Strengthening Secondary School Teacher Capacities for Higher Order Thinking with Inclusion and Equity

CL4STEM Project Phase II Scaling
Open Educational Modules Report
BHUTAN
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Subject: Chemistry

The module implementation reports presented here are an outcome of the *Connected Learning for Teacher Capacity Building in Science, Technology, Engineering, and Mathematics (CL4STEM) project*, which aimed to enhance the capacities of secondary STEM teachers to foster higher-order thinking and promote inclusion and equity (HOTIE) in their classroom practices. The CL4STEM project is funded by the International Development Research Centre (IDRC) under the Global Partnership for Education Knowledge and Innovation Exchange (GPE-KIX). It is a South-South collaboration among higher education institutions from Tanzania, Nigeria, and Bhutan, which curated subject-specific, contextualised Open Educational Resources (OER) modules to support the professional development of teachers in enhancing their knowledge, attitudes, and practices (KAP). These OERs were created based on the Connected Learning Initiative (CLIx) model, which was implemented in India by the Tata Institute of Social Sciences (TISS).

The OER modules were hosted on the Moodle Learning Management System (LMS) and PD was supported by scaffolding their progress through the LMS and a social learning platform, Telegram chat group. Each OER module was implemented over six weeks, with teacher participants expected to dedicate approximately 5 hours per week. Since the design of the PD programme was practice-based, teacher participants were required to complete pre-tests and post-tests, design two lesson plans, implement them, conduct peer or supervisor-observed teaching sessions, and write reflections on their experiences.

This report documents the teachers' experiences and the lessons learned throughout the modules implementation. It highlights the outcomes of their engagement with the modules, including their achievements, professional growth, and the knowledge-sharing and learning dynamics within the Telegram chat group.

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Disclaimers

The views expressed herein do not necessarily represent those of IDRC or its Board of Governors.

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Module 1: Atomic Structure

1.1 Introduction

The module on Atomic Structure was curated by chemistry teacher educators at Samtse College of Education in collaboration with a chemistry curriculum developer from the Department of Curriculum and Professional Division (DCPD), Ministry of Education and Skills Development (MoESD). 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 to accommodate the learning needs and abilities of all learners. The content in the module is expected to enhance teachers' understanding of atomic structure and associated concepts, as well as their pedagogical knowledge of teaching atomic structure. Apart from PCK, the module is designed by incorporating the principles of Universal Design for Learning (UDL) to make chemistry teaching and learning inclusive, accommodating the learning needs and abilities of diverse learners. Similarly, this module emphasises the use of technology in teaching, learning, and assessments.

The module progressed 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. The course content was designed to align with the competency-based teaching and learning principles outlined in the Science Curriculum Framework of Bhutan. This alignment ensured a seamless integration of learning objectives, emphasising the development and assessment of key competencies in learners. 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

According to the research calendar, the module was scheduled for a six-week implementation, with an initial start date of April 25, 2024. However, due to delays as some teachers needed additional time to complete the common Pedagogy module, the module was launched on May 6, 2024. Consequently, the implementation period ran from May 6 to June 17, 2024.

b. Learning objectives

At the end of the module, participants were expected to:

(i) Demonstrate a comprehensive understanding of atomic structure, including historical development, atomic models, and the structural components of the atom.

(ii) Explain key concepts such as atomic number, mass number, isotopes, electronic configurations, and the arrangement of elements in the periodic table.

(iii) Apply research-based strategies to effectively address common misconceptions related to atomic structure and associated concepts.

(iv) Develop and implement lesson plans that incorporate effective teaching strategies for conveying complex atomic structure concepts to diverse learners.

(v) Integrate principles of Universal Design for Learning (UDL) into teaching practices to create an inclusive learning environment that meets the needs of all students.

(vi) Utilise technology effectively in teaching, learning, and assessment processes to enhance students' understanding of atomic structure.

(vii) Design lesson plans aligning with the competency-based teaching and learning principles.

(viii) Implement various interactive modes of assessment to evaluate student learning and understanding of atomic structure.

(ix) Engage in reflective writing on the effectiveness of the lessons taught, identifying areas for improvement and future instructional strategies.

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

This module on atomic structure is structured into four units, each covering key concepts essential for a deep understanding of the subject. Unit 1: Introduction to Atom, begins with the historical development of the concepts of atoms, molecules, elements, and compounds, providing a foundational understanding of matter's basic building blocks. Unit 2: Evolution of Atomic Models explores the progression of atomic models, from early philosophical ideas to more sophisticated scientific theories, highlighting the contributions of various scientists to our current understanding of atomic structure. Unit 3: Subatomic Particles and Isotopes (Nuclides) delves into the structural components of the atom, including protons, neutrons, and electrons, as well as the concepts of atomic number, mass number, and isotopes. Finally, Unit 4: Periodic Table focuses on the electronic configurations of elements and their systematic arrangement in the periodic table, emphasising the periodicity and trends observed across different groups and periods. Through these units, the module not only builds a comprehensive understanding of atomic structure but also equips learners with the knowledge to address common misconceptions and effectively teach these concepts in a classroom setting.

e. Resources - activities, reading

The resources utilised in this module included a variety of materials such as 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 employed throughout the module to evaluate the participants' learning progress. The module began with a mandatory pre-test consisting of 45 multiple-choice questions (MCQs) focused on three key themes: learners, content, and teaching-

learning. Participants were required to complete this pre-test within one hour before proceeding with the module. Each of the four units included various formative assessment activities such as quizzes, short answer writing, reflections, and practical activities with students. At the end of the module, participants were required to complete a similar 45-MCQ post-test, also within an hour. Additionally, participants had to submit two lesson plans on concepts related to the module's content and one reflection after implementing these lesson plans. Beyond tutor assessments, participants' lesson plans and recorded teaching sessions were evaluated by an assigned peer. Out of the 38 teachers involved, eight were selected as a focus group sample. Their lesson plans and teaching were evaluated by the tutor, officials from the Ministry of Education and Skills Development (MoESD), and their supervisors. All evaluations were conducted using a standardised rubric that emphasised learners, content, and teaching-learning effectiveness.

1.2 Course completion rate

1.2.1 Overall completion

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

1.2.2 Assessment completion rate

All participants completed the assessments. They were evaluated using a pre-test, a post-test, two lesson plans, and a reflection report.

1.3 Time spent on the course platform

Table 1.1: *Time spent by teachers on Moodle platform*

Hours spent	**Total Teachers**	**Total**
Less than 10	16	16
10 to 20	17	17
21 to 30	5	5
More than 30	-	0
Total	**-**	**38**

Teachers were expected to spend a total of 30 hours to complete the module, with a weekly commitment of 5 hours. According to the data, 16 teachers completed the tasks in less than 10 hours, 17 teachers took between 10 to 20 hours, and 5 teachers spent 21 to 30 hours. It should be noted that teachers invested significant time in developing lesson plans, implementing them, recording videos for peer review, and writing reflection reports, which were not tracked by the Learning Management System (Moodle).

1.4 Change from pre- and post- test

The average total score in the pre-test 72.51
The average total score in the post-test 74.85
The average score from pre to post-tests have increased by only 2.34 %

Table 1.2: *Distribution of Teachers' Performance Levels in Pre-Test and Post-Test Across Proficiency Categories*

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
	51-75% Proficient	-	1	10	5
	76-100% Accomplished	-	-	6	15

1.5 Detailed analysis of pre-post-test data

Table 1.3: *Comparison of Means, Standard Deviation and Effect Size by Theme*

Competencies	**Measure**	**Mean**	**SD**	**Change in Mean**	**Cohen's d value**	**Effect size**
K1.2 Recognise students' prior conceptions and misconceptions	Pre-test	0.43	0.19	0.04	0.2	small
	Post-test	0.47	0.22			
K1.3 Recognise areas of difficulty that students face	Pre-test	0.55	0.19	0.03	0.2	small
	Post-test	0.58	0.11			
K2.1 Understand the nature of science	Pre-test	0.76	0.11	0.01	-0.1	Very small
	Post-test	0.76	0.09			
K2.2 Identify 'Big' ideas, key concepts and theories	Pre-test	0.82	0.12	0.04	0.4	small
	Post-test	0.86	0.10			
K2.3 Explain goals of teaching the subject/topic	Pre-test	0.79	0.27	0.01	0.0	Very small
	Post-test	0.79	0.29			
K2.4 Sequence and connect between concepts within subjects and across grades	Pre-test	0.84	0.21	-0.03	-0.1	Very small
	Post-test	0.81	0.25			
K3.1 Evaluate resources for multiple forms of representing content	Pre-test	0.70	0.13	0.06	0.5	medium
	Post-test	0.76	0.11			
K3.2 Select instructional strategies to support multiple forms of students' engagement	Pre-test	0.82	0.12	0.08	0.7	medium
	Post-test	0.90	0.11			
K3.3 Choose multiple tools of assessments to encourage multiple modes of expression	Pre-test	0.83	0.11	0.03	0.2	small
	Post-test	0.85	0.12			

In Theme K1.2, both the pre-test and post-test scores remained below 50%, indicating that participants were still at the developing level in this skill. However, there was a slight improvement in their ability to recognize participants' prior conceptions and misconceptions, as evidenced by an increase in the mean score from 0.43 (SD = 0.19) on the pre-test to 0.47 (SD = 0.22) on the post-test. While this change suggests that the instructional strategies had a positive impact on developing this critical skill, the increase in standard deviation indicates greater variability in

participants' progress. Moreover, the small effect size of 0.2 underscores that the overall impact of the intervention was modest.

In Theme K1.3, the data indicates a modest improvement in the participants' ability to recognize areas of difficulty faced by students, as reflected by an increase in the mean score from 0.55 (SD = 0.19) on the pre-test to 0.58 (SD = 0.11) on the post-test. The decrease in standard deviation suggests that the participants' post-test scores were more consistent, indicating a narrowing range of performance levels. However, the small effect size highlights that the overall improvement among teacher participants was minimal, suggesting limited impact of the module on this particular skill.

Theme K2.1, which focuses on the ability to understand the nature of science, shows that the overall mean scores for both the pre-test and post-test remained at 0.76. This indicates that participants already possessed a strong foundation in this area prior to the training. The data suggests an opportunity to explore new methods for deepening and reinforcing these concepts in future training sessions. Furthermore, the decrease in standard deviation implies that participants' post-test scores were more consistent, indicating a convergence in their understanding of this topic.

Theme K2.2, which focuses on identifying 'Big' ideas, key concepts, and theories, demonstrates a positive effect of the instructional strategies on participants' content knowledge. The data reveal an increase in the mean score from 0.82 (SD = 0.12) on the pre-test to 0.86 (SD = 0.10) on the post-test, reflecting a 4% improvement in the mean score. The reduction in the standard deviation suggests that participants' post-test scores were more consistent. Although the effect size is small, the results indicate that participants already had a strong foundation in this theme, with the instructional strategies contributing to a modest enhancement of their understanding.

