Four-Year B.Ed. Course Manual

MATHS: FURTHER ALGEBRA

The Government of Ghana

mastercard
foundation

UKaid
from the British people

T-TEL
Transforming Teaching, Education & Learning

FOREWORD

These Initial Teacher Education course manuals were developed by a team consisting of members from Colleges of Education and four universities namely the University of Ghana, Kwame Nkrumah University of Science and Technology, University of Education, Winneba, and University for Development Studies. This team was originally constituted by the National Council for Tertiary Education (now the Ghana Tertiary Education Commission) in 2019 to support the delivery of the new B.Ed. curriculum with assistance from T-TEL and UK Aid. The revision, finalization and printing of these manuals took place in 2021 with support from T-TEL and Mastercard Foundation.

The course manuals have been produced for use as general guides for the delivery of the new four-year B.Ed. curriculum in Colleges of Education in collaboration with their affiliated universities. They are designed to support student teachers, tutors and lecturers in delivering a complete B.Ed. course for training student teachers which meet the requirements of the National Teachers' Standards, enabling them to teach effectively in basic schools.

The first section of the manuals is focused on the course information and vision for the B.Ed. curriculum. The second section presents the course details, goal for the subject or learning area, course description, key contextual factors as well as core and transferable skills and cross-cutting issues, including equity and inclusion. The third section is a list of course learning outcomes and their related learning indicators. The fourth section presents the course content which is broken down into units for each week, the topic and sub-strands and their related teaching and learning activities to achieve the learning outcomes and the teaching and learning strategies. This is followed by course assessment components in section five. Each manual contains a list of required reading and references as well as teaching and learning resources. The final section presents course related professional development for tutors and lecturers to be able to use each section of the manual.

Field instructions to guide Supported Teaching in School are integrated into the course manuals to provide the student teacher with guidance in developing teaching throughout the entire period of study to be able to meet the requirements of the National Teachers' Standards (NTS) and the National Teacher Education Curriculum Framework (NTECF). To ensure maximum benefit the course manuals should be used in addition to other resources such as the NTS, NTCEF, National Teacher Education & Assessment Policy and the National Teacher Education Gender Equality and Social Inclusion (GESI) Strategy and Action Plan. This will help to ensure that student teachers learning is integrated within the wider teacher education policy framework.

Professor Mohammed Salifu Director General, Ghana Tertiary Education Commission

ACKNOWLEDGEMENTS

CORE WRITING TEAM

Names of writers	Subject		Names of writers	Subject
Dr. Isaac Eshun			Cletus Ngaaso	Social Studies
Dr. Anthony Baabereyir			Mohammed Adam	
Ms. Shirley Dankwa	African Studies		Dr. Emmanuel Adjei-Boateng	
Prof. S.Y. Annor	Agriculture		Dr. Yaw Nyadu Offei	Special Education
Dr. Salome praise Otami			Prof. Samuel Hayford	
Dr. Samuel Frimpong			Dr. Awuni	
Robert Quansah	Early Grade		Rev.(Dr) Nyueko Avotri	Technical Vocational Education and Training
Dr. Abraham Kwadwo Okrah			Elizabeth Lani Ashong	
Dr. Sarah Emma Eshun	English Language			
Vivian Acquaye			Michael Tsorgali	
Felix A. Odonkor			Frnacis Donkor	
Dr. Cecilia Esinam Agbeh			Dr. Maxwell Nyatsikor	
Ibrahim Osmanu	French		Prof. Salomey Essuman	
Dr. Kofi Adu-Boahen			Dr. Paul Kwadwo Addo	
Dr. M. Kusimi			Dr. Winston Kwame Abroampa	
Dr. Aboagye Dacosta			Mr. Kwaku Esia-Donkoh	
Mr. Alexander Otoo	Geography		Mohammed Z. Abdulmumin	Pedagogy
Dr. Yvonne A.A. Ollennu	Ghanaian Language		Dr. Mohammed Hafiz	Arabic
Kwasi Adomako			Iddris Mohammed	
Dr. Akwasi Kwarteng Amoako-Gyampah			Mohammed Almu Mahaman	
Anitha Oforiwah AduBoahen			Murtada M. Muaz	
Gertrude Nkrumah	History		Dr M. Q. Adjahoe	Music

Prof Charles Owu-Ewie	Literacy	Prof Cosmas Mereku	
Dr. Ahmed Amihere	Mathematics	Prof. Reginald Ocansey	Physical Education
Zakaria Sadiq		Dr. Emmanuel Osei Sarpong	
Dr. R. Addai-Mununkum	RME	E. Kwaku Kwaa-Aidoo	ICT
Dr Charles Nyarko Annobil		Victor Anyamful	
Mr. Owusu Afiriyie			
Dr. V. Ankamah-Lomotey	Science		
Jonathan Ayelsoma Samari			
Prof. Ruby Hanson			

INTRODUCTION TO COURSE MANUALS

Welcome to this B.Ed. Course manual.

Following the accreditation of the B.Ed. by the national accreditation Board with its recognition as a world class teacher education curriculum, the decision was taken to support effective implementation through the development of course manuals. the course manuals provide tutors and lecturers with the materials necessary to support teaching each of the B.Ed. courses. The manuals adhere directly to, and emphasise, the principles and standards set out in the NTS, NTECF and in the B.Ed. and will help ensure operationalising the Government's teacher education reform Policy.

The manuals serve the following purposes:

- they are the key educational agreements between the training institution and the student teachers. In this way student teachers know what the expectations are for them and for the training they will receive.

- they lay out the course outcomes, content, strategies, and assessment, thereby providing direction to and consistency in training and B.Ed. implementation among tutors across the country.

- they are explicit documents that provide other institutions with information on which to base transfer/ articulation decisions.

Specifically, they also:

- support coherent lesson planning and teaching which will enable student teachers to achieve the NTS and become good teachers who ensure all pupils' learning whilst offering tutors the flexibility for adaptation for local needs and contexts.

- Provide a lesson by lesson overview of the course, building on and developing the material in the course specifications.

- Inform tutors, student teachers and others working with student teachers about:

  1. What is to be taught and why.

  2. how it can be taught.

  3. how it should be assessed.

- Provide opportunities for student teachers to develop and apply knowledge during supported teaching in school, creating a strong bond between learning in school and in the training institution.

- Reflect the stage of student teacher development, set out in the model for progress across the four years of the B.Ed.

- Can be used as self-study tools by student teachers.

- Ensure that all information necessary to inform teacher training is in one place (serves as reference document).

- The manuals are the basis of the codes and university professional development sessions to ensure Principals, tutors, lecturers and heads of department are fully familiar with the details of: courses, outcomes, content, approaches, assessments and lessons.

Who are course manuals for:

- College of Education Tutors

- Teacher Education University Lecturers

- Student Teachers

- Mentors and Lead Mentors

- All Those with An Interested In Teacher Education.

USING THIS MANUAL

Writers of the manuals engaged widely with colleagues in each subject area at each stage of development. Besides, writers envisaged themselves in varied contexts as they wrote, to suggest methodologies and strategies for teaching the strands which would ensure student teachers are enabled to achieve the learning outcomes. In view of our commitment to creativity, problem solving, collaboration and to lifelong learning, we expect that individual tutors will "own" their manuals and become user-developers. lessons in the manuals will be strands for weekly Pd meetings where tutors/lecturers will situate the lessons in the contexts of their colleges and their student teachers, to maximize the benefits.

It is also expected that tutors will model the best pedagogic practices for student teachers. Key among such practices is the communication of the importance of having a personal teaching philosophy. We expect that tutors and lecturers will explicitly communicate their personal teaching philosophies to their student teachers during the first meeting of every course. in preparation for this, we suggest you set out your personal teaching philosophy and how it will be demonstrated in your teaching using, or adapting, the sample sentence introductions below.

My teaching philosophy is   …………………………………………………………………………………………….....

In view of this philosophy, I will facilitate this course by/through …………………………………………………….

Course Manual Writing Guide

Resources for Course Manual Writing

- Soft copies of the CWG, New Four-Year B.Ed. Curriculum introduction
- Soft and hard copies of the course specifications for the subject for year one and two
- Soft and hard Course Manual Writing Guide (CMWG)
- Relevant subject texts

Target Audience

- College of Education Tutors

Teacher Education University Lecturers

- Student Teachers
- Mentors

The purpose of course manuals

- To provide a lesson by lesson overview of the course, building on, adapting and developing the material in the course specifications
- To provide a resource to support professional development sessions for tutors/lecturers on how to plan for and teach courses from the New Four-Year B.Ed. Curriculum
- To inform tutors /lecturers, student teachers and others working with student teachers about:
  - ✓ what is to be taught and why
  - ✓ how it can be taught
  - ✓ how it should be assessed
- To support consistency in the implementation of the New Four-Year B.Ed. across institutions who train teachers
- To ensure that all **training** information on skills, processes, and other information necessary to perform the teaching task are together in one place.
- To operationalize the Teacher Education Reform Policy; the requirements of the NTS & NTECF and the Four-Year B.Ed.

Guiding principles of course manual writing

1. They are written with the learner, the student teacher, in mind: what they will *be able* to cope with and only include what student teachers need to know, understand, be able to do and be as a basic school teacher
2. They take in to consideration the learner's, the student teacher's, context and possible barriers to, and enablers for, learning
3. They are written with the tutors /lecturers who are going to teach the course in mind. Tutors must be able to adapt and develop the plans in course manuals to fit the context they are teaching in and to support their teaching
4. They are aligned to the key principles and practices of the Teacher Education Reform Policy: the NTS, the NTECF andthe New Four-Year B.Ed.
5. They are written to provide opportunities for student teachers to develop and apply knowledge during supported teaching in school
6. They are written to reflect the stage of student teacher development, set out in the model for progress in the New Four-Year B.Ed.
7. They are written to support progress in student teacher learning, including building on prior learning from the previous programme or course/s and supporting progress to the next course.
8. They are to be used as self-study tools.
9. They are written to have the following characteristics: easy to read; uses active voice and avoids jargon; uses bullet points to offset text; uses images

What a teacher educator needs to know, understand and use to inform what they do

- The aims and structure of the education system and Education strategic Plan
- The Basic School Curriculum
- The Inclusion Policy
- The teacher education system: The National Teacher's Standards, the vision for teacher education and the core principles of the New Four-Year B.Ed.
- Andragogy, effective methods and practices for teaching adult learners
- Assessment Literacy. Assessment for, of and as learning -Educative Assessment

Guidance for completing the course manual writing format: two sections

A. Course Information

Title Page

Course name: as in course specification unless important reason why not

The vision for the New Four-Year B.Ed. Curriculum
''To transform initial teacher education and train highly qualified, motivated new teachers who are effective, engaging and fully prepared to teach the basic school curriculum and so improve the learning outcomes and life chances of all learners they teach as set out in the National Teachers' Standards. In doing this to instil in new teachers the Nation's core values of honesty, integrity, creativity and responsible citizenship and to achieve inclusive, equitable, high quality education for all learners. ''

Course Details: as in course specification unless important reason why not					
Pre-requisite/s	**The programme / previous semester courses studied.**				
Co-Requisites	**Links to other courses being taught, support coherence in student experience and avoid duplication**				
Course Level		**Course Code**		**Credit Value**	**3**

Table of contents
Each manual will include:

1. The goal for the subject or learning area
2. Course description
3. Key contextual factors
4. Core and cross cutting issues, including equity and inclusion
5. Course Learning outcomes
6. Course content
7. Teaching and learning strategies
8. Course Assessment components
9. Reading and reference list
10. Handouts, power points and other resources for lessons
11. Plans for each lesson in the semester

A. Course information

1. Goal for the Subject or Learning Area
This can be found in subject goal document. It should be a short statement which captures what new teachers will know, understand and be able to do in this subject at the end of their training. This statement should be linked to achieving the vision for the curriculum.

2. Key contextual factors
This can be found in the course specification. It should address what needs are to be considered to reflect the Ghanaian context at local and national levels.it includes potential knowledge and skills gaps and any specific: gender, cultural, linguistic, conceptual, infrastructural issues, for example, that might be barriers to learning forstudent teachers and eventually basic school children? E.g. issues of subject related bias that need addressing. Potential barriers to learning must be explicitly addressed to enable student teachers to achieve the learning outcomes.

3. Course Description
This can be found in the course specification. This brief statement should provide a clear understanding of what studying this course involves, what student teachers will get out of studying this course.

4. Core and transferable skills and cross cutting issues, including equity and inclusion
This can be found in the course specification. Which core and transferable skills or cross cutting issues will be applied or developed through this course? This needs to be made explicit to student teachers. Are there specific issues to do with equity and inclusion which must be addressed so that all student teachers can fully take part? For example, issues related to gender and mathematics or science.

5. Course Learning Outcomes	*6. Learning indicators*
These are in the course specification. The course learning outcomes should specify the expectations of what the student teachers will know, understand and be able to do at the end of the course *not* what student teachers will do **on** the course. They must be appropriate and realistic to the learner's abilities, experience, the identified level of the course and *content.* They must be measurable – allowing	• Measurable/assessable/observable performances that provide evidence of learning or other changes taking place in student teachers' behaviour which demonstrate that they have met the learning outcome/s. • What the student teacher will need to do to show they have achieved the learning outcome. (in an inclusive lesson, this should vary and be responsive to student

assessment of student teacher achievement	teacher's individual characteristic)

7. *Course content*

In the course specification. This should provide an outline of the academic and / or practical content of the course. It should be clear how this content relates to the achievement of the intended learning outcomes.The name of each unit in the course should be *briefly* set out – the name should make it clear what the unit is about.

Unit	Topic	Sub-topic (If any)	Teaching and learning activities to achieve the learning outcome

8. *Course Assessment Components*

In the course specification. The NTS and the NTECF require a move away from largely examination-based assessment to strategies to enable assessment of student teachers' skills, knowledge and understanding against the learning outcomes and through these the against the NTS

- There should be a maximum of 3 assessment components per 3 credit-course; to avoid over loading student and tutors/ lecturers
- The learning outcomes to be assessed by each assessment component should be identified.
- Each assessment component should explicitly reference the NTS or aspects of the NTS it will assess.
- Each assessment component should include:
  - ✓ The category or type, for example: written, coursework or practical, teaching, examination, collaborative project or presentation, poster, TLM
  - ✓ The type of assessment: of, for and /or as.
  - ✓ An indication of the size of each assessment component (e.g. duration of exams, word limit of written submissions, length of presentations; whether presentations have an individual or group etc.).
  - ✓ The weighting of each assessment component should be expressed as a % of total course mark (overall in each course: 60% continuous assessment of course work, 40% examination of course work).
- Each assessment should be manageable and relevant to supporting the student teachers' development.

The guidance on assessing student teachers from the NTS, the NTECF the CWG and the New Four Year B.Ed. should be used.

