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

CL4STEM Project Phase II Scaling Open Educational Modules Report BHUTAN 2024

Subject: Physics

BHUTAN | NIGERIA | TANZANIA | INDIA

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.

Writers: Ugen Pem, Karma Utha (PhD) & Tandin Penjor
@ Samtse College of Education, Royal University of Bhutan

Proofread by: Dr. Sonam Rinchen

Disclaimers

Acknowledgment

This work was supported by the Global Partnership for Education Knowledge and Innovation Exchange, a joint endeavour with the International Development Research Centre, Canada.

Table of Contents

Module 1: Work, Energy and Power

1.1 Introduction

The open educational resources (OERs) module "Work, Energy, and Power' was curated by physics educators at Samtse College of Education, with support and review from academics at the Tata Institute of Social Sciences. In the year 2022, the module was offered to 20 teacher-participants from six schools under Samtse District. The same module is reviewed in collaboration with a physics curriculum officer from the Department of Curriculum and Research Development (DCRD) under Ministry of Education and Skills Development (MoESD), aligning it with the latest revisions in the National Science Curriculum Framework. In this revision, the previously missing focus on area of competency-based teaching and learning for each lesson was articulated. Also, the feedback from the teacher-participants were incorporated, especially regarding the number of lesson plans to be implemented in the classroom. Additionally, in order to learn the module, the participants were given multiple chances to attempt the quiz questions to get a correct response with instant feedback.

The module is a six-week course that started on 13th March and ended on 24th April, 2024. The course duration was extended till 5th May 2024 because of teaching engagement in their schools. A total of 36 teacher- participants were enrolled in the OER module.

The module consists of 3 units which are Work, Energy, and Power. The teacher-participants have to learn a total of eight lessons of the three units of the module. The teacher-participants are required to attempt a pre-post-tests which consists of 45 multiple choice questions (MCQs) covering nine themes related to Learner, Content and Teaching & Learning. In this module, there are interactive lessons and quiz questions to test the subject matter, essay questions to reflect how their students learn the concepts through classroom activities, and to identify the common mistakes or misconceptions that their students made in the class. The interactive lessons, combined with formative assessments, will motivate the teacher-participants to actively engage with the learning activities of the module.

The teacher-participants are required to develop/prepare two lesson plans from the module and implement one lesson plan in the class. The practice of teaching a lesson in the class will enhance their pedagogy content knowledge, where they applied the Universal Design Learning (UDL) principles in their classroom, related their lessons with real-life applications, and identify and address any student's misconceptions. At the end, they are required to write a reflection on the lesson implemented in the class which focuses on how their students are engaged in an inclusive environment, how to facilitate their students' high order thinking skills, how their students' misconceptions are identified and addressed, how their students interact with the content of the lesson by providing opportunities through active learning strategies, utilising locally available materials, and linking the concepts to everyday life experiences. The learning outcomes of the module are as follows:

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

- explain the meaning of work and energy in the context of Physics.
- identify and describe different forms of energy in real-world scenarios.
- differentiate between potential energy and kinetic energy.

- state the principle of conservation of energy.
- explain the meaning of energy transformation and describe real-life examples of energy conversion.
- explain the meaning of mechanical work done and write and interpret the formula for calculating it.
- classify common mistakes students make when solving mechanical work numerical problems.
- explain the meaning of electrical energy and provide real-life examples.
- derive formulas for calculating electrical energy and explain common student mistakes in solving related problems.
- explain the differences between energy, heat, and temperature.
- describe the meaning and importance of thermal energy and common student errors in related numerical problems.
- explain the meaning of mechanical power, state its SI unit, and convert it to related units.
- explain the meaning of electrical power, provide examples, derive equations, and convert SI units.
- explain the heating effect of electric current, derive the equation for heat produced, and discuss its application in appliances; and
- identify lesson contents that can be used as teaching resources for mechanical work, energy, electrical energy, thermal energy, mechanical power, and electrical power

Resources (activities and reading materials): In this module, the activities are designed to be feasible using locally available materials, everyday experiences, and e-resources (pictures, links, PhET, videos, online quizzes). These activities include:

- Interactive videos using H5P Moodle feature
- Online quizzes for formative assessment of learning the concepts
- Design a model (2D or 3D) to demonstrate the types of potential and kinetic energy using the materials available
- Listing possible examples of kinetic energy and potential energy in real life with justification.
- Using figures and images to explain concepts of energy, work, and power.
- Incorporating PhET simulations for virtual experiments and answering the questions.
- Providing links to explore more about work done.
- Utilising flow charts to understand different forms of energy.
- Employing free-body diagrams to solve numerical problems.
- Engaging in calculations and discussions on common errors students make in numerical questions.
- Connecting representations to real-world scenarios.
- Demonstrating and applying the heating effects of electric current.

Additionally, there are activities related to applying learned concepts, such as calculating household energy consumption bills, discussing the ways of saving energy and analysing free-body diagrams for solving numerical problems

Nature and purpose of assessments

The OER module is designed with both formative as well as summative assessment. The use of automatic progress bars on Virtual Learning Environment (VLE) Moodle platform helped both the teacher-educators and the teacher-participants to check their own progress in learning the module. Also, the teacher-educators can access the time spent by the teacher-participants using dedication tools. In addition, the teacher-participants are allowed to move to the next lesson after fulfilling the required assessment of each lesson. There are embedded quizzes in each lesson to assess their learning lessons of the units. The close-ended quiz questions are set so that they cannot move to the next activity without getting the correct response. This ensures that they cannot compromise their learning. Moreover, there are essay questions asking their understanding of the concepts or the students' responses during the implementation of the activities in the classroom.

The 36 participants were able to interact with the OER module and a progress bar displayed their performance. Eight out of 36 participants were selected from different schools across Bhutan as focal teachers, whose lessons were observed and evaluated by the teacher educators and curriculum officials from the Ministry of Education and Skills Development. The final evaluation of the lesson plans and a reflection of the participants are evaluated by the teacher educators to find out the level of the teacher-participants' competencies in three categories such as "Content", "Learners" and "Teaching & Learning". Further, the teacher-educators took the responsibilities of 12 teacher-participants each to provide any necessary support that they may require in learning the module. This arrangement was used to evaluate their lesson plans, observation form 7A and evaluation form 7B made the assessment component easy and systematic. The pre-tests and post-tests were conducted to find the teacher-participants to find the effectiveness of the module. A total of 45 questions under nine themes were identified to see the impacts of the module. All these nine themes can be categorised under the "Content", "Learners" and "Teaching & Learning".

1.2 Course completion rate

1.2.1 Overall completion

All 36 participants completed the OER module as shown in Table 1.1.

Table 1.1: *Course completion rate*

Completion Rate (%)	**Teacher-participants**
1 - 20%	-
21 - 40%	-
41 - 60%	-
61 - 80%	-
81 - 100%	100%
Total	100%

1.2.2 Assessment completion rate

All assessment components were completed as shown in Table 1.2.

Table 1.2: *Teacher-participants assignment completion rate*

Assignments	**Completion Rate**
Pre-tests-Part 1 and Part 2	100%
Session plans	100%
Reflection	100%
Post-tests- Part 1 and Part 2	100%

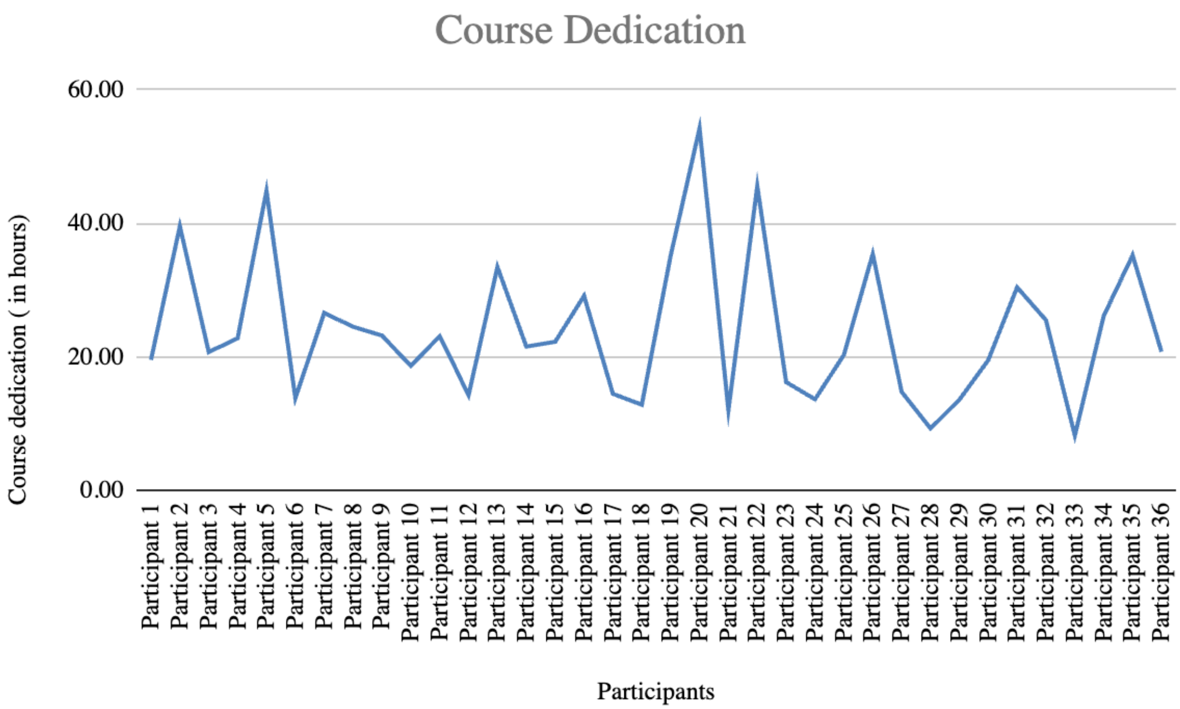
1.3 Time spent on the course platform

Table 1.3 illustrates that 13 teacher-participants spent between 20 to 30 hours on the Moodle platform followed by 12 teacher-participants between 10 to 20 hours and six teacher-participants between 30 to 40 hours. Interestingly, three teacher-participants spent more than 40 hours on the platform, while, at the other end of the spectrum, two participants spent less than 10 hours. The detailed time spent on the Moodle platform by each teacher-participants is shown in Figure 1.1. On average, teacher-participants spent 23.92 hours on the platform, with the maximum time being 54.23 hours and the minimum time being 8.22 hours.

Table 1.3: *Time spent by teacher-participants on Moodle platform*

Hours spent	**No of teacher-participants**
More than 50	1
40-50	2
30-40	6
20-30	13
10-20	12
Less than 10	2
Total	**36**

Figure 1.1: Time spent by each teacher-participants on the Moodle platform



1.4 Analysis of pre-test and post- test

The mean score of 36 teacher participants in the pre-test is 57.24%, while the mean score in the post-test increased to 63.69%. This improvement of 6.45% suggests that the teacher-participants performed better in the post-test compared to the pre-test. Further analysis of the pre- and post-test performance by themes, as shown in Table 1.4 reveals the following categories: themes K1.2 and K1.3 are grouped under 'Learners'; themes K2.1, K2.2, K2.3, and K2.4 are grouped under 'Content'; and themes K3.1, K3.2, and K3.3 are grouped under 'Teaching & Learning'. Comparing the pre-test and post-test scores using Cohen's d can determine whether the implemented OER module had a meaningful effect size.

Table 1.4: *Performance* of the teacher-participants in pre-test and post-test

	Pre test		Post test		Change in mean	Change in SD	Cohen's d	Meaning of Cohen's d
Themes	**Mean**	**SD**	**Mean**	**SD**				
K1.2 Recognise students' prior conceptions and misconceptions	0.52	0.19	0.63	0.19	0.10	0.00	0.53	Medium effect

Themes	Pre test		Post test		Change in mean	Change in SD	Cohen's d	Meaning of Cohen's d
	Mean	SD	Mean	SD				
K1.3 Recognise areas of difficulty that students face	0.55	0.17	0.51	0.22	− 0.04	0.04	− 0.17	Very small effect
K2.1 Understand nature of science/ mathematics	0.71	0.24	0.77	0.25	0.06	0.00	0.23	Small effect
K2.2 Explain goals of teaching the subject	0.76	0.20	0.84	0.16	0.08	− 0.04	0.50	Medium effect
K2.3 Identify 'Big' ideas, key concepts and theories	0.66	0.20	0.72	0.18	0.06	− 0.01	0.30	Small effect
K2.4 Sequence and connect between concepts within subjects and across grades	0.69	0.24	0.75	0.24	0.06	0.01	0.25	Small effect
K3.1 Select instructional strategies to support multiple forms of students' engagement	0.49	0.18	0.58	0.19	0.09	0.01	0.48	Small effect
K3.2 Evaluate resources for multiple forms of representing content	0.42	0.21	0.49	0.19	0.06	− 0.02	0.35	Small effect
K3.3 Choose multiple tools of assessments to encourage multiple modes of expression	0.44	0.20	0.45	0.23	0.01	0.03	0.05	Very small effect

The analysis of the pre-test and post-test data indicate that the OER module on Work, Energy and Power had different impacts on the teacher-participants as shown in Table 1.4. Descriptive statistics is used to find the impacts of the OER module on the teacher-participants by comparing the mean scores and standard deviations of pre-test and post-test. Cohen's d is an effect size used to indicate the standardised difference between pre-test and post-test means. The interpretation of Cohen's d-value is shown in Table 1.5 (Cohen, 1988).

Table 1.5: *Interpretation of Cohen's d-value*

Cohen's d	**Meaning**
d < 0.2	Very small effect
0.2 <= d < 0.5	Small effect
0.5 <= d < 0.8	Medium
d >= 0.8	Large

https://cran.r-project.org/web/packages/effectsize/vignettes/interpret.html

Discussion on nine themes under three categories are:

A) Learner

i. Theme K1.2: Recognise students' prior conceptions and misconceptions

There is a "medium effect" in the ability to recognise students' prior conceptions and misconceptions with mean difference of 0.1, pre-test mean of 0.52 (*SD* = 0.19) to a post-test mean of 0.63 (*SD* = 0.19) (Table 1.4). This clearly shows that the teacher-participants are able to build their lessons based on the prior knowledge of their students and some of them have ability to address misconceptions in the class.

ii. Theme K1.3: Recognise areas of difficulty that students face

There is a "very small effect" in the ability to areas of difficulty that students face with a mean difference of − 0.04, pre-test mean of 0.55 (*SD* = 0.17) to a post-test mean of 0.51 (*SD* = 0.22) (Table 1.4). This clearly shows that the teacher-participants are not able to recognise areas of difficulty that their students faced in the class. The minus sign indicates that there is a negative impact on the teacher-participants ability to recognise areas of difficulty that students face.

B) Content

iii. Theme K2.1: Understand nature of science/ mathematics.