Theme K2.3, which evaluates teachers' ability to explain the goals of teaching a subject or topic, shows no change in the mean score, which remained at 0.79 after the post-test. The data also indicate a slight increase in the standard deviation by 0.02, suggesting a minor decrease in consistency among participants' scores, though this change is negligible. Given the consistently high mean score, it can be concluded that participants already possess a strong understanding of the importance of explaining learning goals in science.

Theme K2.4, which focuses on participants' ability to sequence and connect concepts within subjects and across grades, showed a slight decline in the mean score, from 0.84 (SD = 0.21) on the pre-test to 0.81 (SD = 0.25) on the post-test. The small increase in standard deviation suggests a slight increase in variability in post-test scores. Additionally, the minimal effect size indicates that the intervention had little to no impact on improving this competency.

Theme K3.1, which evaluates participants' ability to assess resources for representing content in various forms, demonstrated an improvement in the mean score from 0.70 (SD = 0.13) on the pre-test to 0.76 (SD = 0.11) on the post-test. The slight reduction in standard deviation reflects greater consistency among participants' post-test scores, and the medium effect size of 0.5, as indicated by Cohen's d, underscores the significance of this change. These results suggest that the instructional strategies implemented were effective in enhancing participants' competency in this area.

Theme K3.2, which evaluates participants' abilities to choose instructional strategies that support various forms of student engagement, shows a positive impact from the intervention. The pre-test mean score of 0.82 (SD= 0.12) increased to a post-test mean score of 0.90 (SD=0.11),

demonstrating an improvement in this competency. The Cohen's d test indicates a moderate effect size, suggesting that the intervention was successful. The relatively high mean scores for both the pre-test and post-test suggest that participants already possess strong knowledge and skills in employing diverse methods to engage students in learning.

K3.3, which evaluates participants' ability to select appropriate assessment tools to support diverse modes of student expression, shows a slight improvement in performance, with the pre-test mean at 0.83 (SD = 0.11) and the post-test mean at 0.85 (SD = 0.12). The marginal increase in the mean score, coupled with the relatively stable standard deviation in the post-test, suggests that participants have become more consistent in their understanding and application of these assessment strategies. The consistently high mean scores in both the pre-test and post-test further indicate that participants are already well-versed in providing students with flexible options for demonstrating their learning, fostering an inclusive and supportive learning environment.

Summary

In Theme K1.2, participants showed limited improvement in recognising misconceptions, with mean scores increasing slightly from 0.43 to 0.47, yet still below 50%. The larger standard deviation indicates variability in progress. Theme K1.3 reported a modest rise from 0.55 to 0.58, with decreased variability suggesting more consistent performance, yet the effect size remains small. Theme K2.1 revealed stable mean score (0.76), indicating a strong prior foundation, while a decrease in standard deviation suggests improved consistency. In Theme K2.2, participants improved from 0.82 to 0.86, with a modest enhancement noted. Theme K2.3 maintained a mean of 0.79, showing strong understanding unchanged. However, Theme K2.4 experienced a slight decline from 0.84 to 0.81, indicating limited impact. Themes K3.1 and K3.2 showed significant improvements, with mean scores rising from 0.70 to 0.76 and 0.82 to 0.90, respectively, signifying effective instructional strategies. K3.3 also exhibited slight improvement, reinforcing strong existing knowledge.

1.6 Practice (Session plan and reflection together)

To effectively evaluate teacher practice, it is essential to examine multiple aspects of their instructional activities. This section will delve into evaluation of teachers' practice through classroom teaching, lesson planning, and teachers' reflection reports. By analysing these components, we can gain valuable insights into the quality and effectiveness of teachers' pedagogical approaches supported through the open educational resources' module.

The key areas of focus under practice have been further analysed through the perspectives of learners, content, and teaching and learning, as outlined in Table 1.4 below.

Table 1.4: *Descriptive Statistics for Categories, Themes, Mean Scores, and Standard Deviations*

Category	Theme	Mean	SD
a. Learners	P1.1 Promote inclusion and equity	1.66	0.42
	P1.2 Build on students' prior conceptions	1.58	0.50
	P 1.3 Address misconceptions and areas of difficulties	1.38	0.71
	P2.1 Use processes on science and mathematics	1.30	0.69

b. Content	P2.2 Facilitate higher order thinking	1.71	0.38
	P2.3 Plan to build students' competences to meet the goals of teaching science/ mathematics	1.44	0.41
c. Teaching and Learning	P3.1 Use instructional strategies for active learning	1.89	0.26
	P3.2 Use multiple representations of content	1.82	0.32
	P3.3 Create opportunities for multiple modes of expression	1.67	0.39
	P3.4 Use locally available materials	0.97	0.66
	P3.5 Link conceptual content to students' everyday life experiences and prior knowledge	1.48	0.56

Note: Mean levels 1.00 - 1.24 Low; 1.25 - 1.74 Moderate; 1.75 - 2.00 High

In section 5a, 5b and 5c describe the patterns emerging from the major themes and give at least 2 examples/ evidence/ direct quotes per category.

Evaluating Teacher Practice

a. Learners

Subtheme P1.1: Promote inclusion and equity

The sub themes under the main category "Learners" were designed to focus on the diverse needs and characteristics of students in the classroom. They aimed to ensure that teaching and learning practices are responsive to these individual differences. The highest mean score of 1.66 for "P1.1 Promote inclusion and equity," suggests that teachers were aware of the importance of creating inclusive learning environments and have made some efforts to implement strategies to achieve this.

However, the standard deviation of 0.42 implies a certain level of variability in teacher practices. This could be due to factors such as differences in teacher experience, confidence levels, or access to resources. Teachers have effectively promoted inclusion and equity in their classrooms by utilising pair and group activities, such as "think-pair-share" and "round robin." These collaborative strategies provide students with equal opportunities to learn and succeed. Pair and group activities also foster a more equitable learning environment where all students feel empowered to contribute and succeed. When students work together, they have opportunities to interact, share ideas, and build relationships, which can help them feel more connected to their classmates and the classroom community.

Additionally, the lesson plans were learner-centred and teachers have incorporated targeted learning objectives from the cognitive, psychomotor, and affective domains. This ensured that instructions were aligned with students' needs and promoted holistic development.

Subtheme P1.2: Build on students' prior conceptions

With a mean score of 1.58, teachers demonstrated a moderate level of focus on building on students' prior knowledge. This is a crucial aspect of effective teaching as it help students connect new information to their existing understanding. Teachers assessed students' prior knowledge of atomic structure concepts through open-ended questioning, quizzes, and brainstorming sessions.

The standard deviation of 0.50 suggests that while some teachers effectively incorporated students' prior knowledge into their instruction, others may need further development in this area.

Subtheme P1.3: Address misconceptions and areas of difficulties

The lowest mean score of 1.38 for this sub theme indicates that teachers may need more support in addressing student misconceptions and difficulties. This is an essential component of effective teaching as it helps prevent misunderstandings and promotes deeper learning.

The standard deviation of 0.71 suggests a wide range of practices among teachers in addressing misconceptions. Some teachers may have effectively identified and addressed student difficulties, while others may require additional training and support.

b. Content

P2.1 Use processes on science and mathematics:

The mean score of 1.30 indicates a moderate level of teacher practice in using processes related to science and mathematics. While teachers effectively incorporated questioning, observation, reasoning, and communication into their classroom instructions, they did not fully apply higher-level processes like experimentation, hypothesis formation, data analysis, problem-solving, and modelling. These processes are crucial for developing students' critical thinking, problem-solving, and communication skills, which are essential for success in both science and mathematics. The standard deviation of 0.69 suggests a wide range of practices among teachers, with some demonstrating more effective use of processes than others.

P2.2 Facilitate higher order thinking:

Teachers demonstrated a higher level of practice in facilitating higher-order thinking, with a mean score of 1.71. This suggests that teachers have created opportunities for students to develop higher order thinking such as critical thinking and problem-solving skills among their students. A standard deviation of 0.38 indicates that teachers have common understanding of the importance of higher-order thinking and have implemented similar strategies in their classrooms. Furthermore, teachers follow the same national curriculum and resources, these factors likely contributed to the consistent facilitation of higher-order thinking skills.

P2.3 Plan to build students' competencies to meet the goals of teaching science/mathematics: The mean score of 1.44 indicates a moderate level of teacher practice in planning to build students' competencies. This suggests that teachers are generally aware of the importance of aligning their instruction with learning goals but may require further development in this area. A standard deviation of 0.41 for P2.3 indicates a moderate level of variability among teachers in their ability to plan for building student competencies. This suggests that, while there is overall consistency in teacher practices, differences exist in how teachers approach this aspect of instruction, particularly in relation to individual approaches, curriculum, and the professional development support they have received.

Overall, the data suggests that teachers have made moderate progress in incorporating content-related practices into their instruction. However, there is still room for improvement, particularly in the use of processes related to science and mathematics.

c. Teaching-Learning

Teaching and Learning provide a comprehensive framework for understanding and evaluating effective instructional practices. The given subthemes focus on various aspects of the teaching

and learning process, including the use of instructional strategies, the representation of content, the creation of opportunities for expression, the utilisation of local resources, and the connection between conceptual content and students' everyday experiences.

P3.1: Use Instructional Strategies for Active Learning

This subtheme emphasises the importance of engaging students in active learning activities that promote critical thinking, problem-solving, and creativity. Teachers demonstrated a high level of practice in using instructional strategies for active learning, with a mean score of 1.89 and a standard deviation of 0.26. The low standard deviation suggests a high degree of consistency in this area, indicating that teachers are generally effective in employing strategies that promote student engagement and participation.

P3.2: Use Multiple Representations of Content:

This subtheme highlights the value of presenting content in various ways to cater to different learning styles and help students develop a deeper understanding of concepts. Teachers demonstrated a high level of practice in using multiple representations of content, with a mean score of 1.82 and a standard deviation of 0.32. This suggests that they are effectively employing various strategies to help students understand and apply concepts from different perspectives.

P3.3: Create Opportunities for Multiple Modes of Expression:

This subtheme underscores the importance of providing students with opportunities to express their understanding through different modes, such as writing, drawing, solving problems or performing an experiment. Teachers demonstrated a moderate level of practice in creating opportunities for multiple modes of expression, with a mean score of 1.67 and a standard deviation of 0.39. While the mean score is slightly lower than the previous two subthemes, it still indicates that teachers are generally providing students with various ways to express their understanding, such as writing, drawing, presentation or performing an experiment.

P3.4: Use Locally Available Materials:

This subtheme emphasises the benefits of incorporating locally relevant materials into instruction, as it can make learning more meaningful and culturally relevant.

The mean score 0.97 indicates a low level of practice among teachers in using locally available materials. It was evident in the lesson plans that teachers have not used locally available materials much to discuss the contents. Likewise, the high standard deviation 0.66 suggests a wide range of practices in this area. This variability could be due to factors such as the availability of local resources, teacher training, and school policies. To improve the use of locally available materials, it is important to provide teachers with professional development opportunities, access to resources, and support in identifying and utilising relevant materials. Additionally, schools can create a culture that encourages the use of local materials and values their contribution to student learning.