9. *Teaching and learning strategies*

Detail in this section should show how the total learning hours will be used to achieve the intended learning outcomes, to provide a guide to the teaching and learning strategies to be used. Each teaching strategy should be selected as most appropriate to achieving the learning outcomes. This may include team teaching or additional tutors. As stated in the B.Ed. experiential learning and interactive teaching approaches are encouraged

10. *Required Reading and reference list*

e or two compulsory texts which must be made available to the student teachers and a SHORT list of 5 relevant references. These lists should be annotated with the key value of each text. Use APA style of writing.

11. *Teaching and Learning Resources*

Instructional resources required to support learning during the course e.g.: TLMs, lab and workshop equipment, videos, projectors

Course related professional development for tutors/ lecturers

This is not included the course manual but professional development needs must be identified to ensure all tutors / lecturers are prepared to teach the course identify any specific topics or issues which may be challenging for tutors / lecturers.

B. Semester lesson plans

Guidance for Lesson planning

The expanded format is ddesigned to support writing lessons which address the key features of the new B.Ed. curriculum
   The completed format will be an important piece of evidence for CoE in being awarded **Transitional Support Funding (TSF)**
Things to consider when writing and reviewing lessons:
- Will all student teachers be able to achieve the learning outcomes and demonstrate the indicators by undertaking the activities set out in the lesson?
- What might be barriers to learning? How can you address these barriers?
- How does the lesson support progress in and or consolidate student teacher learning; including building on prior learning and supporting progress to next lessons?
- How will you can address transition from school to CoE in the first semester?
- Are there explicit links between learning outcomes, learning indicators and assessments?
- Do all activities support student teachers in achieving the lesson learning outcomes?

• Is there an emphasis on interactive, learner focused approaches to training new teachers?
• Does it explicitly address cross cutting -issues: equity and inclusion, gender, SEN,ICT?
• Does it explicitly develop core skills, including: professional values and attitudes, classroom enquiry and reflection?
• Overall the lesson must be 'do-able' for the student teacher
   ✓ in the time available
   ✓ with the skills, knowledge and understanding they have	

Title of Lesson **Lesson Duration**							
Lesson description	**It is essential that student teachers know what this lesson is about. The lesson description should be short, clear, and accessible to all students.**						
Previous student teacher knowledge, prior **learning (assumed)**	• What links to previous knowledge / prior learning need to be built in to the lesson? • Prior learning could be from: this course and previous lessons; from senior high school; from supported teaching in school/practicum; from other courses. NB important to build on work from previous lessons • If you are unsure about previous knowledge or prior learning how you need to check for this as part of the activity in the lesson/s.If the expected prior knowledge is not adequate you will need to modify the lesson.						
Possible barriers to learning in the lesson	• What specific conceptual, linguistic, social, cultural, conceptual, gender, or ability related issues might stop student teachers in achieving the learning outcomes; act as barriers to their learning? • How will you address these? • Does this lesson require that student teachers examine their own bias? If so, you will need to plan to support and address this						
Points on equity, inclusivity (gender, SEN), and addressing diversity	• You need to represent and address diversity in your lesson-plan. Are there multiple diversity issues (see diversity wheel) ? • How would these issues be addressed with student teachers during activities for both their own learning and the learning of the students they will teach? • How are issues of diversity (equity and inclusion) addressed in your lesson plan so that student teachers can see diversity modelled during this teaching and learning activity? • How are issues of diversity (equity and inclusion) addressed in your lesson plan so that student teachers can learn how to address it with the students they will teach? • For example: gender stereotype issues related to: PE, literacy and language, science and mathematics.						
Lesson Delivery – chosen to support students in achieving the outcomes	**Face-to-face**	**Practical Activity**	**Work-Based Leaning**	**Seminars**	**Independent Study**	**e-learning opportunities**	**Practicum**
Lesson Delivery – main mode of delivery chosen to support student teachers in achieving the learning outcomes.	**Face-to-face:** opportunity for an extended and coherent line of argument. It includes discussion, brainstorming, question and answer, etc. This can be tutor and / or student teacher led. It should not usually be the main mode. **Practical Activity:** enabling experimentation and the analysis and discussion of issues, documents and materials, as well as physical activities. **Work based learning:** to allow students to undertake observation, enquiry and/or hands-on development work (mostly TVET) **Seminars:** to generate group and individual creativity, discussion and reflection: student and / or tutor led **Independent study:** to enable students to engage with relevant and appropriate materials to promote individual and collaborative enquiry, more in-depth analysis and development. This can be part of any of the above modes **E-learning** *opportunities* – involving the use of interactive packages and virtual learning environments. This can be part of any of the above modes of delivery. It is unlikely to be a delivery mode in its own right. **Practicum (supported teaching in school):** support to enable student teachers to experience and learn from the basic school context by doing observations and child study in Y1 to full class teaching in and action research in Y4.						
• **Purpose for the lesson, what you want the students to achieve, serves as basis for the learning outcomes. An**	• What is the main thing you want student teachers to know, understand and be able to do as a result of this lesson? • Is this lesson aimed at: Learning or embedding a new concept? Developing a skill? Understanding how various concepts and skills come together to create a body of knowledge? Practicing the application of new knowledge? • This will relate back to the overall intention and learning outcomes for the course.						

- expanded version of the description. **Write in full aspects of the NTS addressed**			
Learning Outcome for the lesson, picked and developed from the course specification **Learning indicators for each learning outcome**	**Learning Outcomes** - The learning outcomes for the lesson will enable student teachers to achieve the purpose for the lesson. - For example, in mathematics: student teachers are prepared to teach a specific mathematics operation. In this instance, the learning outcomes would be the things the students would need to know and do in order to be able to teach the operation. - What the student teacher will know and be able to do as a result of this lesson. 'By the end of the lesson the student will….' - Learning outcomes may be developed and re-visited over a number of lessons - Be realistic in terms of what can be achieved in any one lesson - Some learning outcomes may address specific student teacher needs		**Learning Indicators** - Measurable/assessable/observable performances that provide evidence of learning or other changes taking place in student teachers' behaviour which demonstrate that they have met the learning outcome/s. - What the student teacher will need to do to show they have achieved the learning outcome. (in an inclusive lesson, this should vary and be responsive to student teacher's individual characteristic)
Content of lesson picked and developed from the course specification **Unit/s covered from the course specification:**	**Time or stage** Identify how much time will be required for each part of the lesson	**Topics and sub-topics (if any):**	**Teaching and learning to achieve learning outcomes: depending on delivery mode selected. Teacher led, collaborative group work or independent study**

			Teacher Activity	**Student Activity**
			- Plan to model what is expected of student teachers - Plan for activities to support student teachers in working towards and / or demonstrating achieving the learning outcomes. - Where possible set up activities with students as active participants - Make links to other aspects of the New Four-Year B.Ed. programme or between subject and pedagogic knowledge - State if team teaching involved or additional tutors contributing	**For example: Interactive and collaborative group and pair work, e.g.,** - identifying, developing, presenting and evaluating suitable resources and materials - picking out key points from education texts, raising questions and issues - sharing practice and experience - preparing for school visits **self and peer assessment** **Other examples** - Student teacher led seminars - ICT e.g. discussion using VLE - Video observation of and analysis of teaching - Role-play

Which core or transferable skills will be used or developed and how	Core and transferable skills include: critical thinking, problem solving, social skills, creative thinking and communication skills, use of ICT
Which cross cutting issues will be addressed or developed and how	Cross cutting issues include: assessment literacy and assessing students' progress and professional values and attitudes, reflection and classroom enquiry

Lesson assessments – evaluation of learning: of, for and as learning within the lesson	• Assessment as learning: ongoing self-*assessment* by student teachers reflecting on their own *learning* and making adjustments so that they achieve deeper understanding, occurs throughout the learning process. *This needs to be planned for in the lesson*. • Assessment of learning: is usually summative and is mostly done at the end of a task, unit of work, placement etc. Weighted Assessment Components in course outlines. *This needs to be planned for in the lesson*. • Assessment for learning: is using assessment as a means of finding out what students know, understand and are able to do and using that information to adapt teaching approaches and to differentiate according to different student needs, it occurs through the learning process, may be part of the Assessment components, and it occurs when assessing prior learning • Differentiation in lessons (UDL guidelines): the lesson needs to include a range of teaching and assessment strategies to motivate and reach all learners • The approach to assessment in lessons must be appropriate to the teaching and learning strategies
Instructional Resources	This may include: handouts, power points, examples of children's work, video, ICT activities, examples of previous student teachers' work
Required Text (core)	
Additional Reading List	

Lesson 1

Year of B.Ed.	2	Semester	1	Place of lesson in semester	1 2 3 4 5 6 7 8 9 10 11 12

Title of Lesson	Binary Operation: *Learning, teaching and applying*	Lesson Duration	3 Hours

Lesson description	This is a first lesson under the topic Further Algebra in Year two Semester 1. Number and Algebra treated in Year one Semester two is a pre-requisite of this lesson. General introduction of course manual will be discussed to enable student teachers to audit their content knowledge and experiences to establish and address their learning needs, perceptions and misconceptions in Binary Operation. Conscious effort should be made to create awareness in student teachers the course is the first content course in the JHS mathematics specialism. The areas to be covered include the concept and definition of Binary Operations, Evaluation of a Binary Operation, Properties of the Binary Operations – Closure, Associative, Commutative, Distributive, Identity Element and Inverse. The lesson begins with starters or mental mathematics games, reinforcement games and activities about knowledge of operation of numbers. The main lesson focuses on reviewing the student teachers' conceptual understanding of Binary Operations and its properties**.**
Previous student teacher knowledge, prior learning (assumed)	Student teachers have knowledge on operations of numbers and their properties from Basic School mathematics, JHS mathematics and SHS Core mathematics.
Possible barriers to learning in the lesson	Different entry behaviours, Socio-cultural issues, different learning needs, different teaching styles from previous teachers which may not support the student teachers to acquire the concept of Binary operations.

Lesson Delivery – chosen to support students in achieving the outcomes	Face-to-face ⊠	Practical Activity ⊠	Work-Based Leaning ☐	Seminars ☐	Independent Study ☐	e-learning opportunities ⊠	Practicum ☐

Lesson Delivery – main mode of delivery chosen to support student teachers in achieving the learning outcomes.	**Face-to-face:** opportunity for an extended and coherent line of argument. It includes discussion, brainstorming, question and answer, etc. This can be tutor and / or student teacher led. It should not usually be the main mode. **Practical Activity:** enabling experimentation and the analysis and discussion of issues, documents and materials, as well as physical activities. **Independent study:** to enable students to engage with relevant and appropriate materials to promote individual and collaborative enquiry, more in-depth analysis and development. This can be part of any of the above modes **E-learning *opportunities*** – involving the use of interactive packages and virtual learning environments. This can be part of any of the above modes of delivery. It is unlikely to be a delivery mode in its own right.
• **Purpose for the lesson, what you want the students to achieve, serves as basis for the learning outcomes. An expanded version of the description.**	**The purpose of the lesson is to;** • build on the content knowledge and experiences of student teachers to establish their competence in handling Binary Operation problems and address their learning needs, perceptions and misconceptions in Binary Operations. • develop student teachers' understanding of Binary Operations and apply Binary Operation concepts in other fields of mathematics • to develop student teachers' conceptual knowledge in order to prepare them well enough to be able to handle concepts in Binary Operations as required by the JHS curriculum. • To create awareness of the student teachers in building on what has been learnt previously in year 1 semester 1 (Number and algebra)

• Learning Outcome for the lesson, picked and developed from the course specification • Learning indicators for each learning outcome	Learning Outcomes	Learning Indicators	Identify Which cross-cutting issues-core and transferable skills, inclusivity, equity and addressing diversity. How will these be addressed or developed?
	1. Demonstrate the understanding of Binary Operations (NTS 2c, 3i, NTECF Pillar 1) 2. Use a variety of activities or ways in learning Binary Operations concepts. (NTS 3e, 3f, 3g, 3k, 3l, 3m, 3n, 3o, 3p NTECF pillar 4) • Demonstrate value as well as respect for equity and inclusion in the mathematics classroom. (NTS, 2f)	• Identify and analyse the characteristics and the properties of Binary Operations • Evaluate a defined binary operation within a set of numbers and illustrate the results on a table. (The table assists in discussing the properties of Binary Operations). • Engage all student teachers in collaborative group work on Binary operations.	• Problem solving, critical and creative thinking:through objective analysis of facts and concepts • Communication skills: through discussion, critiquing and presentations of results • Respect and diversity: designing lesson for diverse learners with different learning styles • Personal development: Through presentation and developing of arguments to ensure the development of conceptual understanding • Equity and inclusivity: by providing equitable learning opportunities for all learners

Topic	Sub-topic(s)	Stage/ Time	Teaching and learning to activities to achieve learning outcomes depending on delivery mode selected. Teacher-lead collaborative groupwork or independent.	
			Teacher Activity	Student Activity
Binary Operations:*Learning , teaching and applying.*		**10 mins**	Introduce student teachers to the Course Manual and discuss the various components including assessment procedures **(See Course Assessment Components),** *(PD Theme 1)*	Participate in the discussion of various components of the course manual, take opportunity to ask questions about the Course Manual including assessment procedures. Outline their expectations and views about the mathematics course.
	Misconceptions and barriers in teaching and learning of Binary Operations	**20 mins**	Initiate discussion on students' previous knowledge and experiences on binary operations to explore their misconceptions	Student teachers discuss their perception, misconceptions and barriers about concepts in Binary Operations
	Concept of Binary Operations, definition and evaluation of two numbers under a defined binary system.		Put student teachers into groups for collaborative activities to evaluate binary operations	Evaluate binary operation defined on a set of numbers. Eg. A binary operation * is defined on a set of real numbers by $x * y = x + y + xy$, evaluating $3 * 5 = 3 + 5 + 3(5) = 23$
		50 mins	Lead discussion on closure, commutative and associative and distributive properties	Fill binary operation Cayley table to establish the concepts of closure, commutative and associative properties. Eg. The binary operation * is defined on the set $Q = \{0, 1, 2, 3, 4\}$modulo 5by $x * y = x + y + 2xy$.
	Properties of Binary Operations	**60 mins**		

					Fill the Cayley table and use it to investigate closure, commutative and associative properties

*	0	1	2	3	4
0	0	1	2	3	4
1	1	4	2	0	3
2	2	2	2	2	2
3	3	0	2	0	1
4	4	3	2	1	0

Ie.

Closure Property: The set Q is closed under the operation * since for $a, b \in Q, a * b \in Q$

Commutative Property: Let $a, b \in Q$ and investigate from the table whether $a * b = b * a$

Associative Property: Let $a, b, c \in Q$ and investigate from the table whether $(a * b) * c = a * (b * c)$ [and investigate further whether is equal to $(a * c) * b$].