There is a "small effect" on the teacher-participants learning of the OER module with mean difference of 0.06, shows a small yet meaningful improvement in understanding the nature of science, with the mean score increasing slightly from 0.71 (*SD* = 0.24) to 0.77 (*SD* = 0.25) as shown in Table 1.4. This clearly shows that the teacher-participants were able to design activities for their students to explore and build knowledge and skills through experiments.

iv. Theme K2.2: Explain goals of teaching the subject

There is a "medium effect" on the teacher-participants learning of the OER module with mean difference of 0.08, shows a significant improvement in explaining the goals of teaching the subject, with the mean score increasing slightly from 0.76 (*SD* = 0.20) to 0.84 (*SD* = 0.16) with a small variability as shown in Table 1.4. This clearly shows that the teacher-participants were able to design lessons to build their students' competencies in order to achieve goals for teaching the subject in the class.

v. Theme K2.3: Identify ‘Big’ ideas, key concepts and theories

There is a “small effect” on the teacher-participants learning of the OER module with mean difference of 0.06, indicating a significant improvement in Identify ‘Big’ ideas, key concepts and theories, with the mean score increasing slightly from 0.66 (*SD* = 0.20) to 0.72 (*SD* = 0.18) with a small variability as shown in Table 1.4. This clearly indicates that the teacher-participants are able to frame higher order thinking questions for their students to respond. Also, the National Science Curriculum Framework focuses more on competency-based education.

vi. Theme K2.4: Sequence and connect between concepts within subjects and across grades

There is a “small effect” on the teacher-participants learning of the OER module with mean difference of 0.06, indicating a significant improvement in sequencing and connecting between concepts within subjects and across grades, with the mean score increasing slightly from 0.69 (*SD* = 0.24) to 0.75 (*SD* = 0.24) as shown in Table 1.4. This clearly indicates that the teacher-participants are able to make the students to recall the previous knowledge of the topics of the subject and able to build on the prior knowledge and skills learnt in the lower grades. Also, the National Science Curriculum Framework is spiral in nature, where the same concept is taught across the grades with increase in the area of difficulty in higher grades.

C) Teaching and Learning

vii. Theme K3.1: Select instructional strategies to support multiple forms of students’ engagement

There is a “small effect” on the teacher-participants learning of the OER module with mean difference of 0.09, indicating a significant improvement in selecting instructional strategies to support multiple forms of students’ engagement, with the mean score increasing slightly from 0.49 (*SD* = 0.18) to 0.58 (*SD* = 0.19) as shown in Table 1.4. This clearly indicates that the teacher-participants were able to weigh the best instructional strategies to support different types of students in the classroom.

viii. Theme K3.2: Evaluate resources for multiple forms of representing content

There is a “small effect” on the teacher-participants learning of the OER module with mean difference of 0.06, indicating a significant improvement in evaluating resources for multiple forms of representing content, with the mean score increasing slightly from 0.42 (*SD* = 0.21) to 0.49 (*SD* = 0.19) as shown in Table 1.4. This clearly indicates that the teacher-participants were able to evaluate resources which are available in the school and home and use UDL principle to engage the students effectively in the class.

ix. Theme K3.3: Choose multiple tools of assessments to encourage multiple modes of expression

There is a “very small effect” on the teacher-participants learning of the OER module with mean difference of 0.01, indicating there is no significant improvement in choosing multiple tools of assessments to encourage multiple modes of expression, with the mean score increasing slightly from 0.44 (*SD* = 0.20) to 0.45(*SD* = 0.23) with a small variability as shown in Table 1.4. This clearly indicates that the teacher-participants were not able to choose multiple tools of assessments to encourage multiple modes of expression

1.5 Practice (Session plan and reflection together)

Table 1.5: *Analysis of grading sheet on session plans and reflections*

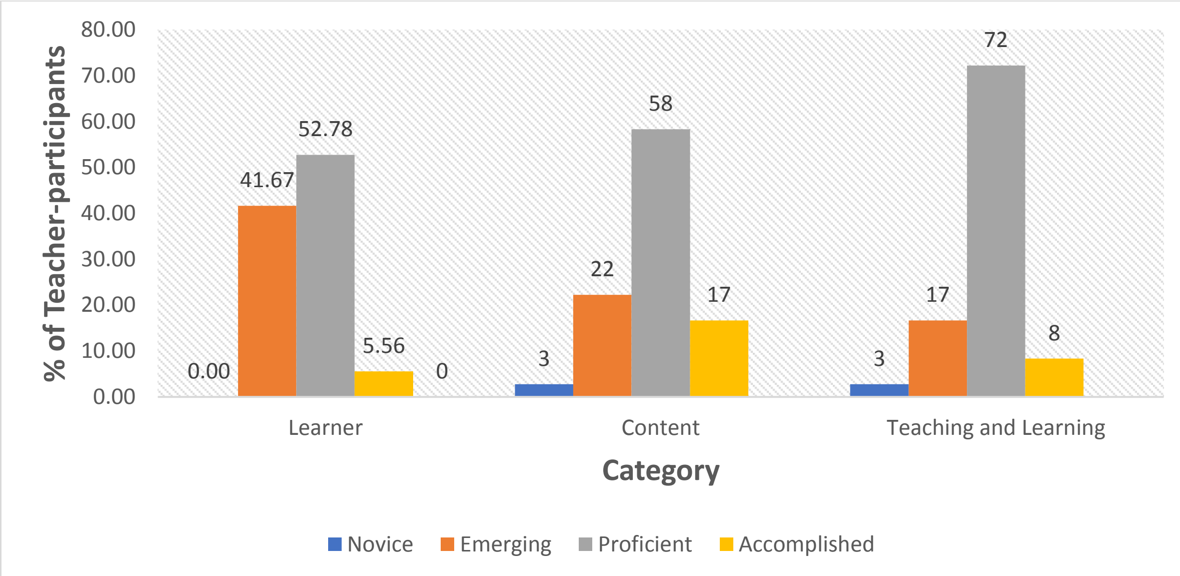
Category	Themes	Mean	SD	Impact
1.Learner	P1.1 Promote inclusion and equity	0.97	0.37	Small
	P1.2 Build on students' prior conceptions	1.15	0.40	Medium
	P 1.3 Address misconceptions and areas of difficulties	0.99	0.65	Small
2.Content	P2.1 Use processes on science and mathematics	1.06	0.35	Medium
	P2.2 Facilitate higher order thinking	1.32	0.62	Medium
	P2.3 Plan to build students' competences to meet the goals of teaching science/ mathematics	1.07	0.35	Medium
3.Teaching and Learning	P3.1 Use instructional strategies for active learning	1.11	0.39	Medium
	P3.2 Use multiple representations of content	1.13	0.45	Medium
	P3.3 Create opportunities for multiple modes of expression	1.22	0.43	Medium
	P3.4 Use locally available materials	1.22	0.67	Medium
	P3.5 Link conceptual content to students' everyday life experiences and prior knowledge	1.03	0.43	Medium

The interpretation of mean value is shown in table 1.6.

Table 1.6: *Interpretation of mean value*

Mean value(x)	Meaning
x < 0.50	Very small impact
0.50 <= x < 1.00	Small impact
1.00 <= x < 1.50	Medium impact
x >= 1.50	Large impact

Figure 1.2: *Performance of teacher-participants in classroom practices*



1.5.1 Learner

As shown in the Table 1.5, all the themes fall in the medium impact of the OER module in their classroom practices except themes P1.1 and P1.3. Also, Figure 1.2 illustrates that the first category of the professional experience related to "Learner" is the lowest compared with the other two categories of professional experiences of "Content" and "Teaching and Learning". In the "learner" category, 41.67% of teacher-participants fall in the emerging level of classroom practices (Figure 1.2).

i) Theme P1.1: Promote inclusion and equity

In the learner category, the majority of the teacher-participants fall in the professional and emerging performances of promoting inclusion and equity in the classroom (Figure 1.2) with (*M*=0.97 ; *SD* =0.37), which falls in the "Small" impact of the OER module on the professional experiences in the classroom(Table 1.5). For example, giving group work with gender balance is considered inclusive in nature. Group activities promote active participation which promote equity. However, there are a few teacher-participants who are experiencing working with differently-abled students in the normal class. Teacher-participant 5095 implementing differentiated instruction strategies to address diverse learning needs.

ii) Theme P1.2: Build on students' prior conceptions

The performance of teacher-participants in this theme has a "Medium" impact of the OER module with (*M*=1.15 ; *SD* =0.04) as shown in the Table 1.5 , because the teacher-participants know how to recall previous knowledge by asking questions or using diagnostics testing tools. For example, Teacher-participant 5085 used flipped classrooms by asking the students to watch the video on work and power outside the class and answering a few important questions in the class.

iii) Theme P 1.3: Address misconceptions and areas of difficulties

The performance of teacher-participants in this theme has a “Small” impact of the OER module with (M=0.99; *SD* =0.65) as shown in Table 1.5. This indicates that the majority of the teacher-participants are aware of misconceptions and areas of difficulties through question and answer sessions and observations but they do not have specific strategy to address misconceptions. For example, Teacher-participant 5103 reflected that he provides a worksheet to diagnose misconceptions held by students, and he found that many students failed to see inertia as a property of a body and that force was needed to bring about change in inertia of the body. In addressing misconceptions, Teacher-participant 5100 said, “To support learners who faced difficulties, I provide additional practice opportunities and individualized support. Moreover, I encourage more peer collaboration and discussion to deepen understanding and address any misconceptions effectively”.

1.5.2 Content

The impact of OER module on the category of “Learner” falls in “Medium” as shown in Table 1.5 with maximum mean score for theme P2.2 on facilitating higher order thinking skills in the class. In the “content” category, the percentage of teacher-participants falling in the emerging level of classroom practices decreased to 22% and the percentage of teacher-participants increased to 58% in proficient level of classroom practice (Figure 1.2). This indicates that the performance of classroom practices is far better in the category of “content” than the category of “learner”.

iv) Theme P2.1: Use processes on science and mathematics

The performance of teacher-participants in this theme has a “Medium” impact of the OER module with (*M* = 1.06; SD =0.35) as shown in the Table 1.5. This indicates that the majority of teacher-participants are applying the knowledge of nature of science gained from the common OER module on Pedagogy. Almost all the teacher-participants have designed their lesson activity based on a student-centric approach. For example, teacher participant 5096 has employed a POE (predict-observe explain) strategy where students were made to hypothesise, experiment, and draw conclusions based on their findings. Similarly, teacher participant 5097 also used Predict-Observe-Explain (POE) strategy- predict the result or consequences using pictorial representation related to dissipation of energy, make them to validate their prediction by letting them carry out experiment using locally available materials (observe), and draw the inferences based on the observations of the experiment (explain).

v) Theme P2.2: Facilitate higher order thinking

The performance of teacher-participants in this theme has “Medium” impact of the OER module with (M =1.32; *SD* =0.62) as shown in the Table 1.5. This indicates that almost all teacher-participants designed questions of different levels to engage the students in group discussions related to real life examples, videos, simulations which enable the students to foster deep learning of the content of the subject. For example, the teacher-participant 5090 demonstrated the potential and kinetic energy using simple objects (e.g., a stretched rubber band, a pendulum) and supplemented by the demonstration of PhET simulation to facilitate students to visualise their understanding of the content of the subject.

vi) Theme P2.3: Plan to build students' competences to meet the goals of teaching science/ mathematics

The performance of teacher-participants in this theme has a "Medium" impact of the OER module with (M=1.07; *SD* =0.35) as shown in the Table 1.5. This indicates that the majority of teacher-participants have plans to build students' competences to meet the goals of teaching physics by developing students' competency in carrying out scientific experiments, designing experiments, and application of content knowledge in their schools and home through use of UDL principles and emerging technologies. For example, participant 5113 likes to incorporate more interactive simulations or digital tools to enhance engagement and cater to different learning styles. Also he provides additional examples and explanations to clarify concepts that students find challenging, such as the calculation of work involving angles.

1.5.3 Teaching and Learning

The impact of OER module on the category of "Teaching and Learning " falls in "Medium" as shown in Table 1.5 with maximum mean score for themes P3.3 and P3.4 as shown in Table 1.5. Also the teacher-participants' professional experiences in terms of "Teaching and Learning" is the highest as shown in Figure 1.2. In the category of "teaching and learning" category, the percentage of teacher-participants falling in the emerging level of classroom practices decreased to 17% and the percentage of teacher-participants falling in proficient level of classroom practice increased to 72% (Figure 1.2). This indicates that the performance of classroom practices is far better in the category of "teaching and learning" than in the category of "content". However, the percentage of teacher-participants falling in the accomplished level under the category of "teaching and learning" decreased to 8% because of one teacher-participant teaching the lesson on a topic not related to the OER module on work, energy and power.

vii) Theme P3.1: Use instructional strategies for active learning

The performance of teacher-participants in this theme has "Medium" impact of the OER module with

(*M*=1.11; *SD* =0.39) as shown in Table 1.5. This indicates that the majority of teacher-participants are aware of using instructional strategies for active learning like activity-based learning, inquiry-based learning, and problem solving. For example, teacher-participant 5081 asked the students in groups to solve numerical questions and displayed the solution on the chart paper. And teacher-participant 5093 asked the students to perform hands-on experiments and fill in a worksheet.

viii) Theme P3.2: Use multiple representations of content

The performance of teacher-participants in this theme has a "Medium" impact of the OER module with (*M*=1.13 ; *SD* =0.45) as shown in Table 1.5. This indicates that the majority of teacher-participants are able to present information of the lesson in different ways using technology app like Nearpod, worksheet, video, experiment, PhET simulation, pictures, charts and textbooks to support the diverse style of students in the class. For examples, the teacher-participant 5115 asked students to watch video and images depicting various scenarios where energy is being transformed between potential and kinetic forms (e.g., a roller coaster, a swinging pendulum, a stretched rubber band).The teacher-participant 5100 used real objects and visual aids such as diagrams, animations, or videos to demonstrate oscillatory motion. And the teacher-participant 5107 made the students read, write and watch videos to fill in the worksheet provided.

ix) Theme P3.3: Create opportunities for multiple modes of expression

The performance of teacher-participants in this theme has a "Medium" impact of the OER module with (*M*=1.22; *SD* =0.43) as shown in Table 1.5. This indicates that the teacher-participants gave the option for students to design charts for presentation. The teacher-participant 5088 used different kinds of worksheets (worksheet with pictures, worksheet with text) in the peer activity done in the class.

x) Theme P3.4: Use locally available materials

The performance of teacher-participants in this theme has a "Medium" impact of the OER module with (*M*=1.22; *SD* =0.67) as shown in Table 1.5. This indicates that the teacher-participants used the materials which are available in their schools. Moreover, many of them use online resources and worksheets as effective teaching resources. For example, teacher-participant 5100 used real object locally available materials such as strings and football for swing pendulum and teacher-participant 5111 used a heavy wooden log, two 3 – 4 meters strong rope to drag the log, measuring tape to measure the displacement of the log, a radish to represent a log, 3 – 4 sticks to represent the forces acting on the log while dragging it on the ground.

xi) Theme P3.5: Link conceptual content to students' everyday life experiences and prior knowledge

The performance of teacher-participants in this theme has a "Medium" impact of the OER module with (*M*=1.03; *SD* =0.43) as shown in Table 1.5. This indicates that the student-participants were able to link conceptual knowledge of content to students' everyday life experiences or prior knowledge through open discussion or watching videos and simulations to recall their experiences, activity-based learning in applying the content with the real-life applications. For example, teacher-participant 5081 asked the students to calculate electrical energy consumption at home. Teacher-participant 5086 asked the students to discuss practical applications of potential energy in everyday life.