P3.5: Link Conceptual Content to Students' Everyday Life Experiences and Prior Knowledge:

This subtheme highlights the importance of connecting abstract concepts to students' personal experiences and prior knowledge, which can help students make sense of new information and apply it to real-world situations. The mean score of 1.48 indicates a moderate level of practice among teachers in connecting conceptual content to students' everyday life experiences and prior knowledge. This suggests that teachers are generally aware of the importance of making learning relevant and meaningful for students.

However, the standard deviation of 0.56 suggests a moderate level of variability in this practice. This implies that some teachers may be more effective than others in connecting content

to students' experiences and prior knowledge. Factors contributing to this variability could include: teacher experience and expertise, curriculum design, and professional development in learner-centred teaching -learning approaches.

The findings reveal that teachers have made progress in their practices. While strengths exist in promoting inclusion, facilitating higher-order thinking, and using active learning strategies, areas for improvement include addressing misconceptions effectively, using science and mathematics processes more extensively, and incorporating locally available materials. By acknowledging these areas and providing necessary support, the quality of teaching and learning can be further enhanced.

1.7 Social learning in CoPs

1.7.1 Frequency of posts by participants

Table 1.5: *Frequency of posts by participants*

Role	**Number of posts**
Participants	182
Teacher Educators	152
Total	**334**

1.7.2 Frequency of posts by content and types

Table 1.6: *Frequency of posts by content and types*

Frequency of posts by content	
Type of Posts	**Number of posts**
PCK	29
UDL	0
Technical	130
Communication/ Administrative	144
Others	31
Total	**334**
Frequency of posts by type	
Type of post	**Number of posts**
Text only	126
Images	172
External Links to other resources	20
Others	16
Total	**334**

1.7.3 Qualitative dialogues/ discussion threads

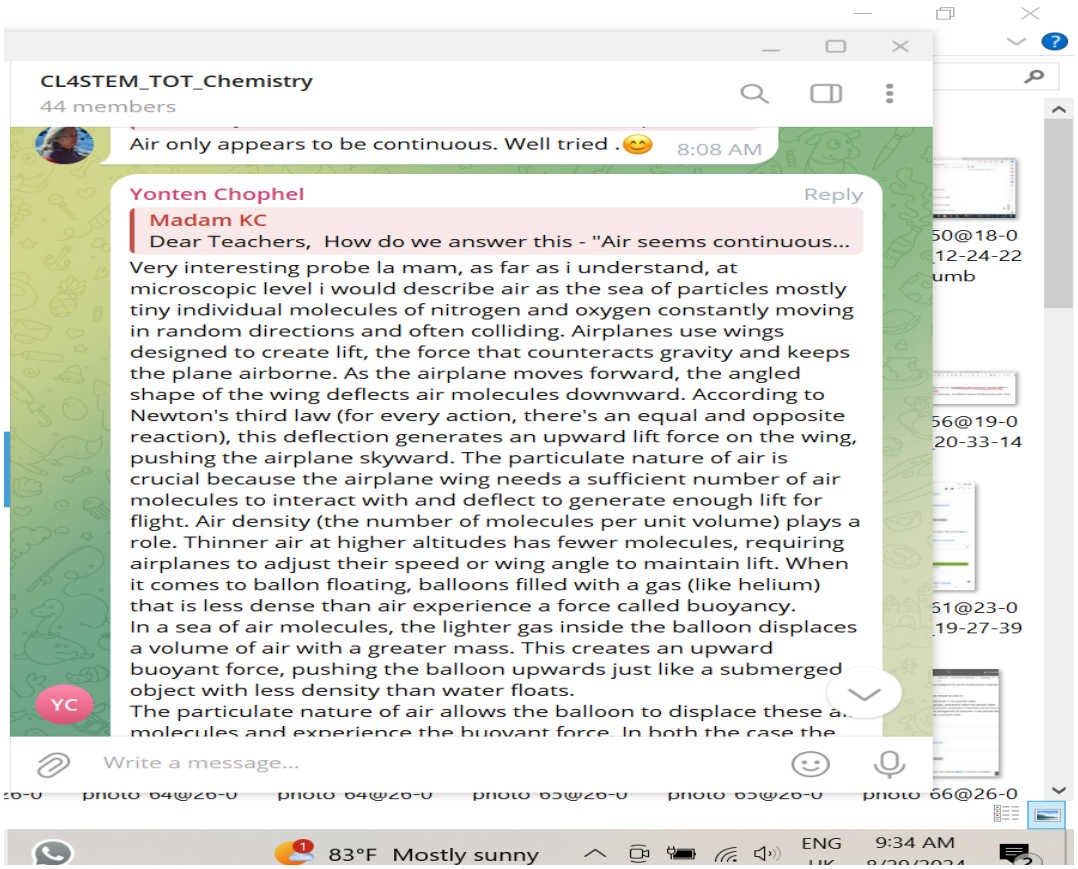
Community of Practice (CoP) is a group of individuals who share a common interest or passion and engage in the same kind of work (practice) and share their work experiences, problems, regularly interact to learn from each other. CoPs facilitate the exchange of knowledge, ideas, and best practices among members. This can lead to the generation of new ideas, innovation, and the improvement of existing practices. Being a part of the CoP, it contributes to one's own professional growth and expertise.

With the same purposes we also formed a CoP of chemistry teachers of Bhutan, professionals from Ministry of Education and Skills development, and Chemistry teacher educators from Samtse College of Education as a part of CL4STEM project.

Though the members knew the benefits of forming a CoP, most of the interactions and discussions were around the technical, communication and administrative issues. There were only 29 posts on PCK and none on the UDL.

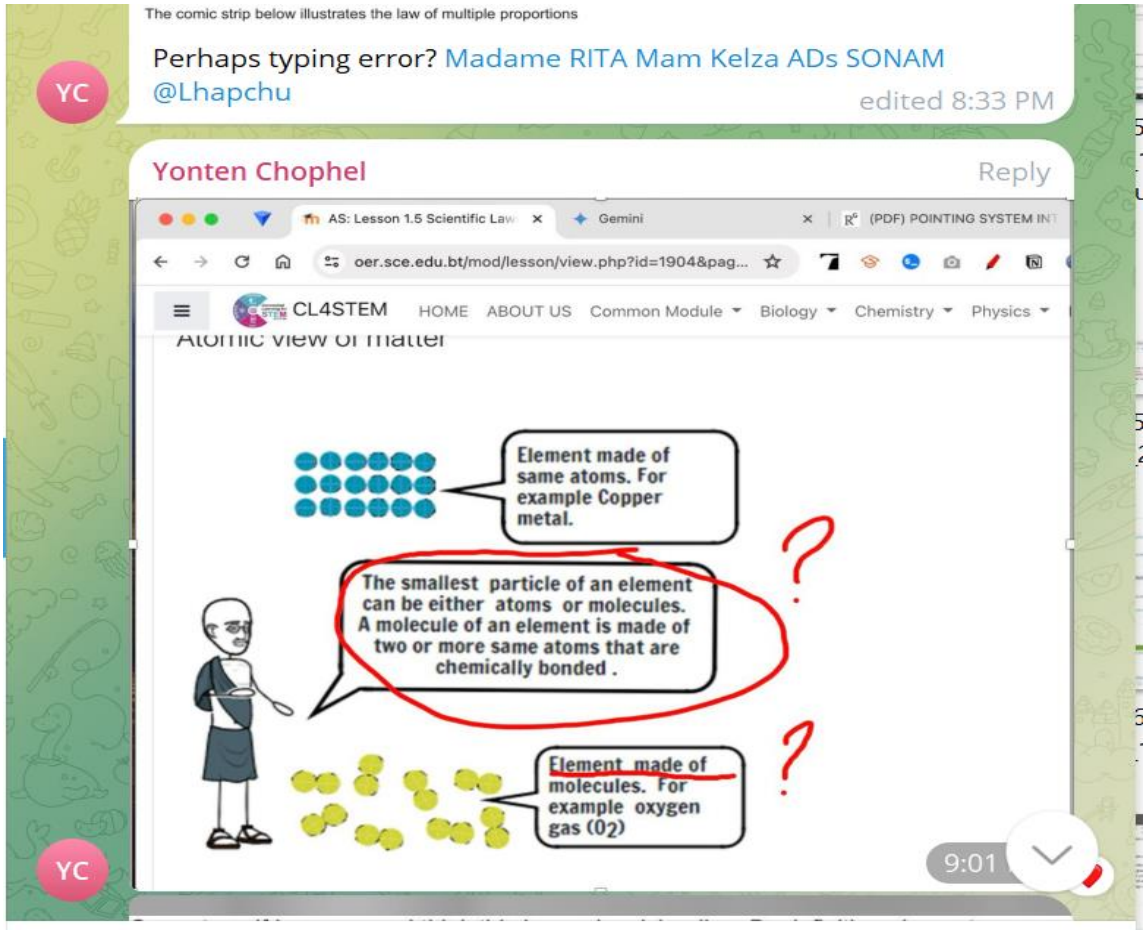
It was also found that the teacher participants felt more comfortable discussing the module amongst their colleagues in their group than in the Chemistry CoP created as part of the CL4STEM project implementation.

Looking at the CoP dynamics, there were not much discussion around the content of the module or about chemistry. Therefore, it is not relevant to indicate good examples though there are many activities in the module OER which should promote or motivate teacher participants to ignite discussions and learning. There are few sharing of links from the teacher educators and one or two teacher participants engaging in the discussion like the one shared below:



Though the CoP has lots of advantages, it looks like teachers were not able to participate in the discussions on the module.

Another benefit of CoP is effective and timely communication about the reminders and progress of the course. Teacher educators could see the progress of the participants and remind them frequently and instantly.



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

1.8.1 Participation of teachers

Overall, the implementation of the course went quite smoothly and it could be considered a success. Everyone completed the module though many of them needed frequent reminders. Teacher participants expressed that the OER and the content and instructional practices used for the module were well organised. Strategies that worked include the integration of ICT into the module to make lessons interactive, check students' progress, and conduct virtual experiments.

We used three mediums to implement the module such as Moodle, CoP, and personal telegram. Teachers participated more in the personal chat. Moodle was mostly used to access course materials and submit the assignments.

1.8.2 Challenges

i) Like the previous participants, 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 to attend at the college 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) Another challenge was also the time factor from the participants. They were not able to attend the module as per the schedule and needed frequent reminders. This is because the all the participants were full time school teachers and sometimes the topics taught in the schools did not match with the topics included in the online module.

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.

1.8.3 Surprises

NA

1.8.4 Any changes required in the module design

The school teachers have their own lesson plan format which is different from the one provided in the module. There is a need to relook at the lesson plan template or ask students to submit video recordings of the lessons taught.