Distributive Property: To investigate distributive property, the binary operations should be two distinct definitions. Eg. Define binary operations * and Δ on the set $Q = \{0, 1, 2, 3\}$ modulo 4 by $x * y = x + y$ and $x\Delta y = x - y$ respectfully.

40 mins

*	0	1	2	3
0	0	1	2	3
1	1	2	3	0
2	2	3	0	1
3	3	0	1	2

Δ	0	1	2	3
0	0	3	2	1
1	1	0	3	2
2	2	1	0	3
3	3	2	1	0

Use these tables to investigate the distributive property $(a\Delta b) * c = (a * c)\Delta(b * c)$, where $a, b, c \in Q$

Initiate discussion on how to find or identify an identity element of a binary operation	Engage in collaborative activities including think-pair-share and group work that will lead to finding out the identity element from a defined operation

Lesson assessments – evaluation of learning: of, for and as learning within the lesson	1. Student teachers to discuss the nature of their professional teaching portfolios (PTP) with respect to Further Algebra in terms of its content and with time lines. 2. Student teachers are assigned to outline and analyse the characteristics and the properties of binary operations for peer review in class. (Assessment as learning) NTS 3h - Sets meaningful tasks that encourages learner collaboration which leads to purposeful learning.
Instructional Resources	Graph sheets, mathematical set, manipulative materials, permanent markers, calculators, mobile phones, Geogebra Apps.;
Required Text (core)	Gordor, B. K., Naandam, S. M., & Nkansah, B. K. (2012). *Core mathematics for senior high schools*. Accra: Sam-Woode Ltd.

	https://amsi.org.au/teacher_modules/Indices_and_logarithms.html. *Retrieved 20-06-2019*
Additional Reading List	Ministry of Education (2015). *Core mathematics modules for SEIP*. Accra: Ministry of Education. Ministry of Education. (2010). *Teaching syllabus for core mathematics* (Senior High School). Accra: Ministry of Education, Science and Sports. Martin, J. et. al. (1994). *Mathematics for teacher training in Ghana: Tutor notes*. Accra: Unimax Publishers. Martin, J. et. al. (1994). *Mathematics for teacher training in Ghana: Students activities*.Accra: Unimax Publishers.
CPD NEEDS	How to design and/or use some innovative materials and ideas for teaching selected concepts in binary operations Instructional strategies needed to consciously connect mathematical ideas, as well as, connect mathematics to other curriculum areas and to the world outside

Lesson 2

Year of B.Ed.	2	Semester	1	Place of lesson in semester	1 **2** 3 4 5 6 7 8 9 10 11 12

Title of Lesson	Sequences and Series: *Learning, teaching and applying*	Lesson Duration	3 Hours
Lesson description	This is the second lesson under the topic Further Algebra in Year two Semester 1. Number and Algebra treated in Year one Semester two is a pre-requisite of this lesson. General introduction of course manual has been discussed in lesson one to enable student teachers to audit their content knowledge and experiences to establish and address their learning needs, perceptions and misconceptions in sequences and series. The areas to be covered include the concept and definition of sequences and series, establishing the nth term and sum of an AP, establishing the nth term and sum of a GP, and application of sequences and series to solving real life problems. The lesson begins with starters or mental mathematics games, reinforcement games and activities about knowledge of operation of numbers. The main lesson focuses on reviewing the student teachers' conceptual understanding of sequences and series**.**		
Previous student teacher knowledge, prior learning (assumed)	Student teachers have knowledge on operations of numbers and their properties from Basic School mathematics, JHS mathematics and SHS Core mathematics.		
Possible barriers to learning in the lesson	Different entry behaviours, Socio-cultural issues, different learning needs, Some student teachers may come SHS schools where they did not have teachers or good mathematics teachers to support them understand basic concepts in Sequences and Series.		

Lesson Delivery – chosen to support students in achieving the outcomes	Face-to-face ☒	Practical Activity ☒	Work-Based Leaning ☐	Seminars ☐	Independent Study ☐	e-learning opportunities ☒	Practicum ☐

Lesson Delivery – main mode of delivery chosen to support student teachers in achieving the learning outcomes.	**Face-to-face:** opportunity for an extended and coherent line of argument. It includes discussion, brainstorming, question and answer, etc. This can be tutor and / or student teacher led. It should not usually be the main mode. **Independent study:** to enable students to engage with relevant and appropriate materials to promote individual and collaborative enquiry, more in-depth analysis and development. This can be part of any of the above modes **E-learning *opportunities*** – involving the use of interactive packages and virtual learning environments. This can be part of any of the above modes of delivery. It is unlikely to be a delivery mode in its own right.

• **Purpose for the lesson, what you want the students to achieve, serves as basis for the learning outcomes. An expanded version of the description.**	The purpose of the lesson is to; • build on thecontent knowledge and experiences of student teachers to establish their competence in handling sequences and series problems and address their learning needs, perceptions and misconceptions about it. • develop student teachers' understanding of sequences and series and how to apply these concepts in other fields of mathematics. • to develop student teachers' conceptual knowledge in order to prepare them well enough to be able to handle concepts sequences and series as required by the JHS curriculum. • To create awareness of the student teachers in building on what has been learnt previously in year 1 semester 2 (Number and algebra)

• **Learning Outcome for the lesson, picked and developed from the course specification** • **Learning indicators for each learning outcome**	**Learning Outcomes**	**Learning Indicators**	**Identify Which cross-cutting issues- core and transferable skills, inclusivity, equity and addressing diversity. How will these be addressed or developed?**
	• Demonstrate the understanding of Sequences and Series (NTS 2c, 3i, NTECF Pillar 1) • Use a variety of	• Identify and analyse the characteristics and the properties of sequences and series • Evaluate a defined sequences and series	• Problem solving, critical and creative thinking:through objective analysis of facts and concepts • Communication skills: through discussion, critiquing and presentations of results • Respect and diversity: designing lesson

| | activities or ways in learning Sequences and Series concepts. (NTS 3e, 3f, 3g, 3k, 3l, 3m, 3n, 3o, 3p NTECF pillar 4) | within a set of strategies and illustrate how these concepts are applied in real lie situations, as well as, in teaching | for diverse learners with different learning styles
• Personal development: Through presentation and developing of arguments to ensure the development of conceptual understanding |
| | • Demonstrate value as well as respect for equity and inclusion in the mathematics classroom. (NTS, 2f) | • Identify and outline strategies used in the basic school curriculum for teaching the development of sequences from number arrays in their collaborative group work on sequences and series | • Equity and inclusivity: Providing equitable learning opportunities for all learners. |

Topic	Sub-topic(s)	Stage/ Time	Teaching and learning to activities to achieve learning outcomes depending on delivery mode selected. Teacher-lead collaborative groupwork or independent.	
			Teacher Activity	Student Activity
Arithmetic Sequences and Series: Learning and applying .	Meaning and types of arithmetic sequences and series;	40 mins	Introduce the concept of sequence using counting, skip counting, calendar and other number arrays.	Explore the concept of sequences through counting, skip counting, calendar and other number arrays. Eg. | 1	2	3	4
5			
6	7	8	9
10			
11	12	13	14	 1, 6, 11 , …; 6,7,8,…; 3,9,15,… etc.
	Finding the general (nth) term of arithmetic sequences and series	40 mins	Model exploration of types (finite and infinite) arithmetic sequences and series,	Use interactive and collaborative group work, with the aid of ICT tools and other manipulatives to explore the types of arithmetic progression (AP).
	Finding sum of n terms of arithmetic sequences (series)	40 mins	Initiate an investigation to establish the rule for finding the nth term of arithmetic progression. Eg. Find the 7th term of 3,9,15, … Assign student teachers to work more examples on AP.	Use interactive and collaborative group work, with the aid of ICT tools and other manipulatives to explore the nth term of arithmetic progression. (ie. $U_n = a + (n-1)d$, Where "a" is the first term, n is number of terms, d common difference and U_n the general or indicated term. Work more examples on APs.
	Application of	40 mins	Initiate an investigation to establish the rule for finding the sum of the first n terms	Use interactive and collaborative group work, with the aid of ICT tools and other manipulatives to explore the sum of the first n terms of arithmetic progression. (ie. $S_n = \frac{n}{2}\{2a + (n-1)d\}$, where a is

			of arithmetic progression	first term, n is number of terms, d common difference and S_n the sum of the first "n" terms of the given sequence. Work more examples on sum of Aps
arithmetic sequences and series			Assign student teachers to work more examples on AP.	
		20 mins	Assign student teachers to pose and solve real life problems.	Pose and solve real life problems on AP for peer review.

Lesson assessments – evaluation of learning: of, for and as learning within the lesson	Group assignment for PTP 1. Students teachers are assigned to complete exercises on types of arithmetic sequences and series to be submitted for peer review (Assessment for learning) NTS 3h - Set meaningful tasks that encourages learner collaboration and leads to purposeful learning. (Assessment for learning) NTS 2f - Takes accounts of and respects learners' cultural, linguistic, socio-economic and educational backgrounds in planning and teaching 2. Student teachers to outline real life applications of arithmetic sequences and series and to design worksheets for presentation in class. (Assessment for learning) NTS 3j - Produces and uses a variety of teaching and learning resources including ICT, toenhance learning.
Instructional Resources	Globe, mathematical set, manila cards, permanent markers, oranges and a knife.
Required Text (core)	Gordor, B. K., Naandam, S. M., & Nkansah, B. K. (2012). *Core mathematics for senior high schools*. Accra: Sam-Woode Ltd. https://amsi.org.au/teacher_modules/Indices_and_logarithms.html. *Retrieved 20-06-2019*
Additional Reading List	Ministry of Education (2015). *Core mathematics modules for SEIP*. Accra: Ministry of Education. Ministry of Education. (2010). *Teaching syllabus for core mathematics* (Senior High School). Accra: Ministry of Education, Science and Sports. Martin, J. et. al. (1994). *Mathematics for teacher training in Ghana: Tutor notes*. Accra: Unimax Publishers. Martin, J. et. al. (1994). *Mathematics for teacher training in Ghana: Students activities*.Accra: Unimax Publishers.
CPD NEEDS	• How to design and/or use some innovative materials and ideas for teaching selected concepts in arithmetic sequences and series. • Instructional strategies needed to consciously connect mathematical ideas, as well as, connect mathematics to other curriculum areas and to the world outside • Design and use of number arrays to generate arithmetic sequences

Lesson 3

Year of B.Ed.	2	Semester	1	Place of lesson in semester	1 2 **3** 4 5 6 7 8 9 10 11 12

Title of Lesson	Sequences and Series: *Learning, teaching and applying 2*	Lesson Duration	3 Hours
Lesson description	This is the third lesson under the topic Further Algebra in Year two Semester 1. Number and Algebra treated in Year one Semester two as well as SHS mathematics curriculum are pre-requisite of this lesson. The concept of sequences and series has been discussed in lesson one, with emphasis on arithmetic progression, to enable student teachers to audit their content knowledge and experiences to establish and address their learning needs, perceptions and misconceptions in sequences and series. The areas to be covered include review of arithmetic sequences, establishing the nth term and sum of a Geometric Progression (GP) and application of geometric sequences and series to solving real life problems. The lesson begins with starters or mental mathematics games, reinforcement games and activities about knowledge of sequences. The main lesson focuses on reviewing the student teachers' conceptual understanding of sequences and series**.**		
Previous student teacher knowledge, prior learning (assumed)	Student teachers have knowledge on operations of numbers and their properties from Basic School mathematics, JHS mathematics and, sequences and series from SHS Core mathematics.		
Possible barriers to learning in the lesson	Different entry behaviours, Socio-cultural issues, different learning needs, Some student teachers may come to SHS schools where they did not have teachers or good mathematics teachers to support them understand advanced concepts in Sequences and Series.		

Lesson Delivery – chosen to support students in achieving the outcomes	Face-to-face ☒	Practical Activity ☒	Work-Based Leaning ☐	Seminars ☐	Independent Study ☐	e-learning opportunities ☒	Practicum ☐

Lesson Delivery – main mode of delivery chosen to support student teachers in achieving the learning outcomes.	**Face-to-face:** opportunity for an extended and coherent line of argument. It includes discussion, brainstorming, question and answer, etc. This can be tutor and / or student teacher led. It should not usually be the main mode. **Practical Activity:** enabling experimentation and the analysis and discussion of issues, documents and materials, as well as physical activities. **Independent study:** to enable students to engage with relevant and appropriate materials to promote individual and collaborative enquiry, more in-depth analysis and development. This can be part of any of the above modes **E-learning *opportunities*** – involving the use of interactive packages and virtual learning environments. This can be part of any of the above modes of delivery. It is unlikely to be a delivery mode in its own right.

• **Purpose for the lesson, what you want the students to achieve, serves as basis for the learning outcomes. An expanded version of the description.**	The purpose of the lesson is to: • build on the content knowledge and experiences of student teachers to establish their competence in handling sequences and series problems and address their learning needs, perceptions and misconceptions about it. • develop student teachers' understanding of sequences and series and how to apply these concepts in other fields of mathematics • develop student teachers' conceptual knowledge in order to prepare them well enough to be able to handle concepts sequences and series as required by the JHS curriculum.

• **Learning Outcome for the lesson, picked and developed from the course specification** • **Learning indicators for each learning outcome**	**Learning Outcomes**	**Learning Indicators**	**Identify Which cross-cutting issues- core and transferable skills, inclusivity, equity and addressing diversity. How will these be addressed or developed?**
	• Demonstrate knowledge and conceptual understanding of fundamental ideas underlying the principles of geometric sequences and	• Identify and analyse fundamental ideas underlying the principles of geometric sequences and series and to present their findings	• Use of ICT: use Excel and other spreadsheets to explore different types of sequences to discover the need forIntegrating ICT in developing number and algebraic concepts in the mathematics classroom. *(CLO 2)* • Problem solving, critical and creative thinking:through objective analysis of facts and concepts

| | | | series; (NTS 2c, 3i, NTECF Pillar 1) • Demonstrate knowledge and understanding of how to use a variety of activities or ways in learning concepts based on geometric sequences and series, including finding the general (nth) term of geometric sequences and series
N(TS 3e, 3f, 3g, 3k, 3l, 3m, 3n, 3o, 3p NTECF pillar 4)
• Demonstrate value as well as respect for equity and inclusion in the mathematics classroom.(NTS, 2f) | • Make connections between mathematical concepts in geometric sequences and series and to apply them in teaching and solving real-life problems, as well as, similar concepts in JHS mathematics curriculum

• Participate in collaborative group work on geometric series and sequences and support others in their groups who might need it | • Personal development: Through presentation and developing of arguments to ensure the development of conceptual understanding

• Equity and inclusivity: Providing equitable learning opportunities for all learners |

Topic	**Sub-topic(s)**	**Stage/ Time**	**Teaching and learning to activities to achieve learning outcomes depending on delivery mode selected. Teacher-lead collaborative groupwork or independent.**	
			Teacher Activity	**Student Activity**
Geometric Sequences and Series: Learning and applying	Meaning and types of geometric sequences and series;	**40 mins**	Introduce the concept of geometric sequence using the notion of repeated multiplication.	Explore the concept of geometric sequences through using the notion of repeated multiplication. Eg. The repeated factors $2, \quad 2 \times 2, \quad 2 \times 2 \times 2, \quad 2 \times 2 \times 2 \times 2, \dots$ will lead to the sequence $2, 4, 8, 16, \dots$ which satisfies the rules of a GP
	Finding the general (nth) term of geometric sequences and series	**40 mins**	Model exploration of types (finite and infinite) geometric sequences and series,	Use interactive and collaborative group work, with the aid of ICT tools and other manipulatives to explore the types of geometric progression. Eg divergent, convergent, etc
	Finding sum of n terms of geometric sequences (series)	**40 mins**	Initiate an investigation to establish the rule for finding the nth term of geometric progression.	Use interactive and collaborative group work, with the aid of ICT tools and other manipulatives to explore the nth term of geometric progression. (ie. $U_n = ar^n$)Where "a" is the first term, n is number of terms, r, the common ratio and U_n the general or indicated term of a GP.

