BHUTAN MODULE

REPORT COMPENDIUM

Samtse College of Education
Bhutan

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Subject : Biology

Introduction to Genetics & Heredity

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1. Introduction

This module is designed to target fresh teacher graduates as the main participants, preparing them to teach this particular area for grade IX students. The following considerations were made during the selection and decision of contents for the module: Bhutan class IX syllabus, needs of the school teachers as revealed through a quick survey, relevance to partner countries, duration, and logical flow of the content ideas. As an introduction to genetics and hereditary, there are three units with selected topics in each of the units.

A. Timeline of implementation in the country:

July 2nd 2022 - 14 August 2022

B. Learning objectives

i. Understand the basic genetic principle
ii. Learn the structure of chromosome
iii. Chromosome type and composition of chromosome
iv. Understand principle of variation
v. Learn the causes of variation
vi. Explain the genetic engineering
vii. Understand the basic principle of genetic engineering
viii. Explain cloning
ix. Contextualise the application of genetic engineering to their day to day life

C. Number of units

Three units namely basics of genetics, variation and inheritance, introduction to concepts of cloning, selective breeding and genetic engineering.

D. Concepts covered

Genetics, gene, dominant & recessive allele, sex chromosomes, autosomes, karyotype, nucleotides, bases, sister chromatid, Non-sister chromatid, inheritance, variation, genetic engineering, cloning
Resources - activities, readings
The activities included were MCQ, Interactive Videos, Discussion, Drag and Drop, Quiz. Wherever required and possible PDF materials were provided to enhance understanding of concepts. Further, some videos were also made available to enhance understanding of the concepts.

E. Nature and purpose of assessments

MCQ - to evaluate the participants learning of the concepts and units, discussion - clarify and contribute knowledge, lesson plans - apply the learning from the OER, reflections - provided opportunity to critically examine their learnings from the OER, drag and drop - motivate and test their understanding of a concept, interactive videos embedded with questions - test their learning from the OER, and essay - provided opportunity to reflect and relate their learning. Overall it was also a platform for participants to develop their knowledge and skills on various forms of online assessment approaches.

2. Course completion rate

A. Overall completion

Table 1: Course completion rate by teachers

	NQTs	Preservice	Inservice	Total
1 - 20%				
21 - 40%				
41 - 60%				
61 - 80%				
81 - 100%	5	9	5	19
Total	**5**	**9**	**5**	**19**

B. Assessment completion rate

Table 2: Teachers' assessment completion rate

	NQTs	Preservice	Inservice	Total
Pre test	5	9	5	**19**
Session plans	5	9	5	**19**
Reflection	5	9	5	**19**
Post tests	5	9	5	**19**

3. Time spent on the course platform

Table 3: Time spent by teachers on Moodle platform

Hours spent	NQTs	Preservice	Inservice	Total
Less than 5	1	1	5	7
5 to 10	2	2	2	6
10 to 20	2	2	2	6
21 to 30	-	-	-	-
More than 30	-	-	-	-
Total	5	5	9	19

4. Change from pre- and post- test

Average total score in pre-test - 12.42 out of 15
Average total score in post-test - 12.89 out of 15

Table 4.1

Number of teachers		Post Test			
		Novice 0-25%	Emerging 26-50%	Proficient 51-75%	Accomplished 76-100%
Pre test	0-25% Novice	-	-	-	-
	26-50% Emerging	-	-	-	-
	51-75% Proficient	-	-	1	3
	76-100% Accomplished	-	-	1	14

Table 4.2

Number of teachers		Post Test			
		0-70%	71-80%	81-90%	91-100%
Pre test	0-70%	-	-	-	-
	71-80%	-	3	4	3
	81-90%	-	3	1	3
	91-100%	-	-	2	-

The prescribed table (table 4.1) was formatted to table 4.2, as most participants scored more than 70%. From the above table (Table 4.2), we can infer that, score (71-80%) for three persons remained unchanged for pre-test and post-test. However, the score for four participants improved from range 71-80% to 81-90% and the score for three participants increased from the range 71-80% to 91-100%. Conversely, the score for three participants dropped from the range 81-90% to 71-80% and 91-100% to 81-90% for the other two participants.

However, a thorough glance at the pre and post score of each participant indicates that 11 participant's score have improved from pre to post test, while 6 participants score have dropped slightly from their pretest score, and 2 participants score remained the same between pre and post-test.

5. Practice

	Number of teachers				Total
Criteria	Novice	Emerging	Proficient	Accomplished	
A. Subject Matter Knowledge					
1. Knowledge of Subject Matter	1	9	9		19
2. Nature of Science/ Mathematics	3	9	6		18
B. Pedagogical Content Knowledge					
3. Instructional Strategies	1	8	9		18
4. Students' misconceptions & Conceptual Difficulties	3	10	6		19
5. Representation of the Content	-	8	11		19
6. Context for Learning	2	11	6		19
7. Curriculum knowledge	1	9	9		19
C. General Pedagogical Knowledge					
8. Equity and Inclusion	1	13	5		19
9. Classroom Management	-	9	10		19
10. Assessment	-	11	8		19

A. Subject Matter Knowledge

The participants seem to have good subject matter knowledge as revealed through their lesson plan and reflection. The other possible reason also could be, since it was the first attempt to curate an OER by the Biology academics of SCE with thorough deliberation in the team it was decided that the first module will be an introduction, so that it leaves us with opportunity to curate second advanced module in future, therefore, only the basics of genetics and hereditary concepts are included in this module consequently it has enabled participants to comprehend and contextualise the learning well in their lesson plans.

B. Pedagogical Content Knowledge

Majority of the participants are aware of PCK. (The teacher included creative activities in his lesson plans and also mentioned about extending the usage in their teaching of other contents)

C. General Pedagogical Knowledge

Except one participant, rest of them the participants fall under emerging to proficient category in the general pedagogical knowledge (eg. use video,simulation, ppt slides, picture)

6. Social learning in CoPs

A. Frequency of posts

Table 4: Frequency of posts by participants

Role	Number of posts
NQTs	32
Preservice Teachers	18
Inservice Teachers	35
Teacher Educators	97
Research fellow	5
Total	187

B. Frequency of posts

Table 5.1: Frequency of posts by content

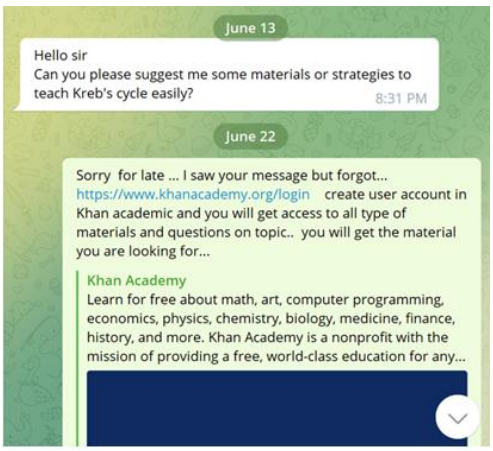
Type of Posts	Number of posts
PCK	2
UDL	2
Technical	13
Communication/ Administrative	36
Total	53

Table 5.2: Frequency of posts by type

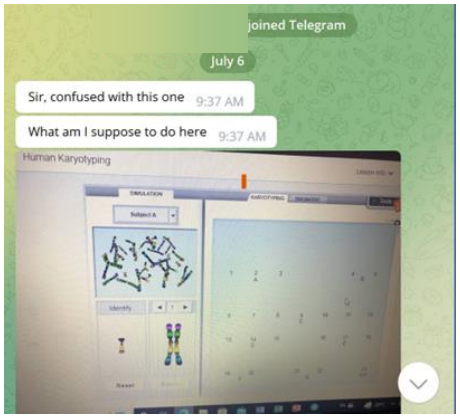
Type of post	Number of posts
Text only	33
Images	6
External Links to other resources	2
Others (pdf)	1
Total	43

C. Qualitative dialogues/ discussion threads

1. Here is an example of a help sought by the NQT teacher from one of the schools, shared sites and apps for teaching and learning. Later the same teacher asked for additional resources for her classroom teaching. Therefore, shared a site to the individual student and also in the group CoP to provide opportunity for participant/s to try and master the contents through interaction and engagement. The sites for learning Biology for lower class, like Krebs Cycle: interactive lyrics, diagrams, and flashcards – learn-biology.

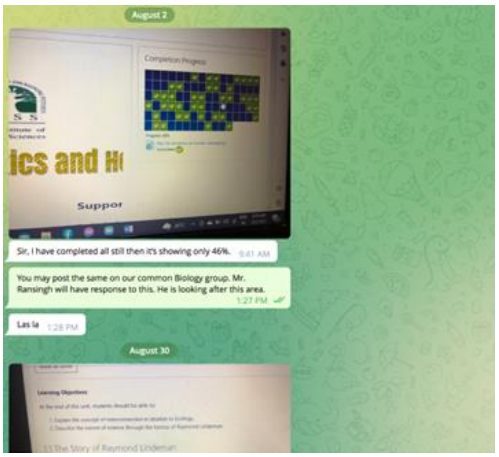


2. Extension of the learning: Supported with new additional apps and link were shared as the participant needed them for classroom teaching.



3. Supported with a deeper meaning for the concept with simulation attached below for study of karyotype.

4. The next example shows students seeking support from the tutor in a personal chat and avoiding posting in the common forum. The tutor redirects the student back to the common forum.



7. Teacher Educator's reflection on the overall implementation (Moodle and CoP)

A. Participation of teachers:

i. Creation of CoP was useful, phone call, constant reminder individually and in group and activities to be completed; face to face orientation on OER was effective as we could meet in person so besides orientation, we were also able to clarify their misconceptions immediately in person and building rapport was seen to be a success. Additionally, often reminding the participants about their professional responsibility to complete tasks has also been useful".

B. Challenges:

i. Completion of the activities on time was a challenge; we had to send repetitive reminder as the participants were also heavily engaged in their teaching and other works; connection with pre-in-service was difficult as they were on vacation and some had network connection issue; implementation of lesson plan was a challenge as the participants found it difficult to adjust with the topics; pre-service participants found it more challenging on the implementation as they were on vacation, getting timely response from the participants. We also had a couple of pre-service participants whose mobile phone and laptop were broken, therefore, they had resource constraints.

ii. Minimal participation in the CoP. The possible reasons are Bhutanese by nature are passive and do not ask many questions nor contribute. Further, for many Telegrams is a new feature as the majority of participants are more familiar with other social media platforms such as Wechat and facebook. However, now the popularity of Telegram is gaining momentum amongst all.

C. Surprises:

i. Poor response from the pre-service participants. The reason we assume is because of the structure of the tools as it was more relevant for inservice teachers.

D. Any changes required in the module design:

i. Decrease the number of lesson plans to one this will enable accomplishing thorough and detailed collaboration between the participant and tutor on the selected concept and PCK.

ii. Focus more on assessment.

Data Sources Used

1. Moodle completion rate raw data
2. Moodle time spent raw data
3. Teacher pre test and post test data
4. All teachers' lesson plans and reflections (3 lesson plan per module per teacher, and 1 reflection per module per teacher)
5. Teachers' responses for the pre and post test surveys
6. Telegram CoP group data download for the during of the module

Subject : Biology

Ecology

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1. Introduction

The Ecology module was designed and curated by the Nigeria team targeting fresh teacher graduates as the main participants, preparing them to teach this particular area for grade IX students. The Bhutan Biology team revised the module to contextualise it to be used in the Bhutanese classrooms by the Biology Intervention participants. The concepts used in the module were chosen and thought of as basics of introductory Ecology for students. The goal of the Module is to produce well-informed students capable of understanding, engaging, problem-solving, and making decisions about the natural world around us. The module on Basic ecological concepts is designed with the pedagogical approach of activity-based learning. The module is organised into five units.

A. Timeline of implementation in the country:

7 September 2022 – 10 October 2022

B. Learning objectives

i. Explain the concept of interconnection in relation to Ecology.
ii. Describe the nature of science through the history of Raymond Lindeman.
iii. Explain the concept of Ecology
iv. Differentiate between the concepts of Environment, Habitat and Niche
v. Explain the concept of the Ecosystem and its components.
vi. Define Autotroph, Heterotroph and Trophic level
vii. Describe the concepts of the food chain and food web.
viii. Explain the concepts of Organization, Population, community, ecosystem and Habitat.
ix. Arrange different organisational levels of organisms based on their complexities
x. Differentiate between an ecosystem and a community
xi. Define the concept of interaction
xii. Differentiate between positive and negative interactions
xiii. Differentiate between the different types of interaction
xiv. Define the concept and causes of pollution
xv. Explain the different types of pollution

C. Number of units

5 units (Nature of science through ecological studies, Basic ecological concepts, Hierarchical organisation, Environmental pollution)

D. Concepts covered

Interaction, intra-action, biosphere, ecosystem components, food chain, food-web ecology, synecology, autecology, habitat, ecological niche, organism, population, community, mutualism, commensalism, parasitism, predation, competition, types of water pollution.

E. Resources - activities, readings

Discussions, stories, self-evaluation, worksheet, individual/pair work, observations, watching video followed by questions

F. Nature and purpose of assessments

Discussions: generate ideas, share their understanding regarding the concepts; build collaboration among the learners, build trust, develop respect, acceptance, critical thinking.

Observations: make keen observations around the surroundings and list the organisms, ecosystem, pollution. This helps the learners to be good observers and notice changes occurring in the immediate surroundings. Develops observation skills.

Group activity: to check the understanding of different learners from their own perspectives regarding the content, develop respect for each other, and teamwork.

Video: motivates the learners, enjoys watching videos, develops observing, can check the understanding of the concepts covered, helps to develop patience, and good listening skill.

2. Course completion rate

A. Overall completion

Table 1: Course completion rate by teachers

	NQTs	Preservice	Inservice	Total
1 - 20%	-	-	-	-
21 - 40%	-	-	-	-
41 - 60%	-	-	1	1
61 - 80%	-	-	-	-
81 - 100%	5	9	4	18
Total	5	9	5	19

17 teachers have completed the course with 100% submissions except one teacher who has completed 91% and two others, who completed only 55%. Despite several reminders, these participating teachers failed to complete the course. This could be due to his/her lack of interest or this teacher failed to understand the usefulness of the course or workload.

B. Assessment completion rate

Table 2: Teachers' assessment completion rate

	NQTs	Preservice	Inservice	Total
Pre test	5	9	5	19
Session plans	5	9	5	19
Reflection	5	9	5	19
Post tests	4	9	5	18

18 teachers have completed all the assessment activities. This was ensured through repeated reminders from the TEs from time to time. One teacher has attempted the post-test but has left in-complete.

3. Time spent on the course platform

(number of hours spent on platform to know how much time is required by to complete the module, data available from Moodle platform)

Table 3: Time spent by teachers on Moodle platform

Hours spent	NQTs	Preservice	Inservice	Total
Less than 5	-	5	1	6
5 to 10	4	4	4	12
10 to 20	1	-	-	1
21 to 30	-	-	-	-
More than 30	-	-	-	-
Total	5	9	5	19

Though the majority of the teachers have spent between 5 to 10 hours, more than 50% of the pre-service teachers have spent less than 5 hours on Moodle to complete the course. The reason could be that they are new to the school system with no teaching experience and they had to spend more time on preparing lesson plans and writing analysis reports of the lesson as it is a compulsory requirement. One NQT has spent time between 10 to 20 hours indicating that the teacher is serious about understanding and implementing the skills and pedagogy of the OER.

4. Change from pre- and post- test

Average total score in pre-test - 8.74 out of 15
Average total score in post-test – 9.16 out of 15

Number of teachers		Post Test			
		Novice 0-25%	Emerging 26-50%	Proficient 51-75%	Accomplished 76-100%
Pre test	0-25% Novice	1			
	26-50% Emerging		4		
	51-75% Proficient			12	
	76-100% Accomplished				2

The post-test score showed improvement by a very narrow margin (2.8%). 36.8% of the participants scored higher in pre-test as compared to post test and 15.7% of the participants had no change in the score between pre-test and post-test. Even though for 48.5% of the teachers, in their scoring from pre to post test, the majority of them showed no improvement indicating that they are not very serious about the CL4STEM modules. Besides, they have a lot of other responsibilities that demand more time and energy. It was also observed that the questions asked in pre and post-test were not based on the module content. These questions were more competency based and hence they require more time and critical thinking.

5. Practice

	Number of teachers				Total
Criteria	Novice	Emerging	Proficient	Accomplished	
A. Subject Matter Knowledge					
1. Knowledge of Subject Matter	4	4	7	7	19
2. Nature of Science/ Mathematics	2	2	9	8	19
B. Pedagogical Content Knowledge					
3. Instructional Strategies	2	2	5	11	19
4. Students' misconceptions & Conceptual Difficulties	1	1	13	5	19
5. Representation of the Content	2	2	7	8	19
6. Context for Learning	1	1	12	5	19
7. Curriculum knowledge			13	6	19
C. General Pedagogical Knowledge					
8. Equity and Inclusion	1	1	13	5	19
9. Classroom Management	1	1	8	9	19
10. Assessment	-	-	11	8	19
Total					

A. Subject Matter Knowledge

Teachers are clear about the nature of science and science knowledge. They are able to relate and contextualise the learning of science through appropriate approaches. This is clearly indicated in their lesson plan and reflection as follows:

"The involvement of the students in the field trip was enriching for all the learners type. Moreover, it gave me the motivation to organise such activities more frequently (1702)".

"Every lesson was conducted through exploration where students gather information from internet, reference books, deliberate among the groups, solve questions, design models and also present their group works which is followed by critique from the friends as a teacher (1705)".

B. Pedagogical Content Knowledge

Most of the teachers checked the prior knowledge of the students. It is evident from their lesson plan.

"Tr. activates prior knowledge by having students do a 3-minute quick write about everything they know about ecosystems. Tr. Provides students an opportunity to share their thoughts with the class(1702)".

Teachers are aware of the multiple means of representation. It is clear from their reflection as follows:

"The lessons had a mix of activities such as whole class approach (lesson through ppt and interactive videos displayed through projector), Individual and as well as group work. Similarly, students attended polls, short answer questions, opinion seeking questions and their takeaway points from every component of the lesson live using the apps such as poll everywhere and mentimeter(1705).

As the class started with an activity which dealt with real life examples of realising the features of their siblings had brought some interest in learning(1717).

The LCD projector made it easy for teachers to deliver the session as well as carry out formative assessments(1709)".

C. General Pedagogical Knowledge

It is clear from the table that as most of the teachers fall under emerging to proficient category in the general pedagogical knowledge. They have organised and engaged students in varied activities, used different assessment techniques and have used different means of representations. It is evident from their reflection as given below:

"The lessons were made inclusive with varied activities to cater for the different learner profiles. The student's learning was assessed through questioning, mini-test, polls and 3-2-1 paper(1705). Since the session was delivered using audio-visual media and group activities after the teacher's input, the concepts taught were well understood (1709)".

6. Social learning in CoPs

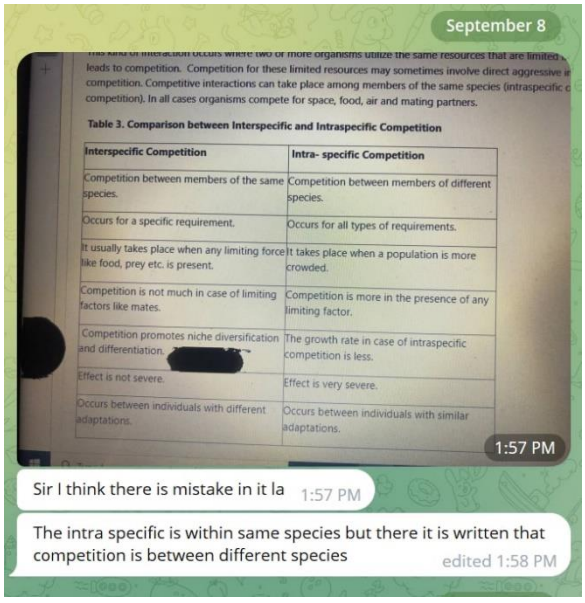
A. Frequency of posts

Table 4: Frequency of posts by participants

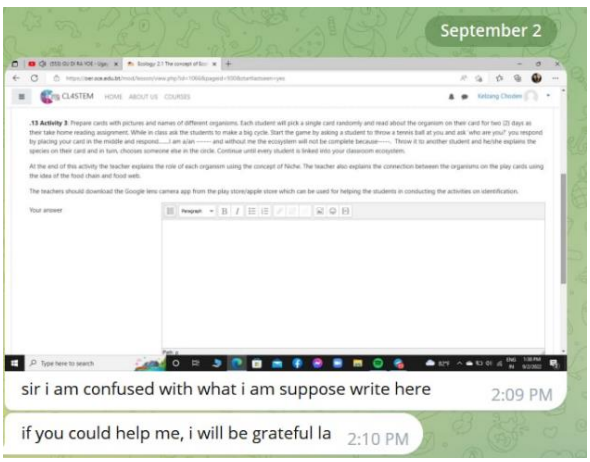
Role	Number of posts
NQTs	10
Preservice Teachers	10
Inservice Teachers	2
Teacher Educators	41
Research fellow	6
Total	69

B. Qualitative dialogues/ discussion threads

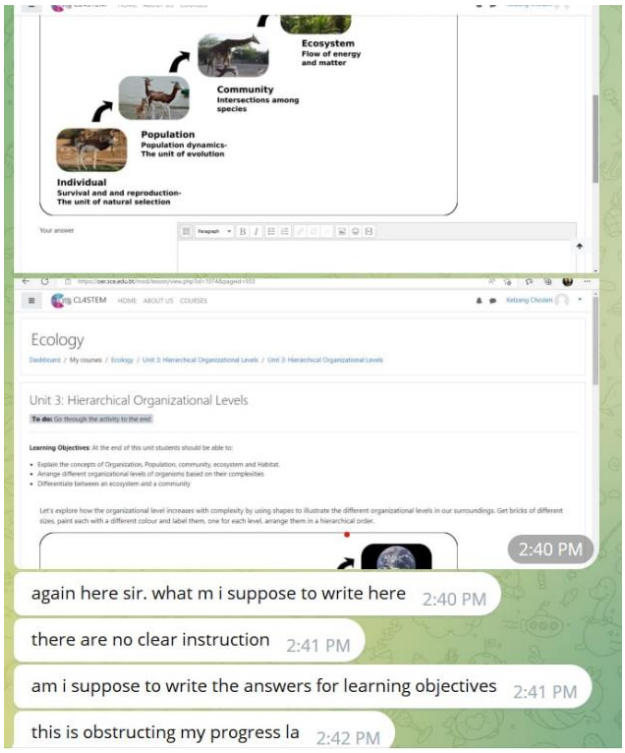
1. Participants seek support to clarify their content on module ecology. Normally they seek clarification of their doubts via personal chat because they find it comfortable.



2. Seek clarification of instruction on the activities. Such instructional clarification helped other members to clarify their doubts as well. This also indicates that they are concerned and therefore they look for the right response.



3. This is another instructional clarification requested by participants of the ecology module. The well-arranged interactive activities encouraged the participant to carry and complete the activities as it is evident from their write up. This also indicated their interest to complete the activities.



7. Teacher Educator's reflection on the overall implementation (Moodle and CoP)

A. Participation of teachers:

While few of the participants were able to complete all tasks either before or on time, some had difficulty since they had their own teaching commitment and other responsibilities. Reinforcement upon completion of a task either through description or emojis and constant reminders with their names highlighted in the CoP had some success in motivating them for active participation and completion of tasks. For a few, we had to send personalised messages in the personal chat and making phone calls were useful to make them complete the tasks.

B. Challenges:

Some of the participants do not read the instructions properly and make attempts with the activities which led to some confusion for themselves. Due to the school curriculum plan and their own syllabus schedule participants had difficulty in implementing the lesson plans.The pre-service participants had some difficulty in committing to the project tasks because often the timing clashed together with the evaluation of their teaching practice lesson evaluations.

C. Surprises:

36.8% of the participants scored higher in pre-test compared to post test and 15.7% of the participants had no change in the score between pretest and post-test. Some of the possible reasons could be that participants were busily engaged in their planned school activities leading to less commitment and seriousness to the CL4STEM tasks, a tendency of not properly reading instructions that led to blind attempt leading random score and also the questions were competency based and open that test their true ability rather than what they learned from module content.

One student attended for only for 45 minutes despite repeated reminder and eventually has still remained at 42% in the module progress

D. Any changes required in the module design:

Not necessary in design but strategically plan in implementation.

Data Sources Used

1. Moodle completion rate raw data
2. Moodle time spent raw data
3. Teacher pre-test and post test data
4. All teachers' lesson plans and reflections (3 lesson plan per module per teacher, and 1 reflection per module per teacher)
5. Teachers' responses for the pre and post-test surveys
6. Telegram CoP group data download for the during of the module

Subject : Biology

Cell Structure & Organization

Authored by:
Mr. Bal Bdr. Mongar, Mr. Ransingh Tamang,
Dr. Kinley, Dr. Kinzang Dorji

1. Introduction

The Cell Structure and Organization module was designed and curated by the Tanzania Biology team targeting fresh teacher graduates as the main participants, preparing them to teach this particular area for grade IX students. The Bhutan Biology team revised the module to contextualise it to be used in the Bhutanese classrooms by the Biology Intervention participants. The concepts used in the module were chosen and thought of as a foundational module for students. The goal of the Module besides providing basic concepts of cell is to produce well-informed students capable of understanding, engaging, problem-solving, and appreciating the interconnectedness of different cell structures and its complex organisation. The module is designed with the pedagogical approach of activity-based learning. The module is organised into five units.