Module 2: Chemical Bonding

2.1 Introduction

The module on Chemical Bonding was curated by chemistry teacher educators at Samtse College of Education in collaboration with a chemistry curriculum developer from the Department of Curriculum and Professional Division (DCPD), Ministry of Education and Skills Development (MoESD). The course content for this module was designed using Bhutan's Science Curriculum Framework for Key Stages III and IV. This module aimed to strengthen the Subject Matter Knowledge (SMK), Pedagogical Content Knowledge (PCK), and General Pedagogical Knowledge (GPK) of teachers on chemical bonding. The contents in the module were expected to enhance teachers' understanding of chemical bonding and associated concepts, as well as their pedagogical knowledge of teaching chemical bonding. Apart from PCK, the module was designed by incorporating the principles of Universal Design for Learning (UDL) to make chemistry teaching and learning inclusive to accommodate the learning needs and abilities of diverse learners. Similarly, this module emphasised the use of technology in teaching-learning and assessments.

The module progressed from the basic understanding of chemical bonding, the various types of chemical bonds, the rules that govern them, and the implications of these bonds on the properties of substances. Some research-based strategies for addressing common misconceptions among students about the above-mentioned concepts were also presented. The course contents were also designed to align with the competency-based teaching and learning principles outlined in the Science Curriculum Framework. This alignment ensured a seamless integration of learning objectives, emphasising the development and assessment of key competencies in learners. Through a variety of PCK, interactive assessments, lesson planning, and reflection, this module aimed to foster a comprehensive understanding of chemical bonding principles while promoting critical thinking and practical application skills among students.

a. Timeline of implementation in the country

The module, which commenced on 6th May and was originally scheduled to conclude on 17th June, had to be extended by several weeks due to teachers' involvement with midterm examinations, followed by the summer break. The module was eventually completed on 15th July.

b. Learning objectives

At the end of the module, participants were expected to:

(i) Analyse the principles of chemical bonding and the influence of valence electrons on the formation of ionic, covalent, and coordinate bonds.

(ii) Evaluate the application of the octet and duplet rules in predicting molecular stability across different types of chemical bonds.

(iii) Differentiate between ionic, covalent, and coordinate bonds.

(iv) Construct molecular models representing ionic, covalent, and coordinate bonds, and justify how electron arrangement affects the physical and chemical properties of compounds.

(v) Estimate and compare lattice energies of various ionic compounds, and explain their implications for the physical properties of materials, such as melting point and solubility.

(vi) Interpret the influence of covalent bond polarity and the types of bonds (single, double, triple) on molecular geometry, polarity, and reactivity.

(vii) Assess the role of ionic and covalent bonding in industrial and everyday applications.

(viii) Explain the process of electron sharing in coordinate bonding, and apply this knowledge to predict molecular behaviour in coordination complexes and complex ions.
(ix) Evaluate how the different bonding types influence the reactivity, stability, and interactions of molecules in various chemical reactions and biological systems.
(x) Correlate the key properties of metals (electrical conductivity, thermal conductivity, malleability, ductility, metallic lustre, and high melting/boiling points) with metallic bonding.

c. Number of units

There are four units in the module.

Unit 1: Understanding Chemical Bonding
Unit 2: Ionic Bond
Unit 3: Covalent Bond
Unit 4: Coordinate Bond
Unit 5: Metallic Bond

d. Concepts covered

The five units covered in the module on chemical bonding, provide a comprehensive understanding of how atoms combine to form stable compounds. The first unit introduces chemical bonding by explaining the role of valence electrons and the importance of the octet and duplet rules in bond formation. The second unit delves into ionic bonding, focusing on electron transfer between atoms, the formation of charged ions, and their real-world applications, such as in ionic compounds with high melting points and electrical conductivity. The third unit explores covalent bonding, where atoms share electrons, and highlights the differences between single, double, and triple bonds and how these affect molecular properties. In the fourth unit, coordinate bonding is introduced, where one atom provides both electrons in a bond, emphasising its significance in complex ions and molecular interactions. The fifth unit covers metallic bonding, describing the delocalisation of electrons among metal atoms and its role in giving metals their distinctive properties like conductivity, malleability, and ductility. Together, these units offer a structured approach to understanding the diverse types of bonding and their practical implications.

e. Resources - activities, reading

The resources utilised in this module included a variety of materials such as reading materials, YouTube videos, self-developed videos, PHET simulations, multiple choice questions (MCQ), games, true and false, quiz, experimental procedures, and virtual experiments.

f. Nature and purpose of assessments

Formative and summative assessments were employed throughout the module to evaluate the participants' learning progress. The module began with a mandatory pre-test consisting of 45 multiple-choice questions (MCQs) focused on three key themes: learners, content, and teaching-learning. Participants were required to complete this pre-test within one hour before proceeding with the module. Each of the five units included various formative assessment activities such as quizzes, short answer writing, MCQ, and practical activities with students. At the end of the module, participants were required to complete a similar 45-MCQ post-test, also within an hour. Additionally, participants had to submit two lesson plans on concepts related to the module's content and one reflection after implementing these lesson plans. Beyond tutor assessments, participants' lesson plans and recorded teaching sessions were evaluated by an assigned peer. Out of the 38 teachers involved, eight were selected as a focus group sample. Their lesson plans and teaching were evaluated by the tutor, officials from the Ministry of Education and Skills Development (MoESD), and their supervisors Head of the Department (HOD). All evaluations

were conducted using a standardised rubric that emphasised learners, content, and teaching-learning effectiveness.

2.2 Course completion rate

2.2.1 Overall completion

All 38 teachers successfully completed the course.

2.2.2 Assessment completion rate

All participants completed the assessments. They were evaluated using a pre-test, a post-test, two lesson plans, and a reflection report.

2.3 Time spent on the course platform

Table 2.1: *Time spent by teachers on Moodle platform*

Hours spent	**Total Teachers**	**Total**
Less than 10	34	34
10 to 20	6	6
21 to 30	0	0
More than 30	-	0
Total	-	**38**

Teachers were expected to spend a total of 30 hours to complete the module, with a weekly commitment of 5 hours. According to the data, 34 teachers completed the tasks in less than 10 hours and 6 teachers took between 10 to 20 hours to complete the module. It should be noted that teachers invested significant time in developing lesson plans, implementing them, recording videos for peer review, and writing reflection reports, which were not tracked by the Learning Management System (Moodle).

2.4 Change from pre-test and post-test

Average total score in pre-test was 68.
Average total score in post-test was 71.

Table 2.2: *Teachers' performance in pre-test and post-test.*

Number of teachers		**Post Test**			
		Novice	Emerging	Proficient	Accomplished
Pre test	0-25% Novice			1	
	26-50% Emerging		2	1	1
	51-75% Proficient		2	13	6
	76-100% Accomplished		1	2	10

Table 2.2 represents the percentage scoring in the pre and post-test of the participants. 13 Participants were in the accomplished level, 21 in the proficient level, 4 in the emerging level and 1 in the novice level in the pre-test scores. After the completion of the module 2 participants from the accomplished level fell to the proficient level while 1 participant from the accomplished level fell to the emerging level. Of the 21 participants who were in the proficient level in the pre-test, 6 got promoted to accomplished level while 2 fell in the emerging level. The 4 participants who were in the emerging level during the pre-test, 1 got promoted to the accomplished level

and 1 to the proficient level and 1 participant who was in the emerging level in the pre-test showed a marked increase to the accomplished level in the post-test. The average increase in the mean score from the pre-test to post-test is only 3%.

The findings reveal that while the module led to some participants moving up to higher levels of understanding, it also resulted in a few individuals falling to lower levels. Overall, there was a modest improvement in the average score, but individual progress varied significantly. Some participants experienced substantial growth, while others showed minimal or no change. These results suggest that the module may be effective for certain learners but may require adjustments to better cater to the diverse needs of the participants.

Table 2.3: *Theme wise mean scores, standard deviations and effect size*

	Competencies		**Mean**	**SD**	**Change in Mean**	**Cohen's d**	**Effect size**
Learner	K1.2 Recognise students' prior conceptions and misconceptions	Pre-test	0.50	0.25	0.07	0.30	small
		Post-test	0.57	0.22			
	K1.3 Recognise areas of difficulty that students face	Pre-test	0.50	0.17	0.03	0.20	small
		Post-test	0.53	0.12			
Content	K2.1 Understand the nature of science/mathematics	Pre-test	0.54	0.22	0.04	0.19	Very small
		Post-test	0.58	0.20			
	K2.2 Identify 'Big' ideas, key concepts and theories	Pre-test	0.56	0.22	0.11	0.48	small
		Post-test	0.67	0.24			
	K2.3 Explain goals of teaching the subject/topic	Pre-test	0.89	0.05	0.01	0.18	Very small
		Post-test	0.90	0.06			
	K2.4 Sequence and connect between concepts within subjects and across grades	Pre-test	0.70	0.22	-0.05	-0.20	small
		Post-test	0.65	0.27			
Teaching and learning	K3.1 Evaluate resources for multiple forms of representing content	Pre-test	0.82	0.13	0.00	0.00	No effect
		Post-test	0.82	0.12			
	K3.2 Select instructional strategies to support multiple forms of students' engagement	Pre-test	0.74	0.03	0.02	0.37	small
		Post-test	0.76	0.07			

	Competencies		Mean	SD	Change in Mean	Cohen's d	Effect size
	K3.3 Choose multiple tools of assessments to encourage multiple modes of expression	Pre-test	0.86	0.09	0.02	0.25	small
		Post-test	0.88	0.07			

2.5 Detailed analysis of pre-post-test data

To gain deeper insight of the pre-test and post-test results, thematic analysis was done.

In Theme K1.2, "Recognise students' prior conceptions and misconceptions," participants showed improved performance after the intervention. The pre-test mean was 0.50 (SD = 0.25), while the post-test mean increased to 0.57 (SD = 0.03), indicating better scores and a slight reduction in the standard deviation, which suggests more consistent post-test results. The small positive effect size points to a modest but beneficial impact. This reflects an improvement in participants' understanding of this essential skill. However, the relatively low mean scores indicate that participants' knowledge is still in the developing stage. Therefore, more effective interventions are necessary to further enhance their knowledge and skills in this area.

In Theme K1.3, "Recognise areas of difficulty that students face," the data shows a comparable positive trend, with a modest improvement in recognising student challenges. The pre-test mean rose from 0.50 (SD = 0.17) to a post-test mean of 0.53 (SD = 0.12), and the slight decrease in standard deviation further supports this observation. This improvement reflects the effectiveness of the training strategies, which helped participants better understand and identify student difficulties. However, similar to Theme K1.2, the low mean scores suggest participants are still developing in this area, and the small positive effect size indicates that the intervention requires further enhancement to improve participants' competency in this skill.

The mean scores for the pre-test (M = 0.54, SD = 0.22) and post-test (M = 0.58, SD = 0.20) in Theme K2.1, which focuses on "Understanding the Nature of Science/Mathematics," reveal only a slight improvement following the intervention. Although there is a marginal increase in the post-test mean score, the effect size is minimal, indicating that the intervention had a limited impact on enhancing participants' competency in this area.