1.6 Social learning in Community of Practices (CoPs) on telegram platform

1.6.1 Frequency of posts by participants

Table 1.6: *Frequency of posts by participants*

Role	**Number of posts**
Teacher- Participants	223
Teacher- Educators	207
Total	430

The interactions among three teacher-educators and 36 teacher-participants in the physics group's CoP on Telegram platform, "CL4STEM_TOT_Physics," from 13th March to 5th May 2024 as shown in Table 1.6, indicate that the total number of posts by teacher-participants is higher compared to those by teacher-educators.

1.6.2 Frequency of posts by content and types

Table 1.7 below presents the frequency of posts by content during the implementation of the "Work, Energy, and Power" module, which took place from March 13 to May 5, 2022. In total there are 441 which is slightly greater than the total reflected in Table 1.7. This is due to few conversations falling under more than one type of post. Out of a total of 441 posts, the majority were related to communication and administration, while the fewest posts in UDL. On further analysis of the type of posts shared on CoP telegram platform, it is found that a total of 110 posts were shared of which 84 were images, followed by 12 video files, nine documents, and five voice messages as shown in Table 1.7.

Table 1.7: *Frequency of posts by content and types*

Frequency of posts by content	**Number of posts**
PCK	31
UDL	8
Technical	93
Communication/ Administrative	309
Total	**441**
Frequency of posts by types	**Number of posts**
Voice messages	5
Video files	12
Photos	84
Files	9
Total	**110**

1.6.3 Qualitative dialogues/ discussion threads

On CoP telegram platform "CL4STEM_TOT_Physics", the teacher-participants actively shared posts related to Learner, Content, and Teaching & Learning. The social learning platform effectively facilitated connections within their group and with the teacher-educators. The three good examples of teacher-participants engagement in the CoP telegram platform are:

a. Addressing misconceptions

Addressing misconceptions falls under the Theme P 1.3. One of the teacher-participants shared how she identified students' misconceptions and implemented strategies to address them, as illustrated below.

CL4STEM_TOT_Physics

Karma Utha 12:03

Hello teachers, many literature report that school students have misconception that work and force are the same thing or that they are directly proportional to each other. Did you come across such cases with your students? if yes, how did you help them to overcome this misconception? Please share

25 March 2024

Passang Lham 12:39

In reply to this message

Yes la, I have encountered students who initially believe that work and force are the same thing or directly proportional to each other. To address this misconception, I use a combination of explanations, examples, and interactive activities.

Firstly, I clarify the definitions of work and force, emphasizing that they are distinct concepts. I explain that force is a push or pull exerted on an object, while work is the result of that force causing the object to move a certain distance.

Then, I provide real-life examples to illustrate the difference. For instance, I describe scenarios where a person applies a force to an object but no work is done because the object doesn't move, highlighting that work requires both force and motion.

To further reinforce the concept, I engage students in hands-on activities and simulations. For example, we might use spring scales to measure force and calculate work done in different situations, allowing students to see the relationship between force, displacement, and work firsthand.

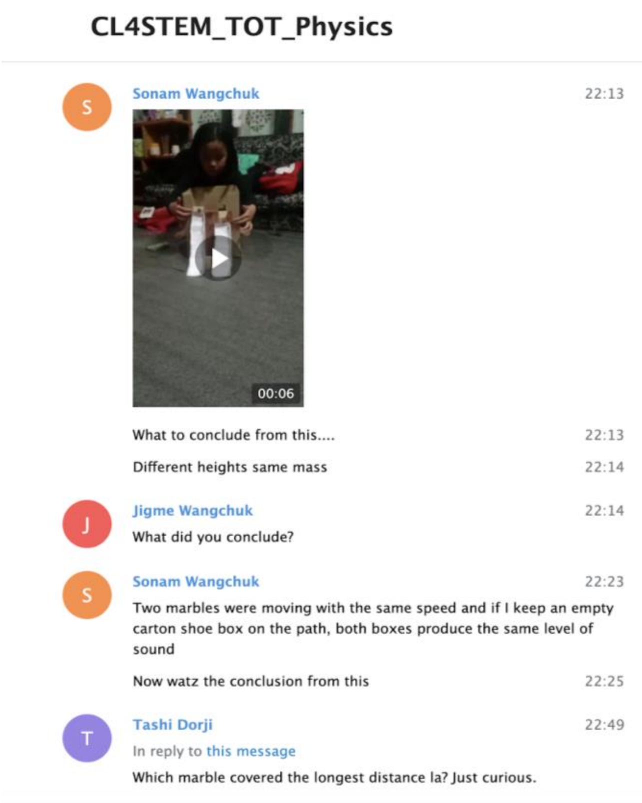
Additionally, I encourage critical thinking by asking probing questions and prompting discussions. I challenge students to explain why work can be done without a change in force or why a greater force doesn't always result in more work being done.

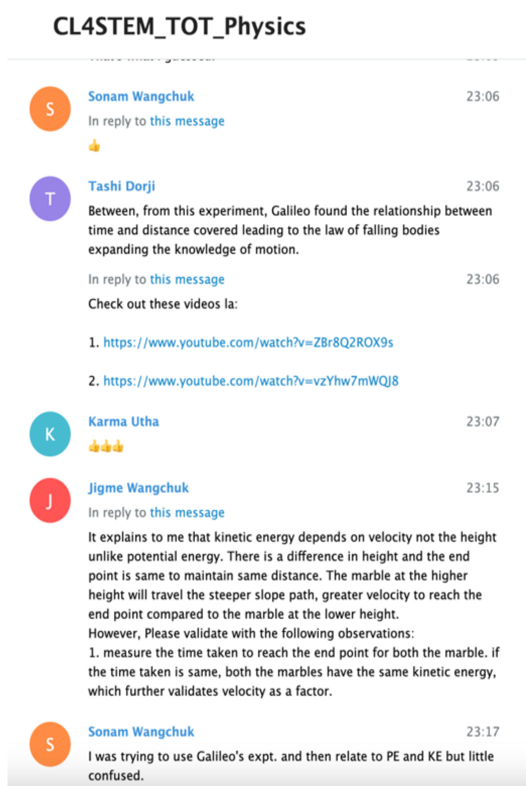
Overall, by providing clear explanations, relevant examples, hands-on experiences, and opportunities for discussion, I aim to help students overcome misconceptions about the relationship between work and force, leading to a deeper understanding of these fundamental physics

b. Sharing a video for discussion

It is interesting to see how some teacher-participants are improvising teaching resources and sharing them on the CoP Telegram platform. For example, a recorded video demonstrates how they used materials available at home to perform an experiment with the help of a family member, clarifying concepts through the demonstration. This activity, which is used for discussion and illustrated below, falls under Themes P2.2 and P3.4.

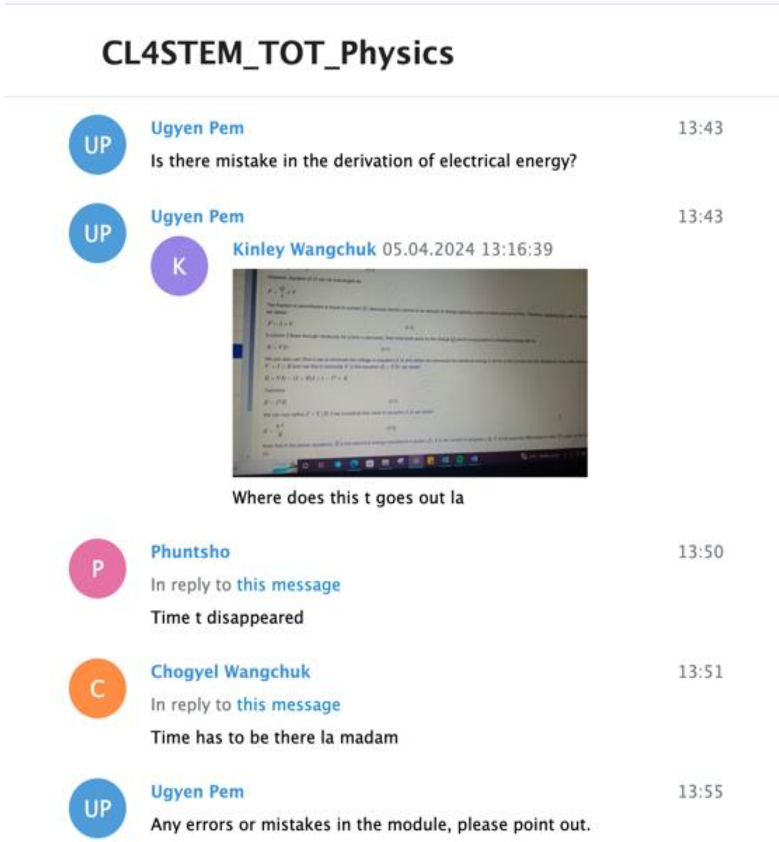
Furthermore, some teacher-participants were able to connect these concepts to earlier topics covered in class, as shown in screenshot below, which aligns with Themes P3.5 and P2.2. Such discussions contribute to the development of higher-order thinking skills, which are essential for mastering the subject.





xii) Correcting a formula

The teacher-participants were able to identify a mistake in the formula for electrical energy, as shown in below. This type of discussion is essential for addressing misconceptions that may arise from learning materials or module writers.



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

1.7.1 Participation of teacher-participants

The implementation of this module was somewhat challenging at the beginning due to the swapping of modules. The teacher-participants were teaching topics related to force and motion in their schools, while the first OER module offered to them was on Work, Energy, and Power. This led to some difficulties in adjusting their teaching plans. However, the participants were able to create classes, implement activities, and successfully complete all tasks in the OER module.

An interesting strategy that motivated the teacher-participants was the immediate feedback provided on their learning activities through interactive videos (H5P) and online quiz questions. The OER module was designed so that participants could resubmit their answers until they got them correct, allowing them to progress to the next lesson. This approach encouraged participants to clarify their mistakes and experience a sense of accomplishment. Additionally, they were able to upload their students' responses in the space provided for open-ended essay questions.

Moreover, a discussion forum was created on the Moodle platform for each unit, where teacher-participants could either post at least one question for clarification or read and comment on posts shared by others. The CoP Telegram platform further facilitated daily communication between teacher-educators and teacher-participants regarding module progress, announcements, reminders, concerns, good practices, and any issues related to the module. All teacher-educators and teacher-participants actively engaged in these discussions, in addition to personal chats.

1.7.2 Challenges

In this OER module, the participants used variety of materials as teaching resources to carryout the activities that needs to be conducted in the class. However, there are a few challenges faced during the implementation of the OER module in the class.

1. Time management

While studying this module, a small percentage of teacher-participants found it difficult to complete all the tasks assigned in the OER module on time. A time extension of around 10 days was provided to some participants due to important school engagements in addition to their teaching responsibilities. The teacher-educators reminded participants of their learning progress on the CoP Telegram platform and also made individual phone calls to understand the reasons behind their difficulties in completing the activities.

2. Workshop feature(Peer-review)

The workshop feature on Moodle for peer assessment is good for randomly assigning the peers and students reviewing and grading peer's lesson. However, there is no provision to incorporate two types of observers/evaluators (face-to-face and online) into the workshop feature. Face-to-face observers/evaluators are the focus group's supervisors in the schools, whereas online observers/evaluators are the peers assigned on Moodle who grade their peers' lessons by watching the teaching videos shared. Thus, the workshop feature of Moodle is not user-friendly, especially when there are external evaluators or observers who are not enrolled in the OER module.

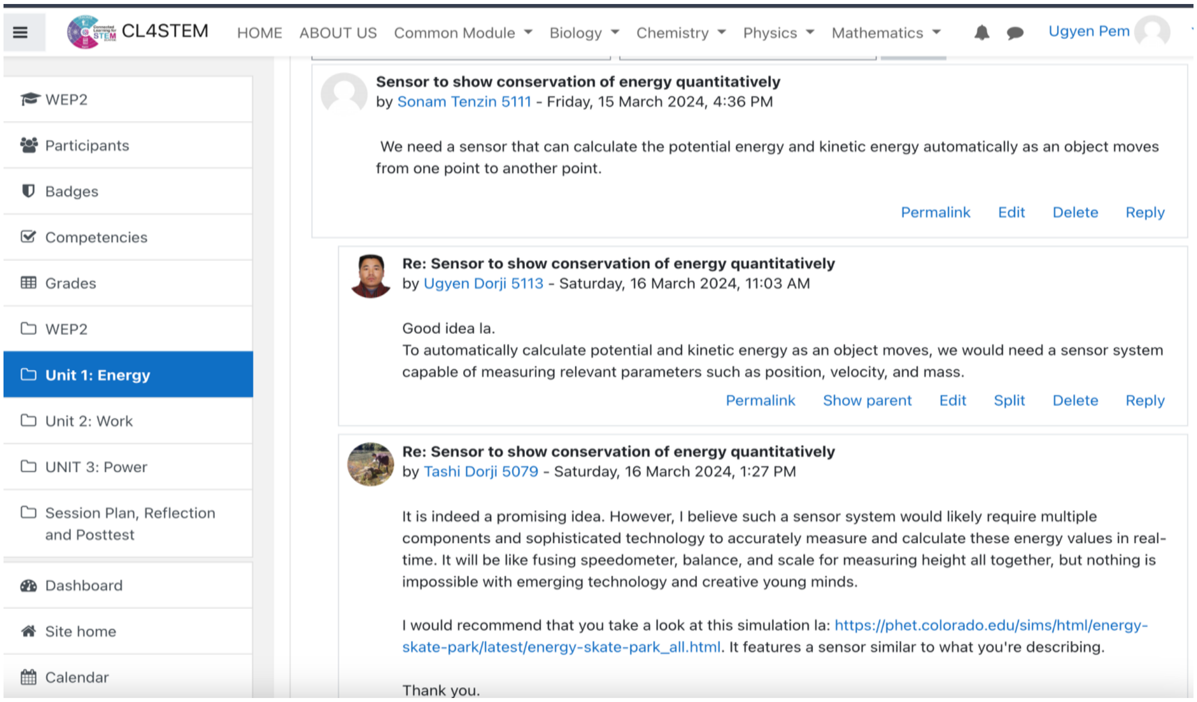
3. Teaching Videos

The majority of student-participants were unable to compress their teaching video clips to a size of less than 1 GB, as shown in the screenshot below.