A. Timeline of implementation in the country:

10 October 2022 – 19 December 2022

B. Learning objectives

i. Describe various types of cells from plants, animals and other living organisms
ii. Differentiate unicellular and multicellular organisms
iii. Trace the discovery of the cell
iv. Trace the historical development of the cell theory
v. State the modern cell theory
vi. Understanding of the structure of a cell which is the functional unit of a living organism
vii. Demonstration of knowledge of tools and methods used in the study of cell structure
viii. Describe the differences and similarities between Prokaryotic and Eukaryotic cells
ix. Explain the differences and similarities between animal and plant cells
x. Draw and label the basic structures of animal and plant cells
xi. Outline the characteristics of the cell
xii. animal and plant cells
xiii. Describe the function(s) of cell organelles
xiv. Illustrate and differentiate the characteristics of plant and animal cells
xv. Observe and identify different parts of animal and plant cells through the microscope
xvi. Explain the concept of cell differentiation
xvii. Describe the importance of cell differentiation
xviii. Describe the differences between cells, tissues, organs and body systems
xix. Draw and label tissue systems in monocots and dicots

C. Number of units

Five units namely: The Cell, Types and Characteristics of Cells, Animal Cell, Plant Cell and Cell Differentiation.

D. Concepts covered

Cell theory, prokaryotic, eukaryotic, organelles, unicellular, multicellular, cell differentiation, monocot, dicot

E. Resources - activities, readings

Reading, observation, recording, self-assessment, listening to video, worksheet, practical work, discussion.

F. Nature and purpose of assessments

i. **Reading:** to enhance in-depth knowledge and develop clarity of concepts, develop reading and comprehension skills

Observations: make keen observations around the surroundings and list the organisms, ecosystem, and pollution. This helps the learners to be good observers and notice changes occurring in the immediate surroundings. develop observation and inference skills, connect theoretical classroom knowledge to reality.

ii. **Group activity:** to check the understanding of different learners from their own perspectives regarding the content, develop respect for each other, team work.

Video: motivates the learners, learners enjoy watching videos, develop observing skills, learners can check the understanding of the concepts covered, videos help to develop patience, good listening skill.

iii. **Discussions:** generate ideas, share their understanding regarding the concepts; build collaboration among the learners, build trust, develop respect, acceptance, critical and logical thinking.

iv. **Self-assessment:** carry out authentic assessment, generate self-motivation, check their own progress.

v. **Practical work:** develop and enhance handling of apparatus and lab equipment, practice safety procedures, provide experiential learning.

2. Course completion rate

A. Overall completion

Table 1: Course completion rate by teachers

	NQTs	Preservice	Inservice	Total
1 - 20%	-	-	-	-
21 - 40%	-	-	-	-
41 - 60%	-	1	1	2
61 - 80%	-	-	-	-
81 - 100%	5	8	4	17
Total	5	9	5	19

94.7% of the participant course completion rate lies in the range of 81-100%. This indicates the participants took the course seriously. The other factor is due to repeated reminders and motivation from the teacher educators. One participant's course completion rate lies in the 41-60% range. Despite reminders, this particular participant did not complete the course as desired. He has been observed to exhibit this behaviour in the rest of the modules as well. This indicates his lack of interest and positive outlook towards the modules.

B. Assessment completion rate

Table 2: Teachers' assessment completion rate

	NQTs	Preservice	Inservice	Total
Pre test	5	9	5	19
Session plans	5	9	5	19
Reflection	5	9	5	19
Post tests	4	8	4	16

As per the activity completion rate table, all the participants except three have completed all the assignments. The three participants have not completed the post-test though they have attempted, which could be due to several reasons such as power cut-off, disruption of internet, emergency call, etc.

3. Time spent on the course platform

Table 3: Time spent by teachers on Moodle platform

Hours spent	NQTs	Preservice	Inservice	Total
Less than 5	1	7	1	9
5 to 10	4	2	3	9
10 to 20	-	-	1	1
21 to 30	-	-	-	-
More than 30	-	-	-	-
Total	5	9	5	19

The data from the table indicates that the majority (77.7%) of the pre-service teachers have spent less than five hours of time in the module in contrast to in-service and NQT teachers. This shows that pre-service teachers have priorities in other activities such as preparation of lesson plans, writing analysis reports, and taking up extra responsibilities.

4. Change from pre- and post- test

From the below table, it can be inferred that the majority (52.6%) of the participants scored under proficient category followed by emerging (42.1%) and accomplished (5.2%) category. It is interesting to note that the number of participants whose score improved from pre-test to post-test is equal to the number of participants whose score dropped from pretest to post-test. Score of one participant remained unchanged. It indicates that learning occurred to 50% of the participants while it did not to the other 50% participants. This could also mean that this group of participants did not take the module seriously or they had other disturbances. However, the overall post-test score improved by 2.45% showing that a certain level of learning occurred in some participants. Through a closer look it was observed that the participants who scored higher in the post test are mostly the pre-service teachers while the majority of in-service teachers and NQTs score dropped. This shows that pre-service teacher participants are enthusiastic to learn the modules.

Table. 4.1

Number of teachers		Post Test			
		Novice 0-25%	Emerging 26-50%	Proficient 51-75%	Accomplished 76-100%
Pre test	0-25% Novice				
	26-50% Emerging		8		
	51-75% Proficient			10	
	76-100% Accomplished				1

5. Practice

Criteria	Number of teachers				Total
	Novice	Emerging	Proficient	Accomplished	
A. Subject Matter Knowledge					
1. Knowledge of Subject Matter		7	12		19
2. Nature of Science/ Mathematics	1	5	11	2	19
B. Pedagogical Content Knowledge					
3. Instructional Strategies		4	13	2	19
4. Students' misconceptions & Conceptual Difficulties	1	9	5	4	19
5. Representation of the Content		9	5	5	19
6. Context for Learning	1	7	11		19
7. Curriculum knowledge	2	7	10		19
C. General Pedagogical Knowledge					
8. Equity and Inclusion		5	9	5	19
9. Classroom Management		5	9	5	19
10. Assessment		6	10	3	19
Total	5	64	95	26	190

A. Subject Matter Knowledge

The data in the table indicates the teachers are competent with regard to subject knowledge since most of them fall under the proficient category. They have designed lessons where students are required to make observations, analyse, plan, design experiments and investigate. This shows the participants are aware of the content as well as the nature of the subject. The below abstract from a lesson plan that shows a strong connection of their proficiency in the subject matter are:

> *"Display the diagram of plant cell and animal cell on the board with the help of projector and make students differentiate them(1704)." ; "Learner plans and designs an experiment to investigate that living things are made up of cells. From the investigation, the learner collects data to show that living things are made up of cells. Similarly, the learner analyzes (tabulation, statistics, graphing, etc.) and interprets the data collected from the observation to show that living things are made up of cells (1705)".*

Similarly, the following excerpt of reflection by the participants also reflects their proficiency level;

> *The aspect of observation as the nature of science is manifested in the lesson. I let the students differentiate the features on prokaryotes and eukaryotes (1702).*
> *Biology is a subject that requires inquiry, investigation, argumentation, experimentation and observation then only we can find answers to the questions (1717).*

B. Pedagogical Content Knowledge

The data in the table conveys that most of the teachers have a high competency level with regard to application of appropriate pedagogy that matches with the nature of the content. This is clear from the reflection of the participants as follows:

> *"My personal observations on the students were, they enjoyed mostly when there is inclusion of ICT. In the 21st century, students learn actively if we try to incorporate games and simulations especially in such abstract topics (1702)".*

> *"However, answering the questions in slido, padlet, and experiment to observe slides and attempting quiz in quizzes were the tasks students enjoyed the most (1703)".*

> *"To meet the needs of the students the resources used were audio visual, pictorial representation, lecture, and UDL digital materials such as padlet and slido. (1719)".*

C. General Pedagogical Knowledge

The data in the table indicates that all the teachers have a higher level of competency and skills regarding the general pedagogical knowledge. It is evident from the lesson plan, example:

> *"Used a few group activities that include all students in groups- provide equal opportunity to discuss and share understanding of each individual, used a variety of resources such as video, simulation, use of different formative assessment such as online quiz and discussion (1705)".*

The reflection of the participants further supports the possession of sound general pedagogical knowledge as indicated below:

> *"The students had enough opportunity to interact and share their works since the students were placed in groups (1702)".*

> *"The lessons had a mix of activities such as whole class approach (lesson through ppt and interactive videos displayed through link in their mobile phone), Individual and as well as group work. (1705)".*

> *Moreover, some students were anxious about their answers in the slido and padlet which was visible to everyone. In order to make it comfortable I let the students post the answers anonymously. (1703)".*

6. Social learning in CoPs

A. Frequency of posts

Table 4: Frequency of posts by participants

Role	Number of posts
NQTs	12
Preservice Teachers	11
Inservice Teachers	15
Teacher Educators	40
Research fellow	12
Total	90

B. Frequency of posts

Table 5.1: Frequency of posts by content

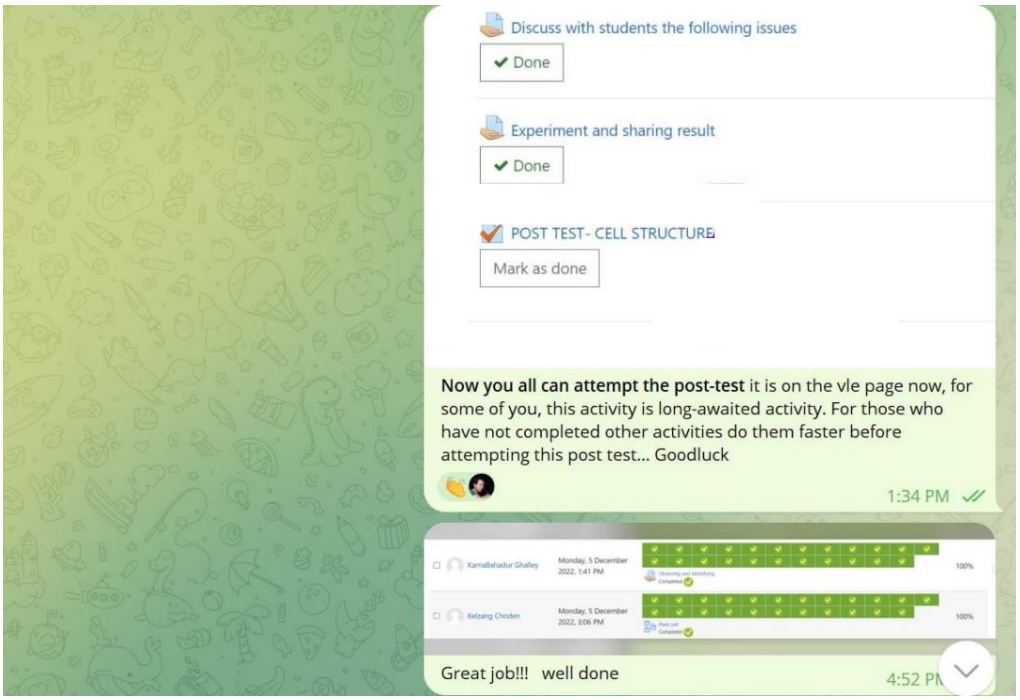
Type of Posts	Number of posts
PCK	7
UDL	5
Technical	8
Communication/ Administrative	20
Total	39

Table 5.2 : Frequency of posts by type

Type of post	Number of posts
Text only	34
Images	17
External Links to other resources	6
Others (pdf)	Nil
Total	57

C. Qualitative dialogues/ discussion threads

Though majority participants were passive in the CoP, however there were few active participants who often communicated either directly to the tutors regarding confusions related to OER activities and some expressed acknowledgement on information or updates shared by the tutors. Besides, some participants shared screenshots of completed tasks and even sought clarification with regard to their progress in the module. Some of the evidences are as follow:



Following sharing on the use of folder-scope by a TISS expert, participants shared evidence of the usage in their classroom.

7. Teacher Educator's reflection on the overall implementation (Moodle and CoP)

A. Participation of teachers:

Keeping close and regular contact with the participants helped them to be open and encouraged them to ask questions and doubts that promoted deeper discussion and learning. The progress bar on the module encouraged them to work and complete activities on time. Constant reminder and positive feedback via CoP also encouraged the participants to progress smoothly.

B. Challenges:

The participants had to be kept on reminding about the work. We also had a time constraint as this module coincided with exam time in the school and our college.

C. Surprises:

Few of the participants showed concern about their progress as they frequently communicated through CoP.

D. Any changes required in the module design:

There should be more interactive videos and games as participants seem to enjoy as well as they are able to use in their classroom. To cite an example, "Drag and drop activity" was found to be interesting which the students enjoyed in the class.

Data Sources Used

1. Moodle completion rate raw data
2. Moodle time spent raw data
3. Teacher pre-test and post test data
4. All teachers' lesson plans and reflections (3 lesson plan per module per teacher, and 1 reflection per module per teacher)
5. Teachers' responses for the pre and post-test surveys
6. Telegram CoP group data download for the during of the module

Subject : Chemistry

Atomic Structure

Authored by:
Dr. Reeta Rai, Ms.Kezang Choden, Dr.Nandu Giri,
Dr. Sonam Rinchen, and Mr. Lhapchu

1. Introduction

The module on atomic structure was curated by the chemistry teacher educators at Samtse College of Education. The course content for this module was designed using Bhutan's Science Curriculum Framework for Key Stages III and IV. This module aimed to support the professional development of participating teachers by enhancing their subject matter knowledge, pedagogical content knowledge (PCK), use of technology and inclusive pedagogies in order to accommodate the learning needs and abilities of all learners.

The module progresses from the historical conception of the ideas of atoms, molecules, elements, and compounds to the formulation of various atomic models, structural components of the atom, atomic number, mass number, isotopes, electronic configurations, and arrangements of elements in the periodic table. Some research-based strategies for addressing common misconceptions among students about the above-mentioned concepts were also presented. Finally, the module introduced teachers to lesson planning, various interactive modes of assessment, and reflection writing about the lessons taught.

A. Timeline of implementation in the country:

July 2 to August 14, 2022

B. Learning objectives

i. Briefly explain the ancient Greeks' ideas of matter;
ii. Explain element, compound and mixtures in their own words;
iii. Explain how the atomic models evolved over time;
iv. Relate scientists' contributions to the atomic model, emphasising flaws and improvements in their models;
v. Evaluate the strengths and limitations of various atomic models;
vi. Differentiate between Bohr model and the quantum model of an atom;
vii. Describe the discovery and characteristics of subatomic particles (electrons, protons, and neutrons) of an atom;
viii. Describe the properties of elements in the periodic table;
ix. Describe the trends in the periodic properties of elements across the period and down the group.

C. Number of units

There are four units in the module.

- Unit 1 - Introduction to Atom
- Unit 2 – Evolution of Atomic Models
- Unit 3 - Subatomic Particles and Isotopes (Nuclides)
- Unit 4 - Periodic Table

D. Concepts covered

The module progresses from the historical conception of the ideas of atoms, molecules, elements, and compounds to the formulation of various atomic models, structural components of the atom, atomic number, mass number, isotopes, electronic configurations, and arrangements of elements in the periodic table.

E. Resources - activities, readings

- Resources used included reading materials, journal articles, Youtube videos, self-developed videos, cartoons and drawings, storyboards, PHET simulations, experimental procedures, and virtual experiments.
- Reading resources included: In Her Element: Women Behind the Discovery of Periodic Table (https://www.energy.gov/articles/her-element-women-behind-discoveries-periodic-table)
- Article on the Heuristic Method of Teaching Science (https://www.preservearticles.com/education/what-is-heuristic-method-of-teaching-science/27827)
- Isotopes of hydrogen (https://study.com/learn/lesson/the-three-isotopes-of-hydrogen.html) Students' Alternative Conceptions about Atomic Properties and the Periodic Table

F. Nature and purpose of assessments

Formative and summative assessments were used throughout the module to assess the learning of the participating teachers. Pretest, posttest, MCQ, quiz, short answer questions, writing reflections, and other assessments were used. Participants were required to submit three lesson plans and a reflection. The rubric for assessing lesson plans and reflections included indicators on subject matter knowledge, Pedagogical Content Knowledge (PCK), and General Pedagogical Content Knowledge for fostering equity and inclusion in the classroom.

2. Course completion rate

A. Overall completion (Data available from Moodle platform)

Table 1: Course completion rate by teachers

	NQTs	Preservice	Inservice	Total
81 - 100%	5 (100%)	10 (100%)	5 (100%)	20
Total	5	10	5	20

Despite their busy schedules, all participants completed the course successfully.

B. Assessment completion rate (Data available from Moodle platform)

Table 2: Teachers' assessment completion rate

	NQTs	Preservice	Inservice	Total
Pre test	5	10	5	10
Session plans	5	10	5	10
Reflection	5	10	5	10
Post tests	5	10	5	10

The assessments were successfully completed by all participants. They were evaluated using a pretest, a posttest, three lesson plans, and a reflection report.

3. Time spent on the course platform

Table 3: Time spent by teachers on Moodle platform

Hours spent	NQTs	Preservice	Inservice	Total
Less than 10	2	7	2	11
10 to 20	3	3	2	8
21 to 30	0	0	1	1
More than 30	5	10	5	20

According to the above table, 11 participants took less than 10 hours, 8 took 10 to 20 hours, and 1 took more than 20 hours to complete the tasks assigned in the module. Participants spent a lot of time developing the lesson plans and reflection report. Participants were constantly reminded of the deadlines for the submissions of lesson plans and reflection.

4. Change from pre- and post- test

Average total score in pre-test: 72
Average total score in post-test: 83
The average score from pre to post tests have increased by only 11 %.

Table. 4.1

Number of teachers		Post Test			
		Novice 0-25%	Emerging 26-50%	Proficient 51-75%	Accomplished 76-100%
Pre test	0-25% Novice				
	26-50% Emerging				
	51-75% Proficient		2	4	7
	76-100% Accomplished			2	5

Table 4.2: Percentage score of participants in pre and post test

%	Pre	Post
1	60	85
2	60	40
3	87	85
4	80	75
5	73	80
6	73	85
7	67	80
8	60	80
9	87	85
10	53	55
11	73	85
12	67	65
13	80	80
14	93	90
15	73	95
16	73	75
17	53	45
18	80	60
19	67	60
20	87	90

The percentage scores of the participants in the pre and post tests are represented in the tables above (tables 4.1 and 4.2). During the pretest, 13 participants scored 51–75% and were proficient, while 7 scored 76–100% and were accomplished. After the completion of the module, seven more were promoted to the accomplished level (76–100%). It demonstrates that the module aided in the enhancement of the participants' subject matter knowledge and pedagogical content knowledge.

5. Practice

Criteria	Number of teachers				Total
	Novice	Emerging	Proficient	Accomplished	
A. Subject Matter Knowledge					
1. Knowledge of Subject Matter	2	7	8	3	20
2. Nature of Science/ Mathematics	4	4	8	4	20
B. Pedagogical Content Knowledge					
3. Instructional Strategies		5	7	8	20
4. Students' misconceptions & Conceptual Difficulties	3	9	8		20
5. Representation of the Content		4	11	5	20
6. Context for Learning	3	8	9	0	20
7. Curriculum knowledge	4	7	9	0	
C. General Pedagogical Knowledge					
8. Equity and Inclusion	3	8	5	4	
9. Classroom Management	1	6	9	4	20
10. Assessment		9	8	3	20
Total					

A. Subject Matter Knowledge

The above table indicates that with respect to subject matter knowledge more than 50% (12) are in the emerging state, while 35% (7) are in or above the proficient state. The teacher participants in the emerging category must improve their chemistry knowledge as well as learn to develop conceptual connections. A good number of teacher participants (9E and 6P) understand the nature of chemistry and how it should be handled in order to achieve effective teaching and learning. On the other hand, it is quite concerning that around 4 teacher participants are unaware of the nature of chemistry and regard it solely as the learning of facts.

B. Pedagogical Content Knowledge

Overall, the teacher participants (6E, 10P, and 4A) are familiar with the various instructional strategies for teaching chemistry. Teacher participants have involved students in a variety of group activities. Around three teacher participants are unaware of addressing student misconceptions, whereas the rest have addressed them using various pedagogies and technologies. To teach the concepts of atomic structure, all of the teacher participants have used a variety of representational methods. With the exception of 3, teacher participants have used everyday experiences/practices to connect different topics. All teacher participants are well-versed in the curriculum and in connecting it to other concepts.

C. General Pedagogical Knowledge

All of the teacher participants (10E, 7P, and 3A) have given all students an equal opportunity to participate in classroom interaction and have properly considered the learners' needs. teacher participants (8E, 10P, and 2A) used effective classroom management strategies to facilitate effective teaching-learning and assessment. Teacher participants know both formative and summative assessment techniques. Since the classes were only for one period, formative assessments were mostly used.

6. Social learning in CoPs

A. Frequency of posts

Table 4: Frequency of posts by participants

Role	Number of posts
NQTs	6
Preservice Teachers	10
Inservice Teachers	24
Teacher Educators	73
Research fellow	0
Total	113

B. Frequency of posts

Table 5.1: Frequency of posts by content

Type of Posts	Number of posts
PCK	12
UDL	3
Technical	46
Communication/ Administrative	52
Total	113

Table 5.2 : Frequency of posts by type

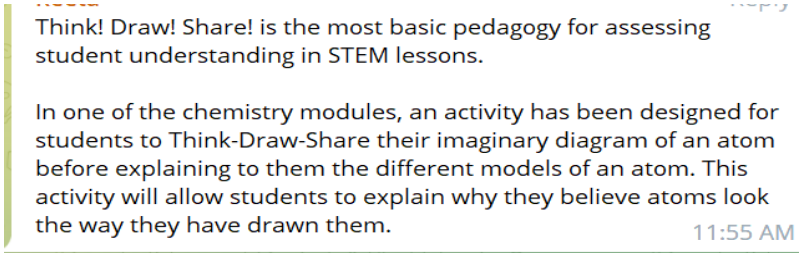
Type of post	Number of posts
Text only	69
Images	32
External Links to other resources	7
Others (pdf)	5
Total	113

C. Qualitative dialogues/ discussion threads

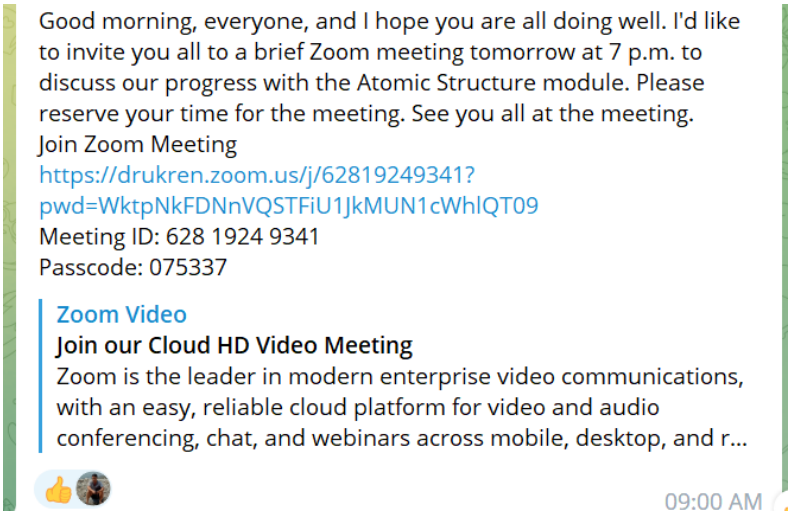
The CoP has been quite active, but it's disheartening to see very few posts from the teacher participants, and also very few posts on the PCK, UDL, etc. Most of the posts were made by teacher educators for administrative and technical purposes. There were no discussions around the module, activities, lesson planning, etc. in the CoP. But it was also noted that many discussions had happened at individual levels between the participants and the teacher educators, which could not be captured in the common CoP.
It was also found that the teacher participants felt more comfortable discussing the module amongst their colleagues in their group than in the CoP created as part of the CL4STEM project implementation.

1. Good examples: reinforcing the strategies incorporated in the module.

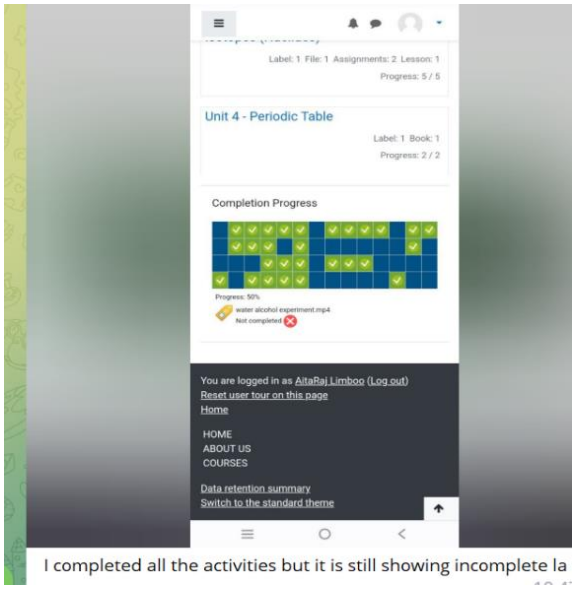
Some of the participants may not be aware of such strategies and may overlook them, but when reminded in such a forum, they may be reinforced to relook at them and try them out in the classroom.