The small effect size suggests that few participants made significant progress in their understanding of the nature of science and mathematics. This outcome underscores the need for revising and strengthening the intervention to ensure it more effectively supports learning and leads to meaningful improvements.

In Theme K2.2, which focuses on "Identifying 'Big' Ideas, Key Concepts, and Theories," participants demonstrated notable improvement. The pre-test mean score (M = 0.56, SD = 0.22) increased to a post-test mean score of 0.67 (SD = 0.24), reflecting an 11% improvement. While the standard deviation showed a slight increase, indicating a marginal rise in score variability, this improvement suggests a positive shift in participants' understanding of central ideas and theories.

Although the effect size remains small, the substantial difference in mean scores points to significant progress for a portion of the participants. This indicates that the intervention was successful in enhancing the comprehension of key concepts and theories for several individuals

In Theme K2.3, which focuses on "Explaining the Goals of Teaching the Subject/Topic," the results showed a slight 1% increase in the mean score, with the pre-test mean at 0.89 (SD = 0.05) and the post-test mean at 0.90 (SD = 0.06). The effect size is very small, indicating that only a few participants demonstrated any significant improvement following the intervention.

However, the consistently high scores in both the pre-test and post-test, supported by a negligible change in standard deviation, suggest that participants were already highly proficient in this competency prior to the intervention. This implies that the intervention had little room to influence their performance further. Alternatively, the minimal change could indicate that the intervention was not effective in differentiating between participants' varying levels of understanding.

In Theme K2.4, which focuses on "Sequencing and Connecting Concepts Within Subjects and Across Grades," the results indicate a decline in participant performance after the intervention. The pre-test mean score was 0.70 (SD = 0.22), while the post-test mean decreased to 0.65 (SD = 0.27). This drop in mean score, coupled with an increase in standard deviation, suggests greater variability in participants' understanding, with some individuals performing worse after the intervention.

The small negative effect size (-0.20) further highlights that the intervention not only failed to enhance competencies in this area but may have had a detrimental impact on some participants. These results suggest that the intervention was not effective in supporting the development of skills related to sequencing and connecting concepts. The increase in variability also indicates that the intervention may have confused or disengaged some participants, reducing their ability to perform in this competency.

In Theme K3.1, which assesses participants' ability to "Evaluate Resources for Multiple Forms of Representing Content," the pre-test and post-test mean scores remained unchanged at 0.82. The standard deviation slightly decreased from 0.13 (pre-test) to 0.12 (post-test), and the effect size was zero, indicating that the intervention had no measurable impact on participants' competency in this area.

The consistently high scores in both the pre-test and post-test suggest that participants already had a strong foundation in evaluating resources for diverse content representation before the intervention. This stability in performance implies that the participants were already proficient, leaving little room for improvement. The lack of variation in the scores and the absence of significant progress highlight the need for future interventions to be more differentiated.

Theme K3.2, which assesses participants' ability to "Select Instructional Strategies to Support Multiple Forms of Student Engagement," showed a modest positive impact following the intervention. The pre-test mean score was 0.74 (SD = 0.10), while the post-test mean increased slightly to 0.76 (SD = 0.07), with a small effect size. This indicates that, although the overall improvement was minor, the intervention did enhance the performance of some participants.

The consistently high mean scores suggest that participants already had a strong foundation in selecting diverse instructional strategies for engaging students. The small gain, however, points to the intervention's limited ability to produce significant improvement across the group.

Theme K3.3, which evaluates participants' ability to "Choose Multiple Tools of Assessment to Encourage Multiple Modes of Expression," exhibited a trend similar to that of Theme K3.2. The mean score increased modestly by 2%, from a pre-test mean of 0.86 (SD = 0.09) to a post-test mean of 0.88 (SD = 0.07), accompanied by a small effect size. This slight improvement suggests that the intervention had a positive impact on some participants, though limited in scope.

The relatively high pre-test and post-test scores indicate that participants were already proficient in this competency, with a solid foundation in selecting varied assessment tools. While the intervention contributed to marginal gains, its overall effect was minimal, pointing to the need for more tailored or advanced instructional strategies to drive further improvement.

2.6 Practice (Session plan and reflection together)

To effectively evaluate teacher practice, it is essential to examine multiple aspects of their instructional activities. This section will delve into evaluation of teachers' practice through classroom teaching, lesson planning, and teachers' reflection reports. By analysing these components, we can gain valuable insights into the quality and effectiveness of teachers' pedagogical approaches supported through the OER module on chemical bonding.
The key areas of focus under practice have been further analysed through the perspectives of learners, content, and teaching and learning, as outlined in the Table 2.4 below:

Table 2.4: *Mean and Standard deviations of teachers' practice through classroom teaching, lesson planning, and teachers' reflection reports.*

Category	Theme	Mean	SD
1.Learners	P1.1 Promote inclusion and equity	1.8	0.2
	P1.2 Build on students' prior conceptions	1.8	0.3
	P 1.3 Address misconceptions and areas of difficulties	1.6	0.5
2.Content	P2.1 Use processes on science and mathematics	1.5	0.4
	P2.2 Facilitate higher order thinking	1.7	0.3
	P2.3 Plan to build students' competences to meet the goals of teaching science/ mathematics	1.6	0.3
3.Teaching and Learning	P3.1 Use instructional strategies for active learning	1.8	0.3
	P3.2 Use multiple representations of content	1.8	0.3
	P3.3 Create opportunities for multiple modes of expression	1.8	0.2
	P3.4 Use locally available materials	1.4	0.4
	P3.5 Link conceptual content to students' everyday life experiences and prior knowledge	1.4	0.3

Note: Mean levels 1.00 - 1.24 Low; 1.25 - 1.74 Moderate; 1.75 - 2.00 High

a. Learners

The analysis of the "Learners" category revealed insights into teachers' practices across three key subthemes, reflecting their focus on promoting inclusion and equity, building on students' prior knowledge, and addressing misconceptions.

Subtheme P1.1: Promote inclusion and equity (Mean: 1.8, Standard Deviation: 0.2): Teachers showed a strong commitment to fostering inclusive and equitable learning environments, with practices that were largely consistent across the schools. The high mean score of 1.8 along with a low standard deviation of 0.2, indicated that teachers were largely aligned in their commitment to fostering inclusive learning environments, successfully implementing strategies that ensured equitable opportunities for all students. This is reflected in their efforts to create opportunities for participation through varied instructional strategies such as collaborative group work and hands-on activities that encouraged engagement. Additionally, teachers paid attention to students who needed extra support, by employing differentiated instruction and assistive technologies to help them thrive. The use of inclusive language further enhanced this environment, as it fostered a

culture where all students felt respected and valued, promoting their willingness to share ideas. Furthermore, the low variability suggested that teachers were effective in avoiding discrimination based on socio-economic status, linguistic backgrounds, or abilities, creating a classroom culture that emphasised respect and acceptance. Overall, the strong mean score and consistent practices highlight teachers' effectiveness in promoting inclusion and equity, while ongoing professional development can further empower them to refine their approaches, ensuring all students receive equitable access to quality education.

Subtheme P1.2: Build on students' prior conceptions

Build on Students' Prior Conceptions (Mean: 1.8, Standard Deviation: 0.3): Similar to the first subtheme, teachers demonstrated importance on leveraging students' prior knowledge before starting the new lesson. While many were successfully connecting new concepts to existing understanding, the slight variability indicates that some teachers may need additional support or training in this area. Teachers mostly used questioning techniques to help students in recollecting their prior knowledge on chemical bonding.

Subtheme P1.3: Address misconceptions and areas of difficulties

Address misconceptions and areas of difficulties (Mean: 1.6, Standard Deviation: 0.5): This subtheme reflects a notable challenge for teachers, as indicated by the lowest mean score. The moderate standard deviation suggests a significant range in practices, with some teachers effectively identifying and addressing student misconceptions, while others struggle. This variability highlights the need for targeted professional development to enhance educators' skills in addressing student difficulties effectively. Most teachers have identified or listed the misconceptions that students have about specific topics, but they have not provided details on the strategies they use to help students overcome these misunderstandings.

b. Content

The "Content" category provides insight into teachers' effectiveness in using processes related to science and mathematics, facilitating higher-order thinking, and building students' competencies in alignment with the goals of teaching science and mathematics.

Subtheme P2.1 Use Processes on Science and Mathematics (Mean: 1.5, Standard Deviation: 0.4):

The mean score of 1.5 indicates that teachers are moderately using processes related to science and mathematics in their teaching. The scientific skills most commonly promoted by teachers included drawing, model-making, imagination, prediction, and comparison. However, the standard deviation of 0.4 reflects some variability in how effectively these processes are being incorporated. While some teachers may be confidently implementing scientific and mathematical processes, others may need additional support in integrating them more effectively into their lessons.

Subtheme P2.2 Facilitate Higher-Order Thinking (Mean: 1.7, Standard Deviation: 0.3):

The mean score of 1.7 suggests that teachers were relatively successful in facilitating higher-order thinking skills, such as analysis, evaluation, and creation, within their classrooms. The low standard deviation of 0.3 indicates that there was less variability in practices, meaning that most teachers are fairly consistent in fostering students' critical and creative thinking skills. However, there remains room for improvement in pushing students towards more advanced cognitive processes.

Subtheme P2.3 Plan to Build Students' Competencies to Meet the Goals of Teaching Science/Mathematics (Mean: 1.6, Standard Deviation: 0.3):

The mean score of 1.6 shows that teachers were moderately planning to build students' competencies in science and mathematics to meet educational goals. The standard deviation of 0.3, though relatively low, indicates a slight variation in how well teachers were planning for competency development. Teachers employed various strategies to help students develop competencies to meet science and mathematics goals. For example, students were engaged in challenging tasks such as analysing, predicting, and modelling.

c. Teaching and Learning

The "Teaching and Learning" category offers insights into teachers' instructional practices based on several indicators, such as active learning strategies, content representation, use of local materials, and connection to students' everyday lives. The following is an analysis based on the mean scores and standard deviations provided:

P3.1 Use Instructional Strategies for Active Learning (Mean: 1.8, Standard Deviation: 0.3):
A mean score of 1.8 suggests that teachers incorporated active learning strategies into their classrooms, engaging students in interactive and participatory learning experiences. Some of the strategies that they used were group and pair works, presentations, question and answer sessions, quiz, gallery walk and probing for students' active engagements. The standard deviation of 0.3 indicates moderate consistency across teachers in employing these strategies, though some variability exists, suggesting that certain educators may need further support in enhancing their active learning techniques in facilitating student centred learning.

P3.2 Use Multiple Representations of Content (Mean: 1.8, Standard Deviation: 0.3):
With a mean score of 1.8, teachers demonstrated a strong ability to present content in multiple forms (e.g., visual, verbal, and practical representations). Teachers have mostly used PowerPoint presentations, simulations, diagrams, molecular kits, analogies, smart phones, posters, etc. This approach helps accommodate diverse learning styles and reinforces understanding. The relatively low standard deviation of 0.3 indicates that most teachers consistently apply this practice to make the learning and teaching more effective.

