

Giant height $= (1.7 \times 753) \div 39 \approx 32.8$ *metres*

Learning activity 2. Active learning: Proportion (25 minutes)

1. Ask the student teachers to work in small groups.
2. Tell them that they will design a short learning activity (maximum five minutes) about proportion for middle school students.
3. Ask student teachers to form pairs in their groups. They will work with one other person to plan the short learning activity. Give them about 10 minutes to prepare this.
4. Ask one student teacher from each pair to lead their small group to do their short learning activity. The student teacher will act as a teacher, while others in the group act as students. After each short learning activity, the group members give constructive feedback using the questions below. Make sure that the student teachers are objective and fair in doing peer-assessment.

Peer-assessment questions:

a. Did the 'teacher' give clear instructions and explanations?

b. Would students develop a good understanding of ratio, proportion and percentage based on this activity?

c. What is one thing that went well? What is one thing that could be improved?

Facilitator's notes

This activity is linked to the content in Lesson 3.1.4. in the Student Teacher Textbook. Student teachers read about playfulness in Mathematics and the importance of exploring and experimenting. Encourage them to design and lead learning activities that are student-centred and engaging.

Assessment

Use observation to assess the student teachers. Move around the room and listen to them as they present their learning activities in their groups and give each other feedback.

Possible student teachers' responses

During student teachers' presentations, check for the following:

- They demonstrate a good understanding of proportion.
- They are able to explain the learning activity and Mathematics topic clearly.
- Their learning activity would give students a better understanding of proportion.

As student teachers do peer-assessment after each activity, make sure that feedback is constructive. You may also provide feedback to student teachers based on what you have heard or observed.

Check student teachers' understanding (5 minutes)

- Ask student teachers to turn to their partner and to explain one application of proportion in their everyday lives.
- Remind student teachers of the learning outcomes of this lesson.
- Remind student teachers that they explored the teaching of proportions and that they will use this when teaching as qualified teachers.

3.1.5. Sets-Period 1

Expected learning outcome

By the end of this lesson, student teachers will be able to:

- Describe the basic concept of sets (subsets, finite sets, infinite sets, empty sets and equal sets).

Competencies gained

A4.1.1 Describe key concepts, content, learning objectives and outcomes of the lower secondary curriculum for the subjects and grade level/s taught

A5.1.1 Describe key concepts, skills, techniques and applications for the subjects covered in the grade levels taught

Time: One period of 50 minutes

Learning strategies: Flipped learning, lecture, whole class discussion, group work, micro-teaching

Assessment approaches: Question and answer, observation, peer-assessment. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read Lesson 3.1.5. in the Student Teacher Textbook. Read or try out Learning activities 1 and 2 before you teach these.

Resources needed: Student Teacher Textbook

Learning activity 1. Flipped learning: Introduction to sets (10 minutes)

1. Introduce the topic of sets (based on Lesson 3.1.5. Period 1in the Student Teacher Textbook).
2. Lead a discussion on sets using the assessment questions below. Select an equal number of male and female student teachers to share.

Assessment

Check for student teachers' understanding of sets using a question and answer session. Lead a discussion using the following questions:

- What is a set? Describe it in your own words.
- What are some examples of a finite set? Of an infinite set?
- Consider the set of positive real numbers. What are some subsets of this set?
- Why do you think it is important for students to understand sets?

Possible student teachers' responses

Accept any responses that show an understanding of sets. These are example responses for each of the above questions:

- *A set is a group of objects or numbers that share a common characteristic.*
- *Finite sets have a finite number of elements, such as A = {2, 3, 4} or B = {positive numbers less than 10}. Infinite sets have an infinite number of elements, such as C = {1, 2, 3, ...} or D = {negative real numbers}.*
- *A set with only positive elements is a subset of the set of positive real numbers.*

Some examples are E = {2, 4, 6, ...}, F = {1, 2}, G = {0.5, 1.5, 2.5}.

- *A good understanding of sets can help students better understand later Mathematics topics, such as functions.*

Learning activity 2. Active learning: Explaining sets (35 minutes)

1. Ask the student teachers to work in groups of three or four.
2. Tell them that each group member will create a short, five-minute lecture on one of the definitions in Table 3.7. of the Student Teacher Textbook (finite set, infinite set, empty set, equal set or subset).
3. Give student teachers 10 minutes to prepare their short lectures.
4. Ask student teachers to each present their lectures to their group members. Each student teacher will act as a teacher, while others in the group act as students. After each lecture, the group members give constructive feedback using the questions below.

   Peer-assessment questions:

   a. Did the 'teacher' give clear instructions and explanations?

   b. Would students develop a good understanding of the given set type based on this activity?

   c. What is one thing that went well? What is one thing that could be improved?

Assessment

Use observation to assess the student teachers. Move around the room and listen to them as they present their lectures in their groups and give each other feedback.

Facilitator's notes

Make sure that the student teachers are objective and fair in doing peer-assessment.

Possible student teachers' responses

During student teachers' presentations, check for the following:

- They demonstrate a good understanding of sets.
- They are able to explain their selected topic clearly and their explanation would give students a better understanding of sets.

As student teachers do peer-assessment after each activity, make sure that feedback is constructive. You may also provide feedback to student teachers based on what you have heard or observed.

Extended learning activity. Make a poster on sets (10 minutes)

For groups that finish early, ask them to prepare a poster that could be used in a Mathematics classroom to show different types of sets. It should help students to understand and differentiate between the types of sets.

Check student teachers' understanding (5 minutes)

- Ask student teachers to turn to their partner and to explain how to identify if one set is a subset of another.
- Remind student teachers of the learning outcome of this lesson.
- Remind student teachers that they explored sets and that they will use this when teaching as qualified teachers.

Facilitator's notes

After teaching this lesson, reflect on your own work as a teacher educator. Did all of the student teachers in your class benefit from the lesson? How could you change or improve this lesson to make student teachers' learning more effective?

3.1.5. Sets-Period 2

Expected learning outcome

By the end of this lesson, student teachers will be able to:

- Demonstrate an understanding of how to teach set operations by using Venn diagrams and number lines.

Competencies gained

A1.1.2 Prepare learning activities to align with students' level of cognitive, linguistic, social, and physical development

A2.1.2 Use teaching methods, strategies and materials as specified in the textbooks and additional low cost support materials, to support student learning

A4.1.1 Describe key concepts, content, learning objectives and outcomes of the lower secondary curriculum for the subjects and grade level/s taught

A5.1.1 Describe key concepts, skills, techniques and applications for the subjects covered in the grade levels taught

B1.1.1 Use different ways to explain the subject matter, related ideas and concepts to meet a range of learning abilities and intended learning outcomes

Time: One period of 50 minutes

Learning strategies: Flipped learning, lecture, whole class discussion, group work, micro-teaching

Assessment approaches: Question and answer, observation, peer-assessment. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read Lesson 3.1.5. Period 2 in the Student Teacher Textbook. Read or try out the learning activities before you teach these.

Resources needed: Student Teacher Textbook

Learning activity 1. Flipped learning: Introduction to set operations (10 minutes)

1. Introduce the topic of set operations using Venn diagrams and number lines (based on Lesson 3.1.5. Period 2 in the Student Teacher Textbook).
2. Lead a discussion on sets using the assessment questions below. Select an equal number of male and female student teachers to share.

Assessment

Check for student teachers' understanding of sets using a question and answer session. Lead a discussion using the following questions:

- When would you use a Venn diagram to show a set operation?
- When would you use a number line to show a set operation?
- Why do you think it is useful to demonstrate set operations visually?
- In what grade do students learn sets? How do Venn diagrams and number lines fit within the curriculum?

Possible student teachers' responses

Accept any responses that show an understanding of sets. These are example responses for each of the above questions:

- *A Venn diagram is useful if the elements of the sets can be listed or easily indicated in different regions of the diagram.*
- *A number line is useful if the sets contain all of the real numbers over a given interval.*
- *Visual representations of sets can help students to identify and compare the elements that are in the sets and easily identify elements in the union or intersection of two sets.*
- *Students learn sets in Grade 9. Venn diagrams and number lines can be used to demonstrate several of the topics in the Grade 9 curriculum, including equality of sets, subsets, operations of sets and number of elements in a set (see the list of Grade 9 topics on sets in the Student Teacher Textbook).*

Facilitator's notes

If student teachers do not show a good understanding of using Venn diagrams and number lines to demonstrate set operations, spend a few more minutes to review using the content in the Student Teacher Textbook. You may represent some sets with Venn diagrams and number lines on the board or ask student teachers to do so.

Learning activity 2. Active learning: Teaching set operations (35 minutes)

1. Ask the student teachers to work in groups of three or four.
2. Explain that each group member will create a short, five-minute lecture on one of the set operations listed below. They should create a visual representation that can be used to explain the operation, using a Venn diagram or number line.

a. $A \cup B$, where $A = \{x \mid x \geq 4\}$ and $B = \{x \mid x < -3\}$

b. $C \cap D$, where $C = \{x \mid x > 0\}$ and $D = \{x \mid x < 7\}$

c. $E \cup F$, where $E = \{1, 3, 5, 7, 9, 11, 13, 15\}$ and $F = \{3, 6, 9, 12, 15\}$

d. $G \cap H$, where $G = \{2, 4, 6, 8, 10, 12\}$ and $H = \{-8, -4, 0, 4, 8\}$

3. Give student teachers 10 minutes to create a visual representation and lecture for Grade 9 students on the operation they selected.
4. Ask student teachers to each present their lecture and visual representation to their group members. After each lecture, the group members give constructive feedback using the questions below.

   Peer-assessment questions:

   a. Did the 'teacher' give clear instructions and explanations?

   b. Was the visual representation drawn clearly and accurately?

   c. What is one thing that went well? What is one thing that could be improved?

Assessment

Use observation to assess the student teachers. Move around the room and listen to them as they present their lectures in their groups and give each other feedback.

Facilitator's notes

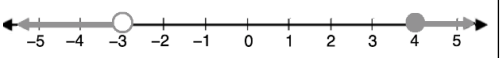
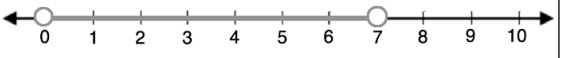
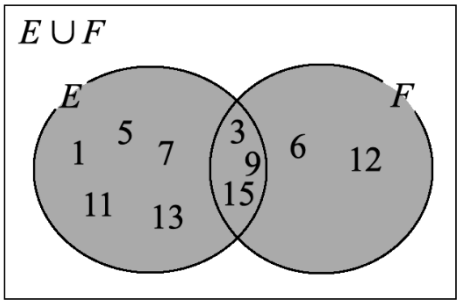
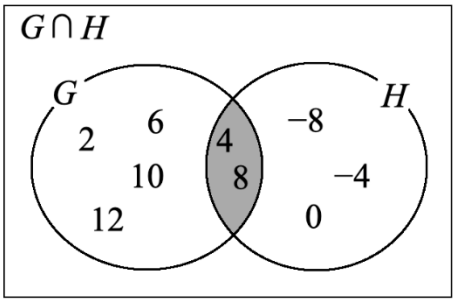
Make sure that the student teachers are objective and fair in doing peer-assessment.

Possible student teachers' responses

During student teachers' presentations, check for the following:

- Their visual representation is accurate (see Venn diagrams and number lines below).
- They are able to explain their selected topic clearly and their explanation

would give students a better understanding of set operations.

$A \cup B$, where $A = \{x \mid x \geq 4\}$ and $B = \{x \mid x < -3\}$ 	$C \cap D$, where $C = \{x \mid x > 0\}$ and $D = \{x \mid x < 7\}$ 
$E \cup F$, where $E = \{1, 3, 5, 7, 9, 11, 13, 15\}$ and $F = \{3, 6, 9, 12, 15\}$ 	$G \cap H$, where $G = \{2, 4, 6, 8, 10, 12\}$ and $H = \{-8, -4, 0, 4, 8\}$ 

Set operations presented by student teachers

As student teachers do peer-assessment after each activity, make sure that feedback is constructive. You may also provide feedback to student teachers based on what you have heard or observed.

Extended learning activity. Creating and displaying sets (10 minutes)

For groups that finish early, ask them to try writing their own pairs of sets for which the intersection and union could be displayed with either a Venn diagram or number line.

Check student teachers' understanding (5 minutes)

- Ask student teachers to turn to their partner. One person should explain how to represent a union visually and the other should explain how to represent an intersection visually.
- Remind student teachers of the learning outcome of this lesson.
- Remind student teachers that they explored set operations and that they will use this when teaching as qualified teachers.

3.1.6. Patterns and sequences-Period 1

Expected learning outcomes

By the end of this lesson, student teachers will be able to:

- Explain the connection between number patterns and sequences; and
- Explain how to get n^{th} term in given sequences.

Competencies gained

A1.1.1 Give examples of how the students' cognitive, physical, social, emotional and moral development may affect their learning

A4.1.1 Describe key concepts, content, learning objectives and outcomes of the lower secondary curriculum for the subjects and grade level/s taught

A5.1.1 Describe key concepts, skills, techniques and applications for the subjects covered in the grade levels taught

Time: One period of 50 minutes

Learning strategies: Flipped learning, active learning, pair work, think-pair-share, discussion

Assessment approaches: Monitoring, question and answer, self-assessment. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read the text for Lesson 3.1.6. in the Student Teacher Textbook. Read or try out the learning activities before you teach these. Optional: any musical instruments such as a drum, triangle, and so on, that you could use for Activity 1b.