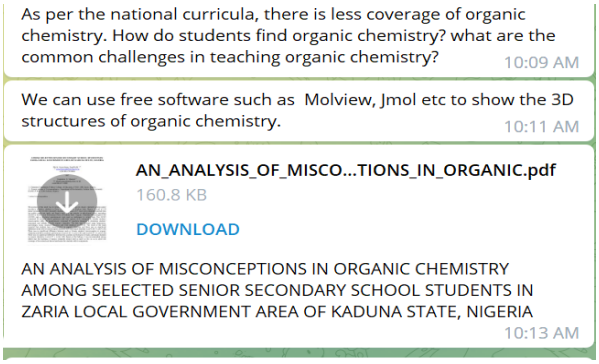
2. Keeping track and timely review of the progress of the course (both TEs and participants)
Teacher participants were called to a Zoom meeting to learn about their status with the module implementation. Such Zoom meetings in between in the CoP will help all to clear their doubts, share their experiences, exchange new ideas, stay connected, and also keep everyone on their toes.



3. Technical glitches: Teacher participants had completed the course, but the module completion rate shown at their end was not 100%. A screenshot of the message received from the participants aided the IT team and teacher educators in fixing the technical glitches on the virtual learning environment (VLE) to show their actual progress.



4. Keeping abreast with the recent changes and developments Some recent journal articles were uploaded to inform participants about the most recent research findings in chemistry education.



7. Teacher Educator's reflection on the overall implementation (Moodle and CoP)

A. Participation of teachers

i. Except for a few teacher participants who needed constant reminders, their participation in online modules and attendance at exercises and activities was very encouraging.
ii. Teacher participants were appreciative of the idea of OER and the content and instructional practices used for the module, except for the time factor. They wished this course was offered during breaks so there would be more interaction and learning.
iii. Strategies that worked include the integration of ICT into the module to make lessons interactive, check students' progress, and conduct virtual experiments.
iv. Three mediums were used to implement the module such as Moodle, CoP, and personal telegram. Teachers participated more in the personal chat. In the moodle they participated to go through the course materials and submit the assignments.

B. Challenges

i. Time constraints were a major factor for the teacher educators in implementing the module. All teacher educators are full time, and they have their own share of work such as teaching, research, meetings, corresponding with partners from different agencies, and administrative work. Implementing modules added to their workload, and they had to extend their working hours including weekends.
ii. The second issue was that some of the participating teachers were not attending the module online or participating/ responding to queries in the Telegram CoP and email. For a number of times, they had to be reminded to attend online modules or respond to queries by calling them on the phone or through secondary sources.
iii. The third issue was making teachers complete their activities on time. When the module was closed, some of the teacher participants would not have submitted their lesson plans, reflections, or attempted quiz. Teacher educators had to send reminders to them repeatedly to get everybody to submit the required documents.
iv. Tutors could not give them quality time, and we had to rush when the deadline for the submission of assignments was near.
v. We cannot blame teacher participants, too, as attending online modules added to their workload. However, there is a lot of learning for the teachers and teacher educators.

C. Surprises

What surprised most of the tutors was the amount of dedicated time recorded by the VLE for implementing and guiding teacher participants, which is far less than our actual input. This difference ensued as we were guiding them through other social forums such as Telegram, phone calls, and emails.

D. Any changes required in the module design

i. Chemistry module in particular was less interactive compared to Physics and Biology, there is a need to make it more interactive and hands-on by integrating technology into the modules. As a result, teachers worked in silos and submitted assignments.
ii. The template of the lesson plan is too limited to capture lessons and activities. Therefore, it is difficult to ascertain whether a teacher falls into the novice, emerging, proficient, or accomplished category. There is a need to relook at the lesson plan template or ask students to submit video recordings of the lessons taught.

Data Sources Used

1. Moodle completion rate raw data
2. Moodle time spent raw data
3. Teacher pre test and post test data
4. All teachers' lesson plans and reflections (3 lesson plan per module per teacher, and 1 reflection per module per teacher)
5. Teachers' responses for the pre and post test surveys
6. Telegram CoP group data download for the during of the module

Subject : Chemistry

Chemical Bonding

Authored by: Dr. Reeta Rai, Ms.Kezang Choden,
Dr.Nandu Giri, Dr.Sonam Rinchen, and
Mr. Lhapchu

1. Introduction

The teacher educators at Ibrahim Badamasi Babangida University, Nigeria developed the course content for this module for grade levels SS1(Grade 10) and SS2 (Grade 11) students in Nigeria. As a part of the CL4STEM project the module content has been contextualised for Bhutanese chemistry teachers and students. This module has been adapted by referring to Bhutan's Science Curriculum Framework for Key Stages IV and V, and it can be used by teachers teaching grades10 and 11 in Bhutan.

The knowledge of chemical bonding enables learners to visualise the combination of atoms in myriad ways to form chemical compounds and materials. Chemical bonding is the process by which atoms combine to form molecules or compounds. The study of chemical bonding is crucial to understanding the properties of materials and how they interact with each other. In this module, we will explore the basics of chemical bonding, including the different types of bonds that exist between atoms and molecules, and the properties of these bonds. The common student misconceptions about the aforementioned concepts have also been presented. Finally, the module introduces teachers to lesson planning, various interactive modes of assessment, and writing reflections on lessons taught.

A. Timeline of implementation in the country:

The module was opened on 12th October and was supposed to be closed on November 23rd but had to be extended by a few weeks because participants were unable to complete it in 6 weeks due to end-of-year academic works. The participants requested an extension of the module completion deadline and accordingly it was kept open until December 7, 2022.

B. Learning objectives

i. Define the concept of chemical bonding;
ii. Identify various classification of chemical bonding ;
iii. Explain the concept of ionic bonding;
iv. Differential ionic bonding from covalent bonding;
v. Draw the Lewis structure of ionic compounds and covalent compounds;
vi. Highlight properties of ionic bonds/compounds;
vii. State the formation of covalent bonds/compounds;
viii. Describe the various forms of covalent bond;
ix. Write down the properties of covalent bonds/compounds;
x. State the concepts of metallic bonding, hydrogen bonding and Van der Waal forces.

C. Number of units

There are four units in the module.

- Unit 1: Chemical Bonding
- Unit 2: Ionic Bonding
- Unit 3: Covalent Bonding
- Unit 4: Other types of Chemical Bonding

D. Concepts covered

- The concept of chemical bonding.
- Classification of chemical bonding.
- Formation and properties of ionic bonds.
- Formation and properties of covalent bonds.
- Concepts of metallic bonding, hydrogen bonding and Van der Waal forces.

E. Resources - activities, readings

The resources used were textbooks, articles, weblinks, simulations, and illustrations. Activities included quizzes, experiments, drawings, collaborative learning, and individual activities.

Reading Links: The online reading links were provided as given below:

- Development of Modern Theory of Bonding: Chemical Bond - Development Of The Modern Theory Of Bonding - Electrons, Atoms, Abegg, and Bonds - JRank Articles https://science.jrank.org/pages/1378/Chemical-Bond-Development-modern-theory-bonding.html#ixzz7Ch1JWWeU
- https://www.aprendercurso.com/salud/estructura-de-lewis.html
- Hydrogen bond: https://chem.libretexts.org/Courses/University_of_Arkansas_Little_Rock/Chem_1403%3A_General_Chemistry_2/Text/11%3A_Intermolecular_Forces_and_Liquids/11.05%3A__Hydrogen_Bonds

F. Nature and purpose of assessments

Formative and summative assessments were used throughout the modules to assess the learning of the participating teachers. Pretest, posttest, MCQ, quiz, short answer question, writing reflection, and other assessments were used. Participants were required to submit three lesson plans and a reflection. The rubric for assessing lesson plans and reflections included indicators on subject matter knowledge, Pedagogical Content Knowledge (PCK), and General Pedagogical Content Knowledge (GPCK) for fostering equity and inclusion in the classroom.

2. Course completion rate

A. Overall completion

One NQT dropped out of the course because she was a contract teacher whose contract was not extended by the Ministry of Education. The remaining 19 participants successfully completed the course, as shown in Table 1.

Table 1: Course completion rate by teachers

	NQTs	Preservice	Inservice	Total
81 - 100%	4 (100%)	10 (100%)	5 (100%)	19

B. Assessment completion rate

Table 2: Teachers' assessment completion rate

	NQTs	Preservice	Inservice	Total
Pre test	4	10	5	19
Session plans	4	10	5	19
Reflection	4	10	5	19
Post tests	4	10	5	19

The assessments were successfully completed by all 19 participants. They were evaluated using a pretest, a posttest, lesson plans, and a reflection report.

3. Time spent on the course platform

The table below indicates that all of the participants(19) took less than 10 hours to complete the tasks assigned on the module. However, they took a lot of time developing the lesson plans and reflection reports as they had to juggle multiple responsibilities. Participants were constantly reminded of the deadlines for lesson plan submission and reflection.

Table 3: Time spent by teachers on Moodle platform

Hours spent	NQTs	Preservice	Inservice	Total
Less than 10	4	10	5	19
Total	4	10	5	19

4. Change from pre- and post- test

Average total score in pre-test=59%
Average total score in post-test=64%
The average score from pre to post tests has increased by only 5 %.

Table 4.1

Number of teachers		Post Test			
		Novice 0-25%	Emerging 26-50%	Proficient 51-75%	Accomplished 76-100%
Pre test	0-25% Novice				
	26-50% Emerging		1	5	1
	51-75% Proficient		2	7	
	76-100% Accomplished		1	2	

Table 4.2: Percentage score of participants in pre and post test

%	Pre	Post
1	60	75
2	50	50
3	50	60
4	65	65
5	100	75
6	65	70
7	65	75
8	75	50
9	55	70
10	45	70
11	30	80
12	35	70
13	60	65
14	45	55
15	60	70
16	85	70
17	80	45
18	60	40
19	40	55
20	60	75

The above tables (table 4.1 & 4.2) represent the percentage scoring in the pre and post test of the participants. Table 4.1 indicates that of the 7(36.84%) participants who scored between emerging level (26-50%) in the pre-test, 1(5.26%) improved to the accomplished level(76-100%) and 5 (26.31%) improved to proficient level (51-75%), after finishing the module. However, of the 9 (47.37%) who were in the proficient level (51-75%) in the pretest, 2 (10.52 %) dropped to the emerging level (26-50%) after the completion of the module. Similarly of the 3(15.78%) who were at the accomplished level (76-100%), 2 (10.52 %) dropped to the proficient level (51-75%) and 1(5.26%) dropped to the emerging level (26-50%) after completing the module. The average increase in the mean score from the pretest to posttest is only 5%. Altogether, 6 participants showed an improvement in post-test while 5 participants showed a drop in their score in the post-test. This indicates that the test items were very challenging for the participants.

5. Practice

Criteria	Number of teachers				Total
	Novice	Emerging	Proficient	Accomplished	
A. Subject Matter Knowledge					
1. Knowledge of Subject Matter		8	9	2	19
2. Nature of Science/ Mathematics		7	9	3	19
B. Pedagogical Content Knowledge					
3. Instructional Strategies		4	13	2	19
4. Students' misconceptions & Conceptual Difficulties		13	5	1	19
5. Representation of the Content		1	13	5	19
6. Context for Learning		12	5	2	19
7. Curriculum knowledge	2	9	7	1	19
C. General Pedagogical Knowledge					
8. Equity and Inclusion		6	10	3	19
9. Classroom Management		4	13	2	19
10. Assessment		7	9	3	19
Total					

A. Subject Matter Knowledge

The subject matter knowledge of the participants was assessed using their Knowledge of Subject Matter and the Nature of Science as depicted in their three lesson plans and a reflection. It is indeed encouraging to see that no one is in the novice category, indicating that all of the participants can confidently teach chemical bonding. The majority (9) are proficient in content knowledge and the nature of science (9). Secondary chemistry teachers must be knowledgeable about the subject as well as understand the nature of science.

B. Pedagogical Content Knowledge

The following indicators were used to assess pedagogical content knowledge: instructional strategies; students' misconceptions & learning difficulties; representation of the content; the context for learning; and curriculum knowledge. 5 participants demonstrated novice curriculum knowledge among the indicators used. With 9 more teachers falling into the emerging category for curriculum knowledge of the teaching subject, immediate steps should be taken to familiarise teachers with the curriculum of the teaching subjects. Teachers should be encouraged to become acquainted with the curriculum framework so that they can plan, design learning activities, and assess students effectively. As 13 are in the emerging category, participants will also require assistance in identifying and overcoming student misconceptions. Learning cannot be effectively promoted if teachers do not correct students' misconceptions. It appears that participants have significantly improved in their use of various instructional strategies (13P and 2A) and content representation (13P and 5A). Likewise, teachers require assistance in creating a context for teaching and learning, as 12 are in the emerging category.

C. General Pedagogical Knowledge

The General Pedagogical Knowledge was also assessed using their lesson plans and reflection report with the variables: Equity and Inclusion and Classroom Management and Assessment. The teachers' capacities in the above areas are above emerging, indicating that they all have good knowledge and experience in fostering equity and inclusion, managing their classrooms, and conducting student assessments using formative and summative methods. It is critical that all teachers understand the importance of facilitating the class with equity and inclusion, or else some students may fall behind. All, however, knew how to manage their classes in terms of making them conducive to learning and dealing with student behaviour. Participants were found to use both formative and summative assessment.

6. Social learning in CoPs

A. Frequency of posts

Table 4: Frequency of posts by participants

Role	Number of posts
NQTs	4
Preservice Teachers	22
Inservice Teachers	8
Teacher Educators	27
Research fellow	4
Total	65

B. Frequency of posts

Table 5.1: Frequency of posts by content

Type of Posts	Number of posts
PCK	14
UDL	2
Technical	12
Communication/ Administrative	27
Total	65

Table 5.2 : Frequency of posts by type

Type of post	Number of posts
Text only	37
Images	22
External Links to other resources	3
Others (pdf)	3 (stickers)
Total	65

C. Qualitative dialogues/ discussion threads

In this module, the number of posts is lower compared to the previous two subject modules. These could be due to year-end academic responsibilities, and everyone was preoccupied with students' assessments.The content of the posts did not differ much from the previous CoP as most of the posts were related to the administrative and technical areas.

Some good posts related to the content and UDL are shown below. Such posts keep CoP members engaged and appreciative of what other teachers are doing. These also help to inspire some teachers to use similar strategies and ideas in their classrooms.

Most of the responses and replies were also related to the administrative and technical.

15:08

15:08

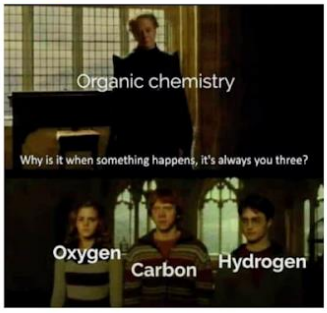
Students exploring Ionic bond and Covalent bond using java-lab at Dorji sir's class in Peljorling school

13:42

13:42

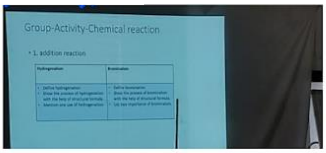
24 October 2022

11:04



27 October 2022

09:18



09:18

7. Teacher Educator's reflection on the overall implementation (Moodle and CoP)

A. Participation of teachers:

In general, the participation of teachers in the module was encouraging. They were very prompt and attended to all the tasks related to the modules on time. One strategy that worked well was guiding them through a mentor-mentee strategy. All the participants were very positive about the module and shared that the module was very helpful as a support for their professional development.

B. Challenges:

The teacher educators were confronted with two challenges.

i. **Time constraints:** Teacher educators are full time teachers besides having to attend to administrative responsibilities and research activities. They had to divide time between teaching, administrative roles, research work and the CL4STEM project. As a consequence, teacher educators didn't get quality time to guide the participants. Participants completed the modules on their own with minimal guidance from the teacher educators.

ii. **Lesson Plan:** The lesson plans submitted by the students were a bit shallow. Secondly, one of them submitted lesson plans from the previous module and another teacher submitted the same lesson plan twice. Teacher educators had to ask them to rectify it.

C. Surprises:

Since this is the last module, we expected rigour and depth in their lesson plans, however to our surprise, the lesson plans were shallow and brief. Further some of the students submitted the same lesson plan twice or lesson plans submitted were from the previous module.The teachers were called up and asked to rewrite the lesson plans.

D. Any changes required in the module design:

Higher concepts in chemical bonding, such as hybridization, molecular polarity, intermolecular forces, and the VSEPR (Valence Shell Electron Pair Repulsion) theory, should be included

E. Experiences, opportunities and challenges with CoP:

Some of the platforms used for CoP were email correspondences, WhatsApp, occasional phone calls and video calls, while Telegram was used to its optimum. Telegram served as a platform to share both official and professional information. Official information included administrative matters, whereas professional information included sharing modules-related resources such as YouTube, articles, web links, best practices from the field, seeking clarifications from teacher educators and colleagues in case of doubt, reminding teacher participants to attend pre and post-tests and submit lesson plans, and so on.

Both the teachers and teacher educators were very positive about the use of the above platforms, especially Telegram. The only resentment from both parties was the cost of data charges, which they had to bear out of their own pockets.

Data Sources Used

1. Moodle completion rate raw data
2. Moodle time spent on raw data
3. Teacher pre-test and post-test data
4. All teachers' lesson plans and reflections (3 lesson plans per module per teacher, and 1 reflection per module per teacher)
5. Teachers' responses for the pre and post-test surveys
6. Telegram CoP group data download for the during of the module (in CSV or Excel format from subject-specific Telegram group)

Subject : Chemistry

Organic Chemistry

Authored by: Dr. Reeta Rai, Ms.Kezang Choden,
Dr.Nandu Giri, Dr.Sonam Rinchen, and Mr. Lhapchu

1. Introduction

Organic chemistry is a branch of chemistry that focuses on the study of carbon-containing compounds, including their properties, reactions, and synthesis. Organic chemistry is important in many fields, such as medicine, materials science, energy, and agriculture. The teacher educators at the Open University of Tanzania (OUT) developed the course content for this module for grade 12 students. As part of the CL4STEM project, the module content was then contextualised for Bhutanese chemistry teachers and students. This module has been adapted using Bhutan's Science Curriculum Framework for Key Stage IV, and it can be used by teachers teaching grades 9 and 10 in Bhutan.This module aimed to support the professional development of participating teachers by enhancing their subject matter knowledge, pedagogical content knowledge (PCK), use of technology and inclusive pedagogies in order to accommodate the learning needs and abilities of all learners.

This module introduces the concept of organic chemistry as well as the historical applications of organic compounds in human life. The module progresses from investigations into the origins, sources, and types of organic compounds to the modern form of nomenclature and the importance of organic compounds. Some research-based strategies for addressing common student misconceptions about the aforementioned concepts have also been presented. Finally, the module introduces teachers to lesson planning, various interactive modes of assessment, and writing reflections on lessons taught.

A. Timeline of implementation in the country:

August 16 to September 30, 2022.

B. Learning objectives

i. Investigate the origins, sources, and types of organic compounds;
ii. Explain correctly the meaning of organic chemistry;
iii. State the nomenclature and the importance of organic compounds;
iv. Address the common student's misconceptions in organic chemistry;
v. Orient the participants on various pedagogical approaches, technology; and modes of assessment to be used in organic chemistry lessons;
vi. Distinguish hydrocarbons from other types of organic compounds;
vii. Explain the uses of hydrocarbons in everyday life;
viii. Explain problems associated with the use of hydrocarbons;
ix. Compare the physical properties of alkanes, alkenes and alkynes;
x. Explain the reasons for variation in physical properties of the hydrocarbons.

C. Number of units

There are three units in the module.

- Unit 1: Introduction to Organic Chemistry
- Unit 2: Hydrocarbons
- Unit 3: Properties of Hydrocarbon

D. Concepts covered

i. Meaning of Organic Chemistry
ii. History of Organic Chemistry
iii. Origin of organic compounds
iv. Organic and inorganic compounds
v. Importance of organic compounds
vi. Hydrocarbons
vii. Uses and problems of hydrocarbons
viii. Student's misconceptions on hydrocarbons
ix. Saturated and unsaturated hydrocarbons
x. Alkanes, alkenes and alkynes
xi. IUPAC nomenclature of organic compounds
xii. Properties of hydrocarbons
xiii. Purification of organic compounds

E. Resources - activities, readings

The resources used were textbooks, articles, weblinks, simulations, and illustrations. Activities included brainstorming sessions, experiments, collaborative learning, and individual activities.

Reading Links: The online reading links were provided as given below:

i. Uses of hydrocarbon https://pixabay.com/images/search/fuel/?pagi=2&
ii. IUPAC Nomenclature https://iupac.org/
iii. Video https://www.youtube.com/watch?v=8s5pH8fO1IE
iv. https://www.google.com/search?as_st=y&tbm=isch&hl=en&as_q=coal+formation+process+diagram&as_epq=&as_oq=&as_eq=&imgsz=&imgar=&imgc=&imgcolor=&imgtype=&cr=&as_sitesearch=&safe=images&as_filetype=&tbs=sur%3Acl#imgrc=4rVRgKh-xjXcfM&imgdii=OxCDUX5OYQSmCM

F. Nature and purpose of assessments

Formative and summative assessments were used throughout the modules to assess the learning of the participating teachers. Pretest, posttest, MCQ, quiz, short answer question, writing reflection, and other assessments were used. Participants were required to submit three lesson plans and a reflection. The rubric for assessing lesson plans and reflections included indicators on subject matter knowledge, Pedagogical Content Knowledge (PCK), and General Pedagogical Content Knowledge (GPCK) for fostering equity and inclusion in the classroom.

2. Course completion rate

A. Overall completion

Table 1: Course completion rate by teachers

	NQTs	Preservice	Inservice	Total
81 - 100%	5 (100%)	10 (100%)	5 (100%)	20
Total	5	10	5	20

B. Assessment completion rate

Table 2: Teachers' assessment completion rate

	NQTs	Preservice	Inservice	Total
Pre test	5	10	5	10
Session plans	5	10	5	10
Reflection	5	10	5	10
Post tests	5	10	5	10

3. Time spent on the course platform

The table below indicates that all of the participants took less than 10 hours to complete the tasks assigned in the module. However, they spent a lot of time developing the lesson plans and reflection report. Participants were constantly reminded of the deadlines for the submissions of lesson plans and reflections.

Table 3: Time spent by teachers on Moodle platform

Hours spent	NQTs	Preservice	Inservice	Total
Less than 10	5	5	10	20
Total	5	5	10	20

4. Change from pre- and post- test

Average total score in pre-test=50%
Average total score in post-test=55%
The average score from pre to post tests has increased by only 5%.

Table. 4.1

Number of teachers		Post Test			
		Novice 0-25%	Emerging 26-50%	Proficient 51-75%	Accomplished 76-100%
Pre test	0-25% Novice	2			
	26-50% Emerging		6		
	51-75% Proficient			11	
	76-100% Accomplished				1

Table 4.2: Percentage score of participants in pre and post test

%	Pre	Post
1	47	65
2	73	70
3	60	55
4	67	85
5	47	70
6	40	50
7	40	65
8	53	75
9	40	60
10	53	70
11	53	40
12	40	60
13	47	45
14	60	60
15	47	15
16	40	40
17	53	55
18	47	40
19	40	25
20	47	50

The percentage scores of the participants in the pre and post tests are represented in the tables above (tables 4.1 and 4.2). Table 4.1 indicates that around eight (40%) participants scored between 51-75% (proficient level) in the pre-test, however, after finishing the module, 1 (5%) participant dropped to the emerging level (26-50%) while 1(5%) participant improved to an accomplished level (76-100%). On the other hand, of the 12 (60%) participants who were in the emerging level in the pretest, 5 (25%) participants improved to proficient level (51-75%) while 2 (10%) participants dropped to novice level (0-25%) after completing the module. The average increase in the mean score from pretest to posttest is only 5%. This indicates that this module is very challenging for the participants. The very low scores of 15% and 25% by two participants can be probably due to some other factors, like not taking the posttest seriously.

5. Practice

	Number of teachers				Total
Criteria	Novice	Emerging	Proficient	Accomplished	
A. Subject Matter Knowledge					
1. Knowledge of Subject Matter	3	4	9	4	20
2. Nature of Science/ Mathematics	2	3	11	4	20
B. Pedagogical Content Knowledge					
3. Instructional Strategies		3	13	4	20
4. Students' misconceptions & Conceptual Difficulties	5	6	8	1	20
5. Representation of the Content		2	9	9	20
6. Context for Learning	1	5	14		20
7. Curriculum knowledge	4	5	9	2	
C. General Pedagogical Knowledge					
8. Equity and Inclusion	4	3	5	8	
9. Classroom Management		4	11	5	20
10. Assessment		9	10	1	20
Total					

A. Subject Matter Knowledge

The participants' subject matter knowledge was assessed through their Knowledge of Subject Matter and the Nature of Science as depicted in their lesson plans and reflection. With three teachers in the novice category for subject matter knowledge and two in the novice category for understanding the nature of science, they need more help to improve their subject matter knowledge and understanding of the nature of science. The majority (9) are proficient in content knowledge and the nature of science (11). Secondary chemistry teachers must have both subject knowledge and a good understanding of the nature of the subject.