	Application of geometric sequences and series		Eg. Find the 7th term of 3,9,15, … Assign student teachers to work more examples on GP.	Work more examples on GPs.
		40 mins	Initiate an investigation to establish the rule for finding the sum of the first n terms of geometric progression Assign student teachers to work more examples on GP.	Use interactive and collaborative group work, with the aid of ICT tools and other manipulatives to explore the sum of the first n terms of a progression. (ie. $S_n = \frac{a(r^n - 1)}{r-1}$, $r > 1$ or $S_n = \frac{a(1-r^n)}{1-r}$, $r < 1$, where "a" is first term, n is number of terms, r common ration and S_n the sum of the first n terms of the given sequence. Work more examples on sum of GPs
		20 mins	Assign student teachers to pose and solve real life problems involving GP.	Pose and solve real life problems on AP for peer review.

Lesson assessments – evaluation of learning: of, for and as learning within the lesson	Class discussions 1. Students teachers are assigned to complete exercises on geometric sequences and series to be submitted for peer review in class (Assessment for learning) NTS 3j - Produces and uses a variety of teaching and learning resources including ICT, toenhance learning. 2. Student teachers to outline real life applications of geometric sequences and series and to design worksheets for presentation in class. (Assessment for learning) NTS 3j - Produces and uses a variety of teaching and learning resources including ICT, to enhance learning.
Instructional Resources	Graph sheets, mathematical set, manipulative materials, permanent markers, calculators, mobile phones, Geogebra Apps.;
Required Text (core)	Gordor, B. K., Naandam, S. M., & Nkansah, B. K. (2012). *Core mathematics for senior high schools*. Accra: Sam-Woode Ltd. https://amsi.org.au/teacher_modules/Indices_and_logarithms.html. *Retrieved 20-06-2019*
Additional Reading List	Ministry of Education (2015). *Core mathematics modules for SEIP*. Accra: Ministry of Education. Ministry of Education. (2010). *Teaching syllabus for core mathematics* (Senior High School). Accra: Ministry of Education, Science and Sports. Martin, J. et. al. (1994). *Mathematics for teacher training in Ghana: Tutor notes*. Accra: Unimax Publishers. Martin, J. et. al. (1994). *Mathematics for teacher training in Ghana: Students activities*.Accra: Unimax Publishers.
CPD NEEDS	• How to design and/or use some innovative materials and ideas for teaching selected concepts in geometric sequences and series. • Instructional strategies needed to consciously connect mathematical ideas, as well as, connect mathematics to other curriculum areas and to the world outside

Lesson 4

Year of B.Ed.	2	Semester	1	Place of lesson in semester	1 2 3 **4** 5 6 7 8 9 10 11 12

Title of Lesson	Quadratic functions: *Learning, teaching and applying*	Lesson Duration	3 Hours

Lesson description	This is the fourth lesson under the topic Further Algebra in Year two Semester 1. Knowledge and understanding of concepts acquired by studying Number and Algebra treated in Year one Semester two, as well as, topics covered in SHS core mathematics curriculum are pre-requisites for this lesson. To help student teachers develop conceptual understanding of concepts in this lesson, some fundamental concepts in quadraticequations (studied at the SHS) will be reviewed. This will enable student teachers to audit their content knowledge and experiences to establish and address their learning needs, perceptions and misconceptions in quadratic equations and to support them continue to keep them in focus about their journey of becoming mathematics teachers at the JHS level. The areas to be covered include Nature and types of quadratic functions; Forming quadratic functions, expressing a quadratic function in the form: $y = ax^2 + bx + c$ and $f(x) = a(x - b)^2 \pm c$. Methods of solving quadratic equations, graphs of quadratic functions; application of quadratics to solve real life problems. The lesson begins with starters or mental mathematics games, reinforcement games and activities about knowledge of sequences. The main lesson focuses on reviewing the student teachers' conceptual understanding of quadratic equations in order to prepare them to handle future mathematics classroom with respect to quadratic equations, their applications and other related concepts.
Previous student teacher knowledge, prior learning (assumed)	Student teachers have knowledge on operations of numbers and their properties from Basic School mathematics, JHS mathematics and, sequences and series from SHS Core mathematics.
Possible barriers to learning in the lesson	Different entry behaviours, Socio-cultural issues, different learning needs, Some student teachers may come to SHS schools where they did not have teachers or good mathematics teachers to support them understand advanced concepts in Quadratic functions.

Lesson Delivery – chosen to support students in achieving the outcomes	Face-to-face ☒	Practical Activity ☒	Work-Based Leaning ☐	Seminars ☐	Independent Study ☐	e-learning opportunities ☒	Practicum ☐

Lesson Delivery – main mode of delivery chosen to support student teachers in achieving the learning outcomes.	**Face-to-face:** opportunity for an extended and coherent line of argument. It includes discussion, brainstorming, question and answer, etc. This can be tutor and / or student teacher led. It should not usually be the main mode. **Practical Activity:** enabling experimentation and the analysis and discussion of issues, documents and materials, as well as physical activities. **Independent study:** to enable students to engage with relevant and appropriate materials to promote individual and collaborative enquiry, more in-depth analysis and development. This can be part of any of the above modes **E-learning *opportunities*** – involving the use of interactive packages and virtual learning environments. This can be part of any of the above modes of delivery. It is unlikely to be a delivery mode in its own right.
• **Purpose for the lesson, what you want the students to achieve, serves as basis for the learning outcomes. An expanded version of the description.**	**The purpose of the lesson is to;** • build thepedagogical content knowledge and experiences of student teachers to help develop their competencies and level of confidence in handling quadratic equations and related concepts to address their learning needs, perceptions and misconceptions about it. • develop student teachers' understanding of quadratic equations and how to apply these concepts in other areas of mathematics • to develop student teachers' conceptual knowledge in order to prepare them well enough to be able to handle concepts of quadratic equations as required by the JHS mathematics curriculum.

• Learning Outcome for the lesson, picked and developed from the course specification • Learning indicators for each learning outcome	Learning Outcomes	Learning Indicators	Identify Which cross-cutting issues- core and transferable skills, inclusivity, equity and addressing diversity. How will these be addressed or developed?
	• Demonstrate knowledge and the understanding of quadratic functions (NTS 2c, 3i, NTECF Pillar 1) • Use a variety of activities or ways in learning quadratic functions concepts. (NTS 3e, 3f, 3g, 3k, 3l, 3m, 3n, 3o, 3p NTECF pillar 4) • Demonstrate value as well as respect for equity and inclusion in the mathematics classroom. (NTS, 2f)	• Identify and analyse the characteristics and the properties of quadratic functions • Use age appropriate subject knowledge, pedagogical content knowledge that can be used to teach concepts related to quadratic functions found in the Basic School Curriculum in a broad, balanced, relevant and creative manner. • Identify and demonstrate the need for participating and supporting others to succeed in collaborative group work on quadratic functions	• Digital literacy: doing internet search for relevant information on strategies for exploring the properties of quadratic functions • Deep understanding of the subject content and ability to teach this using teaching and assessment strategies appropriate for JHS. • Consideration for formal abstract teaching • Collaboration between teachers of other subjects (e.g. Mathematics teaching vectors or trigonometry in collaboration with ICT teacher) • Equity and inclusivity: Providing equitable learning opportunities for all learnersand Identifying student teachers who might need intensive interventions and plan accordingly (identify support human resources)

Topic	Sub-topic(s)	Stage/Time	Teaching and learning to activities to achieve learning outcomes depending on delivery mode selected. Teacher-lead collaborative groupwork or independent.	
			Teacher Activity	Student Activity
Quadratic functions: *Learning, teaching and applying*	Nature and types of quadratic functions;	40 mins	Engage student teachers to give their past experiences of how they were taught quadratic functions previously.	Outline and discuss the learning trajectory their mathematics teachers at the SHS used in teaching quadratic functions and to suggest strategies that can be used to model effective teaching.
	Forming quadratic functions expressing a quadratic function in the form: $y = ax^2 + bx + c,$ and $f(x) = a(x-b)^2 \pm c.$	60 mins	Introduce student teachers to practical everyday activities to generate sequences that can be used to form quadratic expressions, e.g., handshake problem, algebraic tiles, etc., *(PD Theme 1)*	Use handshake and other practical activities to explore sequences that form quadratic expressions. <table><tr><td>No. of people</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>…</td></tr><tr><td>No. of hand shakes</td><td>0</td><td>1</td><td>3</td><td>6</td><td>15</td><td>…</td></tr></table> The sequence 0, 1, 3, 6, 15, … above can be used to form quadratic function of the form $f(n) = \frac{n(n+1)}{2}$ Or $f(n) = \frac{1}{2}(n^2 + n)$

		40 mins	Lead an investigation to explore the nature of quadratic expressions by finding common differences between consecutive terms, as well as, using ICT tools.	Explore the nature of quadratic expressions by finding common differences between consecutive terms, using differentiated teaching with the aid of aid of ICT tools such as Geogebra (software).
		40 mins	Engage student teachers to use interactive group work using ICT to explore the roots of quadratic equations, finding sums and products of given equations and to establish other quadratic equations based on given roots.	Use group activities, supported by ICT tools to explore the roots of quadratic equations, finding sums and products of given equations and to establish other quadratic equations based on the given roots. Solving quadratic equations by factorization, completing the square, the general quadratic formula and graphical approach, through student-teacher initiated and tutor supported presentations. Expressing quadratic function in the form $f(x) = a(x - b)^2 \pm c$ by method of completing the square in small groups.

Lesson assessments – evaluation of learning: of, for and as learning within the lesson	Student teachers to discuss and begin building their professional teaching portfolios (PTP) to be presented at end of the 10th week of the semester. Student teachers are assigned to complete exercises on quadratic functions to be submitted for peer review (Assessment for learning) NTS 3j-Produces and uses a variety of teaching and learning resources including ICT, to enhance learning.
Instructional Resources	Graph sheets, mathematical set, manipulative materials, permanent markers, calculators, mobile phones, Geogebra Apps.;
Required Text (core)	Gordor, B. K., Naandam, S. M., & Nkansah, B. K. (2012). *Core mathematics for senior high schools*. Accra: Sam-Woode Ltd. https://amsi.org.au/teacher_modules/Indices_and_logarithms.html. *Retrieved 20-06-2019*
Additional Reading List	Ministry of Education (2015). *Core mathematics modules for SEIP*. Accra: Ministry of Education. Ministry of Education. (2010). *Teaching syllabus for core mathematics* (Senior High School). Accra: Ministry of Education, Science and Sports. Martin, J. et. al. (1994). *Mathematics for teacher training in Ghana: Tutor notes*. Accra: Unimax Publishers. Martin, J. et. al. (1994). *Mathematics for teacher training in Ghana: Students activities*.Accra: Unimax Publishers.
CPD NEEDS	• How to design and/or use some innovative materials and ideas for teaching selected concepts in quadratic equations, e.g., handshake problem, algebraic tiles • Instructional strategies needed to consciously connect mathematical ideas, as well as, connect mathematics to other curriculum areas and to the world outside • How to use Geogebra (software) to explore concepts based on quadratic functions.

Lesson 5

Year of B.Ed.	2	**Semester**	1	**Place of lesson in semester**	1 2 3 4 **5** 6 7 8 9 10 11 12

Title of Lesson	Quadratic functions: *Learning, teaching and applying 2*	**Lesson Duration**	**3 Hours**
Lesson description	This is the fifth lesson under the topic Further Algebra in Year two Semester 1. Quadratic equations in lesson four of year two semester 1, as well as SHS mathematics curriculum are pre-requisite of this lesson. Basic concepts in quadratic equations studied at the SHS will be reviewed to enable student teachers to audit their content knowledge and experiences to establish and address their learning needs, perceptions and misconceptions in quadratic equations. The areas to be covered include Roots of quadratic equations; nature of roots, quadratic inequalities and application of quadratics to solve real life problems. The lesson begins with starters or mental mathematics games, reinforcement games and activities about knowledge gained from the previous lessons. The lesson focuses on reviewing the student teachers' conceptual understanding of quadratic equations in order to prepare them to handle future mathematics classroom with respect to quadratic equations and their applications.		
Previous student teacher knowledge, prior learning (assumed)	Student teachers have knowledge on operations of numbers and their properties from Basic School mathematics, JHS mathematics and SHS sequences and series from SHS Core mathematics.		
Possible barriers to learning in the lesson	Different entry behaviours, Socio-cultural issues, different learning needs, Some student teachers may come to SHS schools where they did not have teachers or good mathematics teachers to support them understand advanced concepts in Quadratic functions.		

Lesson Delivery – chosen to support students in achieving the outcomes	**Face-to-face** ☒	**Practical Activity** ☒	**Work-Based Leaning** ☐	**Seminars** ☐	**Independent Study** ☐	**e-learning opportunities** ☒	**Practicum** ☐

Lesson Delivery – main mode of delivery chosen to support student teachers in achieving the learning outcomes.	**Face-to-face:** opportunity for an extended and coherent line of argument. It includes discussion, brainstorming, question and answer, etc. This can be tutor and / or student teacher led. It should not usually be the main mode. **Practical Activity:** enabling experimentation and the analysis and discussion of issues, documents and materials, as well as physical activities. **Independent study:** to enable students to engage with relevant and appropriate materials to promote individual and collaborative enquiry, more in-depth analysis and development. This can be part of any of the above modes **E-learning *opportunities*** – involving the use of interactive packages and virtual learning environments. This can be part of any of the above modes of delivery. It is unlikely to be a delivery mode in its own right.