Resources needed: Student Teacher Textbook, flipchart paper, marker pens

Learning activity 1. Flipped learning: Finding patterns (15 minutes)

Part A. Active learning: Finding patterns in times tables[7]

1. Ask the student teachers to work in pairs.
2. Ask the student teachers to do the following:
   a. Count aloud from 1 to 30, clapping on each number.
   b. Repeat this, but now clapping more loudly and speaking loudly on the numbers in the two times table (2, 4, 6, …, 30) and quietly on the other numbers.
   c. Now do the same up to 30, but clapping more loudly and speaking loudly on the numbers in the five times table (5, 10, 15, …, 50).
3. After this, ask the student teachers to discuss and predict:
   a. If one of you claps the twos in this way and one of you claps the fives at the same time, can you predict what you would hear?
   b. Which numbers would be quiet?

[7] Adapted from NRICH (2020a).

c. Which numbers would be loud and which would be very loud?

4. Ask the student teachers to do the following:
   a. Now try it—what did you hear? Were you right?
   b. Choose another pair of times tables and repeat what you have just done.
   c. Each time predict what you will hear before you clap—which numbers will be loud, which ones very loud and which quiet? For example, how about the twos and 10s? Or try the fives and 10s?

Facilitator's notes

You could ask these same questions time and time again during the activity and also write them on the board to remind the student teachers what they are aiming for:

- Can you predict what you will hear? How do you know?
- How do you know what you will be doing on this beat?
- How do you know when you will be clapping together?

Part B. Active learning: Predicting patterns in times tables[8]

This is a very practical part of the activity—you might like to use some musical instruments; for example, a drum or a triangle, or use hands and parts of the body. Ask the student teachers to work in pairs.

1. Begin a rhythm and ask student teachers to join in when they think they know what rhythm you are using: clap, clap, click (your fingers), clap, clap, click, clap, clap, click, clap, clap, click...
2. Ask the student teachers to first discuss in pairs and then share with the whole class:
   a. If we start again, what will we be doing on the 15^{th} beat?
   b. How do you know this without actually doing it?

[8] Adapted from NRICH (2020b).

c. What will we be doing on the 20^{th} beat?

d. Again, explain in your own words how you can predict this.

e. How about on the 99^{th} beat?

f. What would we be doing on the 100^{th} beat?

g. How could you describe this in a mathematical way?

3. Tell the student teachers: Work in pairs. You and your friend are going to both start a different rhythm at the same time. One of you will do clap, clap, click, clap, clap, click...as you did before. The other will do click, clap, clap, click, clap, clap, click, clap, clap...Have a go so that you get a steady rhythm going.

4. Ask the student teachers:

   a. If you both start at the same time, when will you both click your fingers at the same time? Why?

   b. Are there other ways that you could have clapped and clicked for this to be the case?

   c. How could you change your rhythms so that you do click at the same time?

   d. How could you predict when this was?

Assessment

To assess whether the student teachers can recognise patterns when they hear them, ask two student teachers to come to the board to clap and finger-click the rhythms of the two and four times tables simultaneously. Support and encourage both female and male student teachers to come to the board.

Possible student teachers' responses

In the rhythm it should be clear to hear that all multiples of four are also multiples of two (e.g. 8, 12), but not all multiples of two are multiples of four (e.g. 6).

Learning activity 2. Active learning: Describing patterns in mathematical language

Part A. Pair work: Finding a missing number using the phrase 'see-say-write down' (10 minutes)

1. Write the following number sequences on the board or use examples from a Mathematics textbook. Make sure to include a selection of different representations (written as numbers separated by commas, on a number line, etc.) and number patterns in ascending and descending order.

   8, 12, 16, _, _, _

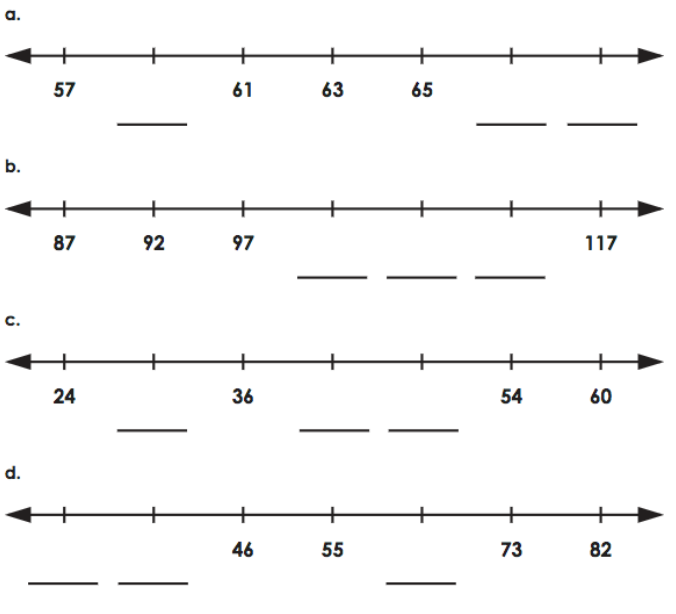
   19, 28, 37, _, _, _

   100, 96, 92, _, _, _

   43, 38, 33, _, _, _

   _, _, 44, 33, 22, _

   _, 40, 60, 80, _, _



Number sequences on a number line

2. Ask the student teachers:

    a. To work in pairs and use the think-pair-share approach and to copy the number sequences/patterns from the board.

    b. First, on their own, to try and see what the pattern is. For example, is the pattern in ascending or descending order, how big are the jumps?

    c. Now, say what you see to your partner. Does he/she see the same?

    d. Predict what the next number will be. Explain why.

    e. Work out what the missing number is by continuing the pattern where there is a gap. Remind them they might have to think backwards. Explain why.

    f. Now 'see-say-write down' the numbers.

    g. Can you make up four more examples? Make sure to include two difficult ones. Share these with another pair of student teachers.

    h. Discuss and share with the class the solutions, using the phrase 'see-say-write down'.

Assessment

To assess the student teachers' understanding of finding missing terms, write some more sequences on the board, for example ..., 6, 3, .., -3, ..., -9, ...

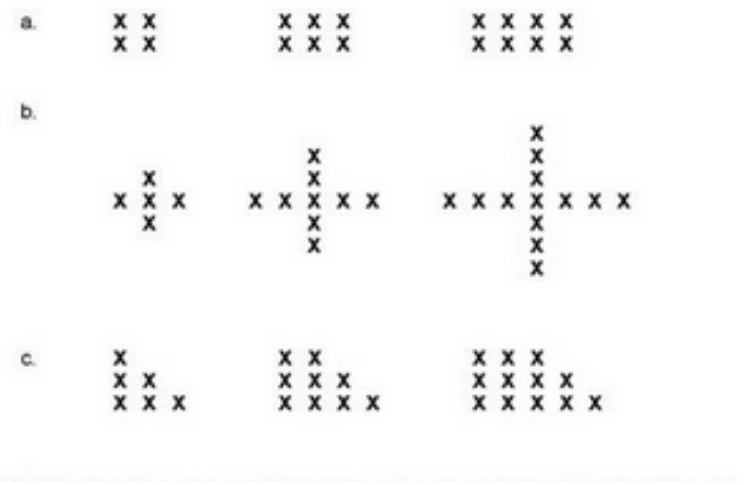
Ask a few student teachers to say what they see, then write down the missing numbers and say why they think this is correct.

Possible student teachers' responses

Accept any answers that reflect the pattern of the sequence followed by the correct missing numbers.

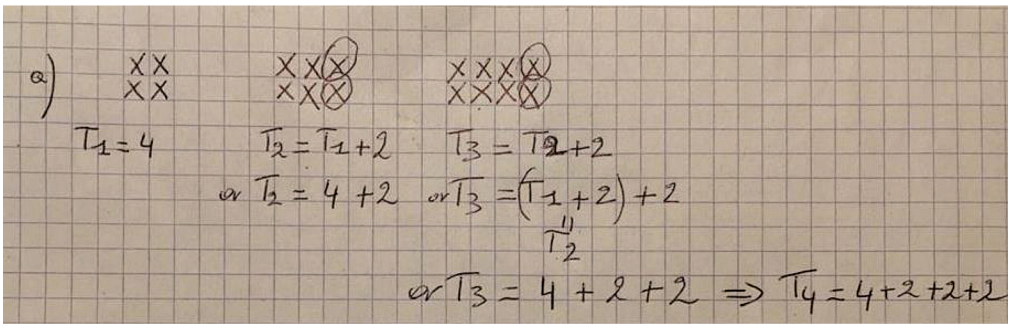
Part B. Pair work: Finding the n^{th} term of a sequence using the phrase 'see-say-write down' (20 minutes)

1. Draw a selection of growing patterns on the board. Leave enough room between them. For example:



Examples of growing patterns to draw on the board

2. Ask the student teachers to work in pairs.
3. Ask them to use the phrase 'see-say-write down' to analyse and explain each pattern to each other and to write a sequence of numbers these drawings could show (answers: (a) 4, 6, 8,...; (b) 5, 9, 13,...; (c) 6, 9, 12, ...).
4. Discuss their ideas; for example, (a) with the class, explain how we label the terms and show one way of how we can annotate the example below.



Example of growing pattern for $a_n = 2(n - 1) + 4 = 2n + 2$

5. Ask what a_4 would look like, then a_5, a_{10}, a_{100}, $a_{100\,000}$. Write this on the board as $a_4 = 10$; $a_5 = 12$; $a_{10} = 22$; $a_{100} = 202$; $a_{100\,000} = 200\,002$.
6. Ask what the rule is in general for any number (finding the n^{th} term). Write

this on the board as $a_n = 2n + 2$. Ask some student teachers to explain why this would be true.

7. Ask what, by using the rule, a_{48}, a_{2039} would be (they need to substitute *n* for 48 or 2,039, then calculate). Can they describe what this would look like if they had to draw it? Then ask the student teachers to work in their pairs and do the same for (b) and (c).
8. Ask the student teachers to reflect: how did using visualisation help your learning? Would it help all middle school students?

Assessment

Ask the student teachers to find the nth term for the following sequences from Learning activity 2:

8, 12, 16, _, _, _

19, 28, 37, _, _, _

100, 96, 92, _, _, _

Check the answers.

Possible student teachers' responses

$a_n = 4n + 4$

$a_n = 9n + 10$

$a_n = -4n + 104$

Differentiated learning activity. Finding the n^{th} term of a sequence using the phrase 'see-say-write down' (10 minutes)

Tell the student teachers that some of them might struggle with the process from saying what they see to writing it down in mathematical language.

If that is that case, they should find a student teacher who is doing this well and work with that person for a few minutes on using the 'see-say-write' down approach with some more examples.

Check student teachers' understanding (5 minutes)

- Ask student teachers to turn to their partner and explain how to get the n^{th} term in given sequences when given drawings of the first three terms.
- Remind student teachers of the learning outcomes of this lesson.
- Remind student teachers that they explored the teaching of numbers and that they will use this when teaching as qualified teachers.

3.1.6. Patterns and sequences-Period 2

Expected learning outcome

By the end of this lesson, student teachers will be able to:

- Demonstrate an understanding of how to teach patterns, sequences and how to get n^{th} term in given sequences.

Competencies gained

A1.1.1 Give examples of how the students' cognitive, physical, social, emotional and moral development may affect their learning

A1.1.2 Prepare learning activities to align with students' level of cognitive, linguistic, social, and physical development

A1.2.2 Identify focused and sequenced learning activities to assist students to link new concepts with their prior knowledge and experiences

A2.1.2 Use teaching methods, strategies and materials as specified in the textbooks and additional low cost support materials, to support student learning

A4.1.1 Describe key concepts, content, learning objectives and outcomes of the lower secondary curriculum for the subjects and grade level/s taught

A5.1.1 Describe key concepts, skills, techniques and applications for the subjects covered in the grade levels taught

B1.1.1 Use different ways to explain the subject matter, related ideas and concepts to meet a range of learning abilities and intended learning outcomes

Time: One period of 50 minutes

Learning strategies: Flipped learning, micro-teaching, group work, pair work, whole class discussion

Assessment approaches: Monitoring, peer-assessment. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: None

Resources needed: Student teachers should have their lesson notes on the previous lesson and their Student Teacher Textbook.

Learning activity. Flipped learning: Teaching patterns and sequences in Grade 9 (45 minutes)

1. Ask the student teachers to work in groups of five or six.
2. Tell them that they will be teaching a short learning activity about patterns and sequences to their group. They can do this as a team-teaching activity in pairs.
3. They should read the instructions in their Student Teacher Textbook and refer back to their notes from the previous lesson. Then they will have to plan a short teaching activity (maximum five minutes) in pairs. They only have about 10 minutes to prepare this. Make sure group leaders are both female and male student teachers.
4. Pairs in turn teach their short learning activity. The others in the group pretend to be students.
5. In their groups, they should discuss first the learning activities used and then the teaching of these learning activities:

    a. Did the learning activity use the ‘see-say-write down’ approach?

    b. Did the learning activity include collaborative learning?

    c. How did it help students to understand patterns and sequences?

6. They should give each other constructive feedback: two aspects they liked and one aspect that could be improved.

Assessment

Use peer-assessment: ask the student teachers to peer-assess the learning activity that has been developed and used.

Peer-assessment questions:

- Did the learning activity that was developed use the 'see-say-write down' approach?
- Was the learning for the students good?

Possible student teachers' responses

Look out for responses that are constructive and that talk about the mathematics that could be learned from using the 'see-say-write down' approach. For example: it helps the student connect patterns with mathematical notation of the sequences of those patterns; it helps with the writing of mathematical expression.

Extended learning activity. Micro-teaching patterns and sequences in Grade 9 (10 minutes)

Ask the groups to prepare a poster that shows how the pedagogies used in their learning activities help the students to understand the concept of patterns and sequences.

Check student teachers' understanding (5 minutes)

- Ask student teachers to turn to their partner and to explain how the 'see-say-write down' approach can help students to understand the concept of patterns and sequences.
- Remind student teachers of the learning outcome of this lesson.
- Remind student teachers that they explored the teaching of numbers and that they will use this when teaching as qualified teachers.