B. Pedagogical Content Knowledge

The pedagogical content knowledge was assessed using the lesson plans and reflection report using the given variables: Instructional Strategies; Students' misconceptions & Learning Difficulties; Representation of the Content; The context for Learning and Curriculum knowledge. Among the indicators used, 5 participants demonstrated novice in addressing student misconceptions, 4 lacked understanding of curriculum knowledge, and 1 lacked understanding of how to set the context for learning. Teachers should be equipped with the pedagogical content knowledge to handle students' misconceptions in order to help students succeed in chemistry. Likewise setting the context for both teaching and learning are critical to achieving the learning outcomes of the planned lesson. Participants showed good progress in other indicators.

C. General Pedagogical Knowledge

The General Pedagogical Knowledge was also assessed using their lesson plans and reflection report using the variables: Equity and Inclusion and Classroom Management and Assessment. Around four participants lacked experience managing classes with equity and inclusion. It is critical that all teachers are aware of the importance of facilitating the class with equity and inclusion, or else some students may be left behind. All, however, knew how to manage their classes in terms of making them conducive to learning and dealing with student behaviour. Participants were found to use both formative and summative assessment methods to assess students' learning.

6. Social learning in CoPs

A. Frequency of posts by role:

The table below shows the number of telegram posts made by various groups of Chemistry CoP participants. Teacher educators made most of the posts and the research fellow posted the least. Teacher educators posted mostly to remind the participants about the course and deadlines.

Table 4: Frequency of posts by participants

Role	Number of posts
NQTs	11
Preservice Teachers	15
Inservice Teachers	10
Teacher Educators	66
Research fellow	5
Total	110

Some anonymized samples of Chemistry CoP conversations are presented next:

Bhutan Chemistry CoP

Students working on their worksheet and discussing nomenclature in groups

12:07

Students drawing hydrocarbons with double bond at Rinchen's class

12:42

module by Sunday, an incomplete remark will be given which will have implications on the PD hours earned so far.

R Reeta 15:42

Participants progress report_Organic Cehmistry.xlsx

10.2 KB

Please see your progress report and attend to the remarks.

15:45

Ch our progress and attend to the remarks by Sunday 9th October.

S 16:10

Dear Mr Jigme and Mr Kelzang Nima, Please submit your LP, reflection and attend to post test for the 2nd module (Organic Chemistry). The modulemwill be closed by the coming sunday. Thanks

8 October 2022

S 09:42

Dear Jigme sir,

B. Frequency of posts

Table 5.1: Frequency of posts by content

Type of Posts	Number of posts
PCK	5
UDL	0
Technical	11
Communication/ Administrative	94
Total	110

Table 5.2 : Frequency of posts by type

Type of post	Number of posts
Text only	51
Images	38
External Links to other resources	
Others (pdf)	21
Total	110

C. Qualitative dialogues/ discussion threads

According to the CoP record in Telegram, the majority of the posts were made by teacher educators. There were fewer posts by other participants in the telegram CoP. There were no posts that could be considered good examples since almost all the posts were related to administrative and technical issues, communicating about the technical problems, reminding the participants to complete the course, incomplete activities, etc. There were no posts about UDL. The only good thing about the CoP was keeping in touch with the participants at any time.

7. Teacher Educator's reflection on the overall implementation (Moodle and CoP)

A. Participation of teachers:

Majority of the teacher educators (75%) were positive about the participation of participants in the module "Organic Chemistry." For instance, Teacher Educator 1 (TE1) expressed,

"This was one module that all the participants completed on time and they didn't require much reminders either."

Similarly, TE2 shared,

"This time the participants were very active and punctual in their tasks. I did not have to send reminders or follow up on the task. They were very prompt in attending to the tasks."

Further, TE3 indicated that:

"Giving some incentives/benefits to the participants motivated them to complete the given task in time. Moreover, the teachers have also used some of the activities from this module into the regular teaching."

On the contrary, one teacher educator (TE4) contended that:

"The participants had to be reminded of due dates to get the assignments done. Most of the time, they were busy with their academic work, and in some cases, the related module was not offered in the class. "

B. Challenges:

Some of the challenges faced by teacher educators while implementing the module included a lack of time to attend the module as they are full-time tutors besides shouldering administrative responsibilities in the College. "It was difficult to work side by side. Most of the time, the subject leader had to remind me what to do. The clogging of messages often made me miss out on some meetings" shared TE1. Similarly, TE2 expressed that "tutors and participants couldn't have joint meetings to review the lesson plan. Participants just wrote the plan and uploaded it."

The next challenge was a delay in the submission of lesson plans and the completion of assignments on time by the participants, as expressed by TE2:

The timely completion of modules on time by teachers was a problem. The participants found it extremely difficult to complete the module within the stipulated 6 weeks as they are full-time teachers. The teacher educators had to remind them time and again to complete the task.

The third challenge was participants submitting poor-quality lesson plans as expressed by TE4. Some of the lesson plans designed by teachers were too brief and faced difficulty in assessing the lesson plan as it was too brief. Furthermore, one of the participants was submitting the same lesson plan for different modules, necessitating additional time for guiding and collecting the new lesson plans.

C. Surprises:

There were two surprises this time, as shared by the teacher educators. Firstly, "there isn't much difference in the marks secured in the pretest and posttest," as indicated by TE3. Secondly, "the participants could complete the module without the support of the tutors, as in the previous module a lot of reminders and requests had to be made by the teacher educators to complete the tasks."

D. Any changes required in the module design:

The teacher educators suggested three changes that need to be made, as indicated below:

i. The modules need to be made more interactive (TE1).
ii. There are fewer experimental activities so in the future, we can increase the number of experimental activities (TE2).
iii. More collaborative student learning activities for addressing misconceptions would be helpful to students (TE3 & TE4).

Data Sources Used

1. Moodle completion rate raw data
2. Moodle time spent raw data
3. Teacher pre test and post test data
4. All teachers' lesson plans and reflections (3 lesson plan per module per teacher, and 1 reflection per module per teacher)
5. Teachers' responses for the pre and post test surveys
6. Telegram CoP group data download for the during of the module

Subject : Physics

Force and Motion

Authored by: Dr. Karma Utha

1. Introduction

The module "Force and Motion' was implemented from 1st July to 17th August 2022. 20 participating teachers were enrolled. The module consisted of 4 units which are Motion, Representation of motion, Forces and their types, and Newton's laws of motion. The learning outcomes of the module are as follows:

At the end of the module, each participating teacher should be able to

i. explain the concept of motion and its relation to time and distance;
ii. facilitate discussion on the concept of motion and address the doubts students may have;
iii. facilitate students to sketch and describe distance-time graph;
iv. facilitate students to sketch velocity-time graph;
v. facilitate students to interpret distance-time and velocity-time graph;
vi. describe the various forces;
vii. explain the effect of the various forces on a body;
viii. differentiate between any two forces;
ix. facilitate students understand Newton's 1st, 2nd and 3rd laws of motion;
x. demonstrate and facilitate simple experiments to discuss laws of motion using real life examples;
xi. Facilitate students to revisit their common understanding of motion after understanding laws of motion; and
xii. apply the formulae to solve problems based on Newton's laws of motion.

A. Resources - activities, readings

In this module, all the activities are designed in such a way that they are doable by the teacher participants. The activities require use of digital resources like simulation and videos. This is made available to the participants on the module itself. Almost all other resources required are mostly available in the school laboratory. Where there are no resources available, an alternative arrangement is made in the module. For example: there is one activity (2.13.1) on non-uniform motion in which participants have to use a ticker timer. Since ticker timer is not available, the Physics team adapted this activity by using simulation from Javalab- https://javalab.org/en/ticker_timer_en/. Participants are given instructions on how to use it and plot the graph. The participants did not have any difficulty in working on the simulation

B. Assessments

The activities are made interactive and hands-on and also to make sure the teacher participants do the activities, follow up questions are given. The questions are designed in such a way that a participant had to do the activity to answer it. Also, the answers had to be submitted in the module itself before proceeding to the next activity. The submitted answers are assessed by the tutors and accordingly feedback is shared to the participants individually through email. The email link is also created within the activity itself. This way, participants could get immediate feedback on the completed activities.

Since there are 20 participants, the 3 tutors agreed to work together in all the modules. We divided the unit's activities amongst ourselves so that we could give the feedback as fast as possible. Further, within ourselves, we took the responsibilities of 7 participants each to provide any other support that they may require. This made the assessment component easier for the team.

2. Course completion rate

A. Overall completion

Table 1: Course completion rate by teachers

	NQTs	Preservice	Inservice	Total
81 - 100%	100%	100%	100%	100%
Total	100%	100%	100%	100%

B. Assessment completion rate

Table 2: Teachers' assessment completion rate

	NQTs	Preservice	Inservice	Total
Pre test	100%	100%	100%	100%
Session plans	100%	100%	100%	100%
Reflection	100%	100%	100%	100%
Post tests	100%	100%	100%	100%

3. Time spent on the course platform

The table below indicates that all of the participants took less than 10 hours to complete the tasks assigned in the module. However, they spent a lot of time developing the lesson plans and reflection report. Participants were constantly reminded of the deadlines for the submissions of lesson plans and reflections.

Table 3: Time spent by teachers on Moodle platform

Hours spent	NQTs	Preservice	Inservice	Total
Less than 5	0	0	0	0
5 to 10	1	8	3	12
10 to 20	4	3	1	8
21 to 30	0	0	0	0
More than 30	4	11	5	20
Total	0	0	0	0

4. Change from pre- and post- test

Average total score in pre-test: 8.20/15
Average total score in post-test: 11.23/15

Table. 4.1

Number of teachers		Post Test			
		Novice 0-25%	Emerging 26-50%	Proficient 51-75%	Accomplished 76-100%
Pre test	0-25% Novice	0	0	0	0
	26-50% Emerging	0	1	6	2
	51-75% Proficient	0	0	4	4
	76-100% Accomplished	0	0	0	3

5. Practice

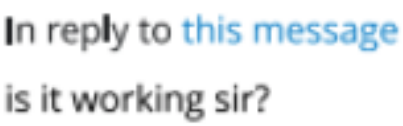
Criteria	Number of teachers				Total
	Novice	Emerging	Proficient	Accomplished	
A. Subject Matter Knowledge					
1. Knowledge of Subject Matter	0	4	14	2	20
2. Nature of Science/ Mathematics	0	4	16	0	20
B. Pedagogical Content Knowledge					
3. Instructional Strategies	0	9	7	4	20
4. Students' misconceptions & Conceptual Difficulties	1	12	7	0	20
5. Representation of the Content	0	7	12	1	20
6. Context for Learning	0	8	11	1	20
7. Curriculum knowledge	0	9	9	2	20
C. General Pedagogical Knowledge					
8. Equity and Inclusion	0	7	12	1	20
9. Classroom Management	0	5	14	1	20
10. Assessment	0	8	10	12	20
Total	1	73	112	14	200

A. Subject Matter Knowledge

The teacher participants have a good knowledge of the subject content. However, in a few cases, they were not able to relate it to everyday experiences. For example, the subject matter was on Newton's third law and activities revolved around proving it. One such was on a test tube brush and test tube experiment where some thought that on tapping the bottom of the test tube, the test tube brush should fall down instead of moving up the test tube.

1306

1305



1306

Some also had difficulty in getting the numerical problems solved on force and motion. For example

1305

Anybody can help me to solve this question?

1301

Need necessary help plzz??

Couldn't solve la

B. Pedagogical Content Knowledge

The participants have good pedagogical content knowledge. The topics chosen for session plans implementation showed use of real-life examples, observation and numerical problem-solving.

For example:

1315

Time	5 minutes
Associated LO	• Recall their previous knowledge. • Link it to the new lesson.
*Description of the activity/task/ *based on UDL principles*	Ask the following questions to the whole class to arouse interest in the lesson. ▯ Have you ever seen tug of war match? If seen, explain your observation. ▯ What would happen if two people push the table with equal force? ▯ What will be the consequences if unequal forces are acting on a body?
Main teaching points, *including Questions to be posed to students*	• Forces that are balanced are those that are opposite in direction and equal in size. Equilibrium is defined as the presence of balanced forces. There is no change in direction when forces are balanced. Balanced combined forces are always equal to zero. • Examples • Tug of war equally balanced teams. • Fruit hanging from a tree. • Ball hanging from a rope. • Resting against a wall. • Lying down. • To have unbalanced forces means that **the force applied in one direction is greater than the force applied in the opposite direction**. When unbalanced forces are acting on an object, there is a change in speed and/or direction. • an object sinking in water.

1309

Take a balloon, blow into it and tie the mouth of the balloon. Keep the balloon on one palm and let students predict what would happen to the balloon if force is applied on it. After prediction, make a child do the activity and share his observation and feeling to the class. Once students are done, questions will be asked:

Why did the balloon change its shape? What if downward force is not applied?

Teacher shows a magnet to the students and lets them share how they played with the magnet during their childhood days and asks questions such as how and why the magnet attracts magnetic material.

How is the force in the case of a balloon and force of a magnet different and similar?

Make students predict the topic of the lesson.

Besides, participants used video lessons to support their teaching and make concepts clear to the students. The video lessons were usually followed by question answers. For example:

1309 used this video link Teacher will provide a link (https://www.toppr.com/guides/physics/force-and-pressure/types-of-forces/) and make the students explore the information given using the link. Once they are done with the exploration, make students share their take away from the video.

The same teacher provided additional information using this web link https://www.siyavula.com/read/science/grade-9/forces/15-forces, the link gives information about the types of forces and further to make the concept clear, varieties of experiments are given for the students to perform, as well videos are provided.

C. General Pedagogical Knowledge

It seemed the participants had the pedagogical knowledge as they have used it in their session plans. There was mention of its use in their session plans like group work, demonstration, 4C, 7E, Kagen's group formation, peer work etc. There were details of how group work and peer work are carried out. For example:

1318

Think pair share. Students will be given time to think about the definition of forces and motion with some examples and allow them to share with the pair.

1300

*Associated LO	Student should be able to 1. Explain two types of force 2. Explain the effect of force
*Description of the activity/task	Tr, Explain the two types of force (contact and non-contact force) - Student activity - Tr, gave some example of force and made them to identify contact force and non-contact force (Round Robin) Tr, explain the concept of some of the effect of force - Student activity - Tr, made student to find some effect of force along with types of force associated with it. (example - force can change the shape of a body – compressive force which is a contact force) (Group activity 3 minutes) Tr, made student share their finding to the whole class Tr, monitor the group activity and help the group member to explain the concept
*Main teaching points/ Questions	Types of force (contact and non-contact force) Effect of force

However, the session plan missed details of how 4C and 7E were used though the tutors could see some components present.

In terms of assessment, most participants used questioning. However, few used the 321 strategy. For example:

1309

3-2-1 strategy. Make students write three things that they understood very well from the lesson, 2 things that are not clear to them from the lesson and 1 thing that they would like to know more. After going through the paper, the teacher will respond to students' queries.

6. Social learning in CoPs

A. Frequency of posts

The table below shows the number of telegram posts made by various groups of Chemistry CoP participants. Teacher educators made most of the posts and the research fellow posted the least. Teacher educators posted mostly to remind the participants about the course and deadlines.

Table 4: Frequency of posts by participants

Role	Number of posts
NQTs	24
Preservice Teachers	27
Inservice Teachers	36
Teacher Educators	107
Research fellow	0
Total	**194**

B. Frequency of posts

Table 5.1: Frequency of posts by content

Type of Posts	Number of posts
PCK	40
UDL	8
Technical	26
Communication/ Administrative	120
Total	**194**

Table 5.2 : Frequency of posts by type

Type of post	Number of posts
Text only	5
Images	30
External Links to other resources	7
Others (pdf)	1
Total	**43**

C. Qualitative dialogues/ discussion threads

i. Communication between the participant and tutor seeking clarification. This is a good example of using CoP to seek clarification if one is in doubt. In the beginning when participants had doubts, they posted to individual tutors on their personal chat. The tutors had to make repeated reminders to participants to use the CoP forum.

1306

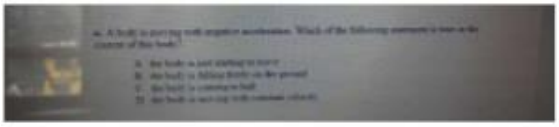
Good afternoon sir and madam, I am not clear about how to go about writing unit reflection. Template is asking to write reflection after implementing the session plan. Would be grateful if sir and madam can clarify on how to go about writing unit reflection.

Tutor

Dear All The reflection template shared is to be submitted after the implementation. For the time being you may leave it. Just a reminder you will have to only prepare three session plan and implement it. So there will be implementation reflection.

ii. Participants seek support from each other to answer the activity questions when they are not sure. This is the first time they have started seeking support from peers. This also shows that they are not worried to let others know that they do not know the answer and can use CoP as a learning platform.

1301



Which is the correct answer for the above question Ia?

1305

In reply to this message

C

Tutor

Good guys. You are learning from each other also

iii. Tutor posting resources that one could use for teaching class XII. This was important though the resource was not directly related to the module because our participants seemed hesitant participating in the CoP. The tutor was indirectly giving them hints that they could use the CoP to share resources.

Tutor

18 July 2022

If you are teaching class XII, you may design this teaching resource to demonstrate charging and discharging of capacitor

7. Teacher Educator's reflection on the overall implementation (Moodle and CoP)

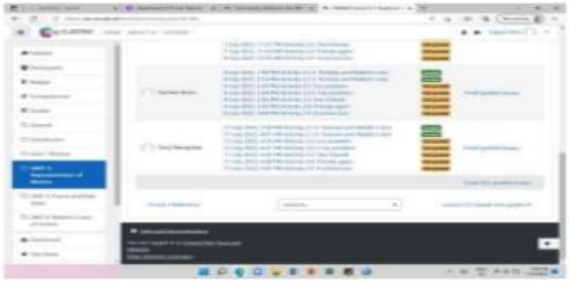
A. Participation of teachers:

In the beginning it was difficult to coordinate and get all the participants to work on the module. The use of CoP forum was not giving a positive result. Then the tutors (3 of us) resorted to calling them up individually. This worked to a certain extent but not always as they came up with many personal problems of their own. Then the tutors started using a number of strategies:

i. The CoP forum to inform the participants on their progress and completion rate as a gentle reminder to those who have not completed the task.For example:

Tutor

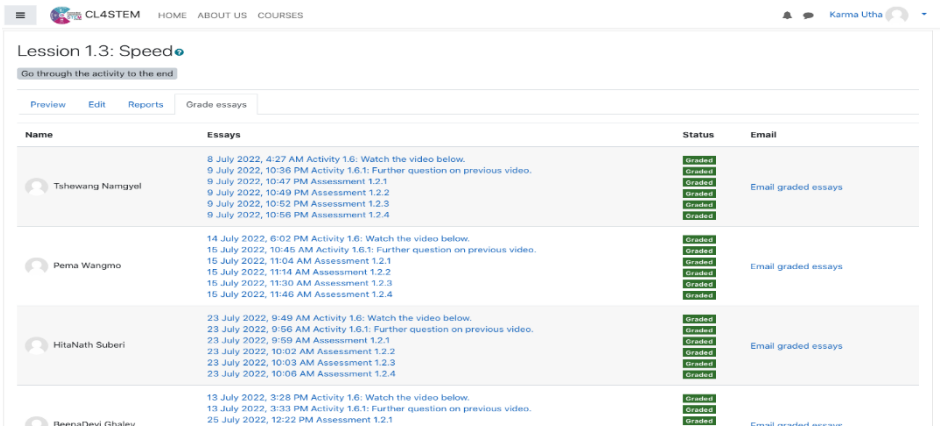
so far only five of you have completed two activities under the lesson 2.1



16:03

ii. Tutors also gave immediate feedback on the completed activities through email via module. For example:

Tutor



iii. Tutors also made sure to ask individuals via CoP forum whether they have any problems and require help from us. For example:

1312

Sry la mdm.. i started doing today only la... due to some circumstances... Will make sure to complete it in time la.....

Sry for the inconvenience 11:22

Tutor

In reply to this message

No problem Sangay. If you face any difficulties in logging in, just message us ok

iv. Telephonic calls- around two participants had limited access to the internet in the beginning. Hence, communication had to mostly be carried out through calls. This was solved later.

All these strategies had a positive impact. The rate of participation increased and participants seemed to have opened up. They seemed to understand that all their completed tasks are read by the tutors, and feedback is sent to them. However, telephonic calls were used only in a few cases.

B. Challenges:

In this module, all the activities were found doable by the teacher participants. There were few glitches, especially in terms of missing information or format. However, as soon as the information was received by the tutors, immediate changes were made. Hence, it was not a big concern.

1303

The lesson are still restricted la madam...we are not able to move to the next lesson as it is asking for reflection la...it would be better if the reflection are kept at the end of each unit.

1303

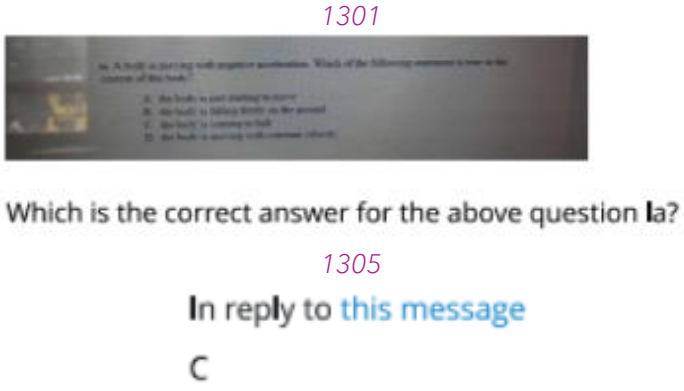
Tutor

I have checked you can try again

It's woking la sir

C. Assessment:

To make the activities interactive and hands-on and also to make sure the teacher participants do the activities, follow up questions are given. The questions are designed in such a way that a participant had to do the activity to answer it. This made the process quite interactive. There were few cases of teacher participants not being sure of the answer. In such cases, instead of tutors giving the answer, CoP was used. For example:



D. Surprises:

When teacher participants faced few problems in getting the activities done in the correct way, they immediately contacted the tutors. The tutors on their part refrained from giving the answers. The tutors took a step back by not responding immediately. After that, I observed that the teacher participants used the CoP and liaised with their colleagues on how to go on about the particular problem (see the screenshot above in assessment). This process was found useful so that they learn from each other.

E. Any changes required in the module design:

As of now, major changes are not required in content and activities. Few minor changes are already taken care of. The minor changes are mostly formatting and access to the module.

In terms of session plans and reflection submission, teacher participants were required to submit 3 session plans and 1 reflection. But in the module, there are 4 units and the system required them to submit a session plan and reflection for each unit. Hence, this is changed as per the requirement in the remaining modules.

Data Sources Used

1. Moodle completion rate raw data
2. Moodle time spent raw data
3. Teacher pre test and post test data
4. All teachers' lesson plans and reflections (3 lesson plan per module per teacher, and 1 reflection per module per teacher)
5. Teachers' responses for the pre and post test surveys
6. Telegram CoP group data download for the during of the module

Subject : Physics

Work, Energy, and Power

Authored by: Ms. Ugyen Pem

1. Introduction

The module "Work,Energy, and Power' was implemented from 18th August to 10th October 2022. A total of 20 teacher participants were enrolled. The module consisted of 3 units: Work, Energy, and Power. The learning outcomes of the module are as follows:

At the end of the module, each participating teacher should be able to:

- explain the meaning of energy in the context of Physics;
- identify and describe different forms of energy in real world scenarios;
- differentiate between potential energy and kinetic energy;
- identify contents from this lesson that you can use to teach the concept of energy in Physics in your class;
- use recommended resources to help students to link between energy in daily life and energy in physics;
- state the principle of conservation of energy;
- explain the meaning of energy transformation;
- describe real life examples of how energy is converted from one form to another;
- identify contents from this lesson that can be used as a resource in teaching your class;
- explain, scientifically, the meaning of mechanical work done;
- write and interpret the formula for calculating mechanical work done;
- convert SI unit of work to different related units;
- classify and explain common mistakes committed by students when solving mechanical work numerical problems;
- identify the contents from this lesson that can be used a resource when teaching mechanical work done in your class;
- explain the meaning of electrical energy and provide real life examples;
- derive different formulas for calculating electrical energy;
- classify and explain different mistakes committed by students when solving numerical problems related to electrical energy;
- identify contents from this lesson that can be used as a resource to teach work done by electrical energy in your class;
- explain properly the differences between energy, heat and temperature;
- describe the meaning and importance of thermal energy;
- classify and elaborate various errors committed by students when solving numerical problems related to thermal energy equation;
- identify contents from this lesson that can be used a resource to teach thermal energy topic in your class;
- explain the meaning of mechanical power as used in Physics;
- state the SI unit of mechanical power and convert SI of power to different related units;
- classify and explain common mistakes encountered by some students when solving numerical problems related to mechanical power;
- identify contents from this lesson that can be used as a resource to teach mechanical work in your class;
- explain the meaning of electrical power and provide examples;
- derive the equations to calculate electrical power;
- convert SI of electrical power to different related units;

- classify and explain common mistakes committed by students when solving numerical problems related to electrical power;
- identify contents from this lesson that can be used as a resource to teach electrical power in your class;
- explain the meaning and cause of heating effect of electric current;
- derive the equation for calculating the amount of heat produced in a conductor by electric current;
- state how the heating effect of current is harnessed in various electric heating appliances;
- classify and explain various errors committed by students when solving numerical problems related to heating effect of electric current; and
- identify contents from this lesson that can be used as a resource to teach thermal energy dissipation in your class.