• **Purpose for the lesson, what you want the students to achieve, serves as basis for the learning outcomes. An expanded version of the description.**	**The purpose of the lesson is to;** • build the pedagogical content knowledge and experiences of student teachers to help develop their competencies and level of confidence in handling quadratic equations inequalities and related concepts to address their learning needs, perceptions and misconceptions about it. • develop student teachers' conceptual understanding, procedural fluency, and strategic competence needed to apply the knowledge gained in this lesson in other areas of mathematics • to develop student teachers' conceptual knowledge in order to prepare them well enough to be able to handle concepts of quadratic equations and related concepts as required by the JHS mathematics curriculum.

• **Learning Outcome for the lesson, picked and developed from the course specification** • **Learning indicators for each learning outcome**	**Learning Outcomes**	**Learning Indicators**	**Identify Which cross-cutting issues- core and transferable skills, inclusivity, equity and addressing diversity. How will these be addressed or developed?**
	• Demonstrate knowledge and understanding of quadratic equations and inequalities (NTS 2c, 3i, NTECF Pillar 1)	• Identify and analyse strategies for solving problems in quadratic equations inequalities and discussing with peers	• Social and communication skills: through developing specific literacy and language of mathematics to support learnersto communicate their mathematical thinking

	• Demonstrate competencies in the use of variety of well-designed activities based on multiple representations in a hands-on learning mode to develop concepts based on quadratic equations and inequalities. (NTS 3e, 3f, 3g, 3k, 3l, 3m, 3n, 3o, 3p NTECF pillar 4) • Demonstrate value as well as respect for equity and inclusion in the learning and teaching of concepts based on quadratic equations and inequalities (NTS, 2f)	• Explain the strategies for solving quadratic equations and inequalities using multiple representation • Orchestrate well-planned instructional activities in a hands-on learning mode, using multiple representations including the use of ICT tools to develop concepts based on quadratic equations and inequalities • Identify gender roles visible in the curriculum (i.e. over-representation of boys in maths), personal bias and stereotypes as well as institutional discrimination within the subject	coherently for academic purposes • Use of ICT: Integrate ICT in developing number and algebraic concepts in the mathematics classroom • Personal development: Through presentation and developing of sound arguments • Inclusion and Equity:by producing learning opportunities that target specific themes in the subject matter, and encouraging all to participate

Topic	Sub-topic(s)	Stage/Time	Teaching and learning to activities to achieve learning outcomes depending on delivery mode selected. Teacher-lead collaborative groupwork or independent.	
			Teacher Activity	Student Activity
Quadratic functions: *Learning, teaching and applying 2*	Methods of solving quadratic equations Graphs of quadratic functions; Roots of quadratic equations; Nature of roots,	**10 mins**	Engage student teachers to give their knowledge on the previous lesson (quadratic functions)	Discuss and supply feedback on their knowledge on quadratics during the previous lesson.
		40 mins	Lead discussion on finding the various methods of solving quadratic equations	Participate in discussions for finding appropriate strategies for solving quadratic equations.
		40 mins	Supply student teachers with manipulative materials including graphs and graph sheets to analyze the relationships between the function $y = x^2$ and $y = ax^2 + bx + c$, as transformations.	Engage in interactive activities to explore relationships between the functions $y = x^2$ and $y = ax^2 + bx + c$, as transformations
		40 mins	Introduce student teachers to various interactive strategies to find roots of quadratic equations.	Use group activities, supported by ICT tools to explore the roots of quadratic equations, finding sums and products of given equations and to establish other quadratic equations based on the given roots. Outline and discuss the nature of roots of given quadratic equations and how this can

	Quadratic inequalities		Task student teachers to discuss the nature of roots of given quadratic equations and how this can inform the selection of solution strategies. *(PD Theme 1)*	inform the selection of solution strategies
		50 mins	Lead an investigation to explore the strategies for solving problems based on quadratic inequalities including algebraic and graphical, with the aid of ICT tools	Explore the strategies for solving problems based on quadratic inequalities including algebraic and graphical, with the aid of ICT tools using differentiated teaching.

Lesson assessments – evaluation of learning: of, for and as learning within the lesson	Project work for the semester
	    1.
	      a. Identify real life or practical activities that can generate quadratic sequences. Example, comparing number of people to number of handshake or the use of floor tiles and linoleum, etc.
	      b. Outline the appropriate procedures for designing your model and explain how to use it with specific example outlined.
	      c. State and justify which learning outcome(s) the design and use the TLMs will satisfy.
	
	    2 2. Design models for teaching quadratic expressions and equation
	NTS 3j - Produces and uses a variety of teaching and learning resources including ICT, toenhance learning,NTS 3h - Sets meaningful tasks that encourages learner collaboration and leads to purposeful learning, NTS 2f - Takes accounts of and respects learners' cultural, linguistic, socio-economic andeducational backgrounds in planning and teaching

Instructional Resources	Graph sheets, mathematical set, manipulatives, permanent markers, calculators, mobile phones, Geogebra Apps.;
Required Text (core)	Gordor, B. K., Naandam, S. M., & Nkansah, B. K. (2012). *Core mathematics for senior high schools*. Accra: Sam-Woode Ltd. https://amsi.org.au/teacher_modules/Indices_and_logarithms.html. *Retrieved 20-06-2019*
Additional Reading List	Ministry of Education (2015). *Core mathematics modules for SEIP*. Accra: Ministry of Education. Ministry of Education. (2010). *Teaching syllabus for core mathematics* (Senior High School). Accra: Ministry of Education, Science and Sports. Martin, J. et. al. (1994). *Mathematics for teacher training in Ghana: Tutor notes*. Accra: Unimax Publishers. Martin, J. et. al. (1994). *Mathematics for teacher training in Ghana: Students activities*. Accra: Unimax Publishers.
CPD NEEDS	• How to design and/or use some innovative materials and ideas for teaching selected concepts in further algebra • Instructional strategies needed to consciously connect mathematical ideas, as well as, connect mathematics to other curriculum areas and to the world outside • Using Geogebra and other resources to explore concepts in quadratic equations and inequalities.

Lesson 6

Year of B.Ed.	2	Semester	1	Place of lesson in semester	1 2 3 4 5 **6** 7 8 9 10 11 12

Title of Lesson	Polynomials: *Learning, teaching and applying*	Lesson Duration	3 Hours

Lesson description	This is the sixth lesson under the topic Further Algebra in Year two Semester 1. Number and Algebra treated in Year one Semester two is a pre-requisite of this lesson. Basic concepts in algebra and quadratic equations studied at the SHS will be reviewed to enable student teachers to audit their content knowledge and experiences to establish and address their learning needs, perceptions and misconceptions in quadratic equations. The areas to be covered include nature of polynomials, operations on polynomials; factorization of polynomials, The Remainder and Factor theorems and applications of polynomial functions to real life situations. The lesson begins with starters or mental mathematics games, reinforcement games and activities about knowledge gained from the previous lessons. The lesson focuses on reviewing the student teachers' conceptual understanding of polynomials in order to prepare them to handle future mathematics classroom with respect to polynomials and their applications.
Previous student teacher knowledge, prior learning (assumed)	Student teachers have knowledge on operations of numbers and their properties. They have also studied quadratic functions which is a type of polynomial function. Student teachers studied algebraic expressions as part of the mathematics they did in JHS, as well as, in SHS Core mathematics.
Possible barriers to learning in the lesson	Different entry behaviours, Socio-cultural issues, different learning needs, Some student teachers may come to SHS schools where they did not have teachers or good mathematics teachers to support them understand concepts in Polynomials.

Lesson Delivery – chosen to support students in achieving the outcomes	Face-to-face ⊠	Practical Activity ⊠	Work-Based Leaning ☐	Seminars ☐	Independent Study ⊠	e-learning opportunities ⊠	Practicum ☐

Lesson Delivery – main mode of delivery chosen to support student teachers in achieving the learning outcomes.	**Face-to-face:** opportunity for an extended and coherent line of argument. It includes discussion, brainstorming, question and answer, etc. This can be tutor and / or student teacher led. It should not usually be the main mode. **Practical Activity:** enabling experimentation and the analysis and discussion of issues, documents and materials, as well as physical activities. **Independent study:** to enable students to engage with relevant and appropriate materials to promote individual and collaborative enquiry, more in-depth analysis and development. This can be part of any of the above modes **E-learning *opportunities*** – involving the use of interactive packages and virtual learning environments. This can be part of any of the above modes of delivery. It is unlikely to be a delivery mode in its own right.
• Purpose for the lesson, what you want the students to achieve, serves as basis for the learning outcomes. An expanded version of the description.	**The purpose of the lesson is to;** • build of content knowledge and experiences of student teachers to establish their competence in handling concepts in polynomials and address their learning needs, perceptions and misconceptions in properties of polynomial functions.. • develop student teachers' conceptual understanding of polynomials so they can and apply such knowledge and understanding in other areas of mathematics, as well as, plan and teach related concepts in the JHS mathematics curriculum.

• Learning Outcome for the lesson, picked and developed from the course specification • Learning indicators for each learning	Learning Outcomes	Learning Indicators	Identify Which cross-cutting issues- core and transferable skills, inclusivity, equity and addressing diversity. How will these be addressed or developed?
	• Demonstrate knowledge and the understanding of fundamental	• Identify and analyse equations that define polynomial functions and explain to members in their group	• Social and communication skills: through developing specific literacy and language of mathematics to support learnersto communicate their mathematical thinking coherently for

outcome	concepts of polynomials. (NTS 2c, 3i, NTECF Pillar 1) • Demonstrate knowledge and understanding of how to connect concepts in polynomial functions to other mathematics concepts, other disciplines, and to real-life situations. (NTS 3e, 3f, 3g, 3k, 3l, 3m, 3n, 3o, 3p NTECF pillar 4) • Demonstrate value as well as respect for equity and inclusion in the mathematics classroom. (NTS, 2f)	• Identify the characteristics and properties of graphs of polynomial functions using ICT tools and other manipulatives and communicate ideas to peers • Compare the properties of operations on polynomial functions to those on numbers, e.g., commutative, associative, etc. • Identify how concepts in polynomials can be connected to other areas both within and outside mathematics • Solve problems based on polynomials using manipulatives and/or technology related strategies in a variety of ways to plan micro lessons that can support pupils with SEN in order to achieve their potential.	academic purposes • Use of ICT: Integrate ICT in developing number and algebraic concepts in the mathematics classroom • Personal development: Through presentation and developing of sound arguments • Respect and diversity: using problem solving strategies appropriate for diverse learners with different learning styles • Problem solving, critical and creativethinking**:**Making problem-solving a central focus of mathematics instructions as well as an integral component of assessment.

Topic	Sub-topic(s)	Stage/Time	Teaching and learning to activities to achieve learning outcomes depending on delivery mode selected. Teacher-lead collaborative groupwork or independent.	
			Teacher Activity	**Student Activity**
Polynomials: *Learning, teaching and applying*	Nature of polynomial functions; Operations on polynomials;	**30 mins** **30 mins** **40 mins** **20 mins**	Engage student teachers in a review of their previous knowledge on polynomial functions to audit their experiences and misconceptions Initiate a discussion to explore the nature of polynomial functions. Assign student teachers in collaborative groups, with the aid of ICT tools and other materials and models to explore operations on polynomial functions and their properties. Engage student teachers to evaluate given polynomial functions Lead student teachers to explore the Remainder and Factor theorems	Participate in a review of their previous knowledge on polynomial functions to audit their experiences and misconceptions to enable them to appreciate what they are likely to learn in the lesson, as well as, develop positive attitude towards the learning of mathematics as developing teachers. Explore the nature of polynomial functions up to cubic functions through a collaborative work with the aid of manipulatives and/or relevant ICT tools. Explore operations and properties on polynomial functions using appropriate supporting materials, in groups.

			using the concept of Factor theorem to factorize cubic functions leading to finding of roots or zeros of given cubic equations, using independent study and group work	Evaluate a function at a point, x_o, ie. $f(x_o) = k$ through small group activities.
	Factorization of polynomials	**50 mins**		
	The Remainder and Factor theorems;			Explore the Remainder and Factor theorems using the concept of factor theorem to factorize cubic functions leading to finding of roots or zeros of given cubic equations, using independent study and group work.
		10 mins	Assign student teachers to explore applications of polynomial functions to real life problems.	
	Applications of polynomial functions.			Use directed and guided independent study or seminar to explore applications of polynomial functions to real life.
Lesson assessments – evaluation of learning: of, for and as learning within the lesson	1. Student teachers are assigned to outline and analyse thenature of polynomials. (Assessment as learning) NTS 3j - Produces and uses a variety of teaching and learning resources including ICT, to enhance learning. 2. Student teachers are assigned, in small groups, to do a brief internet search on the following: (to be presented for peer review)The Remainder Factor Theorem, Factorization of polynomials and Operation on polynomials.(Assessment as learning) NTS 3j - Produces and uses a variety of teaching and learning resources including ICT,toenhance learning.NTS 2b - Has comprehensive knowledge of the official school curriculum, includinglearning outcomes, NTS 2f - Takes accounts of and respects learners' cultural, linguistic, socio-economic and educational backgrounds in planning and teaching. Student teachers are assigned,in small groups,to reflect on their own learning experiences and understanding of polynomials and how to apply it in real-life problem-solving. (Assessment for learning) NTS 1a- Critically and collectively reflects to improve teaching and learning.			
Instructional Resources	Graph sheets, mathematical set, manila cards, permanent markers, calculators, mobile phones, Geogebra Apps.;			
Required Text (core)	Gordor, B. K., Naandam, S. M., & Nkansah, B. K. (2012). *Core mathematics for senior high schools*. Accra: Sam-Woode Ltd. https://amsi.org.au/teacher_modules/Indices_and_logarithms.html. *Retrieved 20-06-2019*			
Additional Reading List	Ministry of Education (2015). *Core mathematics modules for SEIP*. Accra: Ministry of Education. Ministry of Education. (2010). *Teaching syllabus for core mathematics* (Senior High School). Accra: Ministry of Education, Science and Sports. Martin, J. et. al. (1994). *Mathematics for teacher training in Ghana: Tutor notes*. Accra: Unimax Publishers. Martin, J. et. al. (1994). *Mathematics for teacher training in Ghana: Students activities*.Accra: Unimax Publishers.			
CPD NEEDS	How to design and/or use some innovative materials and ideas for teaching selected concepts in polynomial functions. Instructional strategies needed to consciously connect mathematical ideas, as well as, connect mathematics to other curriculum areas and to the world outside			

Lesson 7

Year of B.Ed.	2	**Semester**	1	**Place of lesson in semester**	1 2 3 4 5 6 **7** 8 9 10 11 12

Title of Lesson	Indices and Logarithm: *Learning, teaching and applying*	**Lesson Duration**	**3 Hours**
Lesson description	This is the seventh lesson under the topic Further Algebra in Year two Semester 1. Number and Algebra treated in Year one Semester two is a pre-requisite of this lesson. The areas to be covered include thedefinitions of indices and logarithms establishing relationship between Indices and Logarithms, Laws of indices and logarithm. The lesson begins with starters or mental mathematics games, reinforcement games and activities about knowledge of indices and logarithms. The main lesson focuses on reviewing the student teachers' conceptual understanding of indices and logarithms. Traditionally, indices and logarithms are taught as separate entities with emphasis on developing and using procedures. In this lesson, conscious effort will be made to connect related concepts using interactive pedagogy using appropriate tools to ensure effective participation by all student teachers.		
Previous student teacher knowledge, prior learning (assumed)	Student teachers have knowledge on operations of numbers and their properties from Basic School mathematics, JHS mathematics and quadratic and polynomials from SHS Core mathematics.		
Possible barriers to learning in the lesson	Different entry behaviours, Socio-cultural issues, different learning needs, Some student teachers may come to SHS schools where they did not have teachers or good mathematics teachers to support them understand concepts in Indices and Logarithm.		