3.1.7. Estimation of errors

Expected learning outcomes

By the end of this lesson, student teachers will be able to:

- Explain about estimation of errors; and
- Explain how to solve problems by using estimation of errors (absolute error, relative error and percentage error).

Competencies gained

A4.1.1 Describe key concepts, content, learning objectives and outcomes of the lower secondary curriculum for the subjects and grade level/s taught

A5.1.1 Describe key concepts, skills, techniques and applications for the subjects covered in the grade levels taught

Time: One period of 50 minutes

Learning strategies: Flipped learning, discussion, pair work, group work

Assessment approaches: Question and answer, observation, peer-assessment. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read Lesson 3.1.7. in the Student Teacher Textbook. Read or try out Learning activities 1 and 2 before you teach these.

Resources needed: Student Teacher Textbook

Learning activity 1. Flipped learning: Estimation of error word problems (15 minutes)

1. Introduce the topic of calculating error (absolute error, relative error and percentage error), based on Lesson 3.1.7. in the Student Teacher Textbook.
2. Ask student teachers to work in pairs. They should discuss with a partner about the word problems they solved in Learning activity 1 of their Student Teacher Textbook (see problems below). Give them two minutes to discuss and compare solutions.

Word problems

a. While doing a physics experiment, Thura recorded a distance of 1.325 metres as 1.3 and Zeya recorded the same distance as 1.33 metres. Which student recorded a more accurate distance?

b. A school wants to provide a pencil for each of its 987 students. The head teacher estimated that there are 980 students in the school and the secretary estimated that there are 1,000 students. Which estimation is more accurate?

3. Ask a few volunteers (both female and male) to share the solutions that they wrote for the word problems with the class. Try to find volunteers who calculated different types of error, to demonstrate that the different calculations can be used to solve the same problem.
4. Lead a class discussion with the following questions:
   a. What do the error calculations tell you about these situations?
   b. What are some real-world scenarios where it is useful to use an approximation? Would it be useful to calculate the error? Why or why not?

Assessment

Assess students by checking the solutions that they wrote to the word problems and listening to their discussions and presentations. Assess their understanding of the

application of error calculations based on their responses to the discussion.

Possible student teachers' responses

Student teachers may calculate any type of error (absolute error, relative error or percentage error) to solve the problems. Example solutions to the word problems follow.

- *The distance that Zeya recorded is more accurate, because it has the lowest error. Below are the calculations for each type of error. Student teachers only need to show one type of error in their work. They should use each student's recorded distance and the actual distance, 1.325 metres, in their calculations.*

Thura and Zeya's distances

Thura's recorded distance is 1.3 metres.	Zeya's recorded distance is 1.33 metres.
Absolute Error = $\|1.3 - 1.325\| = 0.025$ Relative Error = $\frac{\|1.3 - 1.325\|}{1.325} \approx 0.019$ Percentage Error = $\frac{\|1.3 - 1.325\|}{1.325} \times 100 \approx 1.9\%$	Absolute Error = $\|1.33 - 1.325\| = 0.005$ Relative Error = $\frac{\|1.33 - 1.325\|}{1.325} \approx 0.004$ Percentage Error = $\frac{\|1.33 - 1.325\|}{1.325} \times 100 \approx 0.4\%$

- *The head teacher's estimation is more accurate, because it has the lowest error. Student teachers only need to show one type of error in their work. They should use each person's estimate and the actual number of students, 987, in their calculations.*

The head teacher's and secretary's estimates

The head teacher's estimate is 980 students.	The secretary's estimate is 1,000 students.
Absolute Error = $\|980 - 987\| = 7$ Relative Error = $\frac{\|980 - 987\|}{987} \approx 0.007$ Percentage Error = $\frac{\|980 - 987\|}{987} \times 100 \approx 0.7\%$	Absolute Error = $\|1000 - 987\| = 13$ Relative Error = $\frac{\|1000 - 987\|}{987} \approx 0.013$ Percentage Error = $\frac{\|1000 - 987\|}{987} \times 100 \approx 1.3\%$

During the discussion, accept any responses that show an understanding of estimation of error and its applications to everyday life.

Facilitator's notes

If student teachers do not show a good understanding of estimation of error, spend a few minutes to review using the content in the Student Teacher Textbook.

Learning activity 2. Active learning: Estimation of error (30 minutes)

1. Ask the student teachers to work in small groups.
2. Tell them that they will each write a word problem that can be solved by calculating error, then they will solve and discuss them in their groups.
3. Give student teachers five minutes to write their word problem, then ask them to solve the problems written by their other group members. After reading and solving all of the word problems, the group members give constructive feedback using the questions below.

   Peer-assessment questions:

   a. Was the word problem clear and easy to understand?
   b. Is the scenario in the problem relevant to a middle school student?
   c. Is the word problem a good application of estimation of error? Why or why not?

Assessment

Use observation to assess the student teachers. Move around the room to read the word problems they write and listen to them as they discuss and give each other feedback.

Facilitator's notes

Make sure that the student teachers are objective and fair in doing peer-assessment.

Possible student teachers' responses

As you observe and listen to the student teachers, check for the following:

- Their word problem is clear and easy to understand.
- Their word problem is an application of estimation of error.
- They are able to solve each other's word problems using error calculations.
- They give each other positive and useful feedback.

You may also provide feedback to student teachers based on what you have heard or observed.

Extended learning activity. Different problem-solving strategies (10 minutes)

If groups finish solving and discussing the word problems early, ask them to look for different ways that they could solve the same problems. Remind them that there are often different paths to the correct answer and creativity in problem-solving should be encouraged in a Mathematics classroom.

Check student teachers' understanding (5 minutes)

- Ask student teachers to turn to their partner and to explain one situation from their everyday life for which they could estimate the error.
- Remind student teachers of the learning outcomes of this lesson.
- Remind student teachers that they explored approximation and error and that they will use this when teaching as qualified teachers.

3.1.8. Counting systems-Period 1

Expected learning outcomes

By the end of this lesson, student teachers will be able to:

- Summarise various counting systems; and
- Explain how to convert between the denary or decimal system (base 10) and the binary system (base 2).

Competency gained

A5.1.1 Describe key concepts, skills, techniques and applications for the subjects covered in the grade levels taught

Time: One period of 50 minutes

Learning strategies: Flipped learning, lecture, discussion, pair work, group work, micro-teaching

Assessment approaches: Question and answer, observation, peer-assessment. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read Lesson 3.1.8. Period 1 in the Student Teacher Textbook. Read or try out Learning activities 1 and 2 before you teach these.

Resources needed: Student Teacher Textbook, computer and projector (if available) for watching the video

Learning activity 1. Flipped learning: Introduction to counting systems (15 minutes)

1. Introduce the topic of counting systems, focusing on the denary (base 10) and binary (base 2) systems (based on Lesson 3.1.8. Period 1 in the Student Teacher Textbook).
2. Lead a discussion on counting systems using the assessment questions below. Select an equal number of male and female student teachers to share.

Facilitator's notes

If you have access to the internet, you may show student teachers the video 'A brief history of numerical systems—Alessandra King' on YouTube (TED-Ed, 2017).

Assessment

Check for student teachers' understanding of counting systems using a question and answer session. Lead a discussion using the following questions:

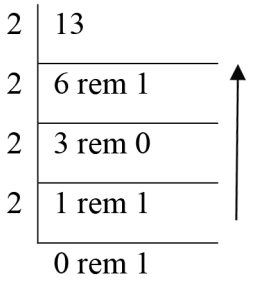
- What are some different counting systems?
- Why do you think we use the base 10 system?
- How can you convert 13 to a base 2 number? (You may have a student teacher solve this on the board.)
- How can you convert $1{,}111_2$ to a base 10 number? (You may have a student teacher solve this on the board.)

Possible student teachers' responses

Accept any responses that show an understanding of counting systems. These are example responses for each of the above questions:

- *Each of the number bases (for example, base 10 and base 2) can be considered a distinct counting system.*

- *It could be because we have 10 fingers. There is no reason why we couldn't use other number bases to count, but they are not conventional.*
- *Divide repeatedly by 2, then record the remainders. The answer is 13 = $1,101_2$.*



- *Write $1,111_2$ in expanded form, with each digit multiplied by a power of 2, then simplify. The answer is $1,111_2 = 15$.*

$$1,111_2 = (1 \times 2^3) + (1 \times 2^2) + (1 \times 2^1) + (1 \times 2^0)$$
$$= (1 \times 8) + (1 \times 4) + (1 \times 2) + (1 \times 1)$$
$$= 8 + 4 + 2 + 1$$
$$= 15$$

Facilitator's notes

If student teachers do not show a good understanding of number bases, spend a few more minutes to review using the content in the Student Teacher Textbook.

Learning activity 2. Micro-teaching: Explaining how to convert between bases (30 minutes)

1. Ask the student teachers to work in groups of three or four.
2. Tell them that each group member will create a short, five-minute lecture on one base conversion problem. Provide these problems:
   a. Convert 11001_2 to a base 10 number.

b. Convert 100111_2 to a base 10 number.

c. Convert 27 to a base 2 number.

d. Convert 14 to a base 2 number.

3. Give student teachers five minutes to create a lecture on the problem they selected.

4. Ask student teachers to each present their lecture to their group members. After each short lecture, the group members give constructive feedback using the questions below.

   Peer-assessment questions:

   a. Did the 'teacher' give clear instructions and explanations?

   b. Would students develop a good understanding of converting between number bases based on the explanation?

   c. What is one thing that went well? What is one thing that could be improved?

Assessment

Use observation to assess the student teachers. Move around the room and listen to them as they present their lectures in their groups and give each other feedback.

Facilitator's notes

Make sure that the student teachers are objective and fair in doing peer-assessment.

Possible student teachers' responses

During student teachers' presentations, check for the following:

- The problem is solved correctly.
- They are able to explain their selected problem clearly and their explanation would give students a better understanding of how to convert between bases.

These are the solutions to the problems:

1. Convert 11001_2 to a base 10 number: $11001_2 = 25$

$$\begin{aligned} 11001_2 &= (1 \times 2^4) + (1 \times 2^3) + (0 \times 2^2) + (0 \times 2^1) + (1 \times 2^0) \\ &= (1 \times 16) + (1 \times 8) + (0 \times 4) + (0 \times 2) + (1 \times 1) \\ &= 16 + 8 + 0 + 0 + 1 \\ &= 25 \end{aligned}$$

2. Convert 100111_2 to a base 10 number: $100111_2 = 39$

$$\begin{aligned} 1100111_2 &= (1 \times 2^5) + (0 \times 2^4) + (0 \times 2^3) + (1 \times 2^2) + (1 \times 2^1) + (1 \times 2^0) \\ &= (1 \times 32) + (0 \times 16) + (0 \times 8) + (1 \times 4) + (1 \times 2) + (1 \times 1) \\ &= 32 + 0 + 0 + 4 + 2 + 1 \\ &= 39 \end{aligned}$$

3. Convert 27 to a base 2 number: $27 = 11011_2$

27	
13 rem 1	↑
6 rem 1	
3 rem 0	
1 rem 1	
0 rem 1	

4. Convert 14 to a base 2 number: $14 = 1110_2$

2	14	
2	7 rem 0	↑
2	3 rem 1	
2	1 rem 1	
2	0 rem 1	

As student teachers do peer-assessment after each activity, make sure that feedback is constructive. You may also provide feedback to student teachers based on what you have heard or observed.

Extended learning activity. Writing problems on number bases (10 minutes)

For the groups that finish early, ask them to try writing their own problem on converting number bases. They may exchange and solve the problems written by their classmates.

Check student teachers' understanding (5 minutes)

- Ask student teachers to turn to their partner. One person should explain how to convert from base 10 to base 2, and the other should explain how to convert from base 2 to base 10.
- Remind student teachers of the learning outcomes of this lesson.
- Remind student teachers that they explored converting between number bases and that they will use this when teaching as qualified teachers.

3.1.8. Counting systems-Period 2

Expected learning outcome

By the end of this lesson, student teachers will be able to:

- Demonstrate an understanding of how to teach different counting systems and how to convert between the denary or decimal system (base 10) and the binary system (base 2).

Competencies gained

A1.1.2 Prepare learning activities to align with students' level of cognitive, linguistic, social and physical development

A2.1.2 Use teaching methods, strategies and materials as specified in the textbooks and additional low cost support materials, to support student learning

A4.1.1 Describe key concepts, content, learning objectives and outcomes of the lower secondary curriculum for the subjects and grade level/s taught

A5.1.1 Describe key concepts, skills, techniques and applications for the subjects covered in the grade levels taught

B1.1.1 Use different ways to explain the subject matter, related ideas and concepts to meet a range of learning abilities and intended learning outcomes

Time: One period of 50 minutes

Learning strategies: Flipped learning, lecture, discussion, group work, pair work, micro-teaching

Assessment approaches: Question and answer, observation, peer-assessment. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read Lesson 3.1.8. Period 2 in the Student Teacher Textbook. Read or try out Learning activities 1 and 2 before you teach these.

Resources needed: Student Teacher Textbook

Learning activity 1. Flipped learning: Introduction to teaching counting systems (10 minutes)

1. Introduce the topic of teaching counting systems (based on Lesson 3.1.8. Period 2 in the Student Teacher Textbook).
2. Lead a discussion on teaching counting systems using the assessment questions below. Select an equal number of male and female student teachers to share.

Assessment

Check for student teachers' understanding of teaching counting systems using a question and answer session. Lead a discussion using the following questions:

- Why do we teach number bases other than base 10 in schools?
- At what grade level are number bases covered in the curriculum?
- What are some methods you could use to teach number bases?
- What are some things that students should understand before they convert between number bases?