A. Resources - activities, readings

In this module, the activities are doable with locally available materials, daily experiences, and e-resources. They are: listing as many as possible examples seen in the school or home; figures and images to explain the concepts; links to explore more about the work done; flow charts to understand the different forms of energy; video and PhET simulations to carry out virtual experiments; free body diagrams for solving problems; calculations and discussion on the common errors students commit while solving numerical questions; how to connect representations to the real world; and demonstration and applications of the heating effects of electric current. There are a few activities that are related to the application of concepts learned, such as calculating household energy consumption bills and analysing free-body diagrams in solving numerical problems.

B. Nature and purpose of assessments

The three teacher educators worked in evaluating the activities carried out by the 20 participants. Also, we graded the two lesson plans and a reflection for each participant to find out the level of the participants' competencies in three areas like subject matter knowledge, pedagogical content knowledge, and general pedagogical knowledge. We divided the unit's lessons amongst ourselves so that we could evaluate the participants' learning in each lesson and give immediate feedback. Therefore, there were no issues in the assessment of the participants' responses to the activities. Further, within ourselves, we took the responsibilities of six/ seven participants each to provide any other support that they may require. This made the assessment component easier for the team.

2. Course completion rate

A. Overall completion

Table 1: Course completion rate by teachers

	NQTs	Preservice	Inservice	Total
81 - 100%	100%	100%	100%	100%
Total	100%	100%	100%	100%

B. Assessment completion rate

Table 2: Teachers' assessment completion rate

	NQTs	Preservice	Inservice	Total
Pre test	100%	100%	100%	100%
Session plans	100%	100%	100%	100%
Reflection	100%	100%	100%	100%
Post tests	100%	100%	100%	100%

3. Time spent on the course platform

Table 3 illustrates that 18 teacher-participants spent between 10 to 20 hours on the moodle platform and the remaining 2 participants spent less than 10 hours. Around 55% of the participants spent less than 14 hours on moodle platform as shown in Figure 1.

Table 3: Time spent by teachers on Moodle platform

Hours spent	NQTs	Preservice	Inservice	Total
Less than 10	0	1	1	2
10 to 20	5	9	4	18
21 to 30	0	0	0	0
More than 30	0	0	0	0
Total	5	10	5	20

4. Change from pre- and post- test

The average score in the pre-test is 68.12%, and the average total score in the post-test is 63.67%. This indicates that the performance of students in the pre-test is better than the post-test. On further analysis of the performance of participants in the pre-test and post-test, the number of participants in the accomplished level decreased to 2 and the number of participants in the emerging level increased to 3, as shown in Figure 1.

Figure 1. Performance of participants in pre-test and post-test

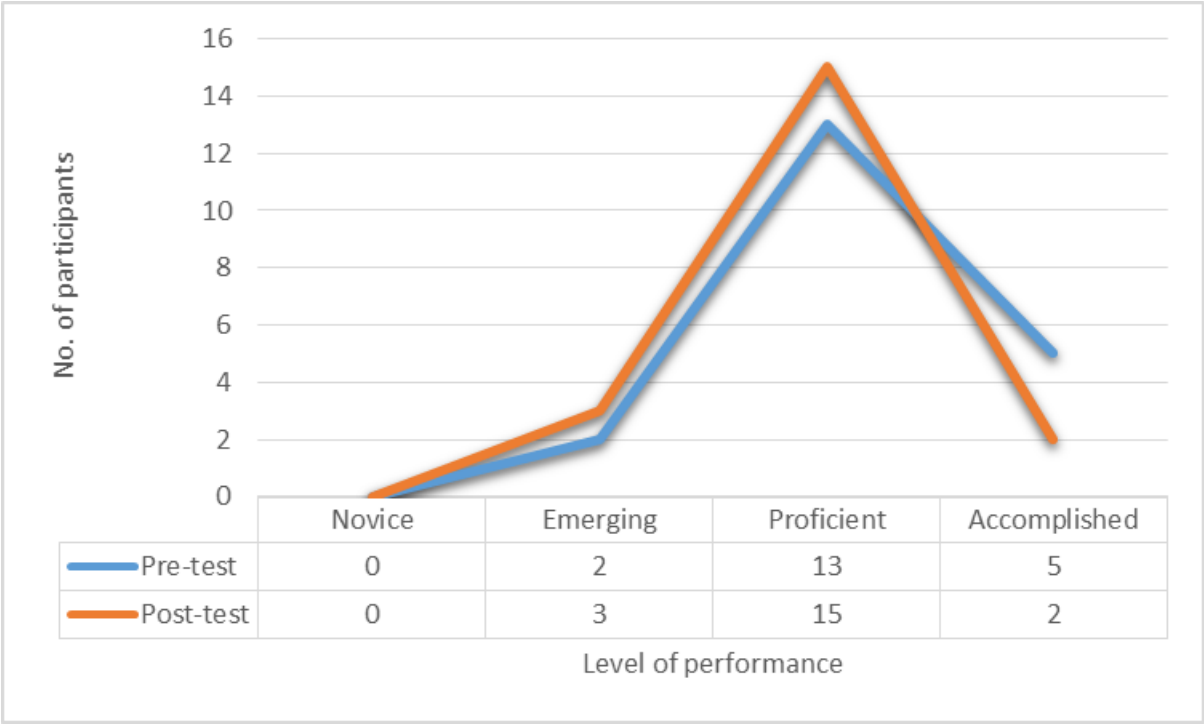


Table 4 indicates the change from pre-test and post-test performance of participants.

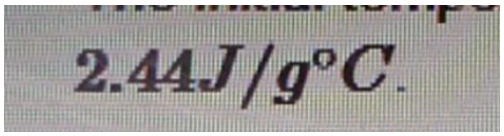
Table 4: Performance of participants in pre-test and post-test

Number of teachers		Post Test			
		Novice 0-25%	Emerging 26-50%	Proficient 51-75%	Accomplished 76-100%
Pre test	0-25% Novice	0	0	0	0
	26-50% Emerging	0	1	2	1
	51-75% Proficient	0	1	9	5
	76-100% Accomplished	0	0	0	1

5. Practice

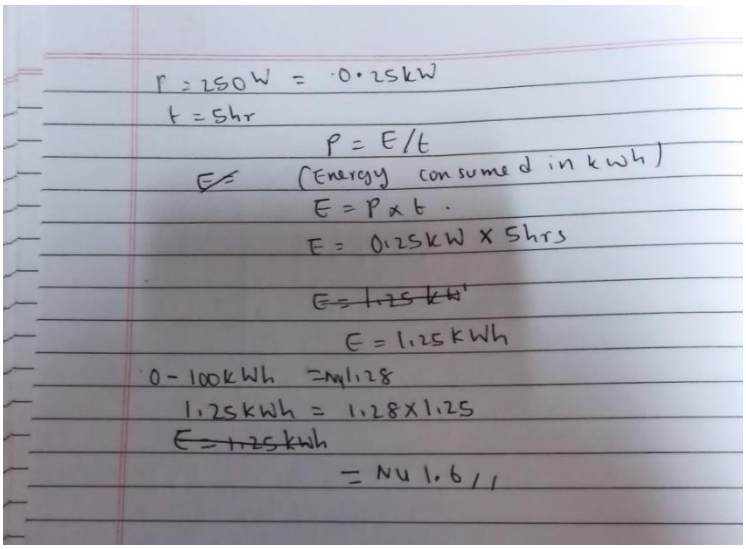
Criteria	Number of teachers				Total
	Novice	Emerging	Proficient	Accomplished	
A. Subject Matter Knowledge					
1. Knowledge of Subject Matter	0	5	13	2	20
2. Nature of Science/ Mathematics	0	9	10	1	20
B. Pedagogical Content Knowledge					
3. Instructional Strategies	0	8	8	4	20
4. Students' misconceptions & Conceptual Difficulties	1	8	10	1	20
5. Representation of the Content	1	5	13	1	20
6. Context for Learning	1	2	17	0	20
7. Curriculum knowledge	0	4	14	2	20
C. General Pedagogical Knowledge					
8. Equity and Inclusion	0	2	17	1	20
9. Classroom Management	0	3	15	2	20
10. Assessment	0	8	11	1	20
Total					

A. Subject Matter Knowledge



As shown in Table 5, more than half of participants have proficient subject matter knowledge. Also, the average score of the pre-test and post-test on subject matter knowledge of the 20 participants falls in the range of a good level of performance (pre-test: 68.12% and post-test: 63.67%).Interestingly, we found that the participants' average score in post-test has decreased after learning the module. We can conclude that the participants have more misconceptions in learning this module. Especially in the calculation of energy consumption bills, units conversion and energy conversion. For example,

Participant 1304 asked, " Is this unit correct?With calories the unit of mass is being used as gram but here with Joule mass unit is gram. I'm confused"



Nearly half of participants made mistakes in the calculation of the energy consumption bill. The application of knowledge of energy consumption in our homes is poor. Here is a sample of error committed by the participant in solving electricity bills for a month from his/her responses in the activity.

B. Pedagogical Content Knowledge

The majority of participants(62%) have proficient pedagogical content knowledge, as shown in Table 5. From the analysis of the grading sheet, it is found that the majority of participants used open-ended questions/tasks/activities to foster discussion on the topic. They were following an activity based learning instructional strategy and numerical solving techniques. Some of the participants have used videos, handouts, and concept maps to supplement the lessons. Participant 1316 mentioned "through the demonstration and hands-on experimentation." Participant 1301 encouraged the students to ask questions. Typically, students are hesitant to ask teachers questions in class. Moreover, a few of the participants checked whether the students were able to relate the theoretical knowledge to real-life applications by asking open-ended questions. Participant 1306 asked an open-ended question, "Why do you eat food?" "Will you be able to work if you do not eat food?" Participant 1307 also asked an open-ended question, "Is the heating of mobile phones also due to the flow of current?"

In the CoP, the teacher educators checked the learner's understanding of scientific and mathematical thinking by asking questions beyond the OER. The participants were in a position to respond to the questions. Participant 1305 shared a video on the demonstration of energy conversion between PE and KE by bouncing a basketball. Another participant 1301 shared that "falling down of fruits from trees and calculating the PE and KE at different positions during its fall" and he usually connects the lesson by sharing an incident of one of my friends getting hit by an almost-ripe jackfruit while at SCoE. There were a few participants who used advanced instructional strategies in the class. For example, participant 1308 "Ask questions, use IDEAS strategies and TAPPLE method of learning(Teach, Ask, Pose a question, pair share, listen, evaluate)" in his class.

The participants identified the learning difficulties of their students in the class. The majority of them said that the students were not able to solve the numerical questions. However, none of them planned to identify the possible misconceptions/alternative conceptions, or areas that are difficult to understand. They focused more on the technique of solving the numerical questions. Participant 1309 said, "Monitoring of students' work should be taken seriously, and their learning should be assessed after every activity and feedback provided instantly, so that students understand what they did wrong and what changes they need to make."

The participants leveraged the features of the resources appropriately (TPACK) to achieve learning outcomes. The majority of them used online videos, simulations, images, and PowerPoints to teach their students in the class. A few of them used a quiz to evaluate whether learning outcomes were achieved or not. Participant 1304 used an online quiz in the class. Participant 1319 gave the opportunity for her students to watch the audio-visual video and solve problems assigned to them. Participant 1313 mentioned, "Some students had difficulty solving numerical problems, especially while choosing the formula for heat produced." "I included one video explaining the concepts of the heating effect of electric current."

The participants used everyday experiences/ daily life practices to connect different topics in work, energy, and power. The majority of the participants used simple everyday experiences like work done, energy transformation, and application of the electric current effect. For example, participant 1310 asked her students to write an application of the electric effect of current in our daily lives. Participant 1318 asked her students to write real life examples of energy transformation.

Only a few participants used a hierarchical sequence of foundational concepts for teaching and their interconnection with other concepts/topics in the curriculum within the grade. For example, participant 1301 indicated the interconnection of work done with trigonometry concepts. Participant 1316 also indicated the interconnection of concepts of electron loss and gain with the charging of a body. Participant 1302 connected energy rating and energy efficiency in his teaching.

C. General Pedagogical Knowledge

The majority of participants(71%) have proficient general pedagogical knowledge, as shown in Table 5. The participants' knowledge of using strategies to provide equal opportunities for all students to participate in the classroom interactions. The majority of them formed groups of mixed ability to carry out classroom activities. Moreover, participant 1319 reinforced the students who were not active in the group work; participant 1318 made sure that the group formation had an equal number of male and female; pair work was done so that every student got the opportunity to share their ideas; and participant 1300 gave each student an equal opportunity to participate in finding their own mechanical power and comparing it with another student.

The participants used multiple modes of classroom interaction—inquiry, problem-solving, students' expression, grouping practices, and demonstrations and activities to foster student engagement. However, the multiple ways of expressing themselves were not visible in their lesson plans. The majority of them conducted hands-on experiments, solved numerical questions, and gave demonstrations. For example, participant 1316 mentioned, "some students had difficulty understanding the concepts. I use the demonstration." Participant 1313 observed that some students had difficulty solving numerical problems, especially when choosing the formula for heat produced. It was quite interesting that the participants utilised the space and teaching resources effectively. Participant 1307 utilised a conference hall for group activity. Participant 1308 stated that the classroom furniture was set up in a row so that two students could share the table-peer and individual activities. Participant 1304 used 4C, group activity, online quiz, problem solving, and students asking questions.

The majority of the participants practised formative assessment. The majority of participants used assessment techniques such as asking and answering questions, but only a few used rubrics, muddiest points, and the 321 strategy. Participant 1303 used questioning (the teacher will check the students' understanding through the above questions. If they are not able to answer, then the teacher will supplement the concept. Participant 1306 used the muddiest point for assessment of the students' learning.

6. Social learning in CoPs

A. Frequency of posts

from 18th August to 10th October 2022

The interactions of 3 teacher educators, teacher participants (5 NQTs, 10 preservice teachers, and 5 inservice teachers), and one research fellow on social learning in the COP of the physics group from August 18 to October 10, 2022, are shown in Table 6, where teacher educators posted the most, followed by inservice teachers and NQTs.

Table 4: Frequency of posts by participants

Role	Number of posts
NQTs	31
Preservice Teachers	10
Inservice Teachers	42
Teacher Educators	122
Research fellow	8
Total	**213**

B. Frequency of posts

Table 5.1: Frequency of posts by content

Type of Posts	Number of posts
PCK	43
UDL	4
Technical	17
Communication/ Administrative	21
Total	**85**

Table 5.2 : Frequency of posts by type

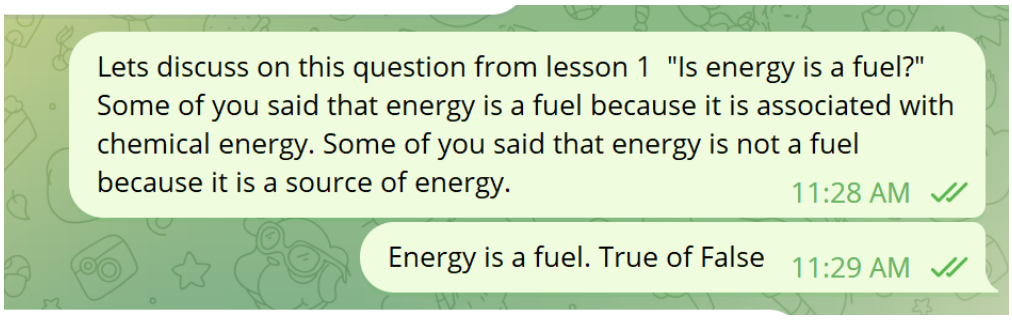
Type of post	Number of posts
Text only	79
Images	115
External Links to other resources	13
Others (pdf)	6
Total	**213**

Table 5.2 shows the frequency of posts by content during the implementation of module "Work, Energy, and Power" from August 18 to October 10, 2022. Out of 85 posts, 43 posts are related to PCK, followed by 21 posts on communication and administration.And Table 7.2 shows the frequency of posts by type during the same period for the same module. Out of 213 posts, 115 are images, followed by 79 text messages on the social learning platform.

C. Qualitative dialogues/ discussion threads

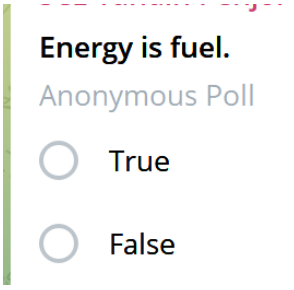
1. Clarification of misconceptions:

There were a few areas of the activities where the participants answered incorrectly or left blanks in learning the module. For example: Teacher educator B posted one question to clarify the misconceptions that a few students committed while answering the question.



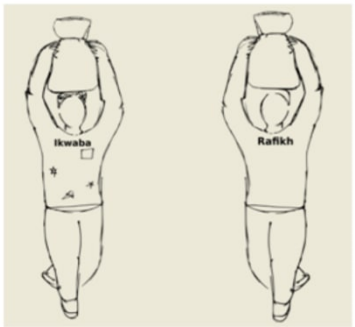
Further, teacher educator C set online polls to clarify the concepts of energy and fuel

Around 50% of the participants participated in the poll.



Teacher educator C posted this question to find out the relationship between power and time.

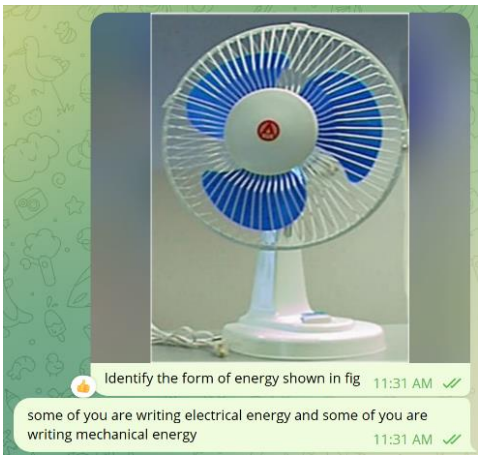
Two physics students, Ikwaba and Rafik are in the weight lifting room as shown in the Figure below. Ikwaba lifts a $50\ kg$ bag of cement over his head 10 times in $60\ s$ and Rafik lifts a $50\ kg$ bag of cement over his head 10 times in $10\ s$. Assuming that both students have the same height, which student does the most work? Which student delivers the most mechanical power? Explain your answers.



Two students in the weightlifting room.

Participant 1306 gave response to the question as
"Work done against gravity = mgh
Power = mgh÷t
My concept la
Number of times lifting can be cancelled since its same for both student"

Teacher educator B posted this question based on energy conversion



Participant 1305 replied to the Teacher educator B's post,

It's not a form of energy. It is a energy converter that convert electric energy into mechanical energy. 11:3

Participant 1312 replied theTeacher educator B's post,

Wind energy???😁

Then participant 1305 replied to participant 1312,

Yes sir. Sound energy, heat energy also. But I think these are dissipation of energy. 11:44 AM

Also, participant 1300 replied to participant 1305,

Converting electrical energy into a mechanical energy

2. Encouraging the participants to discuss in the CoP

Teacher educator A reminded the participants about the post posted by participant1304

has posted this question on the discussion forum. I would like to request the other participants to give your answer to it. The question si "How do levers create energy if the conservation of energy does not allow energy to be created?" 11:09 AM

Participant 1306 replied,

I think lever do not creat energy. It will just multiply force applied over a longer distance. 11:40 AM

Participant 1300 replied,

> Lever is a simple machine which just multiply the effort applied from my point of views la
>
> 12:05 PM

Participant 1305 replied,

> Lever is also doing some work and if work is done then naturally energy is consumed. Without energy we cannot do any work.
>
> 12:11 PM

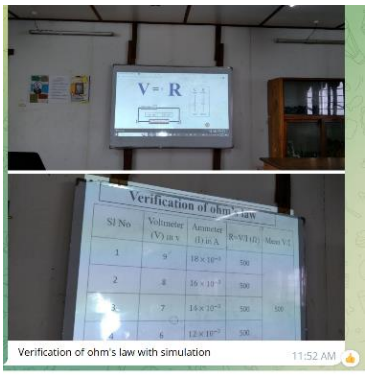
Teacher educator A acknowledged their answers. Good points

3. Participants sharing the videos and images of activities carried out in the schools. As a result of learning the module, the participants showcase the good practices.

Participant 1304 shared,

Electronic device (mobile here) plays vital role in teaching and learning.

9:31 AM

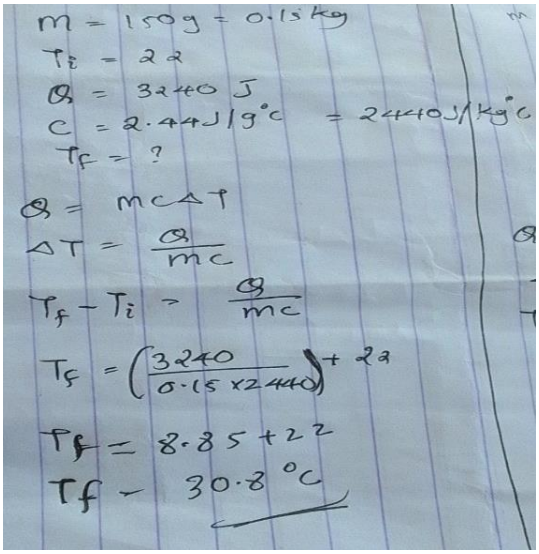


Verification of ohm's law with simulation

11:52 AM

Participant 1309's class activity on thermal energy shared by the research scholar

Participant 1300 shared his solution to the question.

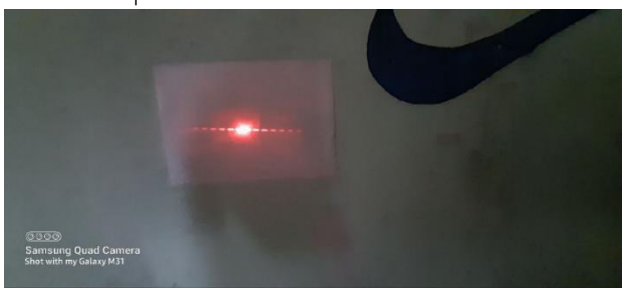


Participant 1305 shared video on teaching the concept of energy conversion.

Participant 1315 shared video on teaching the concept of work done.

4. Teacher educators and participants sharing their teaching resources for teaching class XII. Some of the teaching resources are not directly related to the module.

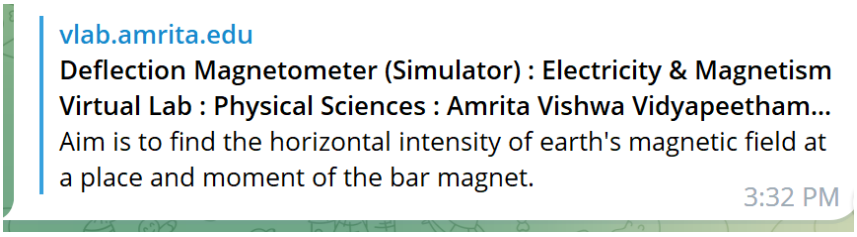
Teacher educator C shared image of a diffraction pattern from hair

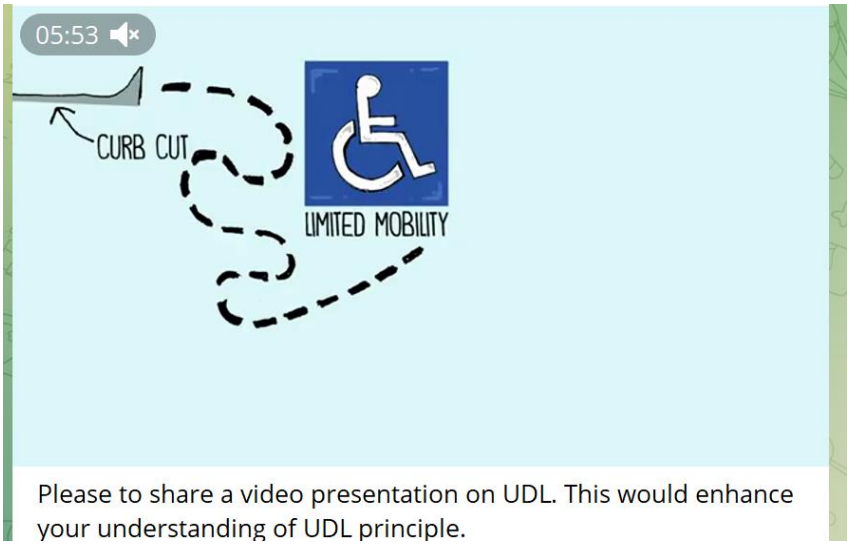


Participant 1304 shared the picture of students performing experiment

Participant 1300 shared picture of students performing experiment with improvised apparatus.