P3.3 Create Opportunities for Multiple Modes of Expression (Mean: 1.8, Standard Deviation: 0.2):
The mean score of 1.8 for this sub theme reflects teachers' success in allowing students to express their understanding through various modes, such as written work, presentations, or projects. A low standard deviation of 0.2 suggests strong uniformity in the implementation of this practice, indicating that most teachers are equally effective in providing diverse opportunities for students to communicate their learning.

P3.4 Use Locally Available Materials (Mean: 1.4, Standard Deviation: 0.4):
The mean score of 1.4 reveals that teachers' use of locally available materials is less frequent. It appears that due to the nature of the module teachers have mostly used multimedia tools to teach this topic and have not used locally available materials except board, textbook, pen, marker, papers, models, etc. The standard deviation of 0.4 suggests a wide range in the extent to which teachers integrate local resources into their instruction. This variability may be due to differences in access to resources or in teachers' awareness of how to incorporate them meaningfully. There is an opportunity to improve the use of local materials to enhance practical and context-relevant learning experiences.

P3.5 Link Conceptual Content to Students' Everyday Life Experiences and Prior Knowledge (Mean: 1.4, Standard Deviation: 0.3):
A mean score of 1.4 indicates that teachers could further improve their efforts to connect classroom content with students' real-life experiences and prior knowledge. This is essential for making learning more relevant and meaningful to students. Teachers have mostly connected the class lesson with prior learning but limited exposure have been to everyday experiences. The

standard deviation of 0.3 suggests moderate variability, indicating that while some teachers are proficient in making these connections, others may require additional guidance on how to relate academic concepts to everyday life effectively.

2.7 Social learning in CoPs

2.7.1 Frequency of posts

Table 2.5: *Frequency of posts by participants*

Role	Number of posts
Teacher Participants	86
Teacher Educators	99
Total	**185**

2.7.2 Frequency of posts by content and types

Table 2.6: *Frequency of posts by content*

Frequency of posts by content	
Type of Posts	**Number of posts**
PCK	2
UDL	0
Technical	24
Communication/ Administrative	99
Others	60
Total	**185**
Frequency of posts by type	
Type of post	**Number of posts**
Text only	123
Images	60
External Links to other resources	2
Others	-
Total	**185**

2.7.3 Qualitative dialogues/ discussion threads

CoPs facilitate the exchange of knowledge, ideas, and best practices among members. This can lead to the generation of new ideas, innovation, and the improvement of existing practices. Being a part of the CoP, it contributes to one's own professional growth and expertise. But sadly, it did not work out as intended with the modules.

As reflected in the Table 2.6 above, most of the posts by both the teacher educators and the participants were related to technical and administrative issues. Some participants also shared images of badges they received after completing the modules. In the others category in the types of posts by content, the images and photos were reflected and that is why it was not reflected in the frequency of posts by types.

There were no worthwhile examples to be reflected as good practices. The CoP served more as a communication forum only. It worked as a timely reminder and communication platform.

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

2.8.1 Participation of teachers

Overall, the participants were very active in both the Moodle and the CoP. Moodle was used as the main platform for the participants to engage in the course materials. As mentioned earlier the CoP was more of a communication platform among the teacher educators and the teacher participants. In general, participation of teachers in the module was encouraging.

One strategy that worked well was guiding them through mentor-mentee strategy. The mentors are able to keep tract of their mentees' progress and status quite efficiently.

All the participants were very positive about the module and shared that the module was very helpful as a support for their professional development.

2.8.2 Challenges

Though the module was implemented quite successfully, there were challenges faced by teacher educators as well as by the participants. The main challenge was time constraint for both. All teacher educators and participants are full time employees, 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.

Another challenge was few participants needed frequent reminders to complete the task on time. Some of them do not respond also.

2.8.3 Surprises

This time there were no surprises

2.8.4 Any changes required in the module design

Changes needed

The school teachers have their own lesson plan format which is different from the one provided in the module. There is a need to relook at the lesson plan template or ask students to submit video recordings of the lessons taught.

Some of the platforms used for CoP are email correspondences, WhatsApp, occasional phone calls and video calls but Telegram was used to the optimum. Telegram served as a platform to share both official information and professional information. Official information includes matters related administrative nature while Professional information include sharing of resources related to the modules such as YouTube, articles, web links; best practices from the field; seeking clarifications from the teacher educators and colleagues in case of doubt; serving reminder to the teachers to attend to pre and post-test and submit lesson plans, etc.

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

Module 3: Organic Chemistry

3.1 Introduction

This module aimed to increase the pedagogical content knowledge (PCK) of chemistry teachers by using open educational resources (OERs) in Organic Chemistry. This module's contents were designed to enhance teachers' understanding of organic chemistry and associated concepts, as well as their pedagogical knowledge of teaching organic chemistry. Aside from the PCK, this module has been designed by incorporating the principles of Universal Design for Learning (UDL) to make organic chemistry teaching and learning inclusive in order to accommodate the learning needs and abilities of all learners. Similarly, this module emphasised the use of technology in teaching-learning and assessments.

This module was aligned with the Bhutan's Science Curriculum Framework for Key Stage IV, targeting to support the professional development of teachers teaching grades 9 and 10. This module introduced the concept of organic chemistry as well as historical applications of organic compounds in human life. The module progressed 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 were also presented. Finally, the module introduced 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 implemented for six weeks, from July 16 to August 27, 2024.

b. Learning objectives

At the end of the module participants were expected to:

(i) Investigate the origins, sources, and types of organic compounds;
(ii) Explain the meaning of organic chemistry;
(iii) State the nomenclature and the importance of organic compounds;
(iv) Identify 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 practical uses of hydrocarbons in everyday life;
(viii) Discuss the challenges 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 viz.

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

d. Concepts covered

The module covered a range of concepts, including the meaning and history of organic chemistry, the origin and distinction between organic and inorganic compounds, the importance and uses of

organic compounds, hydrocarbons (saturated and unsaturated), student misconceptions about hydrocarbons, alkanes, alkenes, and alkynes, IUPAC nomenclature, the properties of hydrocarbons, and the purification of organic compounds.

e. Resources - activities, readings

The module utilised diverse resources, including textbooks, wall charts, and pictures of molecular models, organic compounds, and hydrocarbon processes. Visual aids like images of coal, petroleum, natural gas mines, and hydrocarbon structures supported concept visualisation. Hands-on materials, such as kerosene samples and locally made molecular models, along with samples of organic, inorganic, and synthetic compounds, bridged theory and practice.

The module included interactive activities such as brainstorming, collaborative learning, and analysing a case study on hydrocarbon-related environmental pollution. Group discussions used visual aids like wall charts, while participants built molecular models with local materials to enhance understanding and foster inclusive teaching practices.

The module also provided an extensive list of reading materials and online resources to deepen participants' understanding of organic chemistry. These resources were selected to provide theoretical knowledge, visual aids, and practical examples to support teachers' professional development.

f. Nature and purpose of assessments

Formative and summative assessments were employed throughout the module to evaluate the participants' learning progress. The module began with a mandatory pre-test consisting of 45 multiple-choice questions (MCQs) focused on three key themes: learners, content, and teaching-learning. Participants were required to complete this pre-test within one hour before proceeding with the module. Each of the four units included various formative assessment activities such as quizzes, short answer writing, reflections, and practical activities with students. At the end of the module, participants were required to complete a similar 45-MCQ post-test, also within an hour. Additionally, participants had to submit two lesson plans on concepts related to the module's content and one reflection after implementing these lesson plans. Beyond tutor assessments, participants' lesson plans and recorded teaching sessions were evaluated by an assigned peer. Their lesson plans and teaching were evaluated by the tutor, officials from the Ministry of Education and Skills Development (MoESD), and their supervisors. All evaluations were conducted using a standardised rubric that emphasised learners, content, and teaching-learning effectiveness.

3.2 Course completion rate

3.2.1 Overall completion

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

3.2.1 Assessment completion rate

The assessments were successfully completed by all participants. They were evaluated using a pre-test, a post-test, lesson plans, and a reflection report as shown in the Table 3.1

Table 3.1: *Teachers' assessment completion rate*

Activities	Teachers who completed tasks	Completion Rate (%)
Pre test	38	38
Session plans	38	38

Activities	Teachers who completed tasks	Completion Rate (%)
Reflection	38	38
Post tests	38	38

3.3 Time spent on the course platform

Teachers were expected to spend a total of 30 hours to complete the module, with a weekly commitment of 5 hours.

Table 3.2 shows the time teachers spent on the course platform to complete the module. Out of 38 teachers, 16 spent less than 5 hours, indicating minimal engagement, while 21 teachers, the majority, dedicated between 5 and 10 hours and only one teacher spent between 11 and 20 hours. This data suggests that most teachers completed the module in 10 hours or less. However, it is important to note that tasks like lesson planning, implementation, peer reviews, and reflection reports, which required significant effort, were not tracked by the Learning Management System (Moodle).

Table 3.2: *Time spent by teachers on Moodle platform*

Hours spent	Teachers	Total
Less than 5	16	16
5 to 10	21	21
11 to 20	1	1
21 to 30	0	0
More than 30	0	0
Total	**38**	**38**

3.4 Change from pre- and post- test

Average total score in pre-test=60% (SD=14)
Average total score in post-test=64% (SD=15)
The average score from pre to post-tests has increased by only 4 %.

Table 3.3: *Category of teacher participants based on Pre-test and post-test data*

Proficiency Level	Score Range (%)	Pre-test (n=38)	Post-test (n=38)
Novice	0-25	-	-
Emerging	26-50	11	7
Proficient	51-75	23	24

3.5 Detailed analysis of pre-test and post-test theme wise

Although the analysis of pre-test and post-test scores indicates a modest positive impact, a more detailed investigation was undertaken to gain deeper insights into the effects of the OER module on Organic Chemistry. This involved conducting a thematic analysis of the pre-test and post-test scores across various themes. The results of this analyses are presented in Table 3.4, which details the effect sizes of the pre-test and post-test means along with their respective standard deviations. The interpretation of the impact for each theme is discussed in the subsequent paragraphs.