Possible student teachers' responses

Accept any responses that show an understanding of counting systems. These are example responses for each of the above questions:

- *They are useful for understanding the base 10 system that we use and for understanding other applications of bases in everyday life, such as the base 2 system for computer science or the base 12 system for telling time.*
- *Grade 9.*
- *Number bases can be taught by counting up in the number bases. They can also be demonstrated using a place value table and expanded form.*
- *They should understand the digits that are used in each base system. They should understand place value, including how each place 'fills' and that zero is a placeholder with no value.*

Learning activity 2. Active learning: Teaching counting systems (35 minutes)

1. Ask the student teachers to work in small groups.
2. Tell them that they will design a short learning activity (maximum five minutes) about counting systems for middle school students.
3. Ask student teachers to form pairs in their groups. They will work with one other person to plan the short learning activity. Give them about 10 minutes to prepare this.
4. Ask one student teacher from each pair to lead their small group to do their short learning activity. The student teacher will act as a teacher, while others in the group act as students. After each short learning activity, the group members give constructive feedback using the questions below.

   Peer-assessment questions:

   a. Did the 'teacher' give clear instructions and explanations?

   b. Would students develop a good understanding of counting systems based on this activity?

   c. What is one thing that went well? What is one thing that could be improved?

Assessment

Use observation to assess the student teachers. Move around the room and listen to them as they present their learning activities in their groups and give each other feedback.

Facilitator's notes

Make sure that the student teachers are objective and fair in doing peer-assessment.

Possible student teachers' responses

During student teachers' presentations, check for the following:

- They demonstrate a good understanding of counting systems/number bases.
- They are able to explain the learning activity and topic clearly.
- Their learning activity would give students a better understanding of counting systems/number bases.

Extended learning activity. Planning a sequence of lessons (15 minutes)

For the groups that finish early, ask them to write a sequence of 10 lessons (they may write just the lesson titles and/or learning objectives) that they could follow to teach the number base topics in the Grade 9 curriculum (listed in the Student Teacher Textbook).

Check student teachers' understanding (5 minutes)

- Ask student teachers to turn to their partner and explain why it is important for students to understand number bases.
- Remind student teachers of the learning outcomes of this lesson.
- Remind student teachers that they explored different counting systems and that they will use this when teaching as qualified teachers.

Expected student teachers' responses for the review questions in TB

Question 1: Describe what 'sequence' means.

Answer: *A sequence is the succession of terms formed according to some rule. The numbers are ordered. For example, the list of numbers 2, 4, 6, 8... will be a sequence with the rule* $a_n = 2n$. *A random list of numbers will not be a sequence because there is no rule to describe it.*

Question 2: Describe what 'finding the n^{th} term' means.

Answer: *When asked what is the* n^{th} *term of a sequence, you are asked to identify the general rule you will use to calculate the value of any term. For example, for the sequence 200, 150, 100... the rule to find the* n^{th} *term will be:* $a_n = 200 - 50(n - 1)$.

Question 3: Explain what pedagogical strategies are particularly effective for teacing patterns and sequences and why.

Answer: *Two specific mathematics pedagogies are particularly effective for learning about patterns and sequences: talk for learning and visualisation. Both are used at the same time by using the phrase 'see-say-write down' in the learning activities. This phrase helps you to make sense in a systematic way and will help you analyse the pattern by visualising and verbalising what you notice and to help you make the transition from observing patterns to recording patterns in a mathematical way.*

Question 4: What are some topics related to number systems that students learn during middle school? How do these topics build on each other over the course of the middle school curriculum?

Answer: *Rational and irrational numbers, factors and multiples, exponents and radicals, ratio, proportion, percentage, sets, pattern and sequences, estimation of errors and counting systems. Many of these topics feature in multiple grade levels of the middle school curriculum. Students build their skills and work with more complex topics within number systems as they progress.*

Question 5: What teaching strategies have you identified that you can use to make learning number systems interesting for middle school students?

Answer: *Using word problems relevant to their lives, involving students in participatory classroom activities, using specific activity types like 'think-pair-share'.*

Question 6: Consider the Mathematics topics presented in the lessons of this unit. How are the topics related? How does knowledge of one topic support learning of another? Give examples.

Answer: *Students learn ratio, proportion and percentages in grades 6 and 7. These skills are used and developed at later points in the curriculum, including estimation of error in Grade 9.*

3.2. Measurement

This sub-unit focuses on measurement topics that feature in the curriculum for grades 6 through 9. Student teachers will explore geometry construction, including how to demonstrate and practise constructions in a low-resource classroom. They will then focus on real-world applications of geometry: bearing angles and land dimension. They will see how basic geometry concepts and tools are used to solve real-world problems and will be prepared to teach these in a meaningful and engaging way.

3.2.1. Basic constructions-Period 1

Expected learning outcome

By the end of this lesson, student teachers will be able to:

- Explain how to teach basic constructions by using a pair of compasses, set squares and a protractor; draw perpendicular lines and angles.

Competencies gained

A1.1.2 Prepare learning activities to align with students' level of cognitive, linguistic, social and physical development

A2.1.2 Use teaching methods, strategies and materials as specified in the textbooks and additional low cost support materials, to support student learning

A4.1.1 Describe key concepts, content, learning objectives and outcomes of the lower secondary curriculum for the subjects and grade level/s taught

A5.1.1 Describe key concepts, skills, techniques and applications for the subjects covered in the grade levels taught

B1.1.1 Use different ways to explain the subject matter, related ideas and concepts to meet a range of learning abilities and intended learning outcomes

Time: One period of 50 minutes

Learning strategies: Flipped learning, lecture, discussion, group work, micro-teaching

Assessment approaches: Question and answer, observation, peer-assessment. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Bring and ask student teachers to bring or make tools for geometry construction (a pair of compasses, set squares and a protractor). See guidance in the section 'Tools for geometry construction' in the Student Teacher Textbook and Learning activity 1 in the Student Teacher Textbook, which requests student teachers to prepare tools before class. Read Lesson 3.2.1. Period 1 in the Student Teacher Textbook. Read or try out Learning activities 1 and 2 before you teach these.

Resources needed: Enough geometry construction tools (a pair of compasses, set squares and a protractor) for each pair of student teachers to use at least one, large geometry construction tools for the board, Student Teacher Textbook

Learning activity 1. Flipped learning: Basic geometry construction (10 minutes)

1. Introduce the topic of basic geometry construction (based on Lesson 3.2.1. Period 1 in the Student Teacher Textbook).
2. Ask student teachers to work in pairs. One student teacher should demonstrate and explain to their partner how to construct perpendicular lines. The other

student teacher should demonstrate and explain parallel lines.

3. Lead a discussion on geometry construction using the assessment questions below. Select an equal number of male and female student teachers to share.

Assessment

Walk around as students work in pairs to check whether they understand and can construct geometric figures. Check for student teachers' understanding of teaching geometry construction using a question and answer session.

Lead a discussion using the following questions:

- Why is it important to teach geometry construction?
- What are some challenges you might encounter in teaching geometry construction? How could you overcome these challenges?
- What are some strategies for creating tools for geometry construction? (Encourage student teachers to brainstorm ideas other than those in the Student Teacher Textbook.)

Possible student teachers' responses

Accept any responses that show an understanding of geometry construction. These are example responses for each of the above questions:

- *Practising geometry construction gives students a better understanding of the nature of geometry that they can use to solve problems.*
- *It may be challenging to find enough construction tools for all students to practise. This can be overcome by making tools or asking students to make them. Students can also work in groups and share construction tools.*
- *A pair of compasses can be created by attaching a string to a pencil. If string is unavailable, a piece of paper with a hole for the pencil can be used. Set squares and a protractor can be created by tracing them or copying them onto paper and cutting them out.*

Facilitator's notes

If student teachers do not show a good understanding of geometry construction and how to use the tools, you may spend a few minutes demonstrating constructions on the board.

Learning activity 2. Flipped learning: Geometry construction (35 minutes)

1. Ask the student teachers to work in groups of three or four.
2. Tell them that each group member will create a short, five-minute learning activity on one of the geometry constructions in Table 3.13. 'Some basic constructions', in the Student Teacher Textbook. Each group member should work on a different construction.
3. Give student teachers 10 minutes to create a short learning activity on the topic they selected.
4. Ask each student teacher to lead their small group to do their short learning activity. The student teacher will act as a teacher, while others in the group act as students. After each short learning activity, the group members give constructive feedback using the questions below.

   Peer-assessment questions:

   a. Did the 'teacher' give clear instructions and explanations?
   b. Would students develop a good understanding of geometry construction based on this activity?
   c. What is one thing that went well? What is one thing that could be improved?

Assessment

Use observation to assess the student teachers. Move around the room and listen to them as they present their learning activities in their groups and give each other feedback.

Facilitator's notes

Make sure that the student teachers are objective and fair in doing peer-assessment.

Possible student teachers' responses

During student teachers' presentations, check for the following:

- They demonstrate a good understanding of geometry construction.
- They are able to explain the activity and their selected construction clearly.
- The activity would give students a better understanding of geometry construction.

As student teachers do peer-assessment after each activity, make sure that feedback is constructive. You may also provide feedback to student teachers based on what you have heard or observed.

Extended learning activity: Construct a square (15 minutes)

1. For the groups that finish early, ask them to try constructing a square using only a compass and straightedge and the construction techniques in the lesson.
2. Ask them to demonstrate to each other how they would explain the construction of a square to students.
3. Lead a discussion: what characteristics of a square did you use to construct it? (For example, adjacent sides are perpendicular, while opposite sides are parallel.)

Check student teachers' understanding (5 minutes)

- Ask student teachers to turn to their partner and to explain how to construct perpendicular lines in their own words.

- Remind student teachers of the learning outcomes of this lesson.
- Remind student teachers that they explored different geometry constructions and that they will use this when teaching as qualified teachers.

3.2.1. Basic constructions-Period 2

Expected learning outcome

By the end of this lesson, student teachers will be able to:

- Explain how to teach drawing of perpendicular bisectors and angle bisectors.

Competencies gained

A1.1.2 Prepare learning activities to align with students' level of cognitive, linguistic, social, and physical development

A2.1.2 Use teaching methods, strategies and materials as specified in the textbooks and additional low cost support materials, to support student learning

A4.1.1 Describe key concepts, content, learning objectives and outcomes of the lower secondary curriculum for the subjects and grade level/s taught

A5.1.1 Describe key concepts, skills, techniques and applications for the subjects covered in the grade levels taught

B1.1.1 Use different ways to explain the subject matter, related ideas and concepts to meet a range of learning abilities and intended learning outcomes

Time: One period of 50 minutes

Learning strategies: Flipped learning, lecture, discussion, group work, micro-teaching

Assessment approaches: Question and answer, observation, peer-assessment. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Bring and ask student teachers to bring or make tools for geometry construction (a pair of compasses, set squares and a protractor). Read Lesson 3.2.1. Period 2 in the Student Teacher Textbook. Read or try out the learning activities before you teach these.

Resources needed: Enough geometry construction tools (a pair of compasses, set squares and a protractor) for each small group of student teachers to use at least one, large geometry construction tools for the board

Learning activity 1. Flipped learning: Introduction to perpendicular and angle bisectors (10 minutes)

1. Introduce the topic of perpendicular and angle bisectors (based on Lesson 3.2.1. Period 2 in the Student Teacher Textbook).
2. Lead a discussion on perpendicular and angle bisectors using the assessment questions below. Select an equal number of male and female student teachers to share.

Assessment

Lead a discussion using the following questions:

- When do perpendicular and angle bisectors feature in the middle school curriculum?
- What are the tools needed to bisect an angle or perpendicular bisector?

- What are some things to keep in mind when demonstrating geometry construction in a classroom?

Possible student teachers' responses

Accept any responses that show an understanding of perpendicular and angle bisectors. These are example responses for each of the above questions:

- *Angle bisectors are covered in Grade 6 and perpendicular bisectors are covered in Grade 8.*
- *Only a pair of compasses and straightedge.*
- *Draw the construction large enough for all students to see and explain the steps clearly.*

Learning activity 2. Active learning: Perpendicular and angle bisector (35 minutes)

1. Ask the student teachers to work in groups of three or four. Tell them that each group member will create a short, five-minute explanation of one of the problems listed below:
   a. Construct $\angle ABC$ with measure 82°, then bisect the angle. Measure each of the two angles formed by the bisection.
   b. Construct $\underline{XY}$ with length 6.8 centimetres, then bisect the line segment. Measure each of the two segments formed by the bisection.
   c. Construct an angle of 45° using only bisectors (without a protractor).
   d. Construct an angle of 135° using only bisectors (without a protractor).
2. Give student teachers five to 10 minutes to create their explanation for middle school students on the problem they selected.
3. Ask student teachers to each present their lecture to their group members. After each short learning activity, the group members give constructive feedback using the questions below.

   Peer-assessment questions:

   a. Did the 'teacher' give clear instructions and explanations?

b. Would students develop a good understanding of angle or perpendicular bisection based on the explanation?

c. What is one thing that went well? What is one thing that could be improved?

Assessment

Use observation to assess the student teachers. Move around the room and listen to them as they present their lectures in their groups and give each other feedback.

Facilitator's notes

Ensure everyone, regardless of background or gender, feels equally invited to participate and share feedback and questions. Make sure that the student teachers are objective and fair in doing peer-assessment.

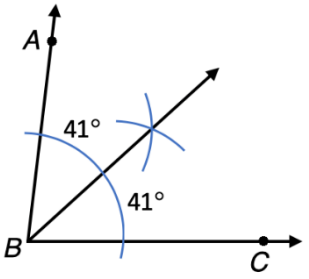
Possible student teachers' responses

During student teachers' presentations, check for the following:

- The construction is drawn correctly.
- They are able to explain their selected problem clearly and their explanation would give students a better understanding of how to construct an angle or perpendicular bisector.