Teacher educator C shared a link for virtual experiment and a video on UDL





7. Teacher Educator's reflection on the overall implementation (Moodle and CoP)

A. Participation of teachers:

The implementation of this module was not as difficult as the first. The participants were familiar with the OER format of work, energy, and power. The content of the module was relevant and easily understood. Although the module progress was 100%, due to slow internet connections at their workplace, a few participants were unable to upload their responses on a virtual learning environment (Moodle). However, in the CoP discussion, only seven out of 20 participants were active and sharing their doubts and knowledge.

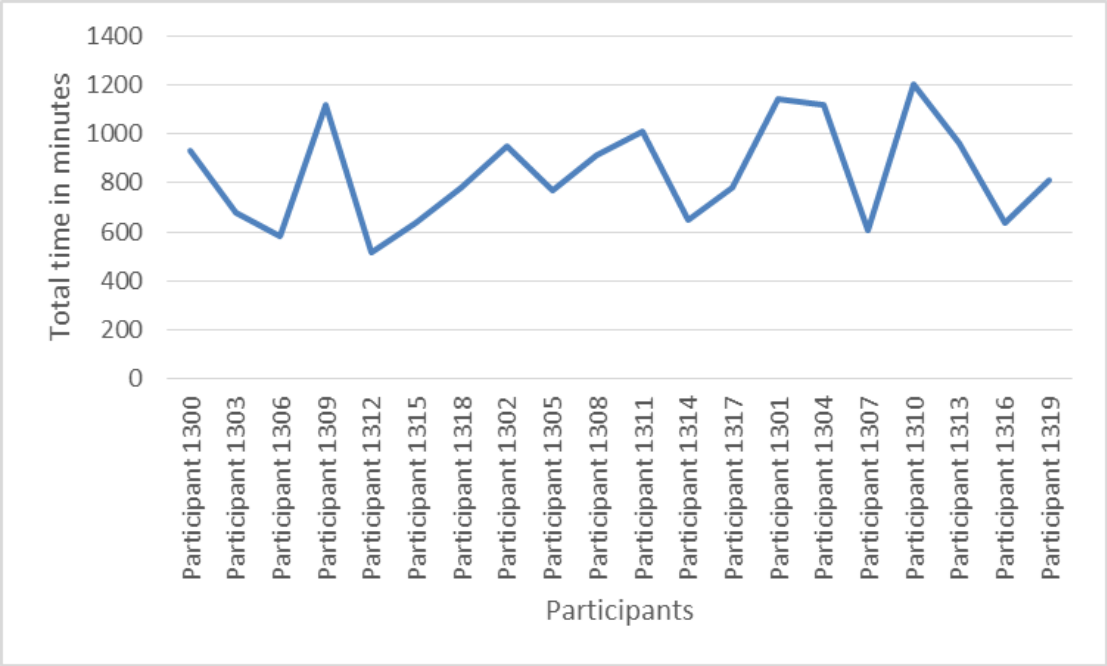
B. Challenges:

In this module, all the activities were found doable by the participants by using the materials available in the school. However, there are a few challenges observed by the teacher educators.

1. Time management

   The teacher educators reminded the participants regarding their learning progress on CoP via telegram. How many hours did the participants spend learning this module? Figure 2 indicates that 11 out of 20 have spent less than 14 hours studying this module.

Figure 2. Graph Course dedication



2. Implementation of lesson plans

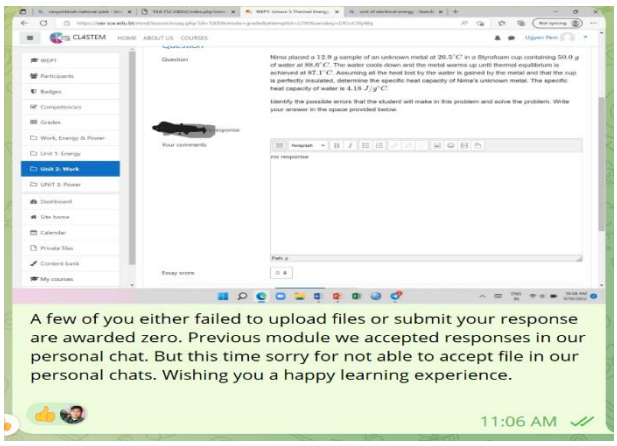
A few participants were to design detailed lesson plans and implement them in the class because the content of the module matched with their teaching subject. However, there are a few of them who have to borrow other teachers' teaching periods to implement the planned lessons. One student called me and said, " I am given class viii science and lesson plan prepared as per the module is for class X. What to do?" This clearly shows that a few teacher-participants had difficulty with the mismatch between the allocated class and topics from the OER.

C. Surprises:

1. When participant 1305 pointed out the mistakes in the OER, it led to a free discussion between the teacher educators and the participants. This small incident helped the participants open up and share any doubts or problems they had during the study of this module.

Figure 2. Message on Telegram CoP physics

2. The mean average mark of the post-test is lower than the pre-test. Usually, the participants should perform better in the post-test after learning the module. But in this module, the performance of students dropped from the pre-test by 4.45%.
One possible reason could be not accepting responses in personal chat(So as shown in Figure 2.



D. Any changes required in the module design

This module needs no major changes. However, there is still room for improvement in terms of usability, with a greater emphasis on formative assessment. There should be a provision where the participants can resubmit their answers until they get at least 60% to move on to the next lesson. This arrangement will encourage the participants to clarify their doubts and feel a sense of accomplishment.

Data Sources Used

1. Moodle completion rate raw data
2. Moodle time spent raw data
3. Teacher pre test and post test data
4. All teachers' lesson plans and reflections (3 lesson plan per module per teacher, and 1 reflection per module per teacher)
5. Teachers' responses for the pre and post test surveys
6. Telegram CoP group data download for the during of the module

Subject : Physics

Electromagnetism

Authored by: Mr. Tandin Penjor

1. Introduction

- Timeline of implementation in the country
- Learning objectives
- Number of units
- Concepts covered
- Resources - activities, readings
- Nature and purpose of assessments

The module "Electromagnetism' was implemented from 10 October to 15 December 2022. 20 teachers were enrolled. The module consisted of 4 units which are Magnetic field around a current carrying conductor, Magnetic field due to Solenoid, Electromagnetic force and application, and Exploring electromagnetic induction. The learning outcomes of the module are as follows:

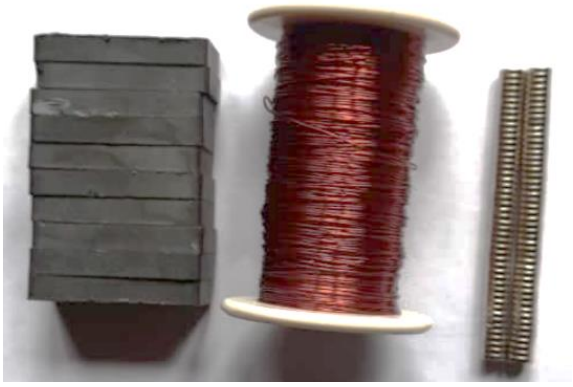
At the end of the module, each participating teacher should be able to

- Design the Oersted experimental setup and use it in the classroom.
- Determine the direction of magnetic field in a current-carrying conductor
- Explain the relationship between current and magnetic field.
- Write the formula of magnetic field due to a straight wire carrying current
- Calculate the magnetic field at a point due to a straight wire carrying current.
- Use the Right Hand Thumb Rule to indicate the direction of magnitude field given the direction of current or vice versa.
- discuss how magnetic fields are created by current passing through solenoids.
- draw the direction of the magnetic field at any point inside and outside the ideal solenoid.
- discuss the factors affecting the magnetic field strength in a solenoid
- discuss the uses of application of a solenoid.
- Analyse the motion of charged particles perpendicular in a magnetic field
- Apply the Right Hand Palm Rule to find the direction of the velocity, magnetic field and magnetic force given any two of these.
- explain what happens when a wire carrying is placed in a magnetic field
- calculate the direction and magnitude of the magnetic force on a current carrying conductor
- apply the Right Hand Palm Rule to find the direction of the current, magnetic field and magnetic force when any two of these are given.
- Construct a simple dc motor.
- State the Faraday's law of electromagnetic induction
- demonstrate electromagnetic induction
- use Conceptual Change Model to address the misconception in working of transformers.
- Use Lenz's to determine the direction of induced emf whenever a magnetic flux changes
- Use Lenz's law with Faraday's law to determine the induced emf in a coil and in a solenoid.
- Discuss the reason for the negative sign in Lenz's law.

A. Resources - activities, readings

In this module, all activities are designed to be carried out by teachers with minimal help. The activities require the use of digital resources such as simulation, videos and mobile apps. These are made available to the participants in the module itself. Almost all other required resources are mostly available in the school laboratory. As a part of the project, schools were provided with a strong magnet and insulated copper wires (Figure 1). These materials were useful for showing the magnetic force experienced by a current carrying conductor in a magnetic field and constructing electromagnet and a simple electric motor.

Figure 1: Strong magnets and copper wire



B. Assessments

The activities are designed to be interactive and practical and follow-up questions are asked to ensure teachers complete the activities. The questions are designed in such a way that a participant had to perform the activity to answer them. Also, the answers had to be submitted in the module itself before proceeding to the next activity. The answers submitted are evaluated by the tutors and the participants receive individual feedback. Since there are 20 participants, the 3 tutors have agreed to work together in all modules. The activities of the unit were shared by tutors to follow the progress of the participants and give feedback on the activities. In addition, the participants were also divided among the tutors to provide the necessary support and to assess the lesson plan and reflection submitted by the participants.

2. Course completion rate

A. Overall completion (Data available from Moodle platform)

The completion rate of the Electromagnetism module is 100%. The impressive participation in the course is due to the fact that the teachers see their participation as a positive opportunity to improve their professional practice and are constantly reminded of this by the teacher educators. Particularly, the pre-service teachers were constantly reminded to complete the course despite their busy schedule due to field practicum in the schools.

Table 1: Course completion rate by teachers

	NQTs	Preservice	Inservice	Total
81 - 100%	100%	100%	100%	100%
Total	100%	100%	100%	100%

B. Assessment completion rate (Data available from Moodle platform)

The assessment task that the teachers had to complete consisted of pre-test, preparation of three session plans, reflection and post-test. The assessment completion rate in all assessment components is 100%.

Table 2: Teachers' assessment completion rate

	NQTs	Preservice	Inservice	Total
Pre test	100%	100%	100%	100%
Session plans	100%	100%	100%	100%
Reflection	100%	100%	100%	100%
Post tests	100%	100%	100%	100%

3. Time spent on the course platform

The total duration of the course is about 6 weeks. 50% of the teachers spent less than 10 hours on the Moodle platform and another 50% spent 10 - 20 hours completing the course on the Moodle platform. The time recorded is only spent accessing the resources in the course and completing activities in each unit. This time does not include the time spent preparing three session plans and implementing them, as well as reflecting on the implementation of the session plans.

Table 3: Time spent by teachers on Moodle platform

Hours spent	NQTs	Preservice	Inservice	Total
Less than 10	2	7	1	10
10 to 20	3	3	4	10
21 to 30	0	0	0	0
More than 30	0	0	0	0
Total	5	10	5	20

4. Change from pre- and post- test

Average total score in pre-test: 9.6/15
Average total score in post-test: 9.98/15

The average score of the teachers in the pre-test was 9.6 and the post-test score was 9.98. As indicated in Table 4, there was a slight improvement in the test results. Analysis of the pre-test results showed that the majority (n=14) of the teachers were rated as proficient followed by three teachers who were rated as accomplished. Out of 14 teachers at a proficient level, the scores of three teachers improved to the accomplished level while post-test scores of two teachers dropped to emerging level. It can also be noted that teachers at an emerging level in the pre-test progressed to accomplish level in the post-test.

Table. 4.1

Number of teachers		Post Test			
		Novice 0-25%	Emerging 26-50%	Proficient 51-75%	Accomplished 76-100%
Pre test	0-25% Novice		1		
	26-50% Emerging		1		1
	51-75% Proficient		2	9	3
	76-100% Accomplished			2	1

5. Practice

The category of teachers from the assessment of three session plans and reflection is shown in Table 5.

	Number of teachers				Total
Criteria	Novice	Emerging	Proficient	Accomplished	
A. Subject Matter Knowledge					
1. Knowledge of Subject Matter	0	2	18	0	20
2. Nature of Science/ Mathematics	0	6	11	3	20
B. Pedagogical Content Knowledge					
3. Instructional Strategies	0	3	15	2	20
4. Students' misconceptions & Conceptual Difficulties	1	11	5	3	20
5. Representation of the Content	0	4	14	2	20
6. Context for Learning	0	10	7	3	20
7. Curriculum knowledge	0	13	7	0	20
C. General Pedagogical Knowledge					
8. Equity and Inclusion	0	5	14	1	20
9. Classroom Management	0	5	12	3	20
10. Assessment	0	14	5	1	20
Total	1	73	108	18	200

A. Subject Matter Knowledge

Overall, the session plans and reflection submitted by teachers for the Electromagnetism module are graded at proficient level (54%) followed by an emerging (36.5%) and an accomplished level (9%). The trend is the same for the Knowledge of Science and Nature of Science. However, there is a difference in the percentage of teachers at each level with 72.5% in proficient level, 20% in at the emerging level and 7.5% at the accomplished level. This clearly shows that the majority of teachers have sufficient subject knowledge.

This is evident from a teacher's lesson in which the student explores the link between the concept of the magnet and electromagnetism. This was done through an activity where the students used electricity to create a magnet. Linking new lessons to previous knowledge is important for several reasons. Firstly, it helps students make connections between new information and what they already know, which can aid in understanding and retaining the new material. Secondly, it can help contextualise the new information, making it more relevant and meaningful to the student. In addition, by connecting new information to what students already know, it can serve as a review and reinforcement of previous learning. This can lead to a deeper understanding and better retention of the learned material. Finally, by providing connections between different areas of knowledge, it can promote a sense of continuity and coherence in the learning process, which can increase motivation and engagement.

There was also evidence from the OER, where participants were tested on their understanding of using the Right-Hand Palm Rule to find the direction of the magnetic force, magnetic field or velocity of charge. Teacher 1319 was able to use RHPR correctly to indicate the direction required in the question (Figure 2).

Figure 2 Using RHPR to indicate the direction of magnetic force

What is the direction of the magnetic force on a negative charge that moves as shown in Figure 20?

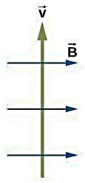


Figure 20

Explain your answer using Right Hand Palm Rule and Right Hand Rule.

Direction of magnetic force on negative charge is out of the page.

Explanation:

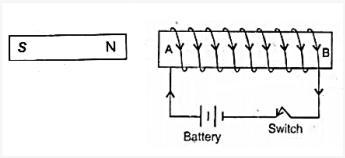
When we stretch our right hand with fingers (B) pointing towards right and thumb (v) in upward direction. Then the palm (F) facing the page. Since palm points into the page, the direction of magnetic force on negative charge is out of the page.

Figure 3, 4 and 5 show the evidence for questions from the OER where the majority of teachers were able to answer correctly.

Figure 3

Multichoice: Activity 1.5.2	**Class statistics**
Question: If the steady current in a wire is coming directly towards you, the magnetic field lines	
Answer:	
☑ circle the wire in counterclockwise direction	71.43% Checked this one.
☐ point radially outward	14.29% Checked this one.
☐ point radially inward	4.76% Checked this one.
☐ circle the wire in clockwise direction	9.52% Checked this one.
Response: #Correct: Using right hand thumb rule, the thumb indicates the direction of current approaching you, the fingers curl in counter-clockwise direction	

Figure 4

Multichoice: Activity 2.2.1	**Class statistics**
Question: A magnet is positioned next to an electromagnet as shown in Figure 25. The current of the electromagnet is then reversed. What will happen?  	
Answer:	
☑ The magnet and electromagnet will repel each other.	66.67% Checked this one.
☐ The magnet and electromagnet will attract each other.	28.57% Checked this one.
☐ The magnet and electromagnet will cancel each other's field.	No one checked this.
☐ Nothing different will happen.	4.76% Checked this one.

However, there are also some who have had difficulty using the RHPR to indicate the direction of magnetic force, the magnetic field or velocity of charge. Some teachers have the misconception that the RHPR can be applied to both positive and negative charges.

Figure 5 Misconceptions in the use of RHPR

What is the direction of the magnetic force on a negative charge that moves as shown in Figure 20?

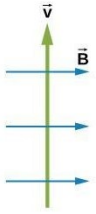


Figure 20

Explain your answer using Right Hand Palm Rule and Right Hand Rule.

Right hand rules states that , to determine the direction of the magnetic force on a positive moving charge F, Point the thumb of the right hand in the direction of v , the finger in the direction of B,and a perpendicular to the palm points in the direction of F. so the direction of force is in to the plane of paper.

Right hand rules states that, to determines the direction of magnetic force on a positive moving charge, point your thumb in the direction of velocity (v), your index finger in the direction of magnetic field (B), and your middle finger will point in the direction of resultant magnetic force. so the direction of magnetic force is in to the page.

B. Pedagogical Content Knowledge

In terms of Pedagogical Content Knowledge, 41% of teachers are graded at an emerging level, 48% at a proficient level and 10% at an accomplished level. The increased percentage of teachers at the emerging level is evident as the participants are newly qualified and pre-service teachers who may lack PCK for effective teaching. They were found to have sufficient knowledge of instructional strategies and representation of content. However, they are found to be particularly lacking in curriculum knowledge, student's misconception and learning difficulties and context of learning.

The teachers use a range of instructional strategies such as group work, activity-based learning, demonstration, questioning, lecture method and pair work. The strategies combined with a range of activities and materials that appeal to different interests and learning styles were used. This helped provide learners with choices about how they engage with the content.

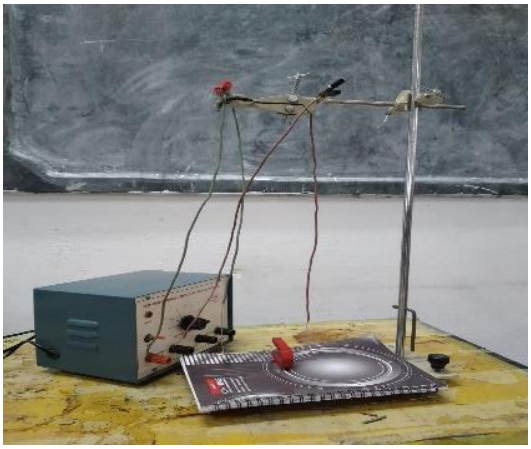
i. For example, Teacher 1305 designed an activity-based learning for Class IX to create electromagnet and use the electromagnet to pick up paper pins. The activity also required students to figure out how to increase the strength of their electromagnet.

Figure 6 Table used by student to record their observation about the strength of the electromagnet

Electromagnet	How many paper did your electromagnet pick up?
With 10 – 15 coils	
With fewer coils How many coils? ____6_____	
With more coils How many coils? ____20_____	
With a different battery #1 No of battery ___2_____	
With a different battery #2 No of battery ___4_____	

ii. Teacher 1314 designed group work to determine the direction of the magnetic force on current carrying wire. The apparatus setup used in the activity is shown in Figure 7. In the activity, the students were required to note the direction of the magnetic force experienced by the wire and verify it by using Fleming's Right Hand Rule.

Figure 7: Setup to determine the magnetic force on a current carrying wire.



The teachers used various media such as videos, pictures and simulations to present the information and content. Below are some of the examples:

- Teacher 1318 used the diagram in the textbook and video on Lenz's law given in the link. https://youtube.com/watch?v=2_M83gNOOEg&feature=share
- Teacher 1309 used Video on the production on magnetic field from the current carrying conductor https://www.youtube.com/watch?v=qS361iadCPA) and https://www.youtube.com/watch?v=qS361iadCPA
- Teacher 1314 used PhET simulation on Faraday's law to show induced current due to change in magnetic field lines. Faraday's Electromagnetic Lab

The teachers used multiple means of expression to demonstrate their understanding of the concept. This included question and answer, Telegram quiz, presentation, sharing the result of the experiment, using an observation table to record their observation, using Google form to record student answers. Below are some examples:

- Teacher 1302 asked four questions to the students. The students answer these questions in Google form whose link is shared via telegram. https://forms.gle/aQe6suEFNyrezCA96
- Teacher 1315 provide opportunities to answer question, predict the observations and outcome of the experiment
- Teacher 1308 asked students to write their observation on the board.
- Teacher 1309 used presentation of the take away from the simulation to the class, questioning and sharing their learning

C. General Pedagogical Knowledge

In terms of General Pedagogical Knowledge, 51.7% of teachers are graded as proficient, 40% emerging and 8.33% accomplished. Most of the teachers are graded in proficient level in terms of equity and inclusion (70%) and classroom management (60%). However, the teachers (70%) are graded at an emerging level in the assessment. This suggests that 70% of the teachers faced some difficulty assessing students in learning electromagnetism concepts.

The assessment of session plans showed equity and inclusion are given importance in the design and delivery of lessons on electromagnetism. To promote equity, teachers made sure that all students have access to the same resources and opportunities to learn the concept of electromagnetism, regardless of their background or identity. There is evidence that teachers create a classroom environment in which all students feel safe and valued and in which their diverse perspectives are recognized and respected. Below are some evidences:

1. Teacher 1304 provided extra time for those students who were a little stressed due to incomplete tasks on time.
2. Teacher 1301 identified and corrected some students' difficulty in learning Flemming's Left Hand Rule.
3. Teacher 1303: Students divided into smaller groups to perform experiments. Both boys and girls participated equally. The students who were anxious or stressed were given extra time to do their task. Their views and opinions were respected and they were given some constructive feedback.

4. Teacher 1318 used group work and pair work. Students will read the instructions on working of simple dc motors and discuss them in pairs. I should have assigned tasks to individual students in a group to make sure equal participation since few students were not participating in the activity. Since there are diverse students in the class, I will try to come up with extended learning activities for those who face difficulties catching up in the class.
5. Teacher 1310: I should not have given the link but could have made them explore and come up with a variety of experiments for the same aim of the experiment. I restricted students from exploring and abstained from seeing varieties of ways of inducing magnetic fields by the current carrying conductor.

Effective classroom management is important in any subject, including physics, to create a safe and productive learning environment. Aside from promoting an inclusive classroom environment, teachers were found to use various active learning strategies such as hands-on activities, group work, experimentation and questioning to keep students engaged and motivated. Also, adequate supervision by the teachers was also carried out during the activities. For example

1. Teacher 1303: The monitoring of the students by moving around and interacting with the students who are not participating were done.
2. Teacher 1310 used group work, pair work and individual work. I should not have given the link but could have made them explore and come up with a variety of experiments for the same aim of the experiment. I restricted students from exploring and abstained from seeing varieties of ways of inducing magnetic fields by the current carrying conductor.

In terms of assessment, teachers mainly used questions to assess the concept learned in the class. Except for one teacher, who used observations to assess how students perform their assigned task. However, the assessment lacked the areas that test the student's ability to apply the concept and principles of electromagnetism. Some example of the assessment used by the teachers are as follows:

1. Teacher 1302 asked four questions to the students. The students answer these questions in Google form whose link is shared via telegram. https://forms.gle/aQe6suEFNyrezCA96
2. Teacher 1318: Students will be assessed based on their answer. Students will be observed on how they carry out the task and working of their motor.
3. Teacher 1312. Checking the graphs of answered questions and supplementing the answers and clarify; Students will be observed on how well they answer the question.
4. Teacher 1314 provide student opportunities to answer question, predict the observations and outcome of the experiment

6. Social learning in CoPs

Social learning refers to the process of learning from each other, tutors and the wider community. This type of learning is characterised by a collaborative and communicative environment in which learners are encouraged to actively participate in discussions, share their understanding and ideas, and build new knowledge through a collective process. The social learning in the electromagnetism module was fostered through the use of the Telegram group which allowed teachers to interact and collaborate with others in real time. The following section discusses the use of CoP in the electromagnetism module.

A. Frequency of posts

Table 6 shows the frequency of posts by the teachers in the Telegram group. The teacher educator (67.6%) leads the number of posts followed by in-service teachers (15%), NQTs (11.3%), pre-service (3.8%) and research fellow (2.3%).

Table 4: Frequency of posts by participants

Role	Number of posts
NQTs	15
Preservice Teachers	5
Inservice Teachers	20
Teacher Educators	90
Research fellow	3
Total	133

The Telegram group was mainly used for communication/ administrative purposes (69.3%). This was followed by posts on PCK (18.4%) and technical (12.3%) queries in the module.

B. Frequency of posts

Table 5.1: Frequency of posts by content

Type of Posts	Number of posts
PCK	21
UDL	0
Technical	14
Communication/ Administrative	79
Total	114

Table 5.1 shows the type of post in the Telegram group. Posts consisted primarily of text messages (74.6%) followed by images (22.8%). The posts also had a poll and quiz on PCK. The most preferred type of post is clearly text message as it takes less time to send the message.