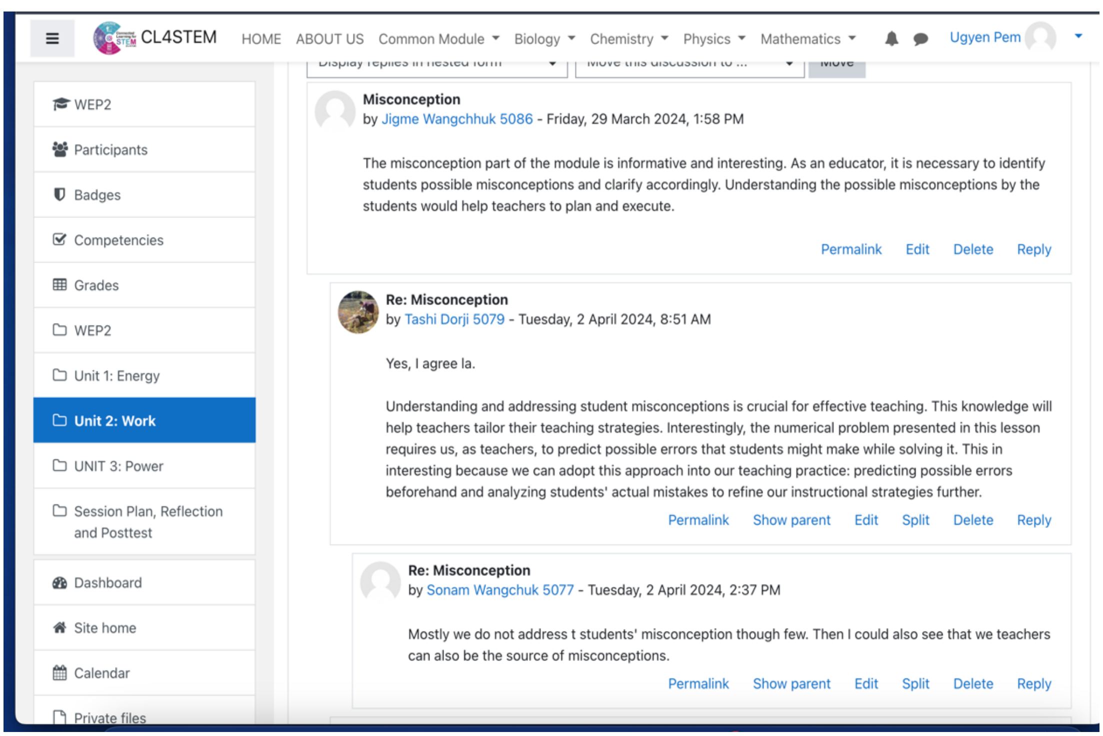
1.7.3 Surprises

1. Active participation on CoP telegram platform and discussion forum on Moodle

Nearly all the teacher participants were actively engaged on the CoP Telegram social learning platform in addition to participating in personal chats. Furthermore, the discussion forum under Unit I: Energy of the module on Moodle facilitated deep subject knowledge discussions on the posts, thereby enhancing their critical thinking, as illustrated in the screenshot below. A total of four posts by the teacher participants and 14 nested replies from other teacher participants and a teacher educator represent valuable practices that could be shared with other teachers in schools.



Similarly, the teacher-participants posted on discussion forum on the Unit II work as sample screenshot below. A total of three posts by the teacher-participants and four nested replies from other teacher-participants represent good practices that could be shared with other teachers in schools.



However, there are no posts for discussion under Unit III on power.

2. Time extension

All the activities are aligned with the latest revision of the National Science Curriculum Framework and can be easily implemented in class. However, some teachers needed extension of time to learn and complete all activities in this OER module.

1.7.4 Any changes required in the module design

This module requires no major changes. The use of the Moodle workshop feature for peer assessment is effective in assigning peers for lesson review and grading. However, there is still room for improvement in the peer-assessment process. Currently, the workshop feature does not allow for the uploading of teaching videos or the assessment of teaching through video reviews as a follow-up activity. Most teacher-participants found it challenging to record their teaching sessions, as their focus shifted from teaching to recording the lesson. Additionally, sending videos to peers posed another challenge. These issues could be avoided through face-to-face observations and evaluations.

Module 2: Force and Motion

2.1 Introduction

The CL4STEM Project is a South-South collaboration involving Ibrahim Badamasi Babangida University, Lapai (IBBUL) in Nigeria, Samtse College of Education (SCE) at the Royal University of Bhutan (RUB), and Open University, Tanzania (OUT), with the Tata Institute of Social Sciences, India (TISS) serving as the technical consultant. This project aims to pilot and research innovations for enhancing the capacities of secondary school teachers in science and mathematics, promoting inclusive and equitable higher-order learning in their classrooms.

As part of the initiative, three Open Educational Resources (OER) modules were developed, with each partner country leading the creation of one module. Other partner countries adapted these modules to fit their local contexts. The "Force and Motion" module, developed by the Nigerian team, was subsequently adapted by Samtse College of Education for local relevance. This module was first offered in 2022 to 20 teachers from seven schools in Samtse District over a six-week period.

For the scaling-up phase, the "Force and Motion" module was reviewed based on feedback from the initial implementation and updated to align with the latest National Science Curriculum Framework revisions. The review, conducted with the physics curriculum officer from the DCRD, Ministry of Education and Skills Development (MoESD), and the teacher educators of SCE, introduced several changes:

- Clear articulation of competency-based teaching and learning objectives for each lesson
- Reduction in the number of lesson plans to two and reflection to one
- Integration of online assessment components within activities for easy evaluation and quick feedback
- Multiple opportunities for participants to attempt activities and receive instant feedback
- Opportunity to undertake peer assessment

These adjustments aim to simplify the module and enhance its effectiveness.

The revised module was offered for six weeks, from May 6 to June 25, 2024. Due to the overlap with school examinations, the course duration has been extended to June 25, 2024, upon request from participating teachers. A total of 36 teachers were enrolled in the OER module.

The "Force and Motion" module comprises four units: Motion, Representation of Motion, Forces and Their Types, and Newton’s Laws of Motion. By the end of the module, teacher-participants should be able to:

- Explain motion and its relationship to time and distance.
- Facilitate discussions to address misconceptions about motion.
- Describe the importance of the frame of reference in understanding motion.
- Sketch and interpret distance-time and velocity-time graphs.
- Describe various types of forces and their effects on objects.
- Differentiate between different forces and analyse their real-world impacts.

- Explain and demonstrate Newton's First, Second, and Third Laws of Motion through simple experiments and real-life examples.
- Apply relevant formulae to solve problems related to Newton's laws.

Resources and Activities: The module includes a variety of resources and activities designed for practical and interactive learning:

- *Interactive Videos*: Created using H5P Moodle features.
- *Online Quizzes:* For formative assessment and concept reinforcement.
- *Model Design*: Construction of 2D or 3D models related to force and motion.
- *Real-Life Examples*: Listing and analysing examples of force and motion from everyday life.
- *Visual Aids*: Use of figures and images to clarify concepts.
- *PhET Simulations*: Virtual experiments with related questions.
- *Additional Resources*: Links for further exploration of force and motion concepts.
- *Problem-Solving*: Activities to tackle common misconceptions and practical problem-solving.

Nature and purpose of assessment

The module includes both pre- and post-tests consisting of 90 multiple-choice questions (MCQs) that evaluate knowledge across nine themes categorised under "Content," "Learners," and "Teaching Practices." The pre-test assesses participants' initial understanding, while the post-test measures progress and the module's effectiveness.

The assessment approach is designed to provide both formative and summative evaluations. Formative assessments are integrated throughout the module in interactive lessons that feature quiz questions and open-ended prompts. These assessments help gauge knowledge, encourage reflection on student learning, and address common misconceptions. Participants must complete these assessments before advancing to the next lesson. Automatic progress bars on the Virtual Learning Environment (VLE) track progress and record time spent on learning activities.

Participants are required to develop two lesson plans from the module and implement one in their classroom. This task aims to enhance both content knowledge and pedagogical content knowledge by applying Universal Design for Learning (UDL) principles and relating lessons to real-life contexts. After implementing their lesson, participants write reflections focusing on student engagement, higher-order thinking skills, addressing misconceptions, and using active learning strategies with locally available materials.

Among the 36 participants, seven were selected as focal teachers for in-person observation and evaluation by appointed observers, including teacher educators and curriculum officials from the Ministry of Education and Skills Development. These observers provided direct feedback and assessed the lesson implementation. The remaining participants recorded their lessons on video and submitted them to peers, who were randomly assigned by the teacher educators for assessment and feedback. The peers used the peer assessment forum available on VLE.

2.2 Course completion rate

2.2.1 Overall completion

All 36 participants completed the OER module as shown in Table 2.1.

Table 2.1: *Course completion rate*

	Teacher-participants
1 - 20%	-
21 - 40%	-
41 - 60%	-
61 - 80%	-
81 - 100%	100%
Total	100%

2.2.2 Assessment completion rate

All assessment components were completed as shown in Table 2.2.

Table 2.2: *Teacher-participants assignment completion rate*

Assignment	**Completion Rate (%)**
Pre-tests-Part 1 and Part 2	100%
Session plans	100%
Reflection	100%
Post-tests- Part 1 and Part 2	100%

2.3 Time spent on the course platform

Table 2.3 illustrates that 24 teacher-participants spent between 10 to 20 hours on the Moodle platform followed by six between 21 to 30 hours and one more than 30 hours. Teacher-participants have spent less than 10 hours. The detailed time spent on the Moodle platform by each teacher-participants is shown in Figure 2.1.

Table 2.3: *Time spent by teacher-participants on Moodle platform*

Hours spent	**Teacher-participants**
Less than 10	5
10 to 20	24
21 to 30	6
More than 30	1
Total	36

2.4 Analysis of pre-test and post- test

The mean score of 36 teacher participants in the pre-test is 59.32%, while the mean score in the post-test increased to 62.01%. This increase in the mean score in post-test though small, still indicates that the teacher-participants performance increased as a result of undertaking the module on Force and Motion. The analysis of the pre- and post-test performance as per the predetermined themes is as shown in Table 2.4.

Table 2.4: *Performance of the teacher-participants in pre-test and post-test*

Themes	Pre test		Post test		Change in mean	SD pooled	Cohen's d	Cohen's d interpretation
	Mean	SD	Mean	SD				
K1.2 Recognise students' prior conceptions and misconception	0.36	0.20	0.38	0.22	0.02	0.21	0.10	Very small effect
K1.3 Recognise areas of difficulty that students face	0.47	0.28	0.56	0.29	0.09	0.29	0.32	Small effect
K2.1 Understand nature of science/ mathematics	0.54	0.22	0.63	0.24	0.09	0.23	0.39	Small effect
K2.2 Explain goals of teaching the subject	0.94	0.13	0.91	0.22	-0.03	0.18	-0.17	Very small effect
K2.3 Identify 'Big' ideas, key concepts and theories	0.74	0.20	0.53	0.23	-0.21	0.22	-0.97	Large effect
K2.4 Sequence and connect between concepts within subjects and across grades	0.74	0.20	0.83	0.19	0.09	0.20	0.46	Small effect
K3.1 Select instructional strategies to support multiple forms of	0.64	0.13	0.66	0.18	0.02	0.16	0.13	Very small effect

Themes	Pre test		Post test		Change in mean	SD pooled	Cohen's d	Cohen's d interpretation
	Mean	SD	Mean	SD				
students' engagement								
K3.2 Evaluate resources for multiple forms of representing content	0.58	0.13	0.53	0.16	-0.05	0.15	-0.34	Small effect
K3.3 Choose multiple tools of assessments to encourage multiple modes of expression	0.48	0.22	0.56	0.21	0.08	0.22	0.37	Small effect

The themes K1.2 and K1.3 are information related to 'learners'; themes K2.1, K2.2, K2.3, and K2.4 are related to 'Content'; and themes K3.1, K3.2, and K3.3 are related to 'Teaching & Learning'. Cohen's d calculation and interpretation is used to compare the mean scores and standard deviation of pre- and post-test to determine whether the module on Force and Motion had a meaningful effect size. The interpretation of Cohen's d-value is based on Cohen (1988) as shown in Table 2.5.

Table 2.5: *Interpretation of Cohen's d-value*

Cohen's d	Meaning
d < 0.2	Very small effect
0.2 <= d < 0.5	Small effect
0.5 <= d < 0.8	Medium
d >= 0.8	Large

https://cran.r-project.org/web/packages/effectsize/vignettes/interpret.html

Table 2.4 shows the OER module on Force and Motion had positive impacts on the teacher-participants though the impact is not very large. The theme wise analysis under three categories using data from Table 2.4 is explained below.

A. Learner

i. Theme K1.2: Recognise students' prior conceptions and misconceptions

For this theme, there was a small change in the scores from the pre-test to the post-test. The pre-test mean score was 0.36 (with a standard deviation of 0.20), while the post-test mean score increased slightly to 0.38 (with a standard deviation of 0.22).

The Cohen's d value of 0.10 reflects a very small effect size, suggesting that the intervention had minimal impact on improving understanding or skills related to this theme. The small increase in the mean score, combined with the low effect size, indicates that while there was a slight improvement, it may not be significant enough to suggest a meaningful change in performance or understanding among the participants. Overall, these findings suggest that further efforts may be needed to achieve more substantial improvements in this area.

ii. Theme K1.3: Recognise areas of difficulty that students face

In Theme K1.3, which emphasises recognising the areas of difficulty that students face, the results indicate an improvement in teacher participants' scores. The pre-test mean score was 0.47 (with a standard deviation of 0.28), suggesting that there was some variability in teachers' initial understanding of students' challenges. The post-test mean score increased to 0.56 (with a standard deviation of 0.29), indicating a positive change in their ability to identify these difficulties. There is a slight increase in standard deviation in the post-test which is not very significant.

The Cohen's d value of 0.32 reflects a small effect size, suggesting that the intervention had a modest impact on enhancing teachers' understanding of the areas where students struggle. Overall, these findings highlight a beneficial shift in teachers' awareness of student difficulties, while also indicating that there is potential for further improvement in this area.

B. Content

iii. Theme K2.1: Understand nature of science/ mathematics

In Theme K2.1 on understanding the nature of science and mathematics, the results indicate an improvement in teachers' scores. The pre-test mean score was 0.54 (with a standard deviation of 0.22), suggesting a moderate initial understanding of the theme. Following the intervention, the post-test mean score increased to 0.63 (with a standard deviation of 0.24), indicating a positive change in understanding.

The Cohen's d value of 0.39 reflects a small effect size, suggesting that the intervention had a meaningful impact on enhancing teachers' understanding of the nature of science and mathematics. Overall, these results demonstrate that the intervention was effective in improving knowledge in this area, though there is still room for further development.

iv. Theme K2.2: Explain goals of teaching the subject

In Theme K2.2, which centers on explaining the goals of teaching the subject, the results show a slight decline in test scores among teacher participants. The pre-test mean score was 0.94 (with a standard deviation of 0.13), indicating a strong understanding of the goals prior to the intervention. However, the post-test mean score dropped slightly to 0.91 (with a standard deviation of 0.22), suggesting a small decrease in their understanding after the intervention.

The negative Cohen's d value of 0.17 indicates a very small effect size, reflecting that the intervention had minimal impact on teachers' grasp of the subject goals. This slight decline suggests that, while teachers were already well-informed about the goals, the intervention may not have effectively enhanced their understanding or may have led to some confusion.

v. Theme K2.3: Identify 'Big' ideas, key concepts and theories

For Theme K2.3 on 'Identify 'Big' ideas, key concepts and theories', the pre-test mean score was 0.74 (with a standard deviation of 0.20) suggesting that teachers had a good understanding of the theme prior to the intervention, with little variability in their scores.
The decrease in the mean score to 0.53 in the post-test indicates a substantial drop in teachers' competencies after the intervention. The increase in standard deviation to 0.23 suggests that

there was an increase in the variability in responses, meaning few teachers may have experienced more difficulty post intervention.

A Cohen's d of -0.97 highlights that the intervention was not only ineffective but may have negatively impacted teachers' competencies in this area.

vi. Theme K2.4: Sequence and connect between concepts within subjects and across grades

The Theme K2.4 on 'Sequence and connect between concepts within subjects and across grades', the pre-test mean score was 0.74 (with a standard deviation of 0.20), while the post-test mean score increased to 0.83 (with a standard deviation of 0.19).