These are the solutions to the problems:

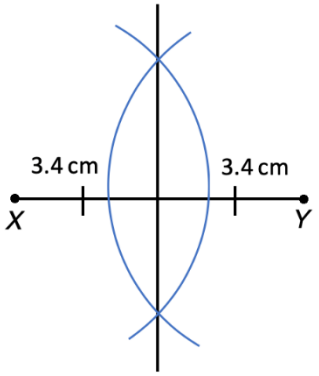
1. Construct ∠ABC with measure 82°, then bisect the angle. Measure each of the two angles formed by the bisection.



Construction of an angle bisector

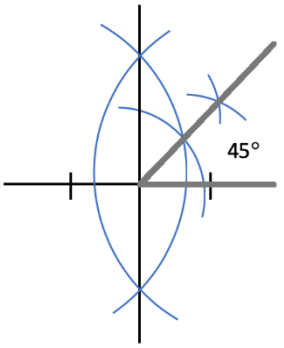
2. Construct $\underline{XY}$ with length 6.8 centimetres, then bisect the line segment. Measure each of the two segments formed by the bisection.

   Image is not to scale:



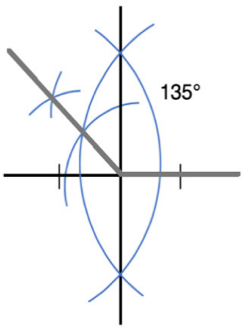
Construction of a perpendicular bisector

3. Construct an angle of 45° using only bisectors (without a protractor). A perpendicular bisector forms a 90° angle, which can be bisected to give a 45° angle.



Construction of a 45° angle

4. Construct an angle of 135° using only bisectors (without a protractor). A perpendicular bisector forms two adjacent 90° angles. Bisecting one of them forms a 45° angle that is adjacent to a 90° angle. These adjacent angles form a 135° angle (90° + 45° = 135°).



Construction of a 135° angle

As student teachers do peer-assessment after each activity, make sure that feedback is constructive. You may also provide feedback to student teachers based on what you have heard or observed.

Facilitator's notes

If student teachers do not show a good understanding of angle and perpendicular bisectors, you may spend a few minutes demonstrating these constructions on the board.

Check student teachers' understanding (5 minutes)

- Ask student teachers to turn to their partner. One person should explain how to bisect an angle and the other should explain how to bisect a line segment.
- Remind student teachers of the learning outcome of this lesson.
- Remind student teachers that they explored bisectors and that they will use this when teaching as qualified teachers.

3.2.2. Bearing angles and land dimension-Period 1

Expected learning outcome

By the end of this lesson, student teachers will be able to:

- Explain how to teach the bearing angles: normal convention of bearing, angle of elevation and depression.

Competencies gained

A1.1.2 Prepare learning activities to align with students' level of cognitive, linguistic, social, and physical development

A2.1.2 Use teaching methods, strategies and materials as specified in the textbooks and additional low cost support materials, to support student learning

A4.1.1 Describe key concepts, content, learning objectives and outcomes of the lower secondary curriculum for the subjects and grade level/s taught

A5.1.1 Describe key concepts, skills, techniques and applications for the subjects covered in the grade levels taught

A5.2.3 Describe approaches to model the use of content specific language, technical terms and skills by providing examples of use in real life contexts

B1.1.1 Use different ways to explain the subject matter, related ideas and concepts to meet a range of learning abilities and intended learning outcomes

Time: One period of 50 minutes

Learning strategies: Flipped learning, active learning, lecture, discussion, group work, micro-teaching

Assessment approaches: Question and answer, observation, peer-assessment. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read Lesson 3.2.2. Period 1 in the Student Teacher Textbook. Read or try out Learning activity 1 before you teach it.

Resources needed: Student Teacher Textbook

Learning activity 1. Flipped learning: Introduction to bearing angles (10 minutes)

1. Introduce the topic of bearing angles (based on Lesson 3.2.2. Period 1 in the Student Teacher Textbook).
2. Lead a discussion on bearing angles using the assessment questions below. Select an equal number of male and female student teachers to share.

Assessment

Lead a discussion using the following questions:

- What are bearing angles? Describe in your own words.
- When do bearing angles feature in the middle school curriculum?
- How are conventional bearings measured?
- How are angles of elevation and depression measured?

Possible student teachers' responses

Accept any responses that show an understanding of bearing angles. These are example responses for each of the above questions:

- *Bearings are used to describe the relationship between two points, based on the angle that the segment given by the two points forms with either a vertical or horizontal line.*
- *Grade 8.*
- *In the clockwise direction from geographic north.*
- *They are the angles formed above or below a horizontal line.*

Learning activity 2. Active learning: Bearing angles (35 minutes)

1. Ask the student teachers to work in groups of three or four.
2. Explain that each group member will create a short, five-minute learning activity on one of the topics of the lesson (normal convention of bearing, angles of elevation or angles of depression). If there are more than three student teachers in a group, two group members may address the same topic.
3. Give student teachers about 10 minutes to prepare their learning activity.
4. Ask student teachers to lead their small group to do their short learning activity. Each student teacher will act as a teacher, while others in the group act as students. After each short learning activity, the group members give constructive feedback using the questions below.

Peer-assessment questions:

a. Did the 'teacher' give clear instructions and explanations?

b. Would students develop a good understanding of the given topic based on this activity?

c. What is one thing that went well? What is one thing that could be improved?

Assessment

Use observation to assess the student teachers. Move around the room and listen to them as they present their activities in their groups and give each other feedback.

Facilitator's notes

Make sure that the student teachers are objective and fair in doing peer-assessment.

Possible student teachers' responses

During student teachers' presentations, check for the following:

- Their explanations are clear and they demonstrate a good understanding of bearings.
- Their activity would give students a better understanding of bearings.

As student teachers do peer-assessment after each activity, make sure that feedback is constructive. You may also provide feedback to student teachers based on what you have heard or observed.

Facilitator's notes

If student teachers do not show a good understanding of bearings, you may spend a few minutes explaining and demonstrating these concepts on the board. If they have difficulty designing their own learning activity, you may give them an example problem relevant to their topic (normal convention of bearing, angles of elevation or angles of depression) and ask them to design an activity around it.

Check student teachers' understanding (5 minutes)

- Ask student teachers to turn to their partner. One person should explain how to teach normal convention of bearing and the other should explain how to teach angles of elevation/depression.
- Remind student teachers of the learning outcome of this lesson.
- Remind student teachers that they explored bearings and that they will use this when teaching as qualified teachers.

3.2.2. Bearing angles and land dimension-Period 2

Expected learning outcome

By the end of this lesson, student teachers will be able to:

- Explain how to teach land dimension, survey, draw the form of patches.

Competencies gained

A1.1.2 Prepare learning activities to align with students' level of cognitive, linguistic, social, and physical development

A2.1.2 Use teaching methods, strategies and materials as specified in the textbooks and additional low cost support materials, to support student learning

A4.1.1 Describe key concepts, content, learning objectives and outcomes of the lower secondary curriculum for the subjects and grade level/s taught

A5.1.1 Describe key concepts, skills, techniques and applications for the subjects covered in the grade levels taught

A5.2.3 Describe approaches to model the use of content specific language, technical terms and skills by providing examples of use in real life contexts

B1.1.1 Use different ways to explain the subject matter, related ideas and concepts to meet a range of learning abilities and intended learning outcomes

Time: One period of 50 minutes

Learning strategies: Active learning, discussion, group work, micro-teaching

Assessment approaches: Observation, peer-assessment. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Bring and ask student teachers to bring or make tools for measuring land dimensions (measuring tapes or rulers). See guidance in the section 'Tools for Surveying Land' in the Student Teacher Textbook. Read Lesson 3.2.2. Period 2 in the Student Teacher Textbook. Read or try out Learning activities 1 and 2 before you teach these.

Resources needed: Enough measurement tools for each small group of student teachers to use at least one, Student Teacher Textbook

Learning activity 1. Active learning: Measurement of land (15 minutes)

1. Ask student teachers to recall the steps for surveying a plot of land and drawing the form of patches from the text in Lesson 3.2.2. in their Student Teacher Textbook. (Example response: *Divide the plot of land into triangles and measure the lengths of the sides, then draw the triangles using an appropriate scale.)*
2. Lead the class in measuring the classroom and drawing it in patches. Involve both female and male student teachers. Follow these steps:
    a. Identify how the room can be divided in triangles. Have student teachers sketch the room and triangles on the board.
    b. Have them measure the dimensions of the triangles in the actual room and label the sketch on the board.
    c. Have them draw the patches accurately using an appropriate scale (on the board or in their notebooks if time allows). Choose a scale based on the size of the classroom and the size of your drawing.

Assessment

Ask student teachers to carry out the steps and observe them to assess their understanding of measurement and drawing patches.

Possible student teachers' responses

During observation, make sure student teachers can divide the room into triangles, measure the triangle sides, choose an appropriate scale and draw patches accurately.

Facilitator's notes

The purpose of drawing patches of the room is to give student teachers a clear, shared understanding of land measurement that they can use to design learning activities. Depending on the size of your class and their understanding of the topic, you may complete this activity as a whole class or ask student teachers to work in groups.

Learning activity 2. Active learning: Teaching land dimension (30 minutes)

1. Ask the student teachers to work in small groups.
2. Tell them that they will design a short learning activity (maximum five minutes) about measurement of land for middle school students.
3. Ask student teachers to form pairs in their groups. They will work with one other person to plan the short learning activity. Give them about 10 minutes to prepare this.
4. Ask one student teacher from each pair to lead their small group to do their short learning activity. The student teacher will act as a teacher, while others in the group act as students. After each short learning activity, the group members give constructive feedback using the questions below.

   Peer-assessment questions:

   a. Did the 'teacher' give clear explanations?

   b. Would students develop a good understanding of land measurement and drawing patches based on this activity?

   c. What is one thing that went well? What is one thing that could be improved?

Assessment

Use observation to assess the student teachers. Move around the room and listen to them as they present their learning activities in their groups and give each other feedback.

Facilitator's notes

Make sure that the student teachers are objective and fair in doing peer-assessment.

Possible student teachers' responses

During student teachers' presentations, check for the following:

- They demonstrate a good understanding of measurement of land.
- They are able to explain their learning activity clearly.
- Their learning activity would give students a better understanding of land measurement.

As student teachers do peer-assessment after each activity, make sure that feedback is constructive. You may also provide feedback to student teachers based on what you have heard or observed.

Extended learning activity. Practise a learning activity (10 minutes)

If student teachers finish early, you may ask them to carry out one of the learning activities designed by their group members (for example, they could measure and draw a nearby plot of land).

Check student teachers' understanding (5 minutes)

- Ask student teachers to turn to their partner and explain how they would teach land measurement in their classroom.
- Remind student teachers of the learning outcome of this lesson.
- Remind student teachers that they explored land measurement and that they

will use this when teaching as qualified teachers.

Expected student teachers' responses for the review questions in TB

Question 1: How can you ensure that all of your students have the opportunity to practise geometry construction?

Answer: *Prepare enough geometry tools for all students to use or for students to share and work with in groups.*

Question 2: Why is it useful for students to practise geometry construction?

Answer: *Geometry construction gives students a good understanding of geometry concepts that they will apply in various topics. For example, experience constructing angles will give them a good concept of angles that they can apply to bearings.*

Question 3: What are some real-world applications of geometry that feature in the middle school curriculum?

Answer: *Compass bearings, angles of elevation and depression, measuring land dimension.*

3.3. Developing Mathematical Problem-Solving Skills

This sub-unit examines the role of language in Mathematics and the learning of Mathematics and some of the issues that students can find difficult. It then focuses on language in the context of problem-solving; that is, the solving of word problems. By focusing on developing strategies for solving word problems, not only barriers to solving word problems are addressed, but also how to enhance mathematical thinking.

3.3.1. Language of Mathematics in Middle School

Expected learning outcomes

By the end of this lesson, student teachers will be able to:

- Describe the importance of considering the language of Mathematics particularly when teaching middle school students; and
- Explain how middle school students will gain problem-solving skills in classrooms.

Competencies gained

A1.1.1 Give examples of how the students' cognitive, physical, social, emotional and moral development may affect their learning

A4.1.1 Describe key concepts, content, learning objectives and outcomes of the lower secondary curriculum for the subjects and grade level/s taught

A5.1.1 Describe key concepts, skills, techniques and applications for the subjects covered in the grade levels taught

Time: One period of 50 minutes

Learning strategies: Flipped learning, active learning, think-pair-share, group work

Assessment approaches: Monitoring, question and answer. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read Lesson 3.3.1. in the Student Teacher Textbook. Prepare some examples of word problems that are used in grades 6 to 9.

Resources needed: Student Teacher Textbook, Mathematics syllabus for grades 6 to 9, any Mathematics textbooks for grades 6 and 9

Learning activity 1. Flipped learning: Reflecting on the role of language in Mathematics (15 minutes)

1. Tell your student teachers to organise themselves in groups of four or five and to use the think-pair-share approach: first think for themselves for a few minutes, then share their ideas with their learning partner, then share within their group.
2. Ask them to reflect and then share their ideas on how they experience now, and have experienced in the past (for example when they were 12 years old), dealing with the language aspects in Mathematics and in the solving of word problems. They can refer to their notes and their Student Teacher Textbook.
3. As a group, they should write a list of issues they themselves have experienced with respect to language in Mathematics. They should also make a note of any suggestions that can help in dealing with these issues.
4. Take feedback from some groups. Support and encourage both female and male student teachers to be presenters for their groups. Are there common themes amongst what is being said?

Assessment

Ask three student teachers what some of the issues are that student teachers may find difficult when dealing with word problems.