Table 5.2 : Frequency of posts by type

Type of post	Number of posts
Text only	85
Images	26
External Links to other resources	4
File	1
Poll & Quiz	3
Total	119

C. Qualitative dialogues/ discussion threads

The discussion between teachers and teacher educators was mainly for communication/ administrative issues and technical issues. Initially, the discussion involves notifying the module opening date, sharing the link of the module and enrolment key. The module coordinator posted the following message to the group.

Congratulation to all the participants. The last module is open now. You may click on this link to enrol to the course
https://oer.sce.edu.bt/course/view.php?id=5

The enrollment key for the module is ELE2022 12:42

Click on the link given above and log in using your username and password. Type ELE2022 as enrollment key

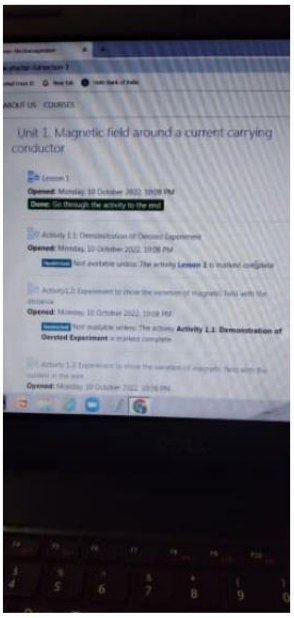
The discussion also had a poll to confirm the number of teachers enrolled in the module. Depending on the responses, another notification was made to the teachers to enrol in the module.

Are you able to enrol to Electromagnetism module?
Anonymous poll
- Yes
- No
16 votes

Four participants have not yet enrolled to the course. Please do it soon.

Figure 8 Technical issue in module

After the teachers were enrolled in the module, there were some technical issues related to moving to the next activity. The problem was immediately solved as the module coordinator had admin rights. Teacher 1305 posted the screenshot of the issue in the forum.



Activity 1.1 not opening

Click next to complete.

In reply to this message

Did it work sir

Yes sir. Thank you sir

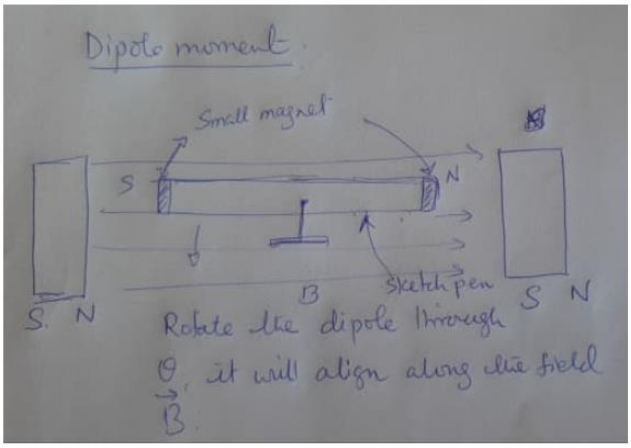
The discussion also had a post from a teacher educator on Pedagogical Content Knowledge. The images of the setup to demonstrate the magnetic moment were sent to the group.

13:58

In reply to this message

We would like you to make use of the material and post the picture of the activity to the common group.

I have found a good way to use the big magnet and small magnet to teach the concept of magnetic moment. I will share the activity here. This will help Class XI and XII student to see the concept torque when the magnet is placed in the magnetic field. 14:00



try this setup to show dipole moment to your class XII std. 12:42

A research fellow also shared images of the use of the materials provided to the school as a part of the project. The materials were used by the teacher to demonstrate electromagnetic induction following the procedure included in the module.

Figure 9 Student performing electromagnetic induction activity

How to use this? Where? 13:52

In which experiment la? 13:54

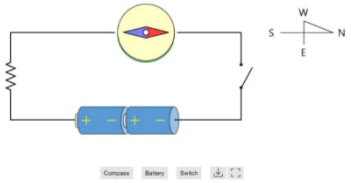
Teacher 1301 posted a picture of a magnet and asked where the magnet could be used.

Teacher 1305 shared a picture of students using the material to build electromagnets. A closer look at the picture shows that students are fully involved in the activity.

Figure 10 Student building electromagnet

Teacher 1306 posted an image of a numerical problem seeking support from the members of the group.

A PCK question was also posted in the group, but the teachers' responses were not very encouraging.

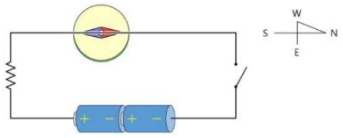


How would the compass needle align when the switch is closed? 12:25

Final results

- Will remain same
- North pole will align to East and South pole to West 1 vote
- North pole will align to West and South pole to East 3 votes
- North pole will align to South and South pole to North

4 votes



The compass is placed below the wire. How would the compass needle align when the switch is closed? 12:32

Final results

- Will remain same 2 votes, chosen vote
- North pole will align to East and South pole to West 1 vote
- North pole will align to West and South pole to East 3 votes
- North pole will align to South and South pole to North 1 vote

7 votes

7. Teacher Educator's reflection on the overall implementation (Moodle and CoP)

A. Participation of teachers:

In the beginning, the participation of the teachers was not very encouraging as many had not enrolled in the module. This happened mainly with the pre-service teachers. They had reasons for the delay as they were busy with their field practicum. Some teachers took almost eight days to complete the pre-test, even with repeated reminders. However, the teachers' were able to complete all the assigned tasks in the module.

B. Challenges:

The activities in this module were found doable by the teachers and some were implemented in the classroom. For example, activities on electromagnets and electromagnetic induction were carried out in the classroom by the teachers (see Figure 9 and Figure 10). There were some technical glitches, especially related to missing information or settings of the few activities in the module. These problems were immediately solved by the tutor and communicated to the teachers in the CoP. Such issues would have exacerbated the problem and hurt the teachers' motivation if the module coordinator had no idea of the issue and the issues had to be forwarded to the IT personnel.

C. Surprises:

The module coordinator saw the challenges teachers would face in implementing the activities in the classroom. The challenge would mainly come from the unavailability of the materials to demonstrate the concept of electromagnetism to the students. Therefore, the materials were procured and sent to the schools. The materials were well used in the school as shown in Figure 9 and Figure 10. A closer look at the image shows the students' interest and engagement level when they can see the application of the concept they are learning.

D. Any changes required in the module design:

As of now, no major changes to content and activities are required. Some minor changes have already been made which are mostly related to the formatting and settings of activities. During implementation, all content and activities can be made available to teachers as they choose the content and activities as and when they appear in the curriculum

Data Sources Used

1. Moodle completion rate raw data
2. Moodle time spent raw data
3. Teacher pre test and post test data
4. All teachers' lesson plans and reflections (3 lesson plan per module per teacher, and 1 reflection per module per teacher)
5. Teachers' responses for the pre and post test surveys
6. Telegram CoP group data download for the during of the module

Subject : Mathematics

Algebra - Linear Equations Module

Authored by: Mr. Purna Bahadur Subba

1. Introduction

A. Timeline of implementation in the country:

July 2, 2022 – Aug 14, 2022

B. Learning objectives

1. Be able to learn about and remember the important pedagogical pillars and student misconceptions while teaching simple equations, linear inequalities and simultaneous equations
2. Be able to understand the various misconceptions that the students have and the pedagogical practices that must be utilised inside the classrooms, and thereby outline these misconceptions and pedagogical pillars in their own words
3. Be able to apply the concepts learnt in the module in their own practice by creating and executing lessons based on the principles learnt in the module.
4. Be able to evaluate their own lesson plans and execution of the principles outlined in the module via self-reflection templates.
5. Be able to create lesson plans and assessments to incorporate the learnings from the module.

C. Number of units: 4

D. Concepts covered

As per the topics mentioned in the following :

Topic 1: Simple Equations	Topic 2: Inequalities in one variable	Topic 3: Simultaneous equations
1. Forming linear equations 2. Solving equations in one variable i. Solving equations using models ii. Solving equations using Guess and Test iii. Solving equations using inverse operations iv. Checking answers to equations	1. Concept of inequalities 2. Operations with inequalities 3. Graphical representation of inequalities	1. Forming Equations 2. Solving equations in two variables i. Guess and Test ii. Graphical method iii. Elimination method iv. Substitution method v. Checking answer to equations

The modality followed was as per the following :

Prepare	Present	Practice	Assess
Overview of the course and what students will encounter in it. Here, students will also collect information about their current level of understanding to help themselves gauge their growth once they are through with the course.	Content that they must engage with to learn and develop new knowledge, skills and mindsets. These exercises will give them opportunities to understand the content and the pedagogy associated with it.	The opportunity to put students` knowledge in practice. In this stage students will be required to execute a lesson as well as create an assessment.	Module will assess students` understanding of the content presented, and thereby provide them with feedback on which areas they should focus on as the teacher.

E. Resources - activities, readings

Throughout the module, there will be case studies, activities and different types of questions to gauge your understanding of the content and help you diagnose the areas where you must focus and practice.

F. Nature and purpose of assessments

The module will assess understanding of the content presented, and thereby provide students with feedback on which areas they should focus on as the teacher.

2. Course completion rate

A. Overall completion

Table 1: Course completion rate by teachers

	NQTs	Preservice	Inservice	Total
1 - 20%	0	0	0	0
21 - 40%	0	0	0	0
41 - 60%	0	0	0	0
61 - 80%		1	0	1
81 - 100%	5	13	5	23
Total	5	14	5	24

Table 1 shows that 23 participants (95.83%) were able to complete the course under category 81-100% followed by 1 participant (4.16%) in 61 – 80% . It indicates the majority of the participants completed the module Linear Algebra successfully.

B. Assessment completion rate

Table 2: Teachers' assessment completion rate

	NQTs	Preservice	Inservice	Total
Pre test	5	14	5	24
Session plans	5	5	5	15
Reflection	5	6	4	15
Post tests	5	14	5	24

Table 2 depicts that all the participants completed the pre-test and post-test successfully. However, only 62.5% of the participants completed the session plans and the reflection. The low completion rate of lesson plans and reflection submissions could be: Delay of reopening the schools after summer vacation owing to the COVID-19. Last minute change in no.of submission of lesson plans.

3. Time spent on the course platform

Table 3: Time spent by teachers on Moodle platform

Hours spent	NQTs	Preservice	Inservice	Total
Less than 5	-	-	-	
5 to 10	-	-	-	
10 to 20	-	-	-	
21 to 30	-	-	-	
More than 30	5	14	5	24
Total	5	14	5	24

All the participants have spent more than 30 hours on the module platform to complete the module Linear Algebra. It indicates that the participants have successfully made the required optimum hours for the module.

4. Change from pre- and post- test

The total number of teachers who attended both the pre-test and the post-test was 24. In the pre-test, the average score was 59.33% whereas in the post-test 58.60% indicating a decrease in performance by 0.73 %.

Table. 4.1

Number of teachers		Post Test			
		Novice 0-25%	Emerging 26-50%	Proficient 51-75%	Accomplished 76-100%
Pre test	0-25% Novice				
	26-50% Emerging		1	2	
	51-75% Proficient		3	17	
	76-100% Accomplished			1	

5. Practice

	Number of teachers				Total
Criteria	Novice	Emerging	Proficient	Accomplished	
A. Subject Matter Knowledge					
1. Knowledge of Subject Matter	3	6	8	0	17
2. Nature of Science/ Mathematics	4	10	2	1	17
B. Pedagogical Content Knowledge					
3. Instructional Strategies	2	8	6	1	17
4. Students' misconceptions & Conceptual Difficulties	5	8	4	0	17
5. Representation of the Content	1	10	6	0	17
6. Context for Learning	3	9	4	1	17
7. Curriculum knowledge	5	8	3	1	17
C. General Pedagogical Knowledge					
8. Equity and Inclusion	3	3	11	0	17
9. Classroom Management	1	9	7	0	17
10. Assessment	1	9	7	0	17
Total	28	80	58	4	170

A. Subject Matter Knowledge

The majority of the teacher participants are in the category of Emerging and Proficient with a few in Novice , and only one in Accomplished . For example, teacher 1110 asked, "Can any of you share with us a few examples where inequalities are used all time in the world around you?" which demonstrates knowledge of the 'big' ideas, key concepts and theories. interconnections between concepts/ topics in a discipline.
Similarly, teacher 1123 demonstrated a conceptual understanding of inequality: $5n + 4 < 39$ is a comparison between the expression $5n + 4$ (4 more than the product of 5 and a number, n) and the value 39, as reflected in the lesson plan.

B. Pedagogical Content Knowledge

In general, the majority of the participating teachers have good Pedagogical Content Knowledge whereas a few of them have very good Pedagogical Content Knowledge. Of the five sub-themes, the participating teachers seem to lack Curriculum knowledge. For example, teacher 1116 stated the definition of the linear equation as "Linear Equation is a mathematical statement, which has an equal sign (=) between the algebraic expressions. Linear equations are the equations of degree 1" which is as in the textbook. Similarly, teacher 1107 instructed students to complete the task from the textbook (Complete the following question number 7 from page 121)

C. General Pedagogical Knowledge

Maximum teacher participants have demonstrated equity and inclusion by providing equal opportunity to all students. For example, teacher 1119 has provided a group activity on Representation and Engagement on different types and forms of simple linear equations. Similarly, teacher 1106 asked any one std to summarise the lesson(popcorn). Also, they have demonstrated effective classroom management through the use of multiple modes of classroom interaction-Inquiry, problem-solving, student expression, grouping practices, and demonstrations/ activities. For example, teacher 1107 administered activities on discussions or Collaboration among the students in respective groups will happen effectively. This is because high achievers can help low achievers. The diverse groups of learners will be formed in accordance with the performance of students in the pre-test. Further, teachers used diagnostic assessments as a part of formative assessment. For example, teacher 1104 conducted a pre-test for students .

6. Social learning in CoPs

A. Frequency of posts

Table 4: Frequency of posts by participants

Role	Number of posts
NQTs	18
Preservice Teachers	4
Inservice Teachers	17
Teacher Educators	130
Research fellow	25
Total	194

Table 4 shows the majority of posts were done by teacher educators (130) followed by research fellows (25) and NQTs (18) and in-service teachers. The least no.of posts done was from the preservice teachers (4).

B. Frequency of posts

Table 5.1: Frequency of posts by content

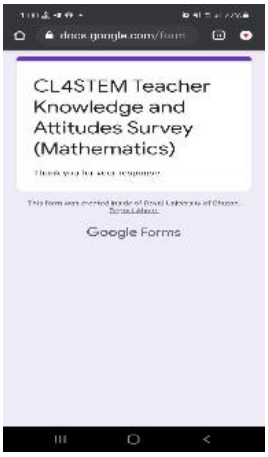
Type of Posts	Number of posts
PCK	2
UDL	1
Technical	28
Communication/ Administrative	52
Total	83

Table 5.2 : Frequency of posts by type

Type of post	Number of posts
Text only	55
Images	10
External Links to other resources	5
Others (pdf)	13
Total	83

C. Qualitative dialogues/ discussion threads

Good afternoon cop members, I would like to request all members to kindly fill in the google form on Teacher Perceptions of
CL4STEM. https://forms.gle/6hsDZiq6gSySvkTD6



7. Teacher Educator's reflection on the overall implementation (Moodle and CoP)

A. Challenges:

As the lone tutor for this module the challenges I faced in implementing this module (Linear Algebra) are going after every participating teacher at school and reminding them to complete the designated tasks on time, monitoring them, and assessing the tasks submitted by them, some teachers do not turn up for interviews despite several times requests.

B. Surprises:

My surprise is that despite several times reminding a, also getting assurance from the participating teachers, at last, only 17 out of 24 teachers submitted lesson plans and reflections on the module. To this end, surprisingly all the NQTs and Other I-service groups of the 5 teachers submitted the assigned tasks completely. The shortfall was from the pre-service teachers only.

C. Any changes required in the module design:

The following changes have been notedly required to do on the module: instructions on assignment; add online quizzes for self-assessment

Data Sources Used

1. Moodle completion rate raw data
2. Moodle time spent raw data
3. Teacher pre-test and post test data
4. All teachers' lesson plans and reflections (3 lesson plan per module per teacher, and 1 reflection per module per teacher)
5. Teachers' responses for the pre and post-test surveys
6. Telegram CoP group data download for the during of the module

Subject : Mathematics

Geometry Module

Authored by: Mr. Pema Drukpa, Mr. Man SIngh Singer

1. Introduction

This module basically focussed on teaching and learning of Geometry and Transformations. Geometry section consisted of deepening concepts of area and perimeter of the geometrical figures. It also helped the students to identify and address through various approaches the misconceptions prevailing under area and perimeter. The module constituted cases, hands-on activities and technology aided activity. Under Geometrical Transformations,the concepts of transformations and types were extensively discussed. Also varied exploratory activities were designed to deepen the learning of concepts. In gist,this module examines case studies of student thinking, their understanding, and misconceptions and explores resources to address the concepts.

A. Timeline of implementation in the country:

Oct.10, 2022 – December 25, 2022

B. Learning objectives

This module helped the students to explore geometric measurements of area and perimeter and also about different types of geometric transformations. It examined students' difficulties in these concepts and learned about ways to deal with them. The module also incorporated case studies of student thinking, their understanding, and misconceptions.Besides these,it provided opportunity to explore resources to address the concepts. Students were expected to acquire the following knowledge and skills:

i. Understanding the concept of area and perimeter
ii. Understanding units for area and for perimeter
iii. Understanding different types of transformations and its effect on shapes
iv. Understanding the variant and invariant properties of area and perimeter
v. Knowing about Special quadrilaterals and deriving formula
vi. Knowing about students' difficulties and misconceptions about the following topics
vii. understanding the perimeter,area and its scope (dimension)
viii. drawing relationship between the two measurements (area and for perimeter)- classroom- examples and their units and
ix. explaining issues with memorising formulas instead of deriving them.

C. Number of units: 4

D. Concepts covered

The concepts covered under this module are: standard and non-standard units, Perimeter, area, Transformations, their variant and invariant properties.

The modality followed was as per the following :

Prepare	Present	Practice	Assess
This section provided the purposes of the measurement as one of the fundamentals in Mathematics followed by module learning objectives, topics to be covered, Assignments and tasks required and the structure of the module.It included pre-test and understanding students' thinking specific to geometry and transformation.	This section provided conceptual understanding of concept map and its usage as a handy tool for making meaningful connections between the main idea and other information followed by numerous hands-on activities and online activities. It also dealt issues with respect to the topics. Case studies as a form of reading were presented with reflection questions.	In the practice section,the participants were exposed to the five model lesson plans,then developed three new lessons of their own,implemented with their students. They were expected to write a reflection of the lesson implementation and submit along with lesson plans.	As a part of assessment,the participants were mandated to complete pre and post tests with questions on belief ,knowledge, and Pedagogy Content. They were also assessed through submission of self reflection paper on the module interaction,discussions in CoP too.

E. Resources - activities, readings

Series of readings were presented in the form of articles and case studies. Every reading was followed by simple activities such as reflection questions. Hands on activities particularly use of GeoGebra were provided. Independent tasks such as youtube and online simulations links were shared. Beside these, sharing of resources related to the module and clarification if any confusions or doubts were also addressed using CoP platform discussion(Telegram).

F. Nature and purpose of assessments

The module assessments were carried out in the form of formative and summative assessment.

Formative : reflection writing on module implementations and lesson plan development
Summative: pre-post test on belief knowledge pedagogy content

2. Course completion rate

1. Overall completion (Data available from Moodle platform)

Table 1: Course completion rate by teachers

	NQTs	Preservice	Inservice	Total
1 - 20%	-	-	-	-
21 - 40%	-	-	-	-
41 - 60%	-	-	-	-
61 - 80%	-	-	-	-
81 - 100%	5	14	5	24
Total	5	14	5	24

Table 1 shows that all 24 participants (100%) were able to complete the course under category 81-100%. In fact, 22 participants(91.6%) have attained 100% completion rate followed by two participants at 86% respectively. This indicates that the course completion rate by the participating teachers is at a very good level of performance.

2. Assessment completion rate

Table 2: Teachers' assessment completion rate

	NQTs	Preservice	Inservice	Total
Pre test	5	14	5	24
Session plans	5	14	5	24
Reflection	5	14	5	24
Post tests	5	14	5	24

Table 2 shows that all the participating teachers completed all assigned tasks. The completion rate is found to be 100%. This could be because the course end deadline happened to be after the end of the academic session of the schools. Consequently,this might have given more time to devote in completing successfully.

3. Time spent on the course platform

Table 3: Time spent by teachers on Moodle platform

Hours spent	NQTs	Preservice	Inservice	Total
Less than 10	4	13	3	20
10 to 20	1	1	2	4
21 to 30	0	0	0	0
More than 30	0	0	0	0
Total	5	14	5	24

The table 3 shows no participants have spent more than 21 hours. However, 83.33% (n=20) of the participants spent less than 10 hours and 16.66% (n=4) spent between 10 to 20 hours. This indicates the participation of the participants in online activities is fairly good. However, they might have spent more time on offline tasks such as lesson planning, implementing the lesson plans, writing reflections, watching video lessons etc.

4. Change from pre- and post- test

Average total score in pre-test: 9.38 (62.53%)
Average total score in post-test: 10.21 (68.07%)

It is observed that there is a difference of 0.83 (5.53 %) in the average score of the pre-test and post-test of the participants. A paired sample t-test was conducted and found to be not significant (p=0.128). In other words,this indicates that the difference of 0.83 (5.53%) is not significant in the change from pretest and post-test scores.

Table 4.1 shows that 33.33% (n=8) of the participants are at the proficient level (51-75%) both in pre-test and post-test. Only 20.83% (n = 5) of them have improved from proficient level in the pre-test to accomplished level in post-test. No one has been seen at novice level.This indicates that there is no significant change from pretest to post-test.

Table. 4.1

Number of teachers		Post Test			
		Novice 0-25%	Emerging 26-50%	Proficient 51-75%	Accomplished 76-100%
Pre test	0-25% Novice	-	-	-	-
	26-50% Emerging	-	2	2	1
	51-75% Proficient	-	2	8	5
	76-100% Accomplished	-	-	2	2

ID	Pretest %	Post test %	Difference	Remarks
1110	53.33	66.67	13.33	Increase
1111	40	46.67	6.67	Increase
1108	93.33	86.67	-6.67	Decrease
1112	73.33	86.67	13.33	Increase
1106	33.33	86.67	53.33	Increase
1109	73.33	73.33	0	No Change
1113	73.33	80	6.67	Increase
1100	66.67	73.33	6.67	Increase
1117	53.33	60	6.67	Increase
1105	53.33	46.67	-6.67	Decrease
1101	53.33	60	6.67	Increase
1116	66.67	60	-6.67	Decrease

ID	Pretest %	Post test %	Difference	Remarks
1123	60	73.33	13.33	Increase
1115	73.33	100	26.67	Increase
1120	46.67	60	13.33	Increase
1118	33.33	33.33	0	No Change
1104	73.33	80	6.67	Increase
1119	53.33	26.67	-26.67	Decrease
1124	86.67	86.67	0	No Change
1121	66.67	80	13.33	Increase
1103	93.33	60	-33.33	Decrease
1121	80	66.67	-13.33	Decrease
107	46.67	73.33	26.67	Increase
1114	53.33	60	6.67	Increase

The result indicates that only 62.5% of the participating teachers improved in the achievement of learning this module whereas 37.5 % of them did not improve; rather they either remained unchanged or decreased in scores from the pretest to the post-test.

5. Practice

Criteria	Number of teachers				Total
	Novice	Emerging	Proficient	Accomplished	
A. Subject Matter Knowledge					
1. Knowledge of Subject Matter	0	20	4	0	24
2. Nature of Science/ Mathematics	6	12	6	0	24
B. Pedagogical Content Knowledge					
3. Instructional Strategies	0	11	13	0	24
4. Students' misconceptions & Conceptual Difficulties	3	14	7	0	24
5. Representation of the Content	2	13	9	0	24
6. Context for Learning	4	14	6	0	24
7. Curriculum knowledge	5	17	2	0	24
C. General Pedagogical Knowledge					
8. Equity and Inclusion	10	8	5	1	24
9. Classroom Management	6	12	6	0	24
10. Assessment	2	18	3	1	24
Total	10	8	5	1	24

Each participating teacher submitted three lesson plans and module reflections. Out of the three lesson plans, the two best lesson plans and the module reflection were assessed collectively by all the mathematics tutors. While implementing the module also, there was the involvement of all the module tutors in helping the participating teachers undertake this module and complete it successfully.

1. Subject Matter Knowledge

With respect to the subject matter knowledge of the participating teachers, the survey showed the majority of participants are in the category of Emerging and Proficient. There is no one in the accomplished category. As an example of the Emerging category, teacher 1111 explained the formula for the surface area if the dimensions are l, w, and h is SA= 2 × (l ×w + w ×h + l ×h).

Similarly, as an example of the proficient category, teacher 1100 explains translation can be represented in two ways: i) Translation rule [2, -3] ii) Mapping notation (x, y)→(x + 2, y – 3), and in General: (x, y) → (x + a, y + b) which translates 'a' unit to the right and 'b' unit to up.

This indicates that their subject matter knowledge is good.

2. Pedagogical Content Knowledge

With respect to the Pedagogical Content Knowledge of the participating teachers, the survey showed the majority of participants are in the Emerging category followed by the Proficient category and a few in the Novice category respectively. There is no one in the accomplished category.