Lesson Delivery – chosen to support students in achieving the outcomes	**Face-to-face** ☒	**Practical Activity** ☒	**Work-Based Leaning** ☐	**Seminars** ☐	**Independent Study** ☒	**e-learning opportunities** ☒	**Practicum** ☐

Lesson Delivery – main mode of delivery chosen to support student teachers in achieving the learning outcomes.	**Face-to-face:** opportunity for an extended and coherent line of argument. It includes discussion, brainstorming, question and answer, etc. This can be tutor and / or student teacher led. It should not usually be the main mode.
	Practical Activity: enabling experimentation and the analysis and discussion of issues, documents and materials, as well as physical activities.
	Independent study: to enable students to engage with relevant and appropriate materials to promote individual and collaborative enquiry, more in-depth analysis and development. This can be part of any of the above modes
	E-learning *opportunities* – involving the use of interactive packages and virtual learning environments. This can be part of any of the above modes of delivery. It is unlikely to be a delivery mode in its own right.

• **Purpose for the lesson, what you want the students to achieve, serves as basis for the learning outcomes. An expanded version of the description.**	**The purpose of the lesson is to**
	• build thecontent knowledge and experiences of student teachers to establish their competence in handling problems based on indices and logarithms and to address their learning needs, perceptions and misconceptions, as well as, develop the ability to plan a lesson on indices to be peer reviewed and included in a portfolio.
	• develop student teachers' conceptual understanding of indices and logarithms and how these concepts can be applied in other areas, as well as, plan micro lessons based on related concepts in the JHS mathematics curriculum
	• develop student teachers' conceptual knowledge in order to prepare them well enough to be able to handle concepts in indices and logarithms as required by the JHS curriculum.

• **Learning Outcome for the lesson, picked and developed from the course specification** • **Learning indicators for each learning**	**Learning Outcomes**	**Learning Indicators**	**Identify Which cross-cutting issues- core and transferable skills, inclusivity, equity and addressing diversity. How will these be addressed or developed?**
	• Demonstrate the understanding of indices and Logarithm(NTS 2c, 3i, NTECF Pillar 1)	• Identify and analyse the characteristics and the properties of indices and logarithm	• Social and communication skills: through developing specific literacy and language of mathematics to support learners to communicate their

				mathematical thinking coherently for academic purposes
outcome	• Use a variety of activities or ways in learning indices and logarithm concepts. (NTS 3e, 3f, 3g, 3k, 3l, 3m, 3n, 3o, 3p NTECF pillar 4) • Demonstrate value as well as respect for equity and inclusion in the mathematics classroom. (NTS, 2f)		• Recognise an exponential function as a rule for applying a growth or decay factor, as well as, the inverse of a logarithmic function; • Graph exponential and logarithmic functions from numerical data and symbolic rules using multiple representation(including the use of ICT tools) • Recognise exponential and logarithmic functions from symbolic rules • Outline strategies for making otherwise reluctant peers in a collaborative group work wish to participate in an activity based on logarithm and indices.	• Use of ICT: Integrate ICT in developing number and algebraic concepts in the mathematics classroom • Personal development: Through presentation and developing of sound arguments • <mark>•</mark> Respect and diversity: using problem solving strategies appropriate for diverse learners with different learning styles • Problem solving, critical and creative thinking: Making problem-solving a central focus of mathematics instructions as well as an integral component of assessment.

Topic	Sub-topic(s)	Stage/Time	Teaching and learning to activities to achieve learning outcomes depending on delivery mode selected. Teacher-lead collaborative groupwork or independent.	
			Teacher Activity	**Student Activity**
Indices and Logarithm: *Learning, teaching and applying*	Definitions of indices and logarithms;	**30 mins** **40 mins**	• Engage student teachers to review their previous knowledge and experiences in their pre-tertiary institutions. • Encourage student teachers to define the concepts indices and logarithms in collaborative groups and to provide appropriate feedback.	• Participate effectively in the discussion by posing questions and giving comments to review their previous knowledge and past experiences with respect to indices and logarithms. • Discuss and present definitions of indices and logarithms in their groups.
	Establishing relationship between Indices and Logarithms	**50 mins** **20 mins**	• Lead a discussion to establish and analyse the relationship between the concepts; logarithm and indices and how this can be used to plan a micro lesson based on similar concepts in the JHS mathematics curriculum • Assign student teachers to outline properties relating the exponential and logarithmic functions	• Engage in internet search for literature on the meanings and computations of logarithm and indices as the basis for establishing the relationships between these concepts in the form of collaborative works. • Outline properties relating the exponential and logarithmic functions with the aid of manipulatives and/or ICT tools
	Laws of indices and logarithms	**40 mins**	• Initiate a discussion to explore the laws of logarithms and indices through problem solving.	• Explore the laws of logarithms and indices using with emphasis on analysing the inverse principle that connects logarithm to indices and vice versa.

Lesson assessments – evaluation of learning: of, for and as learning within the lesson	1. Student teachers are assigned to complete worksheet problems based on indices and logarithms to be submitted for peer assessment (Assessment of learning) NTS 3j - Produces and uses a variety of teaching and learning resources including ICT, toenhance learning. 2. Presentations of self-prepared notes on the concepts of indices and logarithms (Assessment as learning) NTS 1a - Critically and collectively reflects to improve teaching and learning, NTS 2f - Takes accounts of and respects learners' cultural, linguistic, socio-economic and educational backgrounds in planning and teaching 3. Student teachers to embark on group authentic assignments/in the form of project with presentations on the concept of indices and logarithms to promote creativity, innovation, critical thinking and problem- solving.(Assessment of learning) NTS 2f - Takes accounts of and respects learners' cultural, linguistic, socio-economic and educational backgrounds in planning and teaching
Instructional Resources	Graph sheets, mathematical set, manipulative materials, permanent markers, calculators, mobile phones, Geogebra Apps.;
Required Text (core)	Gordor, B. K., Naandam, S. M., & Nkansah, B. K. (2012). *Core mathematics for senior high schools*. Accra: Sam-Woode Ltd. https://amsi.org.au/teacher_modules/Indices_and_logarithms.html. *Retrieved 20-06-2019*
CPD NEEDS	• How to design and/or use some innovative materials and ideas for teaching selected concepts in indices and logarithms. • Instructional strategies needed to consciously connect mathematical ideas, as well as, connect mathematics to other curriculum areas and to the world outside

Lesson 8

Year of B.Ed.	2	Semester	1	Place of lesson in semester	1 2 3 4 5 6 7 **8** 9 10 11 12

Title of Lesson	Indices and Logarithm: *Learning, teaching and applying 2*	Lesson Duration	3 Hours
Lesson description	This is the eighth lesson under the topic Further Algebra in Year two Semester 1. Number and Algebra treated in Year one Semester two is a pre-requisite of this lesson. The areas to be covered include the operations on indices and logarithms, solving indicial and logarithm equations and applications of Indices and Logarithms. The lesson begins with starters or mental mathematics games, reinforcement games and activities about knowledge of indices and logarithms. The main lesson focuses on reviewing the student teachers' conceptual understanding of indices and logarithms. Traditionally, indices and logarithms are taught as separate entities with emphasis on developing and using procedures. In this lesson, conscious effort will be made to connect related concepts using interactive pedagogy using appropriate tools to ensure effective participation by all student teachers.		
Previous student teacher knowledge, prior learning (assumed)	Student teachers have knowledge on fundamental concepts in logarithms and indices. They also have knowledge and understanding of some concepts based on operations on logarithms and indices from their Basic School mathematics, and SHS Core mathematics.		
Possible barriers to learning in the lesson	Different entry behaviours, Socio-cultural issues, different learning needs, Some student teachers may come to SHS schools where they did not have teachers or good mathematics teachers to support them understand advanced concepts in Indices and Logarithms.		

Lesson Delivery – chosen to support students in achieving the outcomes	Face-to-face ⊠	Practical Activity ⊠	Work-Based Leaning ☐	Seminars ☐	Independent Study ☐	e-learning opportunities ⊠	Practicum ☐

Lesson Delivery – main mode of delivery chosen to support student teachers in achieving the learning outcomes.	**Face-to-face:** opportunity for an extended and coherent line of argument. It includes discussion, brainstorming, question and answer, etc. This can be tutor and / or student teacher led. It should not usually be the main mode. **Practical Activity:** enabling experimentation and the analysis and discussion of issues, documents and materials, as well as physical activities. **Independent study:** to enable students to engage with relevant and appropriate materials to promote individual and collaborative enquiry, more in-depth analysis and development. This can be part of any of the above modes **E-learning *opportunities*** – involving the use of interactive packages and virtual learning environments. This can be part of any of the above modes of delivery. It is unlikely to be a delivery mode in its own right.
• **Purpose for the lesson, what you want the students to achieve, serves as basis for the learning outcomes. An expanded version of the description.**	**The purpose of the lesson is to;** • build of content knowledge and experiences of student teachers to establish their competence in handling problems based on indices and logarithms and to address their learning needs, perceptions and misconceptions, as well as, develop the ability to plan a lesson on indices to be peer reviewed and included in a portfolio • develop student teachers' conceptual understanding of indices and logarithms and how these concepts can be applied in other areas, as well as, plan micro lessons based on related concepts in the JHS mathematics curriculum • develop student teachers' conceptual knowledge in order to prepare them well enough to be able to handle concepts in indices and logarithms as required by the JHS curriculum.

• **Learning Outcome for the lesson, picked and developed from the course specification** • **Learning indicators for**	**Learning Outcomes**	**Learning Indicators**	**Identify Which cross-cutting issues- core and transferable skills, inclusivity, equity and addressing diversity. How will these be addressed or developed?**
	• Demonstrate the understanding of strategies for solving exponential and	• Identify strategies for solving problems based on exponential and logarithmic equations	• Problem solving, critical and creative thinking**:** Making problem-solving a central focus of mathematics instructions as

	each learning outcome	logarithmic problems (NTS 2c, 3i, NTECF Pillar 1) • Demonstrate knowledge and understanding of the inverse principle as the strategy for solving indicial and logarithmic equations(NTS 3e, 3f, 3g, 3k, 3l, 3m, 3n, 3o, 3p NTECF pillar 4) • Demonstrate readiness to communicate ideas in a mathematics community of practice. (NTS 2c, 3i, NTECF Pillar 2)	• Use the inverse principle as a basis for solving indicial and logarithmic equations • Recognise and apply appropriate problem solving techniques and exhibiting confidence in explaining such strategies • Participate in the community of practice by sharing by findings in discussions	well as an integral component of assessment • Social and communication skills: through developing specific literacy and language of mathematics to support learners to communicate their mathematical thinking coherently for academic purposes • Problem solving, critical and creativethinking:Makingproblem-solving acentral focus of mathematics instructions as well as an integral component of assessment. • Personal development: Through presentation and group discussion. • Respect and diversity: designing activities and presentations suitable for diverse learners with different learning styles

Topic	Sub-topic(s)	Stage/Time	Teaching and learning to activities to achieve learning outcomes depending on delivery mode selected. Teacher-lead collaborative groupwork or independent.	
			Teacher Activity	**Student Activity**
Indices and Logarithm: Learning, teaching and applying	Operations on indices and logarithms;	**30 mins** **30 mins**	• Engage student teachers to review their previous knowledge and experiences in the previous lesson logarithms and indices. • Assign student to outline and analyse the properties of operations on logarithms and indices	• Participate effectively in the discussion by posing questions and giving comments to review their previous knowledge and past experiences with respect to the definitions of indices and logarithms and to establish relationship between indices and logarithms. This should include the revision on the laws of indices and logarithm • Outline andanalyse the properties of operations on logarithms and indices through the use of manipulatives and relevant ICT tools
	Indicial and logarithm equations;	**40 mins** **60 mins**	• Assign student teachers to Identify and use the inverse principle as a basis for solving exponential equations using logarithm and vice versa. • Engage student teachers in problem solving activities in small groups to be	• Identify and use the inverse principle as a basis for solving exponential equations using logarithm and vice versa. • Solve given problems and present their solutions for peer review. • Work on the assignment and present the work later for grading and feedback.

	Applications of Indices and Logarithms.	**20 mins**	submitted for peer review. • Assign student teachers to answer worksheet problems involving logarithms and indices.	
			• Task student teachers to outline areas including real life situations where logarithms and indices are applicable.	• Search on the internet and other sources on the application of logarithm and indices to real life situations business, economics, planning, and to write a reflective paper on their findings to be discussed later in class.
Lesson assessments – evaluation of learning:of, for and as learning within the lesson	1. Student teachers take a short (tutor-made) quiz based on exponential and logarithmic equations to be submitted for grading and feedback (Assessment of learning) NTS 3j– 2. Student teachers to embark on group project with presentations on the application of Indicial and logarithm equations to real life situations business, economics, planning, and to write a reflective paper on their findings to be discussed later in class. (Assessment of learning) NTS 2f - Takes accounts of and respects learners' cultural, linguistic, socio-economic andeducational backgrounds in planning and teaching			
Instructional Resources	Graph sheets, mathematical set, manila cards, permanent markers, calculators, mobile phones, Geogebra Apps.;			
Required Text (core)	Gordor, B. K., Naandam, S. M., & Nkansah, B. K. (2012). *Core mathematics for senior high schools*. Accra: Sam-Woode Ltd. https://amsi.org.au/teacher_modules/Indices_and_logarithms.html. *Retrieved 20-06-2019*			
Additional Reading List	Ministry of Education (2015). *Core mathematics modules for SEIP*. Accra: Ministry of Education. Ministry of Education. (2010). *Teaching syllabus for core mathematics* (Senior High School). Accra: Ministry of Education, Science and Sports. Martin, J. et. al. (1994). *Mathematics for teacher training in Ghana: Tutor notes*. Accra: Unimax Publishers. Martin, J. et. al. (1994). *Mathematics for teacher training in Ghana: Students activities*.Accra: Unimax Publishers.			
CPD NEEDS	• How to design and/or use some innovative materials and ideas for teaching selected concepts in further algebra. • Instructional strategies needed to consciously connect mathematical ideas, as well as, connect mathematics to other curriculum areas and to the world outside • Identifying and using mobile phones and other innovative resources in teaching concepts in indices and logarithms.			