Table 3.4: *Summary of thematic analysis of pre-test and post-test scores*

Theme	Measure	Mean	SD	Change in Mean	Cohen's d	Interpre ttation
K1.2 Recognise students' prior conceptions and misconceptions	Pre-test	0.81	0.11	-0.01	-0.08	small
	Post-test	0.80	0.13			
K1.3 Recognise areas of difficulty that students face	Pre-test	0.49	0.23	0.07	0.35	small
	Post-test	0.56	0.16			
K2.1 Understand the nature of science/mathematics	Pre-test	0.48	0.12	0.09	0.92	large
	Post-test	0.57	0.07			
K2.2 Identify 'Big' ideas, key concepts and theories	Pre-test	0.64	0.21	-0.06	-0.27	small
	Post-test	0.58	0.24			
K2.3 Explain goals of teaching the subject/topic	Pre-test	0.57	0.27	0.05	0.21	small
	Post-test	0.62	0.19			
K2.4 Sequence and connect between concepts within subjects and across grades	Pre-test	0.46	0.33	0.06	0.17	small
	Post-test	0.52	0.36			
K3.1 Evaluate resources for multiple forms of representing content	Pre-test	0.58	0.14	0.07	0.58	medium
	Post-test	0.65	0.10			
K3.2 Select instructional strategies to support multiple forms of students' engagement	Pre-test	0.68	0.12	0.03	0.25	small
	Post-test	0.71	0.12			
K3.3 Choose multiple tools of assessments to encourage multiple modes of expression	Pre-test	0.73	0.13	0.04	0.30	small
	Post-test	0.77	0.14			

In Theme K1.2, "Recognise students' prior conceptions and misconceptions," there was no observed improvement in participant performance following the intervention. The pre-test mean score was 0.81 (SD = 0.11), compared to a post-test mean of 0.80 (SD = 0.13), indicating a slight decrease in the mean score and a marginal increase in the standard deviation. This increase in variability suggests greater inconsistency in post-test results. The small negative effect size further highlights a lack of positive impact from the intervention.

These findings suggest that the intervention did not enhance teacher participants' understanding of this critical skill. However, the consistently high mean scores across both pre-test and post-test indicate that participants already possess a well-developed competency in this area.

In Theme K1.3, "Recognise areas of difficulty that students face," the data reveals a positive trend, with notable improvement in participants' ability to identify student challenges. The pre-test mean increased from 0.49 (SD = 0.23) to a post-test mean of 0.56 (SD = 0.16), accompanied by a slight reduction in standard deviation, indicating greater consistency in participants' post-test performance. This improvement highlights the effectiveness of the training strategies in enhancing participants' understanding of student difficulties. However, the relatively low mean scores suggest that participants are still in the process of developing this skill. The small positive effect

size of 0.35 further underscores that while the intervention had a beneficial impact, additional refinement and enhancement of the training strategies are necessary to support participants in achieving greater proficiency in this critical competency.

Theme K2.1, "Understanding the Nature of Science/Mathematics," demonstrates a notable improvement in participants' performance following the intervention. The pre-test mean increased from 0.48 (SD = 0.12) to a post-test mean of 0.57 (SD = 0.07), reflecting a 9% gain in scores. The significant reduction in standard deviation indicates greater consistency in participants' post-test performance. Moreover, the large effect size of 0.9 strongly supports the conclusion that the intervention had a substantial positive impact on enhancing participants' understanding of this skill. However, the relatively low mean scores suggest that participants are still in the early stages of developing this competency, despite the observed improvement. This indicates that while the module effectively supported progress, additional interventions may be needed to further enhance participants' proficiency in understanding the nature of science and mathematics.

In Theme K2.2, focusing on 'Identifying Big Ideas, Key Concepts, and Theories,' participants did not show improvement, as the pre-test mean score of 0.64 (SD = 0.21) decreased to a post-test mean score of 0.58 (SD = 0.24), representing a 6% drop in performance. The slight increase in the standard deviation reflects greater variability in post-test scores, suggesting differing levels of understanding among participants. The negative effect size (-0.27) underscores that the intervention was not only ineffective but may have had adverse effects on some participants' competencies in this area. This increased variability indicates the intervention may have introduced confusion or disengagement for certain individuals, thereby hampering their ability to identify 'Big' Ideas, Key Concepts, and Theories. While these findings point to potential flaws in the intervention, further investigation is needed to confirm the reasons behind this decline and to develop strategies to better support participant learning.

In Theme K2.3, which addresses 'Explaining the Goals of Teaching the Subject/Topic,' the results demonstrated a slight improvement following the intervention. The mean score increased by 5%, rising from 0.57 (SD = 0.27) on the pre-test to 0.62 (SD = 0.19) on the post-test. The reduction in standard deviation indicates greater consistency in participants' post-test scores. However, the small effect size of 0.21 suggests that only a limited number of participants showed significant improvement. This indicates that the intervention has potential for further impact but may require refinement to better address and enhance participants' understanding. Alternatively, the minimal overall change could reflect the intervention's limited effectiveness in differentiating between varying levels of participant understanding.

In Theme K3.1, which evaluates participants' ability to 'Evaluate Resources for Multiple Forms of Representing Content,' the results indicate a positive impact of the intervention. The mean score increased by 7%, from 0.58 (SD = 0.14) on the pre-test to 0.65 (SD = 0.12) on the post-test. The slight decrease in the standard deviation suggests greater consistency in participants' performance after the intervention. The medium effect size (0.58) indicates a meaningful and measurable improvement in participants' competencies in this area, demonstrating that the intervention was effective in enhancing their ability to evaluate resources for diverse content representation.

Theme K3.2, which assesses participants' ability to 'Select Instructional Strategies to Support Multiple Forms of Student Engagement,' showed a modest positive impact from the intervention. The pre-test mean score of 0.68 (SD = 0.12) increased slightly to 0.71 (SD = 0.12), with a small effect size of 0.25. This suggests that the intervention helped improve the performance of some participants, but the overall impact across the group was limited. The minor gain indicates that while participants' competency in selecting strategies for engaging students

showed slight improvement, the intervention may not have been robust enough to generate significant changes in this area."

Theme K3.3, which evaluates participants' ability to 'Choose Multiple Tools of Assessment to Encourage Multiple Modes of Expression,' exhibited a similar trend to Theme K3.2. The mean score increased modestly by 4%, from 0.73 (SD = 0.13) on the pre-test to 0.77 (SD = 0.17) on the post-test, with a small effect size of 0.30. While this improvement suggests a positive impact on some participants, the effect was limited.

The relatively high pre-test and post-test scores indicate that participants were already proficient in this competency. Although the intervention contributed to minor gains, its minimal effect highlights the need for more advanced or tailored instructional strategies to further enhance participants' ability to select diverse assessment tools that encourage multiple modes of student expression. The thematic analysis reveals varied impacts of the intervention across competencies. In K1.2, recognising students' prior conceptions showed no improvement, as consistently high scores suggested pre-existing competency. K1.3 displayed moderate improvement in identifying student challenges, though participants remain in development. K2.1, understanding the nature of science/mathematics, showed significant gains, indicating strong intervention effectiveness. However, K2.2, identifying key concepts, showed a decline, possibly due to intervention flaws. K2.3, explaining teaching goals, and K3.1, evaluating resources, demonstrated slight to moderate improvements, with K3.1 showing meaningful gains. K3.2 and K3.3, focusing on engagement strategies and assessment tools, showed modest improvements, highlighting the need for more robust training. Overall, the intervention had limited success, with several areas requiring refinement.

3.6 Practice (Session plans and reflections)

To effectively evaluate teacher practice, it is essential to examine multiple aspects of their instructional activities. This section will delve into evaluation of teachers' practice through lesson planning, classroom teaching, and teachers' reflection reports. By analysing these components, we can gain valuable insights into the quality and effectiveness of teachers' teaching practices supported through the OER module on organic chemistry.

The key areas of focus under practice have been further analysed through the perspectives of learners, content, and teaching and learning, as outlined in the table below:

Table 3.5: *Mean and Standard deviations of teachers' practice through lesson planning, classroom teaching, and teachers' reflection reports.*

Category	Theme	Mean	SD
1.Learners	P1.1 Promote inclusion and equity	1.9	0.2
	P1.2 Build on students' prior conceptions	1.8	0.3
	P 1.3 Address misconceptions and areas of difficulties	1.6	0.5
2.Content	P2.1 Use processes on science and mathematics	1.7	0.3
	P2.2 Facilitate higher order thinking	1.8	0.3
	P2.3 Plan to build students' competences to meet the goals of teaching science/ mathematics	1.7	0.3
3.Teaching and Learning	P3.1 Use instructional strategies for active learning	1.8	0.2
	P3.2 Use multiple representations of content	1.9	0.2
	P3.3 Create opportunities for multiple modes of expression	1.7	0.3
	P3.4 Use locally available materials	1.1	0.7

Category	Theme	Mean	SD
	P3.5 Link conceptual content to students' everyday life experiences and prior knowledge	1.4	0.5

Note: Mean levels 1.00 - 1.24 Low; 1.25 - 1.74 Moderate; 1.75 - 2.00 High

a. Learners

The analysis of the "Learners" category revealed insights into teachers' practices across three key subthemes, reflecting their focus on promoting inclusion and equity, building on students' prior knowledge, and addressing misconceptions.

Subtheme P1.1: Promote inclusion and equity (Mean: 1.9, Standard Deviation: 0.2):

Teachers demonstrated a strong and consistent commitment to fostering inclusive and equitable learning environments in Organic Chemistry lessons. The high mean score of 1.9, combined with a low standard deviation of 0.2, indicates that teachers were largely aligned in their practices. Teachers employed strategies such as collaborative group activities, inquiry-based learning, and differentiated instruction to ensure equitable participation and engagement for all students. By addressing diverse learning needs and providing additional support such as using molecular models and technology teachers created a classroom culture of acceptance and respect. Continued professional development could help maintain this high performance and explore innovative strategies to further strengthen inclusion.

Subtheme P1.2: Build on students' prior conceptions (Mean: 1.8, Standard Deviation: 0.3):

Teachers exhibited effective practices in leveraging students' prior knowledge when introducing new Organic Chemistry concepts. The mean score of 1.8 suggests that many teachers made efforts to connect new topics to students' existing understanding, often using questioning techniques or pre-assessments. However, the slight variability, reflected in the standard deviation of 0.3, indicates that some teachers may require additional support or training to ensure consistency in this area. For example, while some teachers effectively elicited students' knowledge about organic structures or bonding, others struggled to draw connections between foundational and advanced concepts.

Subtheme P1.3: Address misconceptions and areas of difficulties (Mean: 1.6, Standard Deviation: 0.5):

Addressing misconceptions and areas of difficulty remains a challenge for teachers, as reflected by the lowest mean score of 1.6. The moderate standard deviation of 0.5 highlights variability in teachers' ability to address misconceptions effectively. While some teachers successfully identified common misconceptions (e.g., understanding molecular shapes, hybridization, or functional group properties), they often lacked detailed strategies for helping students overcome these issues. For others, misconceptions persisted due to limited intervention strategies or insufficient diagnostic assessments. This highlights the need for targeted professional development that equips teachers with research-based strategies to identify and address misconceptions systematically. By focusing on formative assessments and instructional interventions, teachers can better address persistent difficulties in Organic Chemistry.

b. Content

The "Content" category provides insight into teachers' effectiveness in using processes related to science and mathematics, facilitating higher-order thinking, and building students' competencies in alignment with the goals of teaching science and mathematics.

Subtheme P2.1: Use Processes on Science and Mathematics (Mean: 1.7, Standard Deviation: 0.3):

Teachers showed moderate effectiveness in incorporating processes related to science and mathematics into their teaching. The mean score of 1.7 reflects that teachers are successfully promoting processes such as observation, drawing, prediction, and comparison. However, while the standard deviation of 0.3 indicates low variability across teachers' practices, there remains room for improvement. Some teachers may require further training or resources to consistently and confidently integrate scientific and mathematical processes into their instruction.