Possible student teachers' responses

Accept any answers that reflect the discussions of Learning activity 1. This could include: *Student teachers needed help to consider what is part of the context that is relevant to the mathematics in a word problem and what is not—in other words, to pay attention to what is important and to disregard the rest.*

Learning activity 2. Active learning: Identifying progression in problem-solving skills from grade 6 to 9 (30 minutes)

1. Tell the student teachers to continue working in groups of four or five.
2. Write the examples of your prepared word problems that are used in grades 6 to 9 on the board. Ask the student teachers to look at the Mathematics syllabi for grade 6 to 9 and to identify the grade each word problem would be suitable for. Give them about five minutes to do this.
3. Discuss with the whole class. The student teachers should be able to explain the reasoning why they think a certain word problem would be suitable for a certain grade class.
4. Next, tell the student teachers they should now analyse the word problems and the syllabi further and write down a list of problem-solving skills that students will need to develop in grades 6 and 7 and in grades 8 and 9.
5. Discuss some of their ideas with the whole class. Tell them to make sure they have made a good record of this because they will need to refer to it in the next two lessons.
6. Now ask the student teachers to refer back to Learning activity 1. They should think about what some of the issues might be that students may find difficult when dealing with word problems in grades 6 and 7. Then do the same for grades 8 and 9. Do they foresee any difference in difficulties?
7. Ask them to come up with some ideas to help middle school students overcome these issues. They will look at this in more detail in the next two lessons.

8. Ask two or three groups to share their ideas with the whole class. Then ask if any other groups had any different ideas.

Facilitator's notes

When groups are sharing their ideas with the whole class, they should not repeat ideas that have been mentioned already as there is not enough time to take feedback from all groups.

Assessment

Ask three student teachers what some of the issues are that students could find difficult when dealing with word problems in grades 6 or 7 and then in grades 8 or 9.

Possible student teachers' responses

Accept any answers that reflect the discussions of Learning activity 2. This could include: *Students might need help to consider what is part of the context is relevant to the mathematics in a word problem and what is not—in other words, to pay attention to what is important and to disregard the rest. Word problems in grades 8 and 9 will rely more on the application of algebra and this might cause some additional problems.*

Extended learning activity. Reflecting on the role of language in Mathematics (5 minutes)

Tell the student teachers that dealing with language in Mathematics when you are visually or orally impaired can bring additional challenges. Ask student teachers to discuss what these could be and how they could help students to overcome these challenges.

Check student teachers' understanding (5 minutes)

- Ask student teachers to write down three aspects relating to language in Mathematics that they would like to learn more about.

- Remind student teachers of the learning outcomes of this lesson.
- Remind student teachers that they explored issues around teaching of problem-solving in mathematics and that they will use this when teaching as qualified teachers.

3.3.2. Problem-solving for middle school students-Period 1

Expected learning outcomes

By the end of this lesson, student teachers will be able to:

- Describe various types of problem-solving questions that are useful to enhance mathematical thinking for Grade 6 and 7 students; and
- Explain problem-solving skills that Grade 6 and 7 students should attain.

Competencies gained

A1.1.1 Give examples of how the students' cognitive, physical, social, emotional and moral development may affect their learning

A1.2.2 Identify focused and sequenced learning activities to assist students to link new concepts with their prior knowledge and experiences

A4.1.1 Describe key concepts, content, learning objectives and outcomes of the lower secondary curriculum for the subjects and grade level/s taught

A5.1.1 Describe key concepts, skills, techniques and applications for the subjects covered in the grade levels taught

Time: One period of 50 minutes

Learning strategies: Flipped learning, group work, gallery walk

Assessment approaches: Monitoring, question and answer, peer-assessment. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read Lesson 3.3.2. in the Student Teacher Textbook. Prepare some examples of word problems that are used in grades 6 and 7, or find a source you can refer the student teachers to.

Resources needed: Student Teacher Textbook, Mathematics syllabus for grades 6 and 7, any Mathematics textbooks for grades 6 and 7

Learning activity. Flipped learning: Developing a strategy for solving word problems (45 minutes)

1. Tell the student teachers to organise themselves in groups of four or five.
2. Throughout this lesson, they should refer to the notes they made in the previous lesson, the notes they made in preparation for this lesson, the Mathematics syllabi for Grade 6 and 7, their Student Teacher Textbook and any teaching resources for word problems for students in Grade 6 and 7 that they can find.
3. Write the word problems you prepared on the board or tell the student teachers where they can find examples of word problems for this lesson.
4. Tell the student teachers that in this lesson they will develop and refine a strategy for solving word problems for grades 6 and 7. The aim is that this will enhance mathematical thinking skills. In their groups, they will create a poster that could be used later in a classroom of Grade 6 or 7 that lists these strategies.
5. First, in their groups, they should select a word problem that students in grades 6 and 7 would need to solve.
6. They should then try and think of a strategy to solve the word problem and try it out. They could use the RUCSAC approach described in their Student Teacher Textbook, or they can make up their own, or use another strategy they like to use.

7. They should try and use the strategy, or strategies, on all the remaining word problems and reflect on the usefulness of the strategy.
8. They should make notes of any adjustments to their strategy, if appropriate, and try it out again. If there are designated note-takers during group work, make sure both women and men serve as note-takers.
9. When they think they have the perfect strategy, they should write this as a poster in such a way that students of Grade 6 and 7 would understand fully what it says and that it is helpful to them. They have about 35 minutes to do this.
10. After 35 minutes, ask the student teachers to look at each other's posters and peer-assess. They can leave a question with the posters. They should also leave positive feedback. They have about seven minutes to do this.
11. Ask the student teachers and discuss with the whole class: do we think what we have produced so far would be helpful to assist all middle school students to progress in their learning?

    Peer-assessment questions:

    a. Do you understand everything that is on the poster?
    b. Is anything missing on the poster?
    c. Do you have any suggestions for improvement?
12. Tell the student teachers to go back to their own posters and to examine the peer-assessment remarks. Give them a few more minutes to make amendments to their poster.
13. If possible, put up the posters for display on the walls. Otherwise, tell the student teachers to make sure they bring their posters to the next lesson because they will use these again.

Assessment

Ask one student teacher what the RUCSAC strategy is.

Possible student teachers' responses

The RUCSAC strategy is a strategy for solving word problems. RUCSAC stands for Read, Understand, Choose, Solve, Answer, Check.

Extended learning activity. Developing strategies for solving word problems in grades 6 and 7 (10 minutes)

Ask student teachers to continue working in their groups. Tell them to consider how they would adjust the strategy they recommend for students who have short-term memory problems.

Check student teachers' understanding (5 minutes)

- Ask student teachers to write down three things they learnt today about solving word problems in grades 6 and 7.
- Remind student teachers of the learning outcomes of this lesson.
- Remind student teachers that they explored issues around teaching of problem-solving in mathematics and that they will use this when teaching as qualified teachers.

3.3.2. Problem-solving for middle school students-Period 2

Expected learning outcomes

By the end of this lesson, student teachers will be able to:

- Describe various types of problem-solving questions that are useful to enhance mathematical thinking for Grade 8 and 9 students; and
- Explain the problem-solving skills that Grade 8 and 9 students should attain.

Competencies gained

A1.1.1 Give examples of how the students' cognitive, physical, social, emotional and moral development may affect their learning

A1.2.2 Identify focused and sequenced learning activities to assist students to link new concepts with their prior knowledge and experiences

A4.1.1 Describe key concepts, content, learning objectives and outcomes of the lower secondary curriculum for the subjects and grade level/s taught

A5.1.1 Describe key concepts, skills, techniques and applications for the subjects covered in the grade levels taught

Time: One period of 50 minutes

Learning strategies: Flipped learning, assignments (homework and writing), group work, posters

Assessment approaches: Monitoring, question and answer, peer-assessment. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read Lesson 3.3.3. in the Student Teacher Textbook. Prepare some examples of word problems that are used in grades 8 and 9 or find a source you can refer the student teachers to.

Resources needed: Student Teacher Textbook, Mathematics syllabus for grades 8 and 9, any Mathematics textbooks for grades 8 and 9

Learning activity 1. Flipped learning: Developing strategies for solving word problems in grades 8 and 9 (20 minutes)

1. Tell the student teachers to organise themselves in the same groups of four or five as last lesson and to find the posters they made.
2. Tell them that again, throughout this lesson, they should refer to the notes they made in the previous lesson, the notes they made in preparation for this lesson, the Mathematics syllabi for grades 8 and 9, their Student Teacher

Textbook and any teaching resources for word problems for students in grades 8 and 9 that they can find.

3. Write the word problems you prepared on the board or tell the student teachers where they can find examples of word problems for this lesson.
4. Tell the student teachers that in this lesson they will adapt the strategy they developed last lesson for solving word problems for grades 6 and 7. They have to make it suitable for students solving word problems in grades 8 and 9.
5. First, in their groups, they should select a word problem that students in Grade 8 and 9 would need to solve.
6. They should then try out the strategy they developed last lesson to solve the word problem. Does it need changing? Why?
7. They should try and use the amended strategy on all the remaining word problems and reflect on the usefulness of the strategy. They should make notes of any adjustments to their strategy if appropriate and try it out again.
8. When they think they have the perfect strategy for problem-solving in grades 8 and 9, they should write these amendments on their poster in such a way that it would be clear and helpful to both students of grades 6 and 7 and of grades 8 and 9.
9. Discuss with the whole class what changes were made and why.

Assessment

Invite a female student teacher, maybe one who has been quiet during the lesson, to share some extra skills students of grades 8 and 9 need to have in comparison with students of grades 6 and 7.

Possible student teachers' responses

Accept responses that reflect the discussion at the end of Learning activity 1. This could include: *Different mathematical strategies are to be used such as more advanced algebraic methods, there is more irrelevant information in the word problem, the need for multi-step solutions instead of single step solutions.*

Learning activity 2. Assignment-writing: Reflecting on issues relating to language in Mathematics (25 minutes)

1. Ask the student teachers to look back at their notes from Lessons 3.3.1., 3.3.2. and today's lesson.
2. Tell them that each of them, individually, should now write a short paragraph of around 200 words about the role of language in Mathematics and the learning of mathematics and some of the issues that students in grades 6 and 7 and also in grades 8 and 9 may find difficult. They should also include any suggestions for helping students overcome these issues. They have about 15 minutes to do this.
3. After 15 minutes, ask the student teachers to swap their written work with their learning partner for peer-assessment.

   Peer-assessment questions:

   a. Write three things they like about the writing.

   b. Write two things that can be improved.

   c. Tell the student teachers to return the work and to address any of the comments made. They can ask for clarification if something is not clear.

Assessment

Ask a few student teachers what they have learnt in these last three lessons about language in Mathematics and in learning mathematics in grades 6 to 9. Ask an even number of male and female student teachers to answer.

Possible student teachers' responses

Accept responses that reflect the writing of Learning activity 2. This could include: *Mathematics is seen as a language itself; the problems students can encounter when they are solving word problems; that focusing on problem-solving strategies can help students overcome such issues and enhance their mathematical thinking.*

Extended learning activity. Developing strategies for solving word problems in grades 8 and 9 (5 minutes)

Ask the student teachers to reflect on how knowing what they know now would have helped them as a student in Grade 8 to solve word problems.

Check student teachers' understanding (5 minutes)

- Ask student teachers to write down three things they learnt today about solving word problems in grades 8 and 9.
- Remind student teachers of the learning outcomes of this lesson.
- Remind student teachers that they explored issues around teaching of problem-solving in mathematics and that they will use this when teaching as qualified teachers.

Expected student teachers' responses for the review questions in TB

Question 1: Explain what 'literacy in Mathematics' means.

Answer: *How students access mathematics through language and with the role that language plays in mathematics teaching and learning.*

Question 2: Give a few examples of strategies students could use to solve word problems in mathematics.

Answers may include: *Read the problem carefully; Recognise what is the context and what is important for solving the mathematics; Note down important words, numbers and information, perhaps on a diagram; Ignore irrelevant words and numbers; Think what mathematics must be used to solve it, then use it; Check and decide whether the answer makes sense; Give the answer in a way that relates it to the problem asked—for example, using appropriate units of measurement. They may suggest the RUCSAC approach—Read, Understand, Choose, Solve, Answer, Check.*

3.4. Mathematics in Everyday Life

The lessons that follow are part of 'social mathematics'. In these lessons, student teachers will explore some of the many ways we use arithmetic in everyday life to make calculations, to estimate and to solve problems.

In the first two lessons, student teachers will learn more about solving problems using metric and British systems of measurement and commercial problems. In the last two lessons, they will then demonstrate and practise how to design lessons for middle school students that use numeracy skills and mathematical thinking to solve real-life problems involving measurement and commerce.

3.4.1. Social arithmetic-Period 1

Expected learning outcomes

By the end of this lesson, student teachers will be able to:

- Explore knowledge of Metric and British systems (length, weight, volume and capacity); and
- Describe the strategies of how to teach solving real-life problems connected with this knowledge.

Competencies gained

A5.2.1 Describe ways to contextualise learning activities for the age, language, ability and culture of students to develop understanding of subject related principles, ideas and concepts

A5.2.2 Explain how lessons are contextualised to include localised information and examples related to the subject content, concepts and themes

A5.2.3 Describe approaches to model the use of content specific language, technical terms and skills by providing examples of use in real life contexts

Time: One period of 50 minutes

Learning strategies: Flipped learning, collaborative experiential learning, whole class discussion

Assessment approaches: Peer-assessment. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read Lesson 3.4.1. Period 1 in the Student Teacher Textbook

Resources needed: Flipchart paper and marker pens, Student Teacher Textbook

Learning activity. Collaborative experiential learning: Building a wooden trading store (45 minutes)

1. Review with the student teachers the information that is given in the tables in the Student Teacher Textbook for Lesson 3.4.1.Period 1. Point out to them that they can always refer back to this information.
2. Ask the student teachers to work in groups of five or six.
3. Ask the student teachers to reread the sub-section ‘Strategies for solving real-life problems using metric and British measurements’ and to discuss in their groups to ensure they fully understand this.
4. Tell the student teachers that, in their groups, they have to solve the ‘Building a wooden trading store’ problem. This means they have to calculate how much wood they will need to buy at the sawmill to build this wooden store.
5. Remind the student teachers that in preparation for this lesson they had to think of ideas for making the problem more realistic, for making the problem

harder, and for making the problem easier. They should now discuss these ideas in their group and make a list of those they all agree on. Give them five minutes to do this.