The pre-test score suggests that teachers had a relatively good grasp of how to sequence and connect concepts. The standard deviation also indicates that in general teachers had a good grasp in their understanding. The increase in the mean score to 0.83 in the post-test indicates a substantial enhancement in teachers' abilities to sequence and connect concepts across the module post intervention. The slight decrease in standard deviation (from 0.20 to 0.19) suggests that teachers' scores became a bit more consistent post-intervention, indicating that most teachers likely improved their understanding.

A Cohen's d of 0.46 indicates that the intervention had a small but meaningful impact on teachers' competencies in this theme.

C. Teaching and Learning

vii. Theme K3.1: Select instructional strategies to support multiple forms of students' engagement

The Theme K3.1 on 'Select instructional strategies to support multiple forms of students' engagement', the pre-test mean score was 0.64 (with a standard deviation of 0.13), while the post-test mean score slightly increased to 0.66 (with a standard deviation of 0.18). The increase in mean score from 0.64 to 0.66 suggests a slight enhancement in teachers' ability to select instructional strategies for student engagement. The slight increase in standard deviation from 0.13 to 0.18 indicates a slight increase in variability in scores post-intervention, implying that some teachers may have benefitted more than others.

A Cohen's d of 0.13 indicates that the change, while positive, is very small and may not lead to significant shifts in instructional practice.

viii. Theme K3.2: Evaluate resources for multiple forms of representing content

The Theme K3.2 on 'Evaluate resources for multiple forms of representing content', the pre-test mean score was 0.58 (with a standard deviation of 0.13), while the post-test mean score slightly decreased to 0.53 (with a standard deviation of 0.16). The pre-test score suggests that teachers had a moderate understanding of evaluating resources before the intervention, with a relatively low level of variability in scores. The decrease in the mean score to 0.53 in the post-test indicates a slight decline in teachers' understanding or application of the theme after the intervention. The slight increase in standard deviation suggests some increase in variability in responses post-intervention, meaning that some teachers may have struggled more than others.

The negative Cohen's d (-0.34) indicates a small effect size, signifying a slight negative change in scores. This suggests that the intervention may not have been effective in enhancing teachers' competencies in this area.

ix. Theme K3.3: Choose multiple tools of assessments to encourage multiple modes of expression

For the Theme K3.3 on 'Choose multiple tools of assessments to encourage multiple modes of expression', the pre-test mean score was 0.48 (with a standard deviation of 0.22) indicating that the initial understanding of using multiple assessment tools varied among the teachers, with some scoring significantly higher or lower than the mean. The post-test mean score increased to 0.56 (with a standard deviation of 0.21) showing an improvement in teachers' skills or understanding after the intervention, with a slightly reduced standard deviation, suggesting a more consistent level of understanding among teachers post-intervention.

A Cohen's d of 0.37 suggests that while there was a positive change, it's relatively small in magnitude. This means the intervention had some impact, but it may not lead to widespread changes in practice.

2.5 Practice (Session plan and reflection together)

Table 2.6: *Analysis of grading sheet on session plans and reflections*

Category	Themes	Mean	SD	Impact
1.Learner	P1.1 Promote inclusion and equity	1.20	0.37	Medium
	P1.2 Build on students' prior conceptions	1.33	0.32	Medium
	P 1.3 Address misconceptions and areas of difficulties	1.13	0.57	Medium
	Average	**1.22**	**0.42**	**Medium**
2.Content	P2.1 Use processes on science and mathematics	1.29	0.37	Medium
	P2.2 Facilitate higher order thinking	1.30	0.29	Medium
	P2.3 Plan to build students' competences to meet the goals of teaching science/ mathematics	1.27	0.44	Medium
	Average	**1.29**	**0.37**	**Medium**
3.Teaching and Learning	P3.1 Use instructional strategies for active learning	1.39	0.38	Medium
	P3.2 Use multiple representations of content	1.45	0.38	Medium
	P3.3 Create opportunities for multiple modes of expression	1.32	0.30	Medium
	P3.4 Use locally available materials	1.26	0.42	Medium
	P3.5 Link conceptual content to students' everyday life experiences and prior knowledge	1.15	0.51	Medium
	Average	**1.31**	**0.40**	**Medium**

The interpretation of mean value is shown in table 2.7.

Table 2.7: *Interpretation of mean value*

Mean value(x)	Meaning
$x < 0.50$	Very small impact
$0.50 <= x < 1.00$	Small impact

1.00 <= x < 1.50	Medium impact
x >= 1.50	Large impact

As shown in Table 2.6, all the themes under the three categories Learner, Content, and Teaching and learning shows that the OER module on Force and Motion had positive medium impacts on the teacher-participants. The theme wise analysis under three categories is explained below.

a. Learner

In Table 2.6, the "Learner" category has an average score of 1.22 and a standard deviation of 0.42. This average indicates a medium impact, while the standard deviation suggests there is some variability in the scores among participants. Although the "Learner" category is not considered to have an extremely high or low influence, its medium impact highlights its significance in the context being analysed. This suggests that while the "Learner" category is important, there may be opportunities for further exploration or intervention to improve its effectiveness.

i) Theme P1.1: Promote inclusion and equity

The theme "Promote Inclusion and Equity" specifically looked at teacher's ability to create opportunities for students to participate in the class, providing support to students who need help and have special needs, using inclusive language and non-discriminatory approach in dealing with students. The theme had a mean score of 1.20 and a standard deviation of 0.37, indicating a medium impact. This suggests that while there are commendable efforts made to create an inclusive environment, there is still significant room for improvement. It is observed that many of the teacher participants used group work approach to encourage collaboration and interactions among students, with some using mixed-gender grouping (5115, 5111, 5097). The teacher participants mentioned that students were found actively engaging in group work. There are also instances of attention being paid to students who need additional support. For instance, teacher 5091 has mentioned that additional support was provided for anxious students, 5086 mentioned using class point app to give individual care, and 5079 said supportive environment was provided where any questions from students were welcomed. There is no evidence to indicate any use of discrimination or exclusion based on socio-economic or linguistic backgrounds.

Overall, the current practices show a commitment to promoting inclusion and equity, but the medium impact score implies that further initiatives could ensure that all students feel fully supported and engaged in the learning environment.

ii) Theme P1.2: Build on students' prior conceptions

The theme "Build on students' prior conceptions" received a mean score of 1.33 and a standard deviation of 0.32, indicating that while it is viewed positively, its effectiveness is perceived as moderate. This score suggests that teachers recognise the value of connecting new learning to what students already know, which can enhance comprehension and retention. For example, all teacher participants have introduced the lesson by asking questions to students on what they already have learnt about the topic either in the previous lesson or in lower grades. For instance, teacher 5094 has used questions in the beginning of the lesson to gauge students' understanding of displacement and distance to link with the lesson and have also recalled previously learned Newton's laws. There are also examples of using everyday life experiences. The lesson starts with a discussion on everyday experiences of push and pull, which activates prior knowledge (5092)

iii) Theme P 1.3: Address misconceptions and areas of difficulties

The theme "Address misconceptions and areas of difficulties" has a mean score of 1.13, with a standard deviation of 0.57, indicating a medium impact. This mean score suggests that while teachers recognise the need to address misconceptions in their instruction, they may struggle to effectively integrate this focus into their lesson planning and execution. The moderate variability reflected in the standard deviation points to differing levels of success among teachers; some may find strategies for addressing misconceptions effective, while others may face challenges or feel less confident in their approaches. For example, four teachers have scored ‘0’ in this theme and many have scored less than ‘1’. They (5109, 5107, 5106, 5098, 5096, 5084, 5080) have mentioned the misconceptions students may have, they have not mentioned how these will be addressed. However, other teachers have addressed students’ misconception through question answer, or discussion or explanation.

Overall, this indicates that although identification of students’ misconceptions is acknowledged as important for enhancing student understanding, there are gaps in addressing it.

b. Content

Table 2.6 presents the "Content" category, which includes themes related to the use of processes in science and mathematics, fostering higher-order thinking, and planning to enhance students' competencies in achieving educational goals in these subjects. With a mean score of 1.29 and a standard deviation of 0.37, the Content category suggests a medium impact of OER on teacher participants. The details of theme wise analysis is presented in the following sections.

iv) Theme P2.1: Use processes on science and mathematics

The theme "Use processes on science and mathematics" focused on teachers encouraging students to hypothesise or draw conjecture while teaching concepts. It received a mean score of 1.29, accompanied by a standard deviation of 0.37. This indicates that the application of various processes in teaching science and mathematics has a moderate impact on educational outcomes. The mean score suggests that while the effectiveness is not particularly high, it is also not low; it's positioned in the middle range. The standard deviation reflects some variability in responses, meaning that while many participants may agree on the medium impact, there are differing opinions regarding the extent of its effectiveness. For example, some teachers have not specifically mentioned how they use the science processes but have broadly mentioned that they use through experimentation and problem solving. But there are teachers who have specifically mentioned it. For example: 5102 encourages students to observe and test hypotheses with real-life demonstrations, and questions like “What would happen if there were no friction?” were asked, 5103 asked students to design activities in groups that can prove Newton's second law.

Overall, this theme is seen as reasonably important in the context of enhancing learning in these subjects.

v) Theme P2.2: Facilitate higher order thinking

The theme "Facilitate higher order thinking" looked at areas like defining and monitoring use of scientific terms, using correct explanations/elaboration, facilitating problem solving and reasoning, encouraging students to hypothesise or draw conjectures, promoting conceptual understanding rather than just factual / procedural knowledge, and making connections with other concepts, subjects, daily life experiences. The theme has a mean score of 1.30 and a standard deviation of 0.29, suggesting a medium impact on educational effectiveness. The low standard deviation signifies that there is less variability in responses, implying a general consensus among participants about the moderate impact of this theme. Students higher order thinking skills were facilitated through problem solving, graph interpretation and making students to connect the concepts with everyday life examples (5095, 5104, 5090, 5088, 5087). Few teachers also used extended activity to activate students higher order thinking (5096).

Overall, while the theme is recognised as important for fostering deeper cognitive engagement, it also suggests room for improvement in its implementation.

vii) Theme P2.3: Plan to build students' competences to meet the goals of teaching science

The theme "Plan to build students' competences to meet the goals of teaching science/mathematics" received a mean score of 1.27 and a standard deviation of 0.44, indicating a medium impact. The mean score suggests that planning activities aimed at enhancing students' competencies in these subjects is viewed as moderately effective. However, the slightly lower mean compared to the other themes indicates that this aspect might be perceived as less impactful. The lower mean could also be because a couple of teachers did not receive any score on this theme as the evidence was not available. The standard deviation of 0.44 indicates greater variability in responses, suggesting a wider range of opinions on its effectiveness; some participants may view it as quite beneficial while others see it as less so. Overall, this theme is recognised as significant for achieving educational goals, but it also highlights potential areas for enhancement in planning and implementation.

c. Teaching and Learning

In Table 2.6, the last category "Teaching and Learning". It includes themes related to the use of instructional strategies for active learning, Use multiple representations of content, Create opportunities for multiple modes of expression, Use locally available materials and Link conceptual content to students' everyday life experiences and prior knowledge. It has an overall mean of 1.31 and a standard deviation of 0.40 indicating a medium impact. The detailed analysis theme wise is presented in the following sections.

viii) Theme P3.1: Use instructional strategies for active learning

Table 2.6 indicates that the Open Educational Resources (OER) module has a medium impact on teachers' use of instructional strategies for active learning, with a mean score of 1.39 and a standard deviation of 0.38. This suggests that the OER module has moderately raised awareness among teachers about using instructional strategies that promote active learning. The low standard deviation indicates that most teacher-participants have similar views regarding the module's effectiveness, showing a consistent awareness of the importance of active learning strategies. Almost all the teachers used group work as one prominent instructional strategy. Beside group work, only a few teachers used other strategies like gamification (5106), guided learning (5103), experiential learning (5099), and 5E model (5097). Before implementing the OER, the teachers were introduced to strategies like Design Thinking and Inquiry learning. However, the implementation of these strategies were not evident.

ix) Theme P3.2: Use multiple representations of content

The Table 2.6 indicate that the OER module has a medium impact on teachers' use of multiple representations of content, as evidenced by a mean score of 1.45 and a standard deviation of

0.38. This suggests that while teachers are somewhat positively influenced by the module to incorporate various ways of presenting information, the impact is not exceptionally strong. The relatively low standard deviation points to a consistent perception among participants regarding this impact, implying that most teachers recognise the value of using multiple representations in their teaching but may not be fully integrating them into their practices.

ix. Theme P3.3: Create opportunities for multiple modes of expression

The theme "Create opportunities for multiple modes of expression" focused on expressions through oral, written test, projects, presentations, open ended question, individual and collaborative expressions. The analysis revealed a mean score of 1.32 and a standard deviation of 0.30 (Table 2.6), indicating a moderate level of impact from the OER module on this aspect of teaching and learning. The mean score suggests that while there is some awareness among teachers about the importance of allowing diverse forms of expression in the classroom, the overall influence of the module is limited.

The low standard deviation reflects a consistent viewpoint among participants, indicating that most teachers share a similar perception of the module's effectiveness in creating opportunities for multiple modes of expression. The Universal Design Learning was offered as a professional development to all teacher participants before the implementation of OER. One of the topics under UDL was Multiple Modes of Expression. While many teachers provided opportunities for students to either answer questions or make a presentation, not every student seems to have got an opportunity.

x. Theme P3.4: Use locally available materials

The theme of "Use locally available materials" shows a mean score of 1.26 and a standard deviation of 0.42 (Table 2.6), indicating a moderate impact of the OER module in encouraging teachers to use locally available resources into their instruction. The mean score suggests that teachers are moderately motivated or influenced by the module to utilise locally available materials in their teaching practices. The standard deviation points to greater variability in the responses, meaning that while some teachers may see the value in using local materials, others may not feel as strongly about it. The use of materials were more of what is available in the laboratory or what the teacher owned rather than what would be available locally. For example, some resources used were weights, a stopwatch, graph paper, mobile phones, etc.

xi. Theme P3.5: Link conceptual content to students' everyday life experiences and prior knowledge

The theme "Link conceptual content to students' everyday life experiences and prior knowledge" has the lowest mean score of 1.15 and the highest standard deviation of 0.51 among all themes evaluated. Though the mean falls under moderate impact, it indicates a notably weak impact of the OER module on teachers' ability to connect curriculum content with students' real-life experiences and prior knowledge. The low mean suggests that teachers are incorporating this practice into their instruction moderately only.

Additionally, the high standard deviation indicates considerable variability in responses, suggesting that while some teachers may recognise the importance of making these connections, many do not feel equipped or motivated to do so. This points to a critical area for improvement within the OER module, as enhancing teachers' skills in linking conceptual content to students' experiences could significantly enrich the learning process and make lessons more relevant and engaging.

2.6 Social learning in Community of Practices (CoPs) on telegram platform

2.6.1 Frequency of posts by participants

Table 2.8: *Frequency of posts by participants*

Role	Number of posts
Teacher- Participants	147
Teacher- Educators	245
Total	392

The interactions of teacher educators and teacher-participants on the COP from May 6 to June 25, 2024 is reflected in Table 2.8. The data in the table shows that the number of post by teacher educators is more.