For example, teacher 1110 of the Emerging category used resources like pictorial representations for comparing 4 types of transformations whereas teacher 1106 used the Mix Pair Share Method as follows:

> *Tr. asks all the students to write in the one-minute paper. The one-minute paper includes 3 things they learnt in the lesson, 2 things they found interesting about the lesson. 1 thing they were not clear about. Then the teacher let students stand up and then have a mixed pair share.*

This indicates that the majority of the participants have very good Pedagogical Content Knowledge whereas a few of them have good Pedagogical Content Knowledge.

3. General Pedagogical Knowledge

With respect to the General Pedagogical Knowledge of the participating teachers, the survey showed the majority of participants are in the Novice and Emerging followed by the Proficient and very few in the accomplished category respectively. From the classroom management point of view, there is no one in the accomplished category.

For example, teacher 1123 of the Novice category applied a mixed group ability that helped students discuss and solve the assigned task on time as they helped each other. Similarly, teacher 1124 in the Emerging category applied equity and inclusion as follows:

> *Group work: look at the diagram given on the chart and answer the following questions. (round robin) Individual work: each member will get a chance to answer the questions.*

From the classroom management point of view, teacher 1110 of the proficient category reported as follows:

> *Some students had difficulty understanding at first, but later with more examples with different questions, they understood well and became confident in solving questions.*

This indicates that the majority of the participants have good General Pedagogical Knowledge whereas a few of them have fairly good General Pedagogical Knowledge.

6. Social learning in CoPs

A. Frequency of posts

Table 4: Frequency of posts by participants

Role	Number of posts
NQTs	7
Preservice Teachers	5
Inservice Teachers	4
Teacher Educators	29
Research fellow	24
Total	69

The table 6 shows the number of posts made from 10th October to 25th December 2022. The maximum posts were made by research fellows (42.02%) followed by teacher educators(34.78%). The posts include additional reading resources,administrative requirements and reminders, links of exciting new online links and clarifications on the issues floated by the participants. However the post by other participants in CoP seemed minimal. The post included acknowledgements and issues raised. The minimal post by them indicates that the participants do lack habits of online interactions.

B. Frequency of posts

Table 5.1: Frequency of posts by content

Type of Posts	Number of posts
PCK	25
UDL	2
Technical	2
Communication/ Administrative	40
Total	69

Table 5.2 : Frequency of posts by type

Type of post	Number of posts
Text only	40
Images	24
External Links to other resources	2
Others (pdf)	3
Total	69

Based on the table above, the maximum posts were against the category communication and administrative followed by PCK. However there is minimal post on UDL and Technical categories. This indicates that the participants experienced no or minimal technical issues and glitches confirming everything favoured the success of the module completion. The post on UDL can be construed into two: UDL and its application is well grounded in their teaching or lacks the awareness and the knowledge on it. However, the former seemed true as a face to face orientation and online workshop were conducted with an intent to provide awareness as well as practice in their teaching.
Of the nature of post,text only is the maximum followed by images. The links to other resources were found to be minimal.

C. Qualitative dialogues/ discussion threads

The rationale of CoP was well conceptualised and implemented using the Telegram platform. It has proved as an important platform to thread and discuss or provide clarifications on any issues related to the geometry module implementation. Few yet relevant examples of the use of the platform effectively are put under with justification.

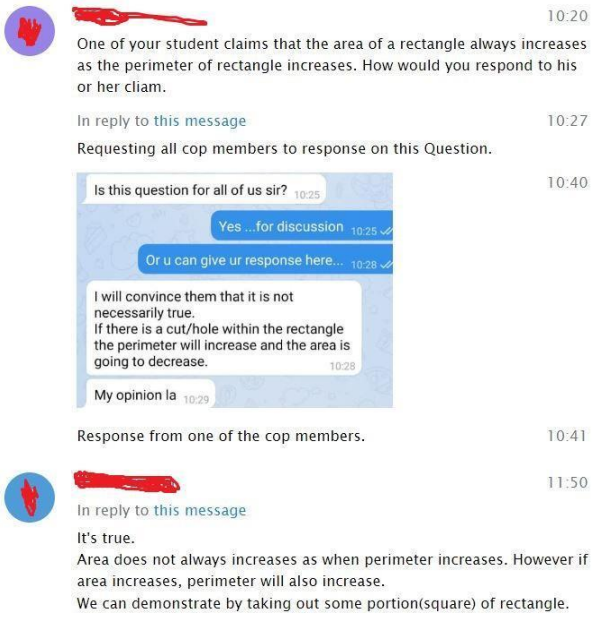
i. CL4STEM Lesson implementation

Figure 1 A picture of students engaged in learning Geometry module in one of the participating schools
Figure 1 shows the sharing students' engagement Geometry module. This is one good example of classroom practices which may inspire other members of the CoP. Also, it may provide insight on incorporating CL4STEM principles such as UDL principles.

ii. Figure 2 A picture of making students develop curiosity

Effective teaching involves motivating and developing students' curiosity so as to lead to deep learning. This figure demonstrates the effective use of pedagogy such as gallery walk, brainstorming, validating, and opinions on the subject matter through discussion.

iii. Figure 3 shows the use of the platform as a discussion. This platform can be effectively used by both teacher educators and participants to initiate discussion pertaining to content clarification, address misconceptions, or even assess the understanding of content besides using it for administrative purposes. This includes notifications and reminders.



7. Teacher Educator's reflection on the overall implementation (Moodle and CoP)

A. Participation of teachers:

As a module tutor,the formation of CoP helped to instantly share materials and notifications or any clarifications in the module content learning. The sharing of screen shots and pictures as evidence of lesson implementation was found worthy.

B. Challenges:

The major challenges faced was constantly reminding the participants about the activities to complete within the deadline as many were found with no schedule developed for the course completion. Getting consent and appointment/schedule for the interview was a challenge. The interviewers however used weekends and evenings after school work.

C. Surprises:

Of 24,eight participants have post test scores less than pre-test. This is a surprise as many believed and from interviews,many participants in the interview shared that the course was important ,relevant and full of new insights. In service participants were found to be more responsible in going through the module and submitting assignments on time than Pre service participants.

D. Any changes required in the module design:

The following changes may be incorporated in the module design:

1. Reading materials should be minimised but include more hands -on activity.
2. Links on online activities be minimised
3. need to improve on making user-friendly and easy access(working offline)

Data Sources Used

1. Moodle completion rate raw data
2. Moodle time spent raw data
3. Teacher pre-test and post test data
4. All teachers' lesson plans and reflections (3 lesson plan per module per teacher, and 1 reflection per module per teacher)
5. Teachers' responses for the pre and post-test surveys
6. Telegram CoP group data download for the during of the module

Subject : Mathematics

Proportions and Percentage Module

Authored by: Ugyen Dorji

1. Introduction

Proportional reasoning is one of the crucial mathematical 34idea's students develop over the school years. It is a good indicator of learners' understanding of the relationship between two quantities through one-to-one correspondence at the primary level. For example, when students compare that the price of 2 cupcakes will be Nu 10 if the price of one cupcake is Nu 5. Proportional reasoning forms the basis for understanding measurement and conversion among units of measurement and therefore a foundation concept for comparing quantities. At the middle and secondary levels, the understanding of proportional reasoning integrates the understanding of rational numbers and related multiplicative concepts and at the same time, it lays the foundation for more complex concepts of mathematics.

A. Timeline of implementation in the country:

Aug 14, 2022 – October 14, 2022

B. Learning objectives

This module explored discussions on part-whole (continuous quantity and discrete quantity), equivalent fractions, proportions, decimals and percentages and relationships among these concepts. It also examined case studies of student thinking, their understanding, and misconceptions and explored appropriate and relevant resources to aid in deepening the concepts. After going through this module teachers were expected to:

- Identify the key concepts and ideas needed to strengthen students understanding of proportions and percentages
- Clarify the misconceptions held by students related to proportions and percentages.
- Demonstrate an understanding of the concept with the help of technology as well as hands-on activities.

C. Number of units: 4

D. Concepts covered

As per the topics mentioned in the following:

i. Topic 1: Key Concepts to Understand "Proportions"

- What is proportional reasoning?
- Unit fractions
- Different meanings of fractions
- Additive, Multiplicative and Relative thinking
- Identifying proportional and non-proportional situations

ii. Topic 2: Percentage
- Expressing one quantity as a percentage of another
- Misconception in the learning of percentage Pedagogy (Multiple representations)
- Percentages consider each 'whole' as broken up into 100 equal parts, each one of which is a single percent.
- Decimal and fraction percentages

iii. Topic 3: Commercial Mathematics on Budget Introduction
The modality followed was as per the following:

Prepare	Present	Practice	Assess
Participants collected information about their current level of understanding to help themselves gauge their growth once they are through with the course.	Presented the contents of the module to engage and learn for developing new knowledge, skills and change of mindsets. The activities in the module provided them opportunities to understand the content and the pedagogy associated with it.	The participants were provided with an opportunity to develop and implement lesson plans.	The participants` understanding of the content of the module was assessed through pre-test, and post-test, assignments that included writing module reflections, an online forum for discussions in CoP (Telegram)

E. Resources - activities, readings

Throughout the module, numerous case studies were presented followed by different types of questions to gauge the participants` understanding of the content and help them diagnose the areas where they must have to focus and practice.
Link to YouTube videos and numerous educational videos are uploaded in the OER for their view. For example, the link used are as follows:

- https://youtu.be/aes71wbjbiM
- https://youtu.be/QL_DDuFf-WM
- https://mathedu.hbcse.tifr.res.in/wp-content/uploads/2014/01/JS-KS-SN-BV_2008_ICME_comb-share-measure-mng-fraction-faclt-std-rsng-abstract.pdf
- https://youtu.be/qRHx9mocrKo
- https://youtu.be/qRHx9mocrKo
- clix - Lesson 4: Ice Cubes in Lemon Juice (tiss.edu) to learn about direct and indirect variations
- A book titled "TEACHING FRACTIONS AND RATIOS FOR UNDERSTANDING" Essential Content Knowledge and Instructional Strategies for Teachers by SUSAN J. LAMON was used for developing Proportional reasoning OER.

F. Nature and purpose of assessments

The module assessed understanding of the content presented and thereby provided the participants with feedback on which areas they should focus on as the teacher.:

Formative : Our teacher participants wrote a series of reflections after completing a topic/unit/task. They were formatively assessed through their reflections.
Summative: Pre-test and Post-test were administered to assess their progress.

2. Course completion rate

A. Overall completion

Table 1: Course completion rate by teachers

	NQTs	Preservice	Inservice	Total
1 - 20%	0	0	0	0
21 - 40%	0	0	0	0
41 - 60%	0	0	0	0
61 - 80%	0	0	0	0
81 - 100%	5	14	5	24
Total	5	14	5	24

Table 1 shows that all 24 participants (100%) were able to complete the course under category 81-100%. In fact, the majority of them have fully completed the course. This indicates that all the participants have completed the course at a very good level of performance.

B. Assessment completion rate

Table 2: Teachers' assessment completion rate

	NQTs	Preservice	Inservice	Total
Pre test	5	14	5	24
Session plans	5	10	5	20
Reflection	5	5	3	13
Post tests	5	14	5	24

Of the categories of NQT, Preservice and Inservice, all NQTs completed the required tasks of the module. Out of 5 in-service teachers, only 3 of them submitted the module reflection. However, preservice teachers have poor records of submission of the prescribed tasks, particularly in submitting module reflections (reflections2). This could be because of heavy engagement in fulfilling the Teaching Practice requirement and the school's policy of intensification of completing the syllabus of the academic latest by the end of November. Further, the implementation of the scheduled module fell on the peak of completing the scheduled sporting and literary activities of the school.

3. Time spent on the course platform

Table 3: Time spent by teachers on Moodle platform

Hours spent	NQTs	Preservice	Inservice	Total
Less than 10	2	13	4	19
10 to 20	3	1	1	5
21 to 30				
More than 30				
Total	5	14	5	24

It is found that no participants spent more than 21 hours. However, 79.16% (n=19) of the participants spent less than 10 hours and 20.83% (n=5) spent between 10 to 20 hours. This indicates the participation of the participants in online activities is fairly good. However, they might have spent more time on offline tasks such as lesson planning, implementing the lesson plans, writing reflections, watching video lessons etc.

4. Change from pre- and post- test

Average total score in pre-test: 8.17 (54.44%)
Average total score in post-test: 8.75 (58.33%)

It is observed that there is a difference of 0.58 (3.89 %) in the average score of the pre-test and post-test of the participants. A paired sample t-test was conducted which revealed p=0.183 which indicates that the difference of 0.58 (3.89 %) is not significant.

Table. 4.1

Number of teachers		Post Test			
		Novice 0-25%	Emerging 26-50%	Proficient 51-75%	Accomplished 76-100%
Pre test	0-25% Novice		-	-	-
	26-50% Emerging		5	4	-
	51-75% Proficient		2	12	-
	76-100% Accomplished		-	-	1

ID	Pretest %	Post test %	Difference	Remarks
1105	46.67	53.3	6.63	Increase
1107	66.67	60	-6.67	Decrease
1104	73.33	60	-13.33	Decrease
1109	40	46.7	6.7	Increase
1106	53.33	46.7	-6.63	Decrease
1103	40	46.7	6.7	Increase
1123	60	53.3	-6.7	Decrease
1101	40	40	0	No Change
1120	40	46.7	6.7	Increase
1112	60	60	0	No Change
1124	60	53.3	-6.7	Decrease
1100	53.33	73.3	19.97	Increase

ID	Pretest %	Post test %	Difference	Remarks
1117	60	60	0	No Change
1108	46.67	66.7	20.03	Increase
1121	86.67	100	13.33	Increase
1118	33.33	33.3	-0.03	Decrease
1110	53.33	73.3	19.97	Increase
1122	66.67	66.7	0.03	Increase
1113	73.33	60	-13.33	Decrease
1119	53.33	33.3	-20.03	Decrease
1115	40	66.7	26.7	Increase
1114	66.67	66.7	0.03	Increase
1116	66.67	66.7	0.03	Increase
1111	26.67	66.7	40.03	Increase

Pre-test and Post-test were administered to a total of 24 teacher participants. In terms of the changes in their scores from the pretest to post-test, 8 of them have their scores decreased; there was no change in the scores of the 3 participants and 13 of them were able to perform better in the post-test. The highest increase is 40.03 observed in the scores of the teacher 1111 followed by the second highest of 20 observed in the scores of the teacher 1108. On other hand, teacher 1119 demonstrated the highest decrease in the score (-20.03) followed by teacher 1113 and 1104 whose decrease in score is found to be -13.33.

The result indicates that only 54.16% of the participating teachers improved in the achievement of learning this module whereas 45.83% of them did not improve rather they either remained unchanged or decreased in scores from the pretest to the post-test.

5. Practice

Criteria	Number of teachers				Total
	Novice	Emerging	Proficient	Accomplished	
A. Subject Matter Knowledge					
1. Knowledge of Subject Matter	4	11	4	1	20
2. Nature of Science/ Mathematics	6	11	2	1	20
B. Pedagogical Content Knowledge					
3. Instructional Strategies	6	10	4	0	20
4. Students' misconceptions & Conceptual Difficulties	9	7	4	0	20
5. Representation of the Content	3	11	6	0	20
6. Context for Learning	6	5	9	0	20
7. Curriculum knowledge	4	11	5	0	20
C. General Pedagogical Knowledge					
8. Equity and Inclusion	5	7	7	1	20
9. Classroom Management	0	17	2	1	20
10. Assessment	5	12	2	1	20

The assessing and grading two best lesson plans and module reflections were done collectively by all the mathematics tutors. While implementing the module, there is involvement of all the module tutors in helping the participating teachers undertake this module and complete it successfully.

A. Subject Matter Knowledge

With respect to the subject matter knowledge of the participating teachers, the survey showed the majority of the participants are in the category of Emerging and Novice with a few Proficient, and at least two Accomplished. This indicates that their subject matter knowledge is somewhat good which means they are able to demonstrate conceptual understanding of relevant mathematics concepts.

For example, in the Emerging category, one of the teacher participants described percentage as a ratio having a denominator equal to 100 considering it as a whole. Teacher 1113 in his/her lesson plan wrote "ratio describes the relationship between the quantities".

Also, teacher 1116 illustrated an alternative method called a grid model for subtracting fractions in his/her lesson plan.

"We'll discover an alternative method for subtracting fractions. That employs the grid model. To deduct 3/4 from 2/3, for instance: As you can see, 2 of 3 columns represent 8/12 of the grid. Currently, 1 counter remains in the grid's 12 squares: 3/4 – 2/3 =1/12 Or 9/12 -8/12 =1/12……..".

B. Pedagogical Content Knowledge

With respect to the Pedagogical Content Knowledge of the participating teachers, the survey showed that the majority of the participants are in the Emerging category followed by an equal number of them in the Proficient and Novice categories respectively. There is no one in the accomplished category. This indicates that our participants have a good pedagogical content knowledge (PCK). Our teachers are able to use open ended task beyond the textbook to foster students' discussion; they can design activities to check students' prior knowledge and identify students' misconceptions; they are able to teach a concept through multiple representations (infographics/images/videos/ examples/ flowcharts) and use their daily life experiences as a resource for their teaching and learning.

For example, teacher 1105 wrote in his lesson plan: To find 45% of 80, rewrite 45% as 0.45 and then multiply: 0.45×80=36, so 45% of 80 is 36.

Similarly, Teacher 1114 shared the following lesson plan:
In a standard deck of cards, there are 4 aces: the ace of Clubs, the Ace of Diamonds, the Ace of Spades and the Ace of Hearts. What is the fraction of the ace of a diamond and heart? What percent of aces are black? Express the number of Spade Aces in decimal.

Teacher 1109 prepared an online quiz https://quizizz.com/admin/quiz/57b4822c9cd82fe8680fdc57/fractions-decimals-and-percentages as found in his lesson plan.

Teacher 1100 gave a link to a video https://en.wikipedia.org/wiki/Ratio for learning ratios as found in his/her plan.

C. General Pedagogical Knowledge

The survey administered in the area of classroom management showed 17 teacher participants were in the Emerging category. Similarly, in the area of assessment, 12 participants were in the Emerging category however in the area of equity and inclusion, there is an almost equal number of participants in each of these categories namely Novice (5), Emerging (7) and Proficient (7).
In addition, for General Pedagogical Knowledge, the survey showed the majority of the participants are in the emerging category followed by the proficient and novice.

This indicates that our teacher participants are aware of multiple modes of classroom interaction which includes inquiry, problem-solving, student expression, grouping practices and use of demonstrations/activities. Also, it shows that they are focussing more on formative assessment than summative assessment as an assessment tool. It also reveals that our participating teachers use practices focusing on equity and inclusion in their classrooms.

For example, in the area of classroom management, teacher 1115 indicated, he/she allows students to sit in pairs and sometimes in groups as found in his/her lesson plan. Similarly, teacher 1110 in his/her lesson plan mentioned, students are made to first answer individually and later in groups.

In the area of formative assessment, teacher 1117 claimed. He/she allows students to solve exercises in pairs and let them discuss the answer as found in the lesson plan.

Teacher 1113 in his/her lesson plan indicated, he asks random students to summarise the lesson (popcorn) Mix pair share Tr. asks all the students to write in the one-minute paper. The one-minute paper includes 3 things they learnt in the lesson. 2 things they found interesting about the lesson.

6. Social learning in CoPs

A. Frequency of posts

Table 4: Frequency of posts by participants

Role	Number of posts
NQTs	3
Preservice Teachers	0
Inservice Teachers	8
Teacher Educators	30
Research fellow	4
Total	45

Table 6 shows the frequency of posts by different groups of participants in our telegram group (Bhutan Mathematic COP) from Aug 14, 2022 – October 14, 2022. The analysis of table 6 shows the highest number of posts was done by the teacher educators (30) followed by the Inservice teachers (8), research fellow (4) and the NQT (3) respectively. No messages were communicated in the group by the preservice teachers. This may be because of their complete engagement in fulfilling the requirement of their teaching practice in the school or they are not at all interested in such social learning activities.

B. Frequency of posts

Table 5.1: Frequency of posts by content

Type of Posts	Number of posts
PCK	5
UDL	12
Technical	10
Communication/ Administrative	24
Total	49

Table 5.2 : Frequency of posts by type

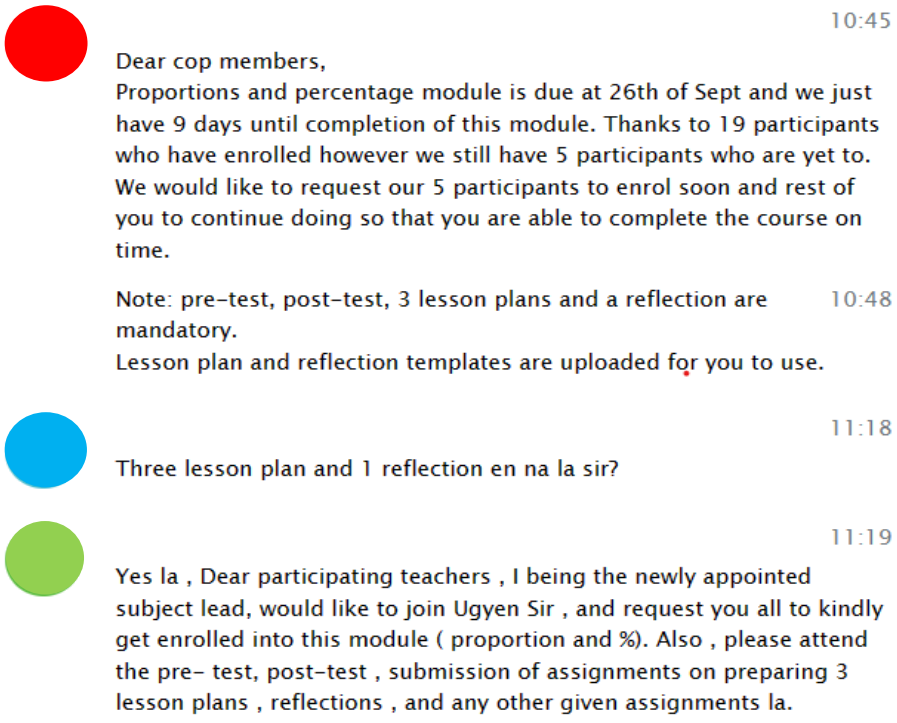
Type of post	Number of posts
Text only	40
Images	10
External Links to other resources	2
Others (pdf)	4
Total	56

Table 5.1 shows the frequency of posts by content type in our telegram group (Bhutan Mathematic COP) from Aug 14, 2022 – October 14, 2022. The analysis of table 6.1 shows the highest number of posts was seen in the area of communication/administrative (24) and followed by UDL (12), technical (10) and PCK (5). This indicates that the telegram group was mainly used for the purpose of communicating ideas, doubts and so on. The PCK area received the least number of posts. This may be because they were already practising PCK in their classroom and are well versed in it or they don't know anything about PCK.

Table 5.2 shows the frequency of post by type in our telegram group (Bhutan Mathematics COP) from Aug 14, 2022 – October 14, 2022. The analysis of table 6.2 shows the highest number of posts was seen in the area of text only (40) and followed by images (10), others (4) and external link to resources (2) respectively.

C. Qualitative dialogues/ discussion threads

This is a good example of a teacher's engagement because this informs them what they are supposed to do in the module. They were informed about the need to submit three lesson plans and one reflection for their task in the module to be deemed complete



Thank you.

09:56

29.09.2022 09:52:50

10:00

working on it la sir.

11:12

Oh...sorry ...this is for the algebra module la.

11:17

Yes la sir

10:13

Tandin maam implementing algebra module lesson plan, showing pan balance to introduce equation.

14:28

Sticker

8 October 2022

09:41

Dear participating teachers, it will be very useful for the CL4STEM Research project if you could share some of your best practices of

13:03

Students trying to find the order of rotational symmetry at Kencho maam's class

13:04

Different groups were solving it for different 3d shapes

Students presentation on transformation

7. Teacher Educator's reflection on the overall implementation (Moodle and CoP)

A. Challenges:

The challenges we faced in implementing this module (Proportions & percentage) are going after every participating teacher at school and reminding them to complete the designated tasks on time, monitoring them, and assessing the tasks submitted by them. Some teachers do not turn up for interviews despite several requests.

B. Surprises:

Some of the participants performed poorly in the post-test compared to their performance in the pre-test. Their post-test scores were less than their pre-test scores. Some of the participants were found to be able to use the lesson plan template well. The UDL principles and the assessment practices were quite visible across their lesson plans.

C. Any changes required in the module design:

The user interface can be made better.

Data Sources Used

1. Moodle completion rate raw data
2. Moodle time spent raw data
3. Teacher pre-test and post test data
4. All teachers' lesson plans and reflections (3 lesson plan per module per teacher, and 1 reflection per module per teacher)
5. Teachers' responses for the pre and post-test surveys
6. Telegram CoP group data download for the during of the module

This work is supported by the Global Partnership for Education Knowledge and Innovation Exchange (GPE-KIX), a joint endeavour with the International Development Research Centre (IDRC), Canada. The views expressed herein do not necessarily represent those of IDRC or its Board of Governors.

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