Lesson 9

Year of B.Ed.	2	Semester	1	Place of lesson in semester	1 2 3 4 5 6 7 8 **9** 10 11 12

Title of Lesson	Binomial expansions: *Learning, teaching and applying*	Lesson Duration	3 Hours
Lesson description	This is the ninth lesson under the topic Further Algebra in Year two Semester 1. The pre-requisite of this lesson "Number and Algebra" which was treated in Year one Semester two. The areas to be covered in this lesson include Binomial expansions, Pascal's triangle, Binomial theorem, and the applications of Binomial theorem to real life. The lesson begins with starters or mental mathematics games, reinforcement games and activities about knowledge of algebraic expansion and factorisation. The main lesson focuses on reviewing the student teachers' conceptual understanding of Binomial theorem which includes binomial expansion and its applications. Interactive pedagogy will be used to encourage participation by all.		
Previous student teacher knowledge, prior learning (assumed)	Student teachers have knowledge on operations of numbers and their properties from Basic School mathematics, JHS mathematics and SHS Core mathematics.		
Possible barriers to learning in the lesson	Different entry behaviours, Socio-cultural issues, different learning needs, Some student teachers may come to SHS schools where they did not have teachers or good mathematics teachers to support them understand concepts in Binomial expansions.		

Lesson Delivery – chosen to support students in achieving the outcomes	Face-to-face ☒	Practical Activity ☒	Work-Based Leaning ☐	Seminars ☐	Independent Study ☐	e-learning opportunities ☒	Practicum ☐

Lesson Delivery – main mode of delivery chosen to support student teachers in achieving the learning outcomes.	**Face-to-face:** opportunity for an extended and coherent line of argument. It includes discussion, brainstorming, question and answer, etc. This can be tutor and / or student teacher led. It should not usually be the main mode. **Practical Activity:** enabling experimentation and the analysis and discussion of issues, documents and materials, as well as physical activities. **Independent study:** to enable students to engage with relevant and appropriate materials to promote individual and collaborative enquiry, more in-depth analysis and development. This can be part of any of the above modes **E-learning *opportunities*** – involving the use of interactive packages and virtual learning environments. This can be part of any of the above modes of delivery. It is unlikely to be a delivery mode in its own right.

• Purpose for the lesson, what you want the students to achieve, serves as basis for the learning outcomes. An expanded version of the description.	**The purpose of the lesson is to;** • build on content knowledge and experiences of student teachers to establish their competence in handling Binomial Theorem and address their learning needs, perceptions and misconceptions in binomial theorems and related concepts. • develop student teachers' understanding of binomial theorems and how to apply the knowledge and understanding in other areas of mathematics and beyond. • develop student teachers' conceptual knowledge in order to prepare them well enough to be able to handle concepts related to binomial theorem and its applications as required by the JHS curriculum.

• Learning Outcome for the lesson, picked and developed from the course specification • Learning indicators for each learning outcome	**Learning Outcomes**	**Learning Indicators**	**Identify Which cross-cutting issues-core and transferable skills, inclusivity, equity and addressing diversity. How will these be addressed or developed?**
	• Demonstrate knowledge and conceptual understanding of binomial theorem. (NTS 2c, 3i, NTECF Pillar 1)	• Identify and analyse patterns for developing binomial expansions and solving problems involving binomial expansions	• Problem solving, critical and creative thinking: Making problem-solving a central focus of mathematics instructions as well as an integral component of assessment. • Communication skills: through critiquing and presentations
	• Demonstrate	• Discuss how the	

competencies in using differentiated instructional strategies, to cater for the needs of all student teachers including those with SEN **(NTS 3f, pg. 14)**	Pascal's triangle can be used for modelling and solving problems involving Binomial expansion • Undertake small scale classroom enquiry focussed on children's learning and progress, demonstrating an emerging ability to reflect on their developing understanding of teaching, learning and assessing adolescents in Junior High School mathematics. (equity and inclusion) • Use a variety of manipulatives and other TLMs to promote differentiated learning of concepts based on binomial theorem and its application.	• Assessment for as and of learning**:** byprovidingstudent teachers an opportunity to develop strategies to guide adolescent children to engage in self-assessment, as well as, use other age-appropriate and learner-friendly assessment formats • Communicative skill**s:** would be enhanced through the examination, interrogation and presentation of the various principles in developing and using varying multimedia

Topic	Sub-topic(s)	Stage/Time	Teaching and learning to activities to achieve learning outcomes depending on delivery mode selected. Teacher-lead collaborative groupwork or independent.	
			Teacher Activity	**Student Activity**
Binomial expansions: *Learning, teaching and applying*	Binomial expansions; Binomial theorem. $(x+a)^n$, where n is rational and $n > 0$; Pascal's triangle;	**20 mins** **40 mins** **40 mins** **40 mins**	Lead student teachers in a discussion to review their knowledge and experiences on factoring and expanding algebraic expressions. Engage student teachers in an interactive group activity to develop the concept of binomial expansion through discussions and presentations, using the knowledge ofalgebraic tiles and understanding of indices Provide student teachers with isometric grid papers or any other manipulatives, including ICT tools to	Participate in a discussion to review their previous knowledge on algebraic expansion and factorisation. Develop the concept of binomial expansion through discussions and presentations, using the knowledge and understanding of indices, e.g. $(x+a)(x+a)=(x+a)^2 = x^2 + 2ax + a^2$. Use the isometric grid, algebraic tiles or any other manipulatives, including ICT tools to generate or build the Pascal's triangle. Express the coefficients of simple binomial expansions using the Pascal's triangle.
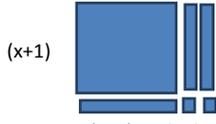
			generate or build the Pascal's triangle	Search for designs in fabrics and other cultural products or artefacts that possess such characteristics and use them to model pascal's triangle.
	Applications of binomial theorem to real life.	**20 mins**	Task student teachers to identify some cultural products and artefacts with designs that can be used to model Pascal's triangle	
		20 mins		
				Use the Pascal's triangle to expand binomials with higher powers through presentations.
			Assign student teachers to determine the coefficients of simple binomial expansions using the Pascal's triangle and/or any other relevant tool including ICT	Use the Pascal's triangle as a tool for expanding binomials with higher powers through presentations
			Engage student teachers to use the Pascal's triangle as a tool for expanding binomials with higher powers through presentations	

Lesson assessments – evaluation of learning: of, for and as learning within the lesson	1. Assign student teachers to identify and analyse the patterns characteristics of binomial expansions to be submitted for peer review (Assessment of learning) NTS 3j - Produces and uses a variety of teaching and learning resources including ICT, to enhance learning
Instructional Resources	Graph sheets, mathematical set, manipulative materials, isometric grid papers, permanent markers, calculators, mobile phones, Geogebra Apps.;
Required Text (core)	Gordor, B. K., Naandam, S. M., & Nkansah, B. K. (2012). *Core mathematics for senior high schools*. Accra: Sam-Woode Ltd. https://amsi.org.au/teacher_modules/Indices_and_logarithms.html. *Retrieved 20-06-2019*
Additional Reading List	Ministry of Education (2015). *Core mathematics modules for SEIP*. Accra: Ministry of Education. Ministry of Education. (2010). *Teaching syllabus for core mathematics* (Senior High School). Accra: Ministry of Education, Science and Sports. Martin, J. et. al. (1994). *Mathematics for teacher training in Ghana: Tutor notes*. Accra: Unimax Publishers. Martin, J. et. al. (1994). *Mathematics for teacher training in Ghana: Students activities*.Accra: Unimax Publishers.
CPD NEEDS	How to design and/or use some innovative materials and ideas for teaching selected concepts in binomial theorems. Instructional strategies needed to consciously connect mathematical ideas, as well as, connect mathematics to other curriculum areas and to the world outside

Lesson 10

Year of B.Ed.	2	Semester	1	Place of lesson in semester	1 2 3 4 5 6 7 8 9 **10** 11 12

Title of Lesson	Simultaneous equations: *Learning, teaching and applying*	**Lesson Duration**	**3 Hours**
Lesson description	This is the tenth lesson under the topic Further Algebra in Year 2 Semester 1. The pre-requisite of this lesson is "Number and Algebra" which was treated in Year one Semester two. Opportunity is offered to audit student teachers' content knowledge and experiences to establish and address their learning needs, perceptions and misconceptions about simultaneous equations. The areas to be covered include the concept and nature of simultaneous equations, evaluation of simultaneous equations and application of simultaneous equation to real life situations. The lesson begins with starters or mental mathematics games, reinforcement games and activities about knowledge of algebraic expansion and binomial theorem. The main lesson focuses on reviewing the student teachers' conceptual understanding of concepts based on simultaneous equations.		
Previous student teacher knowledge, prior learning (assumed)	Student teachers have knowledge on operations of numbers, and their properties from Basic School mathematics, binomials from JHS mathematics and SHS Core mathematics.		
Possible barriers to learning zin the lesson	Different entry behaviours, Socio-cultural issues, different learning needs, Some student teachers may come to SHS schools where they did not have teachers or good mathematics teachers to support them understand concepts in Simultaneous equations.		

Lesson Delivery – chosen to support students in achieving the outcomes	Face-to-face ☒	Practical Activity ☒	Work-Based Leaning ☐	Seminars ☐	Independent Study ☒	e-learning opportunities ☒	Practicum ☐

Lesson Delivery – main mode of delivery chosen to support student teachers in achieving the learning outcomes.	**Face-to-face:** opportunity for an extended and coherent line of argument. It includes discussion, brainstorming, question and answer, etc. This can be tutor and / or student teacher led. It should not usually be the main mode. **Practical Activity:** enabling experimentation and the analysis and discussion of issues, documents and materials, as well as physical activities. **Independent study:** to enable students to engage with relevant and appropriate materials to promote individual and collaborative enquiry, more in-depth analysis and development. This can be part of any of the above modes **E-learning *opportunities*** – involving the use of interactive packages and virtual learning environments. This can be part of any of the above modes of delivery. It is unlikely to be a delivery mode in its own right.

• **Purpose for the lesson, what you want the students to achieve, serves as basis for the learning outcomes. An expanded version of the description.**	**The purpose of the lesson is to;** • build on content knowledge and experiences of student teachers to establish their competence in handling simultaneous equation and address their learning needs, perceptions and misconceptions about simultaneous equation and related concepts. • develop student teachers' understanding of simultaneous equation and how to apply the knowledge and understanding in other areas of mathematics and beyond. • develop student teachers' conceptual knowledge in order to prepare them well enough to be able to handle concepts related to simultaneous equations and its applications as required by the JHS curriculum.

• **Learning Outcome for the lesson, picked and developed from the course specification** • **Learning indicators for each learning outcome**	**Learning Outcomes**	**Learning Indicators**	**Identify Which cross-cutting issues- core and transferable skills, inclusivity, equity and addressing diversity. How will these be addressed or developed?**
	1. Demonstrate the understanding of simultaneous equations	1. Identify and analyse the nature and the properties of simultaneous equations	• Problem solving, critical and creative thinking: Making problem-solving a central focus of mathematics instructions as well as an integral component of assessment

| | 2. Use a variety of activities or ways in learning simultaneous equations and other multiple variable equations and concepts in mathematics.

3. Understand, recognise, make visible and address stigma, bias and other forms of discrimination and other exclusion related matters in the curriculum, school and classrooms. | 2. Evaluate a given set of multiple equations at the same time and illustrate the results to aid in understanding the nature of simultaneous equations

3. Develop strategies to recognise, make visible and address stigma, bias and other forms of discrimination.

4. Pose problems that cater for diversity, equity and inclusivity | • Social and communication skills: through developing specific literacy and language of mathematics to support learnersto communicate their mathematical thinking coherently for academic purposes

• Respect and diversity: designing activities and presentations suitable for diverse learners with different learning styles

• Equity and inclusivity: Providing equitable learning opportunities for all learners

• Personal development: Through presentation and group discussion. |

Topic	Sub-topic(s)	Stage/Time	Teaching and learning to activities to achieve learning outcomes depending on delivery mode selected. Teacher-lead collaborative groupwork or independent.	
			Teacher Activity	**Student Activity**
Simultaneous equations: *Learning, teaching and applying*	Nature of simultaneous equations;	**40 mins**	Lead student teachers in a discussion to review their previous knowledge and conceptual understanding of the nature of simultaneous equation	Participate in a discussion to review their previous knowledge on algebraic expansion, factorisation, binomial expansion, and understanding of simultaneous equation in the JHS mathematics curriculum.
	Solving simultaneous equations,	**40 mins**	Assign student teachers in groups to use differentiated techniques or strategies to evaluate and analyse given sets of simultaneous equations	Use think pair share session to brainstorm techniques to explore the concept of simultaneous equations.
	Applications to real life.	**60 mins**	Assign student teachers in groups to use differentiated techniques or strategies such as elimination, substitution and graphical approaches in solving problems based on simultaneous equations	Solving simultaneous equations by method of elimination, substitution and graphical approaches and to analyse given systems of equations as having no solution, a unique solution, or infinitely many solutions.

		40 mins	Engage student-teachers to pose problems based on simultaneous equations from other disciplines such as Economics and Business real life situations using small group projects	Engaging student-teachers in applying simultaneous equations to real life situations such as determination of national income, household consumption, equilibrium prices, using small group projects.
Lesson assessments – evaluation of learning: of, for and as learning within the lesson	1. Student teachers to embark on group classroom exercise outline and discuss types and application of simultaneous equations to real life to real life situations business, economics, planning, and to write a reflective paper on their findings to be discussed later in class. (Assessment of learning) NTS 3h - Sets meaningful tasks that encourages learner collaboration and leads to purposeful learning.			
Instructional Resources	Mathematical set, manila cards, permanent markers, graph sheets.			
Required Text (core)	Gordor, B. K., Naandam, S. M., & Nkansah, B. K. (2012). *Core mathematics for senior high schools*. Accra: Sam-Woode Ltd. https://amsi.org.au/teacher_modules/Indices_and_logarithms.html. *Retrieved 20-06-2019*			
Additional Reading List	Ministry of Education (2015). *Core mathematics modules for SEIP*. Accra: Ministry of Education. Ministry of Education. (2010). *Teaching syllabus for core mathematics* (Senior High School). Accra: Ministry of Education, Science and Sports. Martin, J. et. al. (1994). *Mathematics for teacher training in Ghana: Tutor notes*. Accra: Unimax Publishers. Martin, J. et. al. (1994). *Mathematics for teacher training in Ghana: Students activities*.Accra: Unimax Publishers.			
CPD NEEDS	• How to design and/or use some innovative materials and ideas for teaching selected concepts in simultaneous equations • Instructional strategies needed to consciously connect mathematical ideas in simultaneous equations to the world outside			

Lesson 11

Year of B.Ed.	2	Semester	1	Place of lesson in semester	1 2 3 4 5 6 7 8 9 10 **11** 12

Title of Lesson	Matrices: *Learning, teaching and applying*	Lesson Duration	3 Hours

Lesson description	This is the eleventh lesson under the topic Further Algebra in Year two Semester 1. The pre-requisite of this lesson is "Number and Algebra" which was taught in Year one Semester two. Activities outlined in the lesson will enable student teachers to audit their content knowledge and experiences to establish and address their learning needs, perceptions and misconceptions in matrices. The areas to be covered include the Concept and definition of matrices, types of matrices, and operations on matrices. The lesson begins with starters or mental mathematics games, reinforcement games and activities about knowledge of operation of numbers. The main lesson focuses on reviewing the student teachers' conceptual understanding of matrices and operations on matrices. The interactive nature of the instructional strategies is meant for encouraging participation by all, irrespective of the entry behaviour of student teachers, especially those who have offered to pursue mathematics in the JHS specialism.
Previous student teacher knowledge, prior learning (assumed)	Student teachers have knowledge on operations of numbers and their properties from Basic School mathematics, JHS mathematics and SHS Core mathematics.
Possible barriers to learning in the lesson	Different entry behaviours, Socio-cultural issues, different learning needs, Some student teachers may come to SHS schools where they did not have teachers or good mathematics teachers to support them understand fundamental concepts in Matrices.