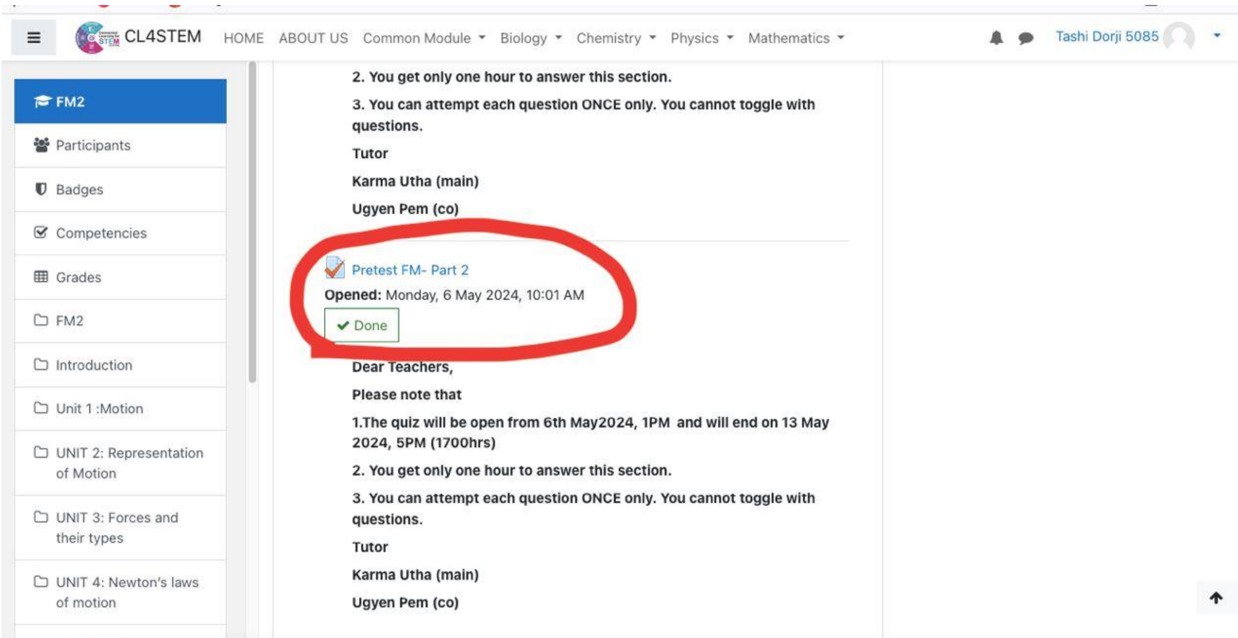
2.6.2 Frequency of posts by content and types

Table 2.9: *Frequency of posts by content and types*

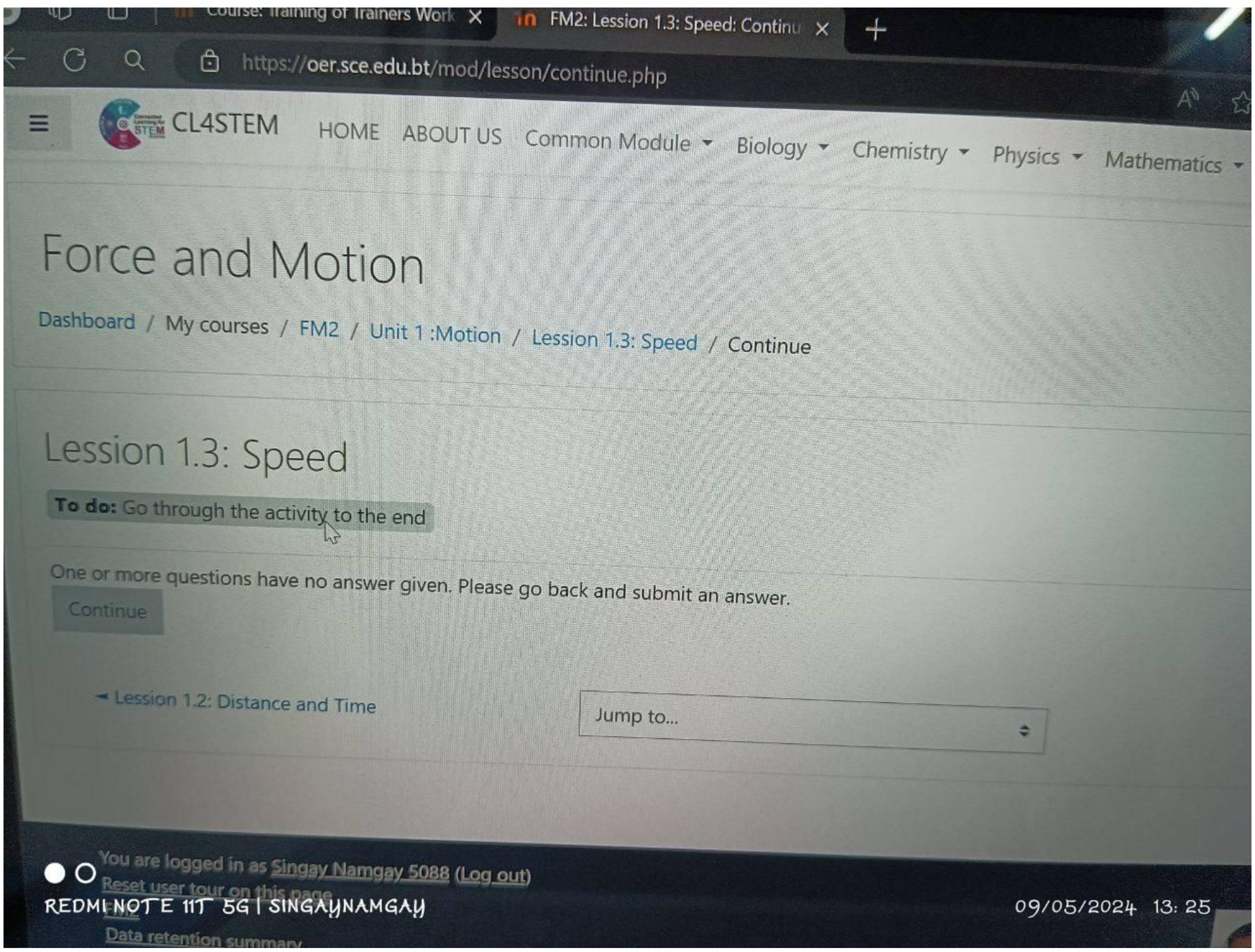
Frequency of posts by content	Number of posts
PCK	2
UDL	0
Technical	61
Communication/ Administrative	582
Total	645
Frequency of posts by type	**Number of posts**
Voice messages	10
Video files	5
Photos	60
Files	8
Total	83

Table 2.9 presents the frequency of posts by content during the implementation of the "Force and Motion" module. Out of the posts, the majority were related to communication and administration, followed by posts related to technical. While the PCK had only 2 posts, the UDL had zero post.
Table 2.9 provides the frequency of posts by type. In total there were 83 posts. Out of these, images in the form of screenshot were shared the most. The screenshot consisted of mostly administrative and technical related information shared by teacher educators with participants. Few examples are as shown below in the figure below.

Figure: Administrative information on pre- and post-test



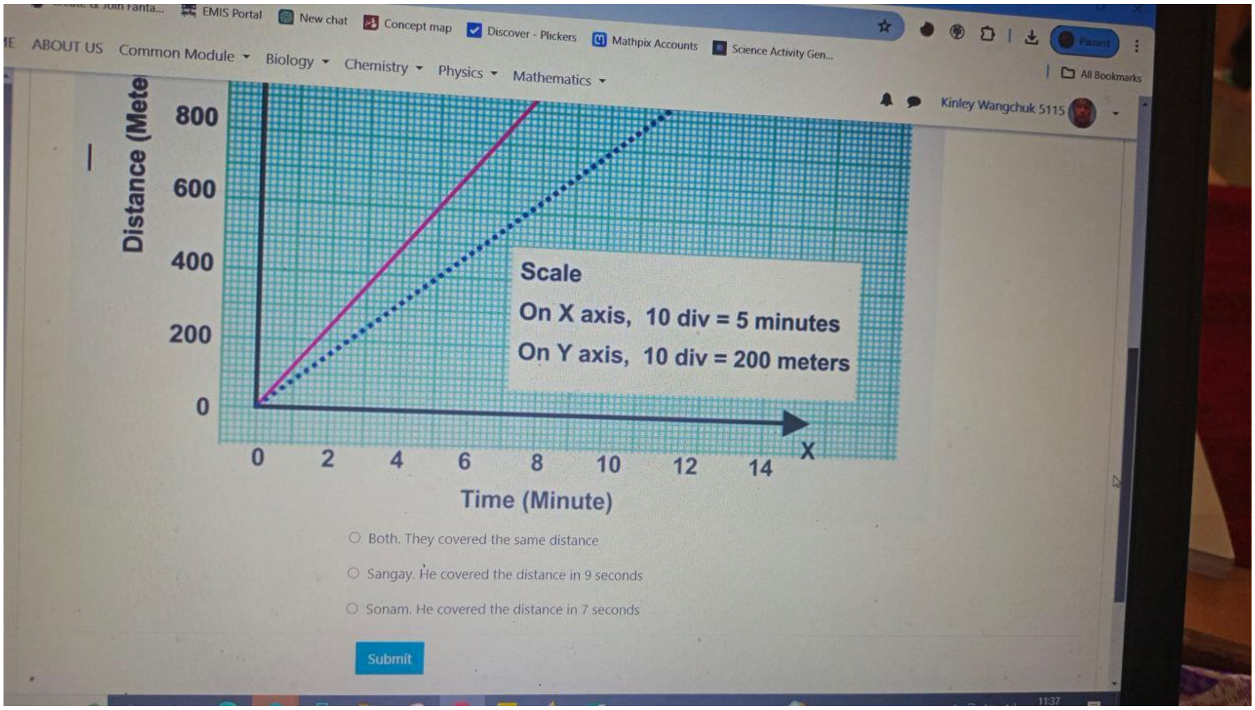
CL4STEM
HOME
ABOUT US
Common Module
Biology
Chemistry
Physics
Mathematics
Tashi Dorji 5085
FM2
Participants
Badges
Competencies
Grades
FM2
Introduction
Unit 1 :Motion
UNIT 2: Representation of Motion
UNIT 3: Forces and their types
UNIT 4: Newton's laws of motion
2. You get only one hour to answer this section.
3. You can attempt each question ONCE only. You cannot toggle with questions.
Tutor
Karma Utha (main)
Ugyen Pem (co)
Pretest FM- Part 2
Opened: Monday, 6 May 2024, 10:01 AM
Done
Dear Teachers,
Please note that
1.The quiz will be open from 6th May2024, 1PM and will end on 13 May 2024, 5PM (1700hrs)
2. You get only one hour to answer this section.
3. You can attempt each question ONCE only. You cannot toggle with questions.
Tutor
Karma Utha (main)
Ugyen Pem (co)



FM2: Lession 1.3: Speed: Continu
https://oer.sce.edu.bt/mod/lesson/continue.php
CL4STEM
HOME
ABOUT US
Common Module
Biology
Chemistry
Physics
Mathematics
Force and Motion
Dashboard / My courses / FM2 / Unit 1 :Motion / Lession 1.3: Speed / Continue
Lession 1.3: Speed
To do: Go through the activity to the end
One or more questions have no answer given. Please go back and submit an answer.
Continue
Lession 1.2: Distance and Time
Jump to...
You are logged in as Singay Namgay 5088 (Log out)
Reset user tour on this page
REDMI NOTE 11T 5G | SINGAYNAMGAY
09/05/2024 13: 25
Data retention summary

2.6.3 Qualitative dialogues/ discussion threads

In CoP telegram platform "CL4STEM_TOT_Physics", as mentioned earlier, there was hardly any post related to PCK and UDL. It seemed that the teachers did not face any challenges in the module implementation. However, when one or two teachers had some problems, they preferred to contact the teacher educators on their personal telegram chat. For example, one of the teachers while carrying out the lesson activity got an answer which was not reflected as an option to choose in it. The clarification was sought in the personal chat itself.



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

2.7.1 Participation of teacher-participants

The teacher participants exhibited a commendable level of engagement on the Moodle and Community of Practice (CoP) platform. This was accorded largely to their prior experience with the first OER module Work, Power and Energy. The earlier module had equipped them with the necessary skills for navigating activities, lesson planning, and video recording of lesson, peer assessment, and writing reflection. Consequently, participants entered the second module with a solid understanding of the expectations and processes involved, which contributed to a more seamless and productive experience. The familiarity with these elements not only boosted their confidence but also allowed them to focus on the new content more effectively.

Additionally, the organisational strategies implemented by the teacher educators played a crucial role in maintaining high levels of participation. Each educator was responsible for a group of 12 participants, which enabled them to offer personalised support and maintain regular communication. This approach was complemented by constant reminders and prompts to ensure task completion. The teacher educators were also highly responsive to any questions or issues raised by participants within the CoP, demonstrating a commitment to addressing concerns promptly.

This combination of structured support and responsive interaction significantly contributed to the overall success of the engagement, fostering an environment where participants felt supported and motivated to actively contribute.

2.7.2 Challenges

Both teacher participants and educators faced significant challenges during the Moodle and Community of Practice (CoP) initiative, with time emerging as a central issue for all involved. For teacher participants, the primary challenge was balancing the completion of the OER module and its associated activities with their regular teaching responsibilities. This juggling act often led to time constraints, making it difficult for participants to engage fully with the module content and deadlines. Teacher educators, on the other hand, had the ongoing task of monitoring activity completion and sending gentle reminders. This required a delicate balance of being both persistent and understanding, as reminders needed to be frequent enough to keep participants on track but also considerate of their busy schedules.

Another notable challenge was the peer assessment process. The Moodle platform’s requirement for all participants to submit their lesson plans before engaging in peer assessment created additional stress. Some teachers experienced delays in uploading their lesson plans, which in turn affected the timing of peer reviews and added pressure on both participants and educators. Educators had to send multiple reminders to ensure timely submissions, further compounding their stress. This process underscored the need for a more streamlined approach to peer assessment that accommodates participants' varying timelines while maintaining the integrity of the review process.

Another significant challenge faced by teacher participants was the requirement to video record their lesson implementations, compress the files, and share with peers for assessment. Video recording posed a considerable hurdle, as not all participants were familiar with the technical aspects of capturing and editing their lessons effectively. Additionally, compressing video files to meet the platforms upload requirements proved to be a complex task for some, leading to frustrations and delays. This process not only demanded additional time but also technical support, which some participants struggled to obtain. The need for assistance in file compression added another layer of complexity to the already demanding task, highlighting the need for clearer guidelines and support resources to assist teachers in managing these technical challenges.

2.7.3 Surprises

Several surprising observations emerged during the Moodle and Community of Practice (CoP) initiative. Notably, physics teacher participants displayed exceptional diligence in completing the module and its associated tasks. Informal interactions revealed that these participants were consistently more proactive in their engagement, often surpassing others in task completion. This dedication was a pleasant surprise and highlighted the strong commitment within the physics teaching community.