Subtheme P2.2: Facilitate Higher-Order Thinking (Mean: 1.8, Standard Deviation: 0.3):

The mean score of 1.8 highlights that teachers were relatively effective in fostering higher-order thinking skills, such as analysis, evaluation, and creation, within science and mathematics lessons. The low standard deviation of 0.3 suggests consistency in teachers' ability to encourage critical and creative thinking among students. While teachers are incorporating strategies to develop higher-order thinking, additional focus on advanced cognitive tasks can further strengthen students' problem-solving and reasoning skills.

Subtheme P2.3: Plan to Build Students' Competencies to Meet the Goals of Teaching Science/Mathematics (Mean: 1.7, Standard Deviation: 0.3):

Teachers demonstrated moderate success in planning to build students' competencies aligned with the goals of science and mathematics education. The mean score of 1.7 reflects that teachers are engaging students in activities such as analysing, predicting, and modelling to develop key competencies. The standard deviation of 0.3 shows limited variability, suggesting that most teachers are implementing similar strategies. However, continued professional development could further enhance teachers' ability to design targeted and challenging tasks that align with curriculum goals.

c. Teaching and Learning

The "Teaching and Learning" category offers insights into teachers' instructional practices based on several indicators, such as active learning strategies, content representation, use of local materials, and connection to students' everyday lives. The following is an analysis based on the mean scores and standard deviations provided:

P3.1 Use Instructional Strategies for Active Learning (Mean: 1.8, Standard Deviation: 0.2):

Teachers demonstrated strong implementation of active learning strategies with a mean score of 1.8. This suggests that most teachers effectively engaged students through interactive methods such as group work, pair discussions, presentations, and question-and-answer sessions. The low standard deviation of 0.2 indicates consistent practices across teachers, showing little variation. Continued professional development could further refine these strategies, ensuring that all students remain actively engaged in student-centred learning environments.

P3.2 Use Multiple Representations of Content (Mean: 1.9, Standard Deviation: 0.2):

Teachers showed a high level of effectiveness in presenting content in multiple forms, such as visual, virtual, and practical representations. The mean score of 1.9 reflects a strong ability to cater to diverse learning styles using tools like PowerPoint presentations, diagrams, simulations, molecular kits, and analogies. The low standard deviation of 0.2 highlights consistency among teachers in employing this approach, contributing to effective content delivery and student understanding.

P3.3 Create Opportunities for Multiple Modes of Expression (Mean: 1.7, Standard Deviation: 0.3):

The mean score of 1.7 suggests that teachers are moderately successful in providing students with opportunities to express their understanding through various modes, including written work, tests, projects, and presentations. The standard deviation of 0.3 indicates slight variability, suggesting that while some teachers excel in this area, others may benefit from additional support or training to expand their use of diverse expression strategies.

P3.4 Use Locally Available Materials (Mean: 1.1, Standard Deviation: 0.7):

The mean score of 1.1 highlights a significant challenge in the use of locally available materials during instruction. Teachers primarily relied on multimedia tools, boards, and textbooks, with limited integration of context-relevant local resources. The high standard deviation of 0.7 indicates considerable variability, suggesting that access to resources or awareness of their use differs widely among teachers. This highlights an opportunity for targeted training on integrating locally available materials to create practical and engaging learning experiences.

P3.5 Link Conceptual Content to Students' Everyday Life Experiences and Prior Knowledge

(Mean: 1.4, Standard Deviation: 0.5):

Teachers' ability to connect classroom content to students' real-life experiences and prior knowledge remains an area for improvement, with a mean score of 1.4. While some teachers were successful in linking lessons to students' prior learning, there was limited focus on everyday experiences. The moderate standard deviation of 0.5 suggests variability in teachers' ability to make these connections effectively. Professional development could help teachers strengthen their skills in contextualising lessons to make learning more relevant and meaningful for students.

3.7 Social learning in CoPs

3.7.1 Frequency of posts

Table 3.6 below shows the number of telegram posts made by various groups of Chemistry CoP participants. The number of posts made by the teacher participants were little bit more compared to the number of posts made by the teacher educators. The types of posts are presented in the Tables 3.7 & 3.8.

Table 3.6: *Frequency of posts by participants*

Role	Number of posts
Teacher Participants	76
Teacher Educators	55
	-
Total	**131**

3.7.2 Frequency of posts

Table 3.7: *Frequency of posts by content*

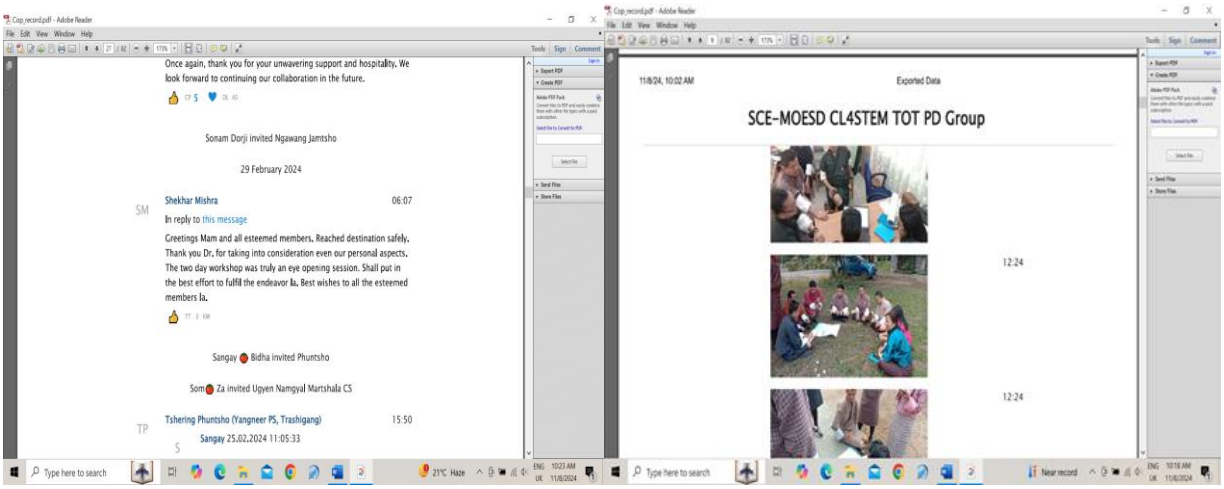
Type of Posts	Number of posts
PCK	6
UDL	4
Technical	28
Communication/ Administrative	76
Others	7
Total	**131**

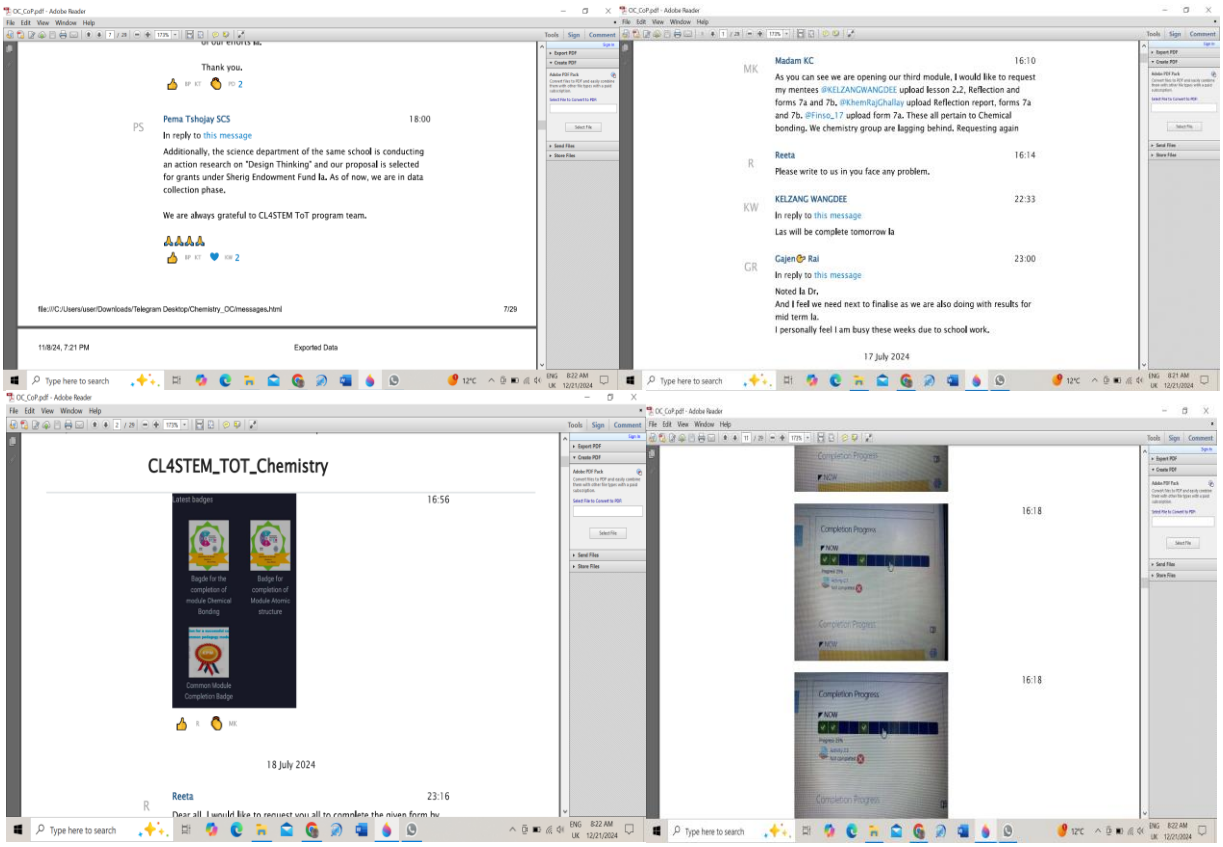
Table 3.8: *Frequency of posts by type*

Type of post	Number of posts
Text only	88
Images	34
External Links to other resources	2
Others	7
Total	**134**

3.7.3 Qualitative dialogues/ discussion threads

The CoP was quite active and lots of interactions took place. As evident from the above tables, the majority of the posts were made by teacher participants. 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 only four posts related to UDL and six posts that could be considered as PCK related. The only good thing about the CoP was keeping in touch with the participants at any time. Some screenshots from the CoP are shared below.





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

3.8.1 Participation of teachers

Teacher educators were very positive about the benefits of the CoP. The platform served as the main means of communication among the members. It kept all the members well informed about the progress of the course and also helped to clear any doubts and misconceptions.

3.8.2 Challenges

Like before, some of the challenges faced by Teacher educators while implementing the module include lack of time to attend to the module as they are a full-time tutor besides shouldering administrative responsibilities in the college. There were also instances where teacher participants needed to be reminded time and again to complete the activities.

The teachers found it extremely difficult to complete the module within the stipulated 6 weeks as they are full-time teachers. The teacher educators had to push them to complete the task.