6. Ask some of the groups to share their 'best' idea.
7. Ask the student teachers to decide in their groups how they would like to change the problem and the information given so it is suitable for middle school students.
8. They now should solve the problem, with the changes they have decided upon. Give them 15 or 20 minutes to do this.
9. Ask a few groups to explain:
    a. What they changed in the problem and why.
    b. The strategies they used for solving the problem.
10. Ask the other student teachers to peer assess using the following questions:

    Peer-assessment questions:

    a. Are the changes the group made relevant to the teaching and learning of middle school students?
    b. Are the strategies the group used effective strategies to solve the problem?

Facilitator's notes

Walk around and ensure everyone, regardless of background or gender, is encouraged to actively engage in the activity. Make sure that the student teachers are objective and fair in doing peer-assessment.

Assessment

Use the peer-assessment mentioned above as assessment.

Possible student teachers' responses

Accept any answers that address the peer review questions. Challenge any comments that are not given in a constructive way.

Extended learning activity. Building a wooden trading store (15 minutes)

Ask the student teachers to look again at the changes they made to the problem.

- Do they think these would need adjusting if they are working with a student that is visually impaired or hard of hearing?

Check student teachers' understanding (5 minutes)

- Ask student teachers to turn to their partner and to explain strategies to solve problems involving metric and British measurements.
- Remind student teachers of the learning outcomes of this lesson.
- Remind student teachers that they explored social arithmetic and that they will use this when teaching as qualified teachers.

3.4.1. Social arithmetic-Period 2

Expected learning outcomes

By the end of this lesson, student teachers will be able to:

- Explore knowledge about purchase lists, profit and loss, stocks and shares; and
- Describe the strategies of how to teach solving real-life problems connected with this knowledge.

Competencies gained

A1.1.2 Prepare learning activities to align with students' level of cognitive, linguistic, social, and physical development

A2.1.2 Use teaching methods, strategies and materials as specified in the textbooks and additional low cost support materials, to support student learning

A5.2.1 Describe ways to contextualise learning activities for the age, language, ability and culture of students to develop understanding of subject related principles, ideas and concepts

A5.2.2 Explain how lessons are contextualised to include localised information and examples related to the subject content, concepts and themes

A5.2.3 Describe approaches to model the use of content specific language, technical terms and skills by providing examples of use in real life contexts

B1.1.1 Use different ways to explain the subject matter, related ideas and concepts to meet a range of learning abilities and intended learning outcomes

Time: One period of 50 minutes

Learning strategies: Collaborative experiential learning, group work, whole class discussion

Assessment approaches: Question and answer. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read Lesson 3.4.1. Period 2 in the Student Teacher Textbook.

Resources needed: Flipchart paper and marker pens, Student Teacher Textbook

Learning activity. Collaborative experiential learning: Running a small goods transport business (45 minutes)

1. Review with the student teachers the vocabulary that is used in the context of mathematics in commerce as it is written in the Student Teacher Textbook for Lesson 3.4.1. Period 2. Make sure they understand the difference between profit and loss.
2. Ask the student teachers to work in groups of five or six.
3. Tell the student teachers that, in their groups, they have to solve the 'Running a small goods transport business' problem. This means they have to decide on the prices they will charge, the costs and expenses for running the business, and how many trips a day they would have to make. They have to make a profit so the business can provide an income for them and their family.
4. Remind the student teachers that in preparation for this lesson they had to identify what is not clear to them in the instructions and data, write down some strategies that might work for solving this problem and think of some ideas for making the problem more realistic, for making the problem harder, and for making the problem easier. They should now discuss these ideas in their group and make a list of those they all agree on. Give them five minutes to do this.
5. Ask some of the groups to share their 'best' idea.
6. Ask the student teachers to decide in their groups how they would like to change the problem and the information given so it is suitable for middle school students.
7. They now should solve the problem, with the changes they have decided upon. Give them 15 or 20 minutes to do this.
8. Ask a few groups to explain:
    a. What they changed in the problem and why.
    b. The strategies they used for solving the problem
    c. What worked well when solving this problem and what they struggled with.
9. Ask the other student teachers to give constructive feedback.

Assessment

Ask one female and one male student teacher to explain the difference between profit and loss.

Possible student teachers' responses

Profit: profit is made when the total revenue or income from a business activity is greater than the sum of all expenses, costs and taxes made and paid.

Loss: loss is made when the total revenue or income from a business activity is smaller than the sum of all expenses, costs and taxes made and paid.

Extended learning activity. Running a small goods transport business (10 minutes)

Ask the student teachers to look again at the strategies they used to solve the problem.

- Do they think these would need adjusting if they are working with students that find it hard to understand what profit and loss is?

Check student teachers' understanding (5 minutes)

- Ask student teachers to turn to their partner and to explain some ideas to make a problem involving commerce more realistic.
- Remind student teachers of the learning outcomes of this lesson.
- Remind student teachers that they explored social arithmetic and that they will use this when teaching as qualified teachers.

3.4.2. Planning a contextualised project-based learning-Period 1

Expected learning outcomes

By the end of this lesson, student teachers will be able to:

- Use the skills with Metric and British systems (length, weight, volume, capacity) to design a lesson around (e.g. playground project); and
- Develop similar practical lessons to demonstrate how numeracy skills and mathematical thinking are used in real-life situations.

Competencies gained

A5.2.1 Describe ways to contextualise learning activities for the age, language, ability and culture of students to develop understanding of subject related principles, ideas and concepts

A5.2.2 Explain how lessons are contextualised to include localised information and examples related to the subject content, concepts and themes

A5.2.3 Describe approaches to model the use of content specific language, technical terms and skills by providing examples of use in real life contexts

Time: One period of 50 minutes

Learning strategies: Active learning, micro-teaching, group work, whole class discussion

Assessment approaches: Monitoring, peer-assessment. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read Lesson 3.4.2. Period 1 in the Student Teacher Textbook.

Resources needed: Flipchart paper and marker pens, Student Teacher Textbook

Learning activity. Active learning: Real-life problem using the metric and British measurement systems (45 minutes)

1. Ask the student teachers to work in groups of five or six.
2. Tell them that they have to develop a practical lesson to demonstrate how numeracy skills and mathematical thinking are used in real-life situations. To solve the problem they design, skills with metric and British measurement systems need to be used. The lesson should be suitable for middle school students.
3. They will then have to teach a short part of that lesson using micro-teaching. They can do this as a team-teaching activity in pairs.
4. They should read the instructions in their Student Teacher Textbook, refer back to their notes from the previous lessons, and look at and discuss the ideas for topics they thought of in preparation for this lesson.
5. In their groups, they should now decide on a topic, develop the problem to be solved and then design a lesson plan for this. Give them 25 minutes to do this and make sure group leaders are both female and male student teachers.
6. Walk around the classroom to monitor the progress of the groups. If they are stuck, tell them to go and have a look at what other groups that are progressing well are doing.
7. After 25 minutes, allow a few minutes to share good ideas.
8. In their groups, pairs in turn should then teach their short learning activity. The others in the group pretend to be students.
9. Ask the student teachers to peer assess each other using the following questions:

   Peer-assessment questions:

   a. Was this activity suitable for middle school students?

b. Did the middle school students have to use their skills for calculations with metric and British measurement systems?

c. Was the activity relevant to real life?

d. Was the teaching clear, inclusive and engaging?

10. They should give each other constructive feedback: two aspects they liked and one aspect that could be improved.

11. Ask the student teachers to reflect: as a teacher, how can you ensure all middle school students in class are learning effectively in this lesson?

Assessment

Use the peer-assessment mentioned above as assessment.

Possible student teachers' responses

Accept any answers that address the peer review questions. Challenge any comments that are not given in a constructive way.

Extended learning activity. Micro-teaching: Real-life problem using the metric and British measurement systems (10 minutes)

Ask the groups to prepare a poster that shows how they developed their lesson plan and problem to be solved.

Check student teachers' understanding (5 minutes)

- Ask student teachers to turn to their partner and to explain two aspects in the planning of a lesson in contextualised project-based learning that they consider important.
- Remind student teachers of the learning outcomes of this lesson.
- Remind student teachers that they explored planning contextualised project-based learning and that they will use this when teaching as qualified teachers.

3.4.2. Planning a contextualised project-based learning-Period 2

Expected learning outcomes

By the end of this lesson, student teachers will be able to:

- Use the skills with purchase lists, profit and loss, stocks and shares to design a lesson around (e.g. marketing project); and
- Develop similar practical lessons to demonstrate how numeracy skills and mathematical thinking are used in real-life situations.

Competencies gained

A5.2.1 Describe ways to contextualise learning activities for the age, language, ability and culture of students to develop understanding of subject related principles, ideas and concepts

A5.2.2 Explain how lessons are contextualised to include localised information and examples related to the subject content, concepts and themes

A5.2.3 Describe approaches to model the use of content specific language, technical terms and skills by providing examples of use in real life contexts

Time: One period of 50 minutes

Learning strategies: Active learning, micro-teaching, group work, whole class discussion

Assessment approaches: Monitoring, peer-assessment. For all activities, try to elicit responses equally from both male and female student teachers.

Preparation needed: Read Lesson 3.4.2. Period 2 in the Student Teacher Textbook.

Resources needed: Flipchart paper and marker pens, Student Teacher Textbook

Learning activity. Active learning: Real-life problems using skills relevant for doing commerce (45 minutes)

1. Ask the student teachers to work in groups of five or six.
2. Tell them that this lesson will be similar to the last lesson. They have to develop a practical lesson to demonstrate how numeracy skills and mathematical thinking are used in real-life situations. However, today, to solve the problem they design, skills relevant for doing commerce need to be used. The lesson should be suitable for middle school students.
3. They will then have to teach a short part of that lesson using micro-teaching. They can do this as a team-teaching activity in pairs.
4. They should read the instructions in their Student Teacher Textbook, refer back to their notes from the previous lessons, and look at and discuss the ideas for topics they thought of in preparation for this lesson.
5. In their groups they should now decide on a topic, develop the problem to be solved and then design a lesson plan for this. Give them 25 minutes to do this and make sure group leaders are both female and male student teachers.
6. Walk around the classroom to monitor the progress of the groups. If they are stuck, tell them to go and have a look at what other groups that are progressing well are doing.
7. After 25 minutes, allow a few minutes to share good ideas.
8. In their groups, pairs in turn should then teach their short learning activity. The others in the group pretend to be students.
9. Ask the student teachers to peer-assess each other using the following questions:

Peer-assessment questions:

a. Was this activity suitable for middle school students?

b. Did the middle school students have to use their skills relevant for doing commerce?

c. Was the activity relevant to real life?

d. Was the teaching clear, inclusive and engaging?

10. They should give each other constructive feedback: two aspects they liked and one aspect that could be improved.

Assessment

Use the peer-assessment mentioned above as assessment.

Possible student teachers' responses

Accept any answers that address the peer review questions. Challenge any comments that are not given in a constructive way.

Extended learning activity. Real-life problems using skills relevant for doing commerce (10 minutes)

Ask the groups to prepare a poster that shows how they would change their lesson plan and the problem they designed if they had to teach a class of 100 middle school students.

Check student teachers' understanding (5 minutes)

- Ask student teachers to turn to their partner and to give two more ideas of topics they could have used for teaching a project-based lesson contextualised in commerce.
- Remind student teachers of the learning outcomes of this lesson.
- Remind student teachers that they explored planning contextualised project-based learning and that they will use this when teaching as qualified teachers.

Expected student teachers' responses for the review questions in TB

Question 1: What are some good strategies for solving real-life problems using metric and British measurements?

Answer:

- *When working in one measurement system, convert all the measurements to one chosen unit of measurement. For example, when working in the metric system for length, express all measurements in centimetres; when working in the British system for length, express all measurements in inches.*
- *When working with the two measurement systems, that is when you have measurements that are expressed in metric measurements and measurements that are expressed in British measurements, great caution is needed. It is best to express all measurements again in one chosen unit of measurement. When converting the measures, use a calculator or a calculating programme on the internet. Do not round the numbers until at the very end to keep the rounding errors as small as possible.*

Question 2: Can you give some ideas of what you can do to make sure you are well prepared for adapting and changing a mathematical real-life problem so that it is suitable for your middle school students?

Answer:

- *Write down ideas for making the problem more realistic.*
- *Write down ideas for making the problem harder.*
- *Write down ideas for making the problem easier.*

Unit Summary

Key messages

- In this unit, student teachers explored some topics in Mathematics that lay the groundwork for middle school studies of mathematics, including topics on numbers and measurement.
- Student teachers developed ideas about how to teach topics on numbers and measurement in the middle school curriculum and demonstrated different teaching strategies through micro-teaching.
- Student teachers practised explaining some of the more complicated topics related to numbers in the middle school curriculum, such as estimation of error and converting between number bases. They considered the challenges that students may encounter when learning these topics and brainstormed ways of addressing any misconceptions.
- Student teachers then explored ways of teaching geometry construction and bearing angles and considered ways to engage students in these topics by relating them to the real world.
- Student teachers then examined the role of language in learning Mathematics. They considered strategies for supporting middle school students to develop problem-solving skills and how solving word problems enhances mathematical thinking.
- Finally, student teachers considered how mathematics applies to our everyday lives to make calculations, to estimate and to solve problems. They explored how learning activities can be designed to build middle school students' numeracy skills and promote mathematical thinking in everyday situations.