Another unexpected yet positive finding was the level of mutual support among teacher participants. Many offered assistance to their peers in technical areas, such as compressing video files, and even went as far as to make personal calls to encourage and remind each other about task deadlines. This spirit of collaboration was further complemented by the overall understanding and patience exhibited by participants, who were supportive and empathetic towards one another's challenges. This supportive network not only helped mitigate individual difficulties but also fostered a more cohesive and collaborative learning environment.

2.7.4 Any changes required in the module design

While the content and activities within the module were generally well-received, certain processes could benefit from refinement. Specifically, the peer assessment component and video recording requirements warrant reconsideration. In the peer assessment process, the feedback provided on lesson plans was found to be less effective than anticipated. Participants often received only grades rather than detailed, actionable feedback, which diminished the value of peer reviews and limited opportunities for meaningful improvement. Enhancing the feedback mechanism to include more comprehensive and constructive comments could significantly improve the effectiveness of this process.

Additionally, the current video recording requirement—where teachers are expected to use their own mobile devices—proved to be cumbersome. Capturing comprehensive classroom interactions with personal devices often fell short, as these recordings struggled to effectively cover the full scope of class dynamics. Revisiting this approach to either provide more robust recording solutions or simplify the requirements could alleviate some of the technical challenges and enhance the overall quality of recorded lessons. Streamlining these processes would not only make the module more user-friendly but also improve the learning experience for all participants.

Module 3: Electromagnetism

3.1 Introduction

The open educational resources (OERs) module "Electromagnetism" was curated by physics educators at Samtse College of Education, with support and review from academics at the Tata Institute of Social Sciences. Initially in the year 2022, the module was offered to 20 teacher-participants from six schools under Samtse District. The same module was reviewed in collaboration with a physics curriculum officer from the Department of Curriculum and Research Development (DCRD) under Ministry of Education and Skills Development (MoESD), aligning it with the latest revisions in the National Science Curriculum Framework. In this revision, the previously missing focus on the area of competency-based teaching and learning for each lesson was clearly articulated. Also, the feedback from the teacher-participants were incorporated, especially regarding the number of lesson plans to be implemented in the classroom. Additionally, in order to learn the module, the participants get multiple chances to attempt the quiz questions to get a correct response with instant feedback.

The module is a six-week course that started on 13th July and ended on 5th September, 2024. The course duration was extended till 9th September 2024 because of teaching engagement in their schools. A total of 36 teacher- participants were enrolled in the OER module.

The teacher-participants have to learn a total of 16 lessons in four units of electromagnetism. The teacher-participants are required to attempt a pre and post-tests which consists of 45 multiple choice questions (MCQs) covering nine themes related to Learner, Content and Teaching & Learning and Universal Design for Learning. In this module, there are interactive lessons and quiz questions to test the subject matter, essay questions to reflect how their students learn the concepts through classroom activities, and to identify the common mistakes or misconceptions that their students made in the class. The interactive lessons, combined with formative assessments, motivate the teacher-participants to actively engage with the learning activities of the module.

The teacher-participants are required to make two lesson plans in this module and implement one lesson plan in the class. The practice of teaching a lesson in the class will enhanced their pedagogy content knowledge, where they apply the Universal Design Learning (UDL) principles in their classroom, related their lessons with real-life applications, and identify and address any student's misconceptions. At the end, they are required to write a reflection on the lesson implemented in the class which focuses on how their students are engaged in an inclusive environment, how to facilitate their students' high order thinking skills, how their students' misconceptions are identified and addressed, how their students interact with the content of the lesson by providing opportunities through active learning strategies, utilising locally available materials, and linking the concepts to everyday life experiences. The learning outcomes of the module are as follows:

a. Timeline of implementation in the country

According to the research calendar, the module was scheduled for a six-week implementation. The module was opened to the participants on July 16 and closed on October 15, 2024.

Learning objectives

At the end of the module, each participating teacher are expected to:

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

Competency

- Design the Oersted experimental setup and determine the direction of the magnetic field in current carrying conductor to establish a relationship between current and magnetic field.
- Compute the magnetic field strength at a specific point generated by a straight current-carrying wire and ascertain its direction to comprehend its practical application in designing motors for everyday use in various electrical appliances
- Describe how a solenoid generates a magnetic field through the flow of electric current in its coil and elucidate the direction of the magnetic field both inside and outside the solenoid, to understand the fundamental mechanism of solenoids and their widespread application in various electrical devices.
- Examine the movement of charged particles within a magnetic field and use the Right Hand Palm Rule to determine the direction of the velocity of particles in the magnetic field

to understand the significance of the motion of charged particles in the operation of numerous electrical devices.
- Demonstrate and explain Faraday's law of electromagnetic induction to appreciate its application in electric generators, transformers, induction cookers, etc.
- Apply Lenz's law to determine the direction of induced electromotive force (emf) in both a coil and a solenoid, emphasizing the significance of the negative sign in Lenz's law for a comprehensive understanding.

Resources (activities and reading materials): In this module, the activities are designed to be feasible using locally available materials, everyday experiences, and e-resources (pictures, links, PhET, videos, online quizzes). These activities include:
- Interactive videos using H5P Moodle feature
- Online quizzes for formative assessment of learning the concepts
- Design a dc motor using the available materials.
- Design experiment to demonstrate the Faraday's law of electromagnetism.

Nature and purpose of assessments

The OER module is designed with both formative as well as summative assessment. The use of automatic progress bars on Virtual Learning Environment (VLE) Moodle platform helped both the teacher-educators and the teacher-participants to check their own progress in learning the module. Also, the teacher-educators can access the time spent by the teacher-participants using dedication tools. In addition, the teacher-participants are allowed to move to the next lesson after fulfilling the required assessment of each lesson. There are embedded quizzes in each lesson to assess their learning lessons of the units. The close-ended quiz questions are set so that they cannot move to the next activity without getting the correct response. This ensures that they cannot compromise their learning. Moreover, there are essay questions asking their understanding of the concepts or the students' responses during the implementation of the activities in the classroom.

The 36 participants were able to interact with the OER module and a progress bar displayed their performance. Eight out of 36 participants were selected from different schools across Bhutan as focal teachers, whose lessons were observed and evaluated by the teacher educators and curriculum officials from the Ministry of Education and Skills Development. The final evaluation of the lesson plans and a reflection of the participants are evaluated by the teacher educators to find out the level of the teacher-participants' competencies in three categories such as "Content", "Learners" and "Teaching & Learning". Further, the teacher-educators took the responsibilities of 12 teacher-participants each to provide any necessary support that they may require in learning the module. This arrangement was used to evaluate their lesson plans, observation form 7A and evaluation form 7B made the assessment component easy and systematic. The pre-tests and post-tests were conducted to find the teacher-participants to find the effectiveness of the module. A total of 45 questions under nine themes were identified to see the impacts of the module. All these nine themes can be categorised under the "Content", "Learners" and "Teaching & Learning".

3.2 Course completion rate

3.2.1 Overall completion

All 36 participants completed the OER module as shown in Table 3.1.

Table 3.1: *Course completion rate*

	Teacher-participants
1 - 20%	-
21 - 40%	-
41 - 60%	-
61 - 80%	-
81 - 100%	100%
Total	100%

3.2.2 Assessment completion rate

All assessment components were completed as shown in Table 3.2.

Table 3.2: *Teacher-participants assignment completion rate*

Assignment	Completion Rate
Pre-tests-Part 1 and Part 2	100%
Session plans	100%
Reflection	100%
Post-tests- Part 1 and Part 2	100%

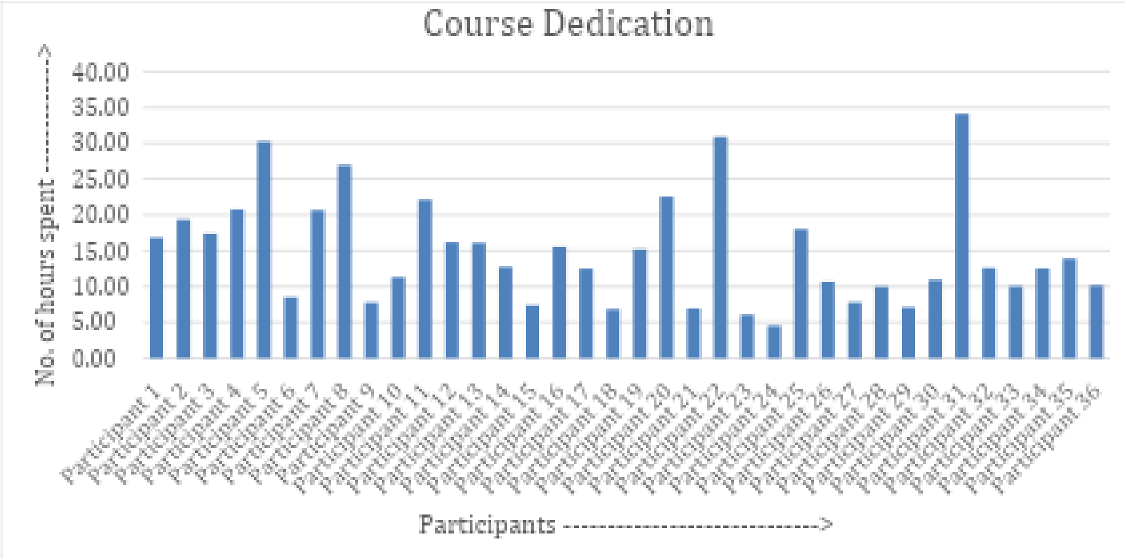
3.3 Time spent on the course platform

Table 3.3 shows the number of hours spent by the teacher participants in Electromagnetism course. Most of the teacher-participants (18 out of 36) spent **10-20 hours** on the course, and no one spent more than **40 hours**. There is also a moderate number of participants who spent **less than 10 hours** (10 participants), and smaller groups who spent **20-30 hours** (5 participants) and **30-40 hours** (3 participants). On the average, teacher participants spent around 14.8 hrs on the course. The maximum spent on the course is 34.13 hrs while the minimum if 4.53 hrs.

Table 3.3: *Time spent by teacher-participants on Electromagnetism course*

Hours spent	No of teacher-participants
More than 50	0
40-50	0
30-40	3
20-30	5
10-20	19
Less than 10	9
Total	**36**

Figure 3.1: *Time spent by each teacher-participants on the Electromagnetism course.*



3.4 Analysis of pre-test and post- test

The mean score of 36 teacher participants in the pre-test is 68.89%, while the mean score in the post-test is 74.14%. This improvement of 5.25% suggests that the teacher-participants performed better in the post-test compared to the pre-test. Further analysis of the pre-test and post-test revealed how the performance of the teacher participants improved in the pre-test after the completion of the course.

In the pre-test, there were 8.33% of the teacher participants in the emerging category, 61.11% in proficient and 30.56% in accomplished category. In the post, the percentage of teacher percent in emerging and proficient category decreased to 5.56% and 22.22% respectively while the percentage doubled to 72.22% in accomplished category. This indicate that there is significant improvement in the performance of the teacher participants after the completion of the course. The progression of the performance from pre-test to post-test is given in Table 3.4.

Table 3.4. Progression of performance from pre-test to post-tests.

Pre-test	**Post Test**				
Performance Category	Novice	Emerging	Proficient	Accomplished	Total
0-25% Novice	0	0	0	0	0
26-50% Emerging	0	2.78	2.78	2.78	8.34
51-75% Proficient	0	2.78	16.66	33.33	52.77
76-100% Accomplished	0	0	2.78	36.11	38.89
Total	**0**	**5.56**	**22.22**	**72.22**	**100**

Further analysis of the pre-test and post-test performance are carried out by grouping them under broad themes of Learner, Content, Teaching and Learning. Table 3.5, shows the following categories: themes K1.2 and K1.3 are grouped under 'Learners'; themes K2.1, K2.2, K2.3, and

K2.4 are grouped under 'Content'; and themes K3.1, K3.2, and K3.3 are grouped under 'Teaching & Learning'. The pre-test and post-test scores are compared using Cohen's d to determine whether the implemented OER module had a meaningful effect size.

Table 3.5: *Performance of the teacher-participants in pre-test and post-test*

Theme	Pre test		Post test		Change in mean	Change in SD	Cohen's d	Meaning of Cohen's d
	Mean	SD	Mean	SD				
K1.2 Recognise students' prior conceptions and misconceptions	0.67	0.20	0.72	0.21	0.05	0.21	0.24	Small effect
K1.3 Recognise areas of difficulty that students face	0.71	0.24	0.79	0.21	0.08	0.23	0.35	Small effect
K2.1 Understand nature of science/ mathematics	0.71	0.24	0.76	0.23	0.05	0.24	0.21	Small effect
K2.2 Explain goals of teaching the subject	0.80	0.25	0.84	0.25	0.04	0.25	0.16	Very small effect
K2.3 Identify 'Big' ideas, key concepts and theories	0.62	0.20	0.82	0.20	0.20	0.20	1.00	large effect
K2.4 Sequence and connect between concepts within subjects and across grades	0.62	0.29	0.76	0.26	0.14	0.28	0.51	Medium effect
K3.1 Select instructional strategies to support multiple forms of students' engagement	0.86	0.13	0.86	0.13	0.00	0.13	0.00	Very small effect
K3.2 Evaluate resources for multiple forms of representing content	0.65	0.17	0.68	0.16	0.03	0.17	0.18	Very small effect
K3.3 Choose multiple tools of	0.37	0.20	0.39	0.21	0.02	0.21	0.10	Very small effect

Theme	Pre test		Post test		Change in mean	Change in SD	Cohen's d	Meaning of Cohen's d
	Mean	SD	Mean	SD				
assessments to encourage multiple modes of expression								

The analysis of the pre-test and post-test data indicate that the OER module on Electromagnetism had different impacts on the teacher-participants as shown in Table 3.5. Descriptive statistics is used to find the impacts of the OER module on the teacher-participants by comparing the mean scores and standard deviations of pre-test and post-test. Cohen's d is an effect size used to indicate the standardised difference between pre-test and post-test means. The interpretation of Cohen’s d-value is shown in Table 3.6 (Cohen, 1988).

Table 3.6: *Interpretation of Cohen’s d-value*

Cohen’s d	Meaning
d < 0.2	Very small effect
0.2 <= d < 0.5	Small effect
0.5 <= d < 0.8	Medium
d >= 0.8	Large

https://cran.r-project.org/web/packages/effectsize/vignettes/interpret.html

3.5 Discussion on nine themes under three categories are:

Learner

Theme K1.2: Recognise students’ prior conceptions and misconceptions

In pre-test mean score for this theme is 0.67 with a standard deviation of 0.20 (Table 3.5). There is a little change in the score of variability, as evidence by the post-test mean score rising marginally to 0.72, with a comparable standard deviation of 0.21. The Cohen's d effect size is 0.24, which is considered a "small effect.” This implies that students' capacity to identify preconceived notions and misconceptions was only marginally impacted by the intervention.

Theme K1.3: Recognise areas of difficulty that students face

The pre-test mean score for the theme of identifying students' areas of difficulty was 0.71, with a standard deviation of 0.24 (Table 3.5). After the intervention, there was a slight improvement and a decrease in score variability, as evidenced by the post-test mean score rising to 0.79 with a lower standard deviation of 0.21. The Cohen's d effect size was 0.35, indicating a "small effect," while the mean change was 0.08. This suggests that although there was some progress, the intervention had little effect on the students' capacity to identify their challenges.