Lesson Delivery – chosen to support students in achieving the outcomes	Face-to-face ☒	Practical Activity ☒	Work-Based Leaning ☐	Seminars ☐	Independent Study ☐	e-learning opportunities ☒	Practicum ☐

Lesson Delivery – main mode of delivery chosen to support student teachers in achieving the learning outcomes.	**Face-to-face:** opportunity for an extended and coherent line of argument. It includes discussion, brainstorming, question and answer, etc. This can be tutor and / or student teacher led. It should not usually be the main mode. **Practical Activity:** enabling experimentation and the analysis and discussion of issues, documents and materials, as well as physical activities. **Independent study:** to enable students to engage with relevant and appropriate materials to promote individual and collaborative enquiry, more in-depth analysis and development. This can be part of any of the above modes **E-learning *opportunities*** – involving the use of interactive packages and virtual learning environments. This can be part of any of the above modes of delivery. It is unlikely to be a delivery mode in its own right. **Practicum (supported teaching in school):** support to enable student teachers to experience and learn from the basic school context by doing observations and child study in Y1 to full class teaching in and action research in Y4
• **Purpose for the lesson, what you want the students to achieve, serves as basis for the learning outcomes. An expanded version of the description.**	The purpose of the lesson is to; • build the content knowledge and experiences of student teachers to establish their competence in handling concepts based on matrices and to address their learning needs, perceptions and misconceptions about matrices and related concepts.. • develop student teachers' understanding of matrices and how to apply concepts in matrices to other areas of mathematics and beyond. • develop student teachers' conceptual knowledge in order to prepare them well enough to be able to handle concepts related to matrices as required by the JHS curriculum.

• Learning Outcome for the lesson, picked and developed from the course specification • Learning indicators for each learning outcome	Learning Outcomes	Learning Indicators	Identify Which cross-cutting issues-core and transferable skills, inclusivity, equity and addressing diversity. How will these be addressed or developed?
	1. Demonstrate knowledge and understanding of fundamental concepts and principles of matrices needed by developing teachers to build their confidence in planning and teaching some groups of adolescents. (NTS 2c, 3i, NTECF Pillar 1) Demonstrate the core and transferrable skills like problem solving and creativity and taking advantage of the affordances of ICT integrating it into teaching and learning **(NTS 3j, NTECF pillar 4,** 2. Demonstrate knowledge of age appropriate assessment strategies and recognise and support children's progress against appropriate developmental milestones and the expectations of the Junior High School mathematics Curriculum (NTS 3k,pg. 14) Demonstrate knowledge and understanding about how adolescents grow, develop and learn mathematics in Junior High School (professional values, knowledge & practice) (NTS, 2b)	• Identify and analyse the fundamental concepts and principles of matrices needed by developing teachers to build their confidence in planning and teaching some groups of adolescents • Determine age and level appropriate assessment strategies and recognise and support children's progress against appropriate developmental milestones and the expectations of the Junior High School mathematics Curriculum • Select and use appropriate ICT tools for modelling and solving problems involving matrices and related concepts. • Select and use developmentally appropriate strategies for teaching and assessment that emphasize the physical, cognitive, emotional and social development of the child. • recognise and support children's progress against appropriate developmental milestones • critique the expectations outlined for the Junior High Schoolmathematics Curriculum	• Commitment and passion for teaching: through developing student teachers' curriculum leadership and the holistic understanding needed for managing transition of learners from middle childhood (primary) to early adolescent (JHS) • Assessment for as and of learning: by providingsstudent teachers an opportunity to develop strategies to guide adolescent children to engage in self-assessment, as well as, use other age-appropriate and learner-friendly assessment formats • Use of ICT: Integrate ICT in developing number and algebraic concepts in the mathematics classroom • Respect and diversity: designing lesson for diverse learners with different learning styles • Equity and inclusivity: Providing equitable learning opportunities for all learners. • Communication skills: through critiquing and presentations.

Topic	Sub-topic(s)	Stage/Time	Teaching and learning to activities to achieve learning outcomes depending on delivery mode selected. Teacher-lead collaborative groupwork or independent.	
			Teacher Activity	**Student Activity**
Matrices: *Learning, teaching and applying*	The concept of matrices;	**30 mins**	Engage student teachers in a review of the previous lesson based on simultaneous equations by writing given simultaneous equations as coefficient matrices.	Participate in the review of the lesson on simultaneous equations by asking questions and giving comments to prepare their minds for the work ahead.
		60 mins	Introduce the lesson by describing real life contexts that can be modeled using matrices, e.g., arrangement of seats in the lecture hall, classroom, or other relevant places; the arrangement of louvre blades in buildings, etc.,	Pay attention to the narratives that prepare the ground for the development of the lesson based on matrices. Use investigations to explore fundamental concepts of matrices;
	Types of matrices; Symmetric	**30 mins**	Engage student teachers in a discussion to explore how to use matrices to represent data.	Participate actively in the discussion to explore representation of data using matrices.
	Operations and properties of matrices	**30 mins**	Provide opportunity for student teachers to identify, outline, and discuss the types of matrices using interactive pedagogy.	Explore the types (zero, unit, square etc.), properties and operations of matrices, using independent study and/or collaborative mixed-ability group work
		30 mins	Engage student teachers through interactive pedagogy to discuss the various operations and properties of matrices	Explore and discuss the various operations and properties of matrices and outline their implications for teaching matrices and related concepts found in JHS mathematics curriculum.
Lesson assessments – evaluation of learning: of, for and as learning within the lesson	**Student teachers to submit the following;** 1. a final portfolio in mathematics, with emphasis on Early Grade Curriculum and relative to theories of learning, **(Course work)**(Assessment as learning) NTS 3k - Integrates a variety of assessment modes into teaching to support learning. (30%) 2. Project work report on designing TLMs for teaching numeracy in early grade. **(Project)** (Assessment as learning) NTS 3h - Sets meaningful tasks that encourages learner collaboration and leads to purposeful learning. (30%)			
Instructional Resources	Graph sheets, mathematical set, manipulative materials, permanent markers, calculators, mobile phones, Geogebra Apps.;			
Required Text (core)	Gordor, B. K., Naandam, S. M., & Nkansah, B. K. (2012). *Core mathematics for senior high schools*. Accra: Sam-Woode Ltd. https://amsi.org.au/teacher_modules/Indices_and_logarithms.html. *Retrieved 20-06-2019*			
Additional Reading List	Ministry of Education (2015). *Core mathematics modules for SEIP*. Accra: Ministry of Education. Ministry of Education. (2010). *Teaching syllabus for core mathematics* (Senior High School). Accra: Ministry of Education, Science and Sports. Martin, J. et. al. (1994). *Mathematics for teacher training in Ghana: Tutor notes*. Accra: Unimax Publishers. Martin, J. et. al. (1994). *Mathematics for teacher training in Ghana: Students activities*.Accra: Unimax Publishers.			
CPD NEEDS	How to design and/or use some innovative materials and ideas for teaching selected concepts in further algebra. Instructional strategies needed to consciously connect mathematical ideas, as well as, connect mathematics to other curriculum areas and to the world outside			

Lesson 12

Year of B.Ed.	2	Semester	1	Place of lesson in semester	1 2 3 4 5 6 7 8 9 10 11 **12**

Title of Lesson	Matrices: *Learning, teaching and applying 2*	Lesson Duration	3 Hours

Lesson description	This is the twelfth lesson under the topic Further Algebra in Year two Semester 1. The pre-requisite of this lesson is "Number and Algebra" which was taught in Year one Semester One. Activities outlined in the lesson will enable student teachers to audit their content knowledge and experiences to establish and address their learning needs, perceptions and misconceptions in matrices. The areas to be covered include the transpose, adjoint, determinants, inverse and applications. The lesson begins with starters or mental mathematics games, reinforcement games and activities about knowledge of operation of numbers. The main lesson focuses on reviewing the student teachers' conceptual understanding of matrices and operations on matrices. The interactive nature of the instructional strategies is meant for encouraging participation by all, irrespective of the entry behaviour of student teachers, especially those who have offered to pursue mathematics in the JHS specialism.		
Previous student teacher knowledge, prior learning (assumed)	Student teachers have knowledge on operations of numbers and their properties from Basic School mathematics, JHS mathematics and, quadratic functions, simultaneous equation, sequences and series from SHS Core mathematics.		
Possible barriers to learning in the lesson	Different entry behaviours, Socio-cultural issues, different learning needs, Some student teachers may come to SHS schools where they did not have teachers or good mathematics teachers to support them understand advanced concepts in Matrices.		

Lesson Delivery – chosen to support students in achieving the outcomes	Face-to-face ⊠	Practical Activity ⊠	Work-Based Leaning ☐	Seminars ☐	Independent Study ☐	e-learning opportunities ⊠	Practicum ☐

Lesson Delivery – main mode of delivery chosen to support student teachers in achieving the learning outcomes.	**Face-to-face:** opportunity for an extended and coherent line of argument. It includes discussion, brainstorming, question and answer, etc. This can be tutor and / or student teacher led. It should not usually be the main mode. **Practical Activity:** enabling experimentation and the analysis and discussion of issues, documents and materials, as well as physical activities. **Independent study:** to enable students to engage with relevant and appropriate materials to promote individual and collaborative enquiry, more in-depth analysis and development. This can be part of any of the above modes **E-learning *opportunities*** – involving the use of interactive packages and virtual learning environments. This can be part of any of the above modes of delivery. It is unlikely to be a delivery mode in its own right.
• **Purpose for the lesson, what you want the students to achieve, serves as basis for the learning outcomes. An expanded version of the description.**	The purpose of the lesson is to; • buildon the content knowledge and experiences of student teachers to establish their competence in matrices problems and address their learning needs, perceptions and misconceptions about matrices. • develop student teachers' understanding of matrices and apply matrix concepts in other fields of mathematics • develop student teachers' conceptual knowledge in order to prepare them well enough to be able to handle concepts in matrices and its application as required by the JHS curriculum.

• **Learning Outcome for the lesson, picked and developed from the course specification** • **Learning indicators for each learning outcome**	**Learning Outcomes**	**Learning Indicators**	**Identify Which cross-cutting issues- core and transferable skills, inclusivity, equity and addressing diversity. How will these be addressed or developed?**
	3. Demonstrate knowledge and understanding of fundamental concepts and principles of matrices needed by	• Identify and analyse fundamental concepts and principles of matrices needed by developing teachers to build their confidence in planning and	• Commitment and passion for teaching: through developing student teachers' curriculum leadership and the holistic understanding needed for managing transition of learners from middle childhood (primary) to early adolescent (JHS)

			developing teachers to build their confidence in planning and teaching some groups of adolescents.	teaching some groups of adolescents • Evaluate student teachers views on the fundamental ideas of matrices in the previous lesson based on varieties of strategies	• Problem solving, critical and creative thinking: Making problem-solving a central focus of mathematics instructions as well as an integral component of assessment

Topic	Sub-topic(s)	Stage/Time	Teaching and learning to activities to achieve learning outcomes depending on delivery mode selected. Teacher-lead collaborative groupwork or independent.		
			Teacher Activity	**Student Activity**	
Matrices: Learning and applying	Transpose,		Engage student teachers in a review of the fundamental ideas of matrices in the previous lesson	Participate in the review of fundamental ideas of matrices	
	Adjoint,	**30 mins**	Lead student teachers in a discussion to collect their views and experiences about the previous lesson(s) and how they were handled.	Provide feedback by giving comments and questions for clarification and further explanation.	
	Determinants;	**40 mins**	Engage student teachers through interactive pedagogy to discuss concepts such as transpose, adjoint and determinant of matrices.	Use activity based techniques to introduce and treat the concepts of transpose; adjoint; determinants of matrices	
	Inverse and applications.	**60 mins**	Assign student teachers to explore and use manipulative and ICT tools to find inverses of matrices and to solve simultaneous equations.	Explore and use manipulative and ICT tools to find inverses of matrices and to solve simultaneous equations	
			Assign student teachers to solve simultaneous equations using Cramer's rule.	Solve simultaneous equations using Cramer's rule	
	Review of lessons in the course	**60 mins**	Engage student teachers in a review of the lessons in this course to ensure mathematical connection	Participate in the review of the lessons in this course to ensure mathematical connection	
Lesson assessments – evaluation of learning:of, for and as learning within the lesson	1. Review of previous lessons and preparation for end of the semester examination. (End of semester examination 40%)				
Instructional Resources	Graph sheets, mathematical set, manipulative materials, permanent markers, calculators, Geogebra Apps.;				

Required Text (core)	Gordor, B. K., Naandam, S. M., & Nkansah, B. K. (2012). *Core mathematics for senior high schools*. Accra: Sam-Woode Ltd. https://amsi.org.au/teacher_modules/Indices_and_logarithms.html. *Retrieved 20-06-2019*
Additional Reading List	Ministry of Education (2015). *Core mathematics modules for SEIP*. Accra: Ministry of Education. Ministry of Education. (2010). *Teaching syllabus for core mathematics* (Senior High School). Accra: Ministry of Education, Science and Sports. Martin, J. et. al. (1994). *Mathematics for teacher training in Ghana: Tutor notes*. Accra: Unimax Publishers. Martin, J. et. al. (1994). *Mathematics for teacher training in Ghana: Students activities*.Accra: Unimax Publishers.
CPD NEEDS	How to design and/or use some innovative materials and ideas for teaching selected concepts in further algebra. Instructional strategies needed to consciously connect mathematical ideas, as well as, connect mathematics to other curriculum areas and to the world outside