Unit reflection

- Which topics on numbers and measurement in the middle school curriculum do student teachers think their students may find challenging? What are some teaching strategies they hope to use to address these challenges?
- What are some strategies student teachers plan to use in their classrooms to build their students' problem-solving skills and encourage mathematical thinking?

- What is project-based learning and how is it useful in a Mathematics classroom?

Further reading

Khan Academy. (2020). Pre-algebra. Retrieved from https://www.khanacademy.org/

Khin Maung Swe. (2011). *သချိၤာအျမင္သခ်ိၤာအေတြး [Mathematical view and mathematical thought]*. Yangon, Myanmar: ZinYaTaNaSaw sarpay.

Marecek, L., & Anthony-Smith, M. (2017). Prealgebra. Houston, TX: OpenStax.

Teacher Education through School-based Support-India. (n.d.-a). *Connecting mathematics: Finding factors and multiples*. Retrieved from https://www.open.edu/openlearncreate/pluginfile.php/134977/mod_resource/content/3/SM04_AIE_Final.pdf

Teacher Education through School-based Support-India. (n.d.-b). *Creative thinking in mathematics: Proportional reasoning*. Retrieved from https://www.open.edu/openlearncreate/pluginfile.php/134965/mod_resource/content/3/EM15_AIE_Final.pdf

Teacher Education through School-based Support-India. (n.d.-c). *Reading, writing and modeling mathematics: Word problems. Retrieved from https://www.open.edu/openlearncreate/pluginfile.__php/135006/mod_resource/content/3/SM13_AIE_Final.pdf*

Tekkatho Maung Thinchar. (2017). *လူမွ်ဘဝဆဲကတပါလော်ဂ်ီ [Topology in social life]*. Yangon, Myanmar: Jupiter Sarpay.

Glossary

Terms	Elaborations
21st century skills in Mathematics	Developing 21st century skills in Mathematics focuses on teaching students to consider problems and then to find mathematical ideas they could use to solve them. Students should be taught to think about the connections there are between ideas and to be curious.
Algebra	Algebra uses symbols in addition to numbers. In algebra we establish mathematical rules. We learn to manipulate algebraic equations to find a solution for the value of the symbols.
Algebraic expression	A mathematical expression that is made up of variables, numbers and operations.
Algebraic formula	An equation that gives a rule or fact and usually has two or more variables.
Angle bisector	A line or line segment that passes through an angle's vertex and divides the angle into two congruent parts.
Angle of depression	An angle formed by a horizontal line and a second line below the horizontal.
Angle of elevation	An angle formed by a horizontal line and a second line above the horizontal.
Arithmetic	Arithmetic is about numbers. This branch covers basic operations such as addition and subtraction, multiplication and division. In arithmetic, different kinds of numbers are defined: real and imaginary, rational and irrational, positive and negative. Arithmetic also deals with fractions and decimals and operations with these.
Arithmetic progression (AP)	Arithmetic progression (AP) is a list of numbers in which each term is obtained by adding a fixed number to the preceding term except the first term. For example: 1, 2, 3, 4.... (add 1 each time. a1 = 1) 200, 150, 100... (subtract 50 each time. a1 = 200)
Bearing angles	A description of the direction from one point to another in terms of an angle.
Binary system	Also known as 'base 2', a counting system that consists of only two distinct digits (0 and 1).
Branches of Mathematics	The four branches of Mathematics in middle school are arithmetic, algebra, geometry and probability and statistics.
Collaborative learning	Collaborative learning in a school setting or learning together, requires students to interact and talk about what they are thinking with one another in a specific learning context. Students are given more opportunities to actively participate in learning by working and discussing in groups. It is an important tool to create an inclusive classroom.
Congruence	The quality of having the exact same shape and size.

Terms	Elaborations
Counting system	An agreed-upon system used to express quantities (such as the binary or denary systems).
Denary system	Also known as 'base 10', a counting system that consists of ten distinct digits (0 through 9).
Error	An error is a mistake; for example, an error made as a result of a miscalculation.
Estimation of error	Calculation of the level of accuracy of an approximated value when compared to the actual amount or measure.
Exponent	A power on a number that indicates how many times that number is multiplied by itself.
Factorisation	The process of expressing a number or algebraic expression as the product of its factors.
Finding the n^{th} term	When asked for what is the n^{th} term of a sequence you are asked what the general rule is that you will be able to use to calculate the value of any term.
Formative assessment or assessment for learning	Formative assessment or assessment for learning is quite different. It is more informal and diagnostic in nature. Teachers use it as part of the learning process, for example questioning to check whether students have understood something. The outcomes of this assessment are then used to change the next learning experience. Monitoring and feedback are part of formative assessment.
Geometry	Geometry is concerned with the space, shape and size of things and their transformations. It includes the study of angles.
Geometry construction	The process of using tools (such as a pair of compasses, set squares and a protractor) to draw figures with accuracy.
Grade-wise (curriculum)	A view of the curriculum that helps us see the scope and sequencing of a topic by grades.
Habits of mind	'Habits of mind' describe how mathematicians think and what they do in their mind when solving a mathematical problem.
Inclusive education	Inclusive education is based on the fundamental right of all children to participate in quality education. It is a continuous process of making the school more welcoming, child-centred and beneficial for all children. Inclusive education is about restructuring education cultures, policies and practises, so that they can respond to a diverse range of learners.
Inequation	A mathematical statement of inequality, featuring one of the symbols $<$, $>$, $\leq$ or $\geq$.
Irrational number	Any number that is not rational, so cannot be written as a fraction of two numbers.
Land dimension	The size of a plot of land, which can be measured and drawn to scale.
Mathematical proof	A mathematical argument which demonstrates the truth of a given statement.

Terms	Elaborations
Mathematical thinking	Mathematicians often describe mathematical thinking as doing real mathematics involving problem-solving, creating ideas and representations, exploring puzzles, discussing methods and many different ways of working.
Memorisation or rote learning	Memorisation or rote learning is a learning technique based on repetition.
Misconception	A misconception is a mistaken belief or a wrong idea.
Percentage	A ratio that compares a part to a whole, expressed out of 100.
Perpendicular bisector	A line or line segment that intersects a line segment at a 90° angle and passes through the segment's midpoint.
Polya's four steps for problem-solving	Polya's four steps for problem-solving is a system developed by Polya that is part of the curriculum for Mathematics in Myanmar. These four steps are: 1. Understand the problem 2. Devise a plan 3. Carry out the plan 4. Look back
Probability	Probability describes and lets us investigate the chance of an event happening.
Problem-based learning	Problem-based learning requires the student to reason with, to use and to apply mathematical concepts and techniques that they have learned.
Progression in learning	This is the order in which students learn about a topic. It follows the order of the sequence of the curriculum.
Proportion	An equation that contains two ratios.
Quadratic equation	An equation that has a term with a variable raised to the power 2.
Radical	The 'opposite' operation of exponents, also known as a 'root'.
Ratio	A numerical way of comparing the sizes of two quantities.
Rational number	Any number that can be written as a simple ratio or fraction of two numbers, where the denominator is not zero.
Real number system	The set of all rational and irrational numbers.
RUCSAC approach	The RUCSAC approach is a strategy for solving word problems. RUCSAC stands for: Read, Understand, Choose, Solve, Answer, Check.
Scope of the curriculum	The scope of the curriculum gives a detailed description of all the topics that need to be covered in each of the grades. This tells the teachers which details they need to cover.

Terms	Elaborations
Sequence	This is the succession of terms formed according to some rule. The numbers are ordered. So, for example the list of numbers 2, 4, 6, 8... will be a sequence with the rule Tn=2n. A random list of numbers will not be a sequence because there is no rule to describe it.
Sequence of the curriculum	The sequence of the curriculum describes the order in which we teach a topic. It reflects the progression in learning of the students.
Set	A collection of numbers or other objects that have something in common or follow a common rule.
Shares	Shares represent ownership of a company**.** When an individual can buy shares in a company, they become one of its owners. Shareholders choose who runs a company and are involved in making key decisions, such as whether a business should be sold. They can be entitled to part of the profits a company makes. However, when the share value of a company drops, shareholders will lose money if they sell their shares at such time.
Similarity	The quality of having the same shape but a different size.
Spiral curriculum	A spiral curriculum is constructed to help the student revisit, extend and deepen their knowledge, understanding and skills. A spiral curriculum is based on the idea that effective learning is best approached by studying the same mathematical topic or theme several times, each time slightly differently or examined more deeply.
Statistics	Statistics concerns how we handle data: how we collect it, analyse it and represent it.
Stocks	Are all shares of a company.
Summative assessment or assessment of learning	Summative assessment or assessment of learning looks back and makes a judgment on what has already been learnt. It is often conducted in the form of tests that are graded, telling students their attainment on the questions in that test. This also helps in reporting learning outcomes.
Surface area	The total area of the outside surface of a solid figure.
Term in a sequence	Each of the numbers in a list of numbers is called a term. For example, all the numbers 2, 5, 8, 11... are terms in the list 2, 5, 8, 11...
Theorem	A mathematical statement that has been proven.
Units and sub-units	Units and sub-units are topic headings in the curriculum and are to a large extent based on the branches of Mathematics.
Venn diagram	A representation of the relationship between two or more different sets, with a circle representing each set.
Visualisation	Visualisation is a technique for creating images. This can be physical (e.g. drawing a shape) or mental (e.g. imagining a shape in your head).
Volume	The measure of the space occupied by a solid figure.
Word problems	Word problems are the problem-solving questions that phrase a mathematical problem in words.

Bibliography

Al Jazeera English. (2018, May 2). Cyclone shield: Breathing new life into Myanmar's mangroves [Video file]. Retrieved from https://www.youtube.com/watch?v=W-kPimfoWpo

CAST. (2018). Universal design for learning guidelines version 2.2. Retrieved from http://udlguidelines.cast.org

Clifford, A., & Ji-Won Son. (2018). Complete the what? The Mathematics Teacher, 112, 218-225.

De Morgan, A. (1865). Speech of Professor De Morgan, President, at the first meeting of the Society, January 16th, 1985. Proceedings of the London Mathematical Society, 1, 1–9.

Hall, T. E., Meyer, A., & Rose, D. H. (Eds.). (2012). Universal design for learning in the classroom: Practical applications. New York, NY: Guilford Press.

Kappiya Paysi. (2014). သချိၤရောင်စဉ်နှင့် လူမှုကမ္ဘာ [Spectrum of mathematics and social world]. Yangon, Myanmar: ZinYaTaNaSaw sarpay.

Khan Academy. (2020). Pre-algebra. Retrieved from https://www.khanacademy.org/

Khin Maung Swe. (2012). နှစ်ဆယ်ရာစုခေတ်ဦးထူးခြားသချိၤဖန်တီးရှင်များ [The creators of distinctive mathematics in the early twentieth century]. Yangon, Myanmar: ZinYaTaNaSaw sarpay.

Khin Maung Swe. (2011). သချိၤအမြင်သချိၤအတွေး [Mathematical view and mathematical thought]. Yangon, Myanmar: ZinYaTaNaSaw sarpay.

Marecek, L., & Anthony-Smith, M. (2017). Prealgebra. Houston, TX: OpenStax.

Mason, J. H. (1988) Learning and doing mathematics. London, England: Macmillan Education.

NRICH. (2020a). Clapping times. Retrieved from https://nrich.maths.org/

NRICH. (2020b). Music to my ears. Retrieved from https://nrich.maths.org/

Perkins, D. N. (2010). Making learning whole: How seven principles of teaching can transform education. San Francisco, CA: Jossey-Bass.

Robinson, K. (2010). Changing education paradigms [Video file]. Retrieved from https://www.ted.com/

Schacter, J. (2000). Does individual tutoring produce optimal learning? American Educational Research Journal, 37, 801-829.

Slavin, R. E., Hurley, E. A., & Chamberlain, A. (2003). Cooperative learning and achievement in W. M. Reynolds & G. E. Miller (Eds.), Handbook of Psychology: Volume 7 Educational Psychology (pp. 178-198). Hoboken, NJ: John Wiley & Sons.

Teacher Education through School-based Support-India. (n.d.-a). Connecting mathematics: Finding factors and multiples. Retrieved from https://www.open.edu/openlearncreate/

Teacher Education through School-based Support-India. (n.d.-b). Creative thinking in mathematics: Proportional reasoning. Retrieved from https://www.open.edu/openlearncreate/

Teacher Education through School-based Support-India. (n.d.-c). Reading, writing and modeling mathematics: Word problems. Retrieved from https://www.open.edu/openlearncreate/

TED-Ed. (2017, January 19). A brief history of numerical systems - Alessandra King [Video file]. Retrieved from https://www.youtube.com/watch?v=cZH0YnFpjwU

Tekkatho Maung Thinchar. (2013). သခ်ၤာအေခြခံအယူအဆသေဘာမ်ားနွင့္မိတ္ဆက္ေခၚဆိုခ်က္ [Introducing the fundamental concepts of mathematics]. Yangon, Myanmar: ZinYaTaNaSaw sarpay.

Tekkatho Maung Thinchar. (2017). လူမွဘဝထဲကတပေါ်လေဂ်ီ [Topology in social life]. Yangon, Myanmar: Jupiter Sarpay.

United Nations Educational, Scientific and Cultural Organization. (2017). A guide for ensuring inclusion and equity in education. Paris, France: United Nations Educational, Scientific and Cultural Organization.

Youcubed. (2017, March 14). Tour of mathematical connections. Retrieved from https://www. youcubed.org/

Youcubed. (2018, September 25). Excerpt of Jo from 'The importance of struggle' [Video file]. Retrieved from *https://www.youcubed.org/*

Youcubed. (2019, October 10). The nature of 21st century mathematics. Retrieved from *https:// www.youcubed.org/*

Notes

Notes

The Government of the Republic of the Union of Myanmar

Ministry of Education