Content

Theme K2.1: Understand nature of science/ mathematics.

In teacher- participants’ understanding of the nature of science / mathematics, the pre-test mean score was 0.71, with a standard deviation of 0.24. The post-test mean rose slightly to 0.76, with a standard deviation of 0.23. This resulted in a small change in mean of 0.05. Cohen's d for this change was 0.24, also categorised as a "small effect," indicating a limited influence of the intervention on enhancing students' understanding of the nature of science and mathematics.

Theme K2.2: Explain goals of teaching the subject

Regarding the theme of explaining teaching goals, the pre-test mean score was 0.80, with a standard deviation of 0.25, and the post-test mean increased slightly to 0.84, with no change in the standard deviation. The change in mean was 0.04, and the effect size, measured by Cohen's d, was 0.16, classified as a "very small effect." This suggests that the intervention had minimal impact on students’ ability to articulate the goals of teaching the subject.

Theme K2.3: Identify ‘Big’ ideas, key concepts and theories

In the theme focused on identifying "Big" ideas, key concepts, and theories, there was a notable improvement. The pre-test mean was 0.62 with a standard deviation of 0.20, and the post-test mean significantly increased to 0.82, with no change in the standard deviation. This substantial mean change of 0.20 resulted in an effect size (Cohen's d) of 1.00, classified as a "large effect." This indicates that the intervention was highly effective in enhancing students' ability to identify major ideas and concepts in the subject.

Theme K2.4: Sequence and connect between concepts within subjects and across grades

For the theme of sequencing and connecting concepts, the pre-test mean was 0.62, with a standard deviation of 0.29, while the post-test mean rose to 0.76 with a slightly lower standard deviation of 0.26. The change in mean was 0.14, and the effect size, measured by Cohen's d, was 0.51, categorised as a "medium effect." This suggests a moderate impact of the intervention in helping students understand connections within and across grade-level concepts.

Teaching and Learning

Theme K3.1: Select instructional strategies to support multiple forms of students’ engagement

In the theme focused on selecting instructional strategies to engage students in various ways, the pre-test and post-test mean scores both remained at 0.86, with a standard deviation of 0.13 for each, indicating no change in the average score or variability after the intervention. The change in mean was 0.00, and the effect size, measured by Cohen’s d, was also 0.00, classified as a "very small effect." This suggests that the intervention had no measurable impact on enhancing the ability to select instructional strategies that support diverse student engagement.

Theme K3.2: Evaluate resources for multiple forms of representing content

For the theme of evaluating resources to represent content in varied ways, the pre-test mean score was 0.65 with a standard deviation of 0.17. Following the intervention, the post-test mean increased slightly to 0.68, with a slightly lower standard deviation of 0.16, indicating a small increase in average score and a slight reduction in score variability. The change in mean was

0.03, with Cohen's d calculated at 0.18, categorised as a "very small effect." This suggests that the intervention had a minimal effect on teacher – participants' ability to assess resources for presenting content in multiple formats and applying UDL principle

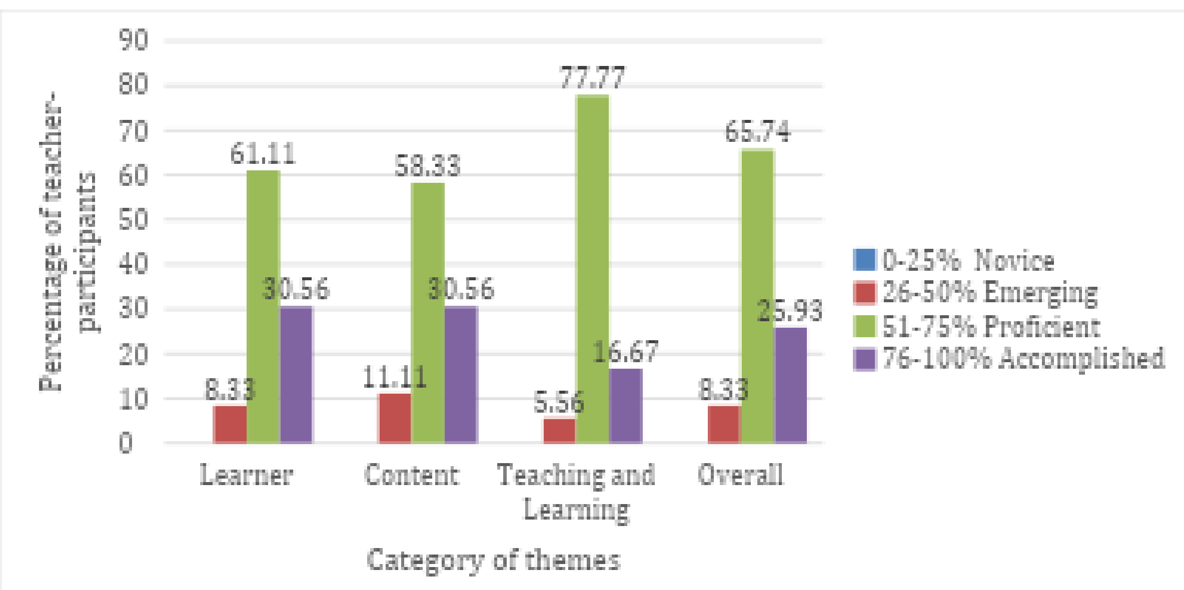
Theme K3.3: Choose multiple tools of assessments to encourage multiple modes of expression

For the theme addressing the choice of multiple tools of assessment to foster multiple modes of expression, the pre-test mean was 0.37 with a standard deviation of 0.20. The post-test mean increased slightly to 0.39, with a post-test standard deviation of 0.21, indicating a slight change in average score and a small increase in score variability. The mean change was 0.02, and Cohen's d was 0.10, indicating a "very small effect." This small effect size implies that the intervention had a negligible impact on students' ability to select diverse assessment tools for encouraging various forms of student expression.

3.6 Practice (Session plan and reflection together)

Overall, most teacher-participants (65.74%) are proficient in utilising the skills gained in their professional practices, with a 25.93% and 8.33% in emerging category. This indicates that the OER is successful in developing high level of competency in teacher-participants in addressing the needs of the learners in their teaching practices. In the learner theme has majority of teacher-participants (61.11%) in proficient category followed by 30.56% in accomplished and are proficient in the learner theme, indicating a strong grasp of OER's impact on their learning processes. A significant portion (30.56%) are accomplished, showing high competency in their teaching practice. In teaching and learning theme, 77.77% of teacher-participants are in proficient followed by 16.67% in accomplished and fewer participants (5.56%).

Figure 3.2: *Performance of teacher-participants in classroom practices*



The analysis of performance of the teacher-participants practices of the knowledge and skills gained form OER courses on Electromagnetism is given in Table 3.7.

Table 3.7: *Analysis of grading sheet on session plans and reflections*

Category	Theme	Overall Mean	SD	Meaning
1.Learners	P1.1 Promote inclusion and equity	1.35	0.33	Medium impact
	P1.2 Build on students' prior conceptions	1.47	0.36	Medium impact
	P 1.3 Address misconceptions and areas of difficulties	1.44	0.43	Medium impact
	Average	**1.42**	**0.37**	Medium impact
2.Content	P2.1 Use processes on science and mathematics	1.44	0.39	Medium impact
	P2.2 Facilitate higher order thinking	1.42	0.34	Medium impact
	P2.3 Plan to build students' competences to meet the goals of teaching science/ mathematics	1.34	0.38	Medium impact
	Average	**1.4**	**0.37**	Medium impact
3.Teaching and Learning	P3.1 Use instructional strategies for active learning	1.54	0.31	Large impact
	P3.2 Use multiple representations of content	1.53	0.25	Large impact
	P3.3 Create opportunities for multiple modes of expression	1.42	0.24	Medium impact
	P3.4 Use locally available materials	1.15	0.44	Medium impact
	P3.5 Link conceptual content to students' everyday life experiences and prior knowledge	1.18	0.53	Medium impact
	Average	**1.36**	**0.35**	Medium impact

The interpretation of mean value is shown in Table 3.8.

Table 3.8: *Interpretation of mean value*

Mean value(x)	**Meaning**
x < 0.50	Very small impact
0.50 <= x < 1.00	Small impact
1.00 <= x < 1.50	Medium impact
x >= 1.50	Large impact

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.

a. Learner

The data in Table 3.6, OER has medium impact the themes except for themes P3.1 and P3.2 which are in large impact. The following discussed the impact of the OER on various themes (Figure 3.2).

Theme P1.1: Promote inclusion and equity

This theme focuses on fostering a classroom environment that values diversity and fairness, allowing all students to feel included. The lower mean score (1.35) and moderate standard deviation (0.33) suggest that OER had medium impact in promoting the inclusion and equity in the teacher-participants professional practices in the classroom. The data practice aimed at inclusion and equity are implemented with a moderate level of consistency. The strategies used to promote inclusion and equity are group work and collaboration (5079, 8084, 5087, 5089), inclusive participation and gender sensitivity (5094), diverse learning styles and UDL principle, ensuring clarity and structure, building ownership and motivation and use of technology.
Participants 5100's lesson plan includes group work and encourages active participation, which provides opportunities for all students to contribute. While participant 5086 stress the use of class point app to understand each learner's ability and accordingly cater to their needs instantly.

Theme P1.2: Build on students' prior conceptions

Building on students' prior conceptions involves recognising and using their existing knowledge as a foundation for new learning. A mean of 1.47 shows medium impact of the OER in this area. The standard deviation of 0.36 suggests slight variability, indicating that while there is some consistency in the use of strategies in the practice that build on prior knowledge. Based on the evidences, the participants mention the emphasis of recapitulation, targeted questions and real-world connections. Participants 5086,5088, 5104 and 5113 mention the use of quiz question as warm up activity to gauge students' prior knowledge of electromagnetism. Participants 5095, 5096 and 5091 emphasise on asking questions in the beginning of the lessons while teaching electric motor, electromagnetic spectrum and relationship between the electric and magnetic field. Some also use the real-life experiences of the student in the particular topic. For example, Participant 5115 ask how electricity from power plants reaches their homes?

Theme P 1.3: Address misconceptions and areas of difficulties

Addressing misconceptions and difficulties is critical for deepening student understanding. This themes have a mean of 1.44 in medium impact category. However, the higher standard deviation (0.43) indicates greater variability, suggesting that while some instances effectively address misconceptions, other situations may require more targeted strategies to ensure consistency.

The evidence for this theme highlights a focused approach in identifying and addressing various student misconceptions in physics. The common misunderstandings such as the nature of magnetic force, differences between AC and DC currents, relationships between electricity and magnetism, and the operation of transformers and generators were tackled through explanations, hands-on activities, and demonstrations. Strategies like peer support, guided questioning, and simulations were also employed to clarify complex ideas, promote conceptual accuracy, and help students better understand foundational physics principles. The following are ways by which many participants tried to address the misconception in electromagnetism.
"Misconceptions such as thinking of magnetism and electricity as separate entities will be addressed through interactive demonstrations and discussions." (**5091**)
"A common misconception was that the magnetic force would act in the direction of the current. It is addressed through hands-on activities in the class." (**5088**)
"All spectrum of EM waves are harmful but no strategies to address." (**5087**)
"The misconception that transformers generate energy was addressed through explanation using examples." (**5115**)

b. Content

The impact of OER module on the category of “Content” falls in “Medium” as shown in Table 3.6 with average mean score of 1.4 and standard deviation of 0.37. The theme P2.1 Use of processes on science and mathematics is maximum (1.44) followed by P2.2 Facilitating higher order thinking skills (1.42) and P2.3 Plans to builds student’s competences to meet the goals of teaching science/ mathematics. The theme wise analysis is discussed in details in the following sections.

In the “content” category, the percentage of teacher-participants falling in the emerging level of classroom practices decreased to 22% and the percentage of teacher-participants increased to 58% in proficient level of classroom practice (Figure 3.2). This indicates that the performance of classroom practices is far better in the category of “content” than the category of “learner”.

Theme P2.1: Use processes on science and mathematics

The performance of teacher-participants in this theme has “Medium” impact of the OER module with (*M* =1.44 ; *SD* =0.39) as shown in the Table 3.6. This indicates that the teacher-participants integrate scientific processes like experimentation, simulation, and hypothesis testing, which are essential for hands-on science and mathematics learning. The moderately high impact score reflects that teacher-participants are regularly apply these processes in ways that align with scientific inquiry. Following are the evidences:

Teacher-participant 5077 mentions the exploration through simulations and discussion as a good to approach for the electromagnetism concept. Teacher -participants *5081* ask questions, demonstrates experiments, and ask students to making deductions. Teacher-participants *5100* encourages students to hypothesise, conduct experiments, and make observations, promoting scientific inquiry and process skills.

Theme P2.2: Facilitate higher order thinking

The performance of teacher-participants in this theme has “Medium” impact of the OER module with (*M* =1.42; *SD* =0.34) as shown in the Table 3.6. The medium impact indicates teacher participants’ emphasis on activities that develop student’s critical thinking, problem-solving, and application-based learning. Higher-order thinking is facilitated through inquiry-based questions, discussions, and real-world connections, helping students apply learned concepts meaningfully. Following are the evidences:

Teacher-participant 5077 use debate to discuss about the factor affecting Lorentz force.

Teacher-participant 5091 make use of question which are higher order questions like “What do you observe when the magnet is moved in and out of the coil? How does this relate to the generation of electric current?"'

"Asking students to explain the relationship between the rate of change in the magnetic field and the magnitude of the induced EMF." *(Teacher participant 5113*)

Teacher participant 5114 ask the student to differentiate the functioning of transformer on application of ac and dc.

Theme P2.3: Plan to build students' competences to meet the goals of teaching science/ mathematics

The performance of teacher-participants in this theme has a "Medium" impact of the OER module with (M=1.34; *SD* =0.38) as shown in the Table 3.6. This theme's moderate impact reflects the focus on activities and structured planning to develop students' competencies for understanding science and math goals. Participant teachers' emphasise skill-building and real-world applications, though further enhancement could better support diverse learners and deeper engagement. Examples of how teacher participants build student competences to meet the goal of teaching science are as follows:

Teacher participant 5077 outline the learning objectives and connected to achieve the goals.

Teacher participant 5077 allocate more time for activity-based learning to allow deeper engagement.

Teacher participant 5100 help students develop experimental and observational skills, critical for understanding Faraday's Law."

Teacher participant 5115 ask questions related to task performance.

c. Teaching and Learning

The overall impact of OER module on the category of "Teaching and Learning" falls in "Medium" as shown in Table 3.6 with maximum mean score of 1.36 and standard deviation of 0.35. However, for themes P3.1 and P3.2, the OER modules have large impact with mean 1.54 and 1.53 respectively.

Theme P3.1: Use instructional strategies for active learning

The performance of teacher-participants in this theme has "Large "impact of the OER module with (*M*=1.54; *SD* =0.31) as shown in Table 3.6. This indicates that the majority of teacher-participants use interactive strategies like group work, inquiry-based learning, use of technology and examples from real life to foster active learning. Following are evidences to support this:

Teacher participants 5090, 5106 and 5113 use group work and collaboration in discussion.

Teacher participants *5081, 5091, 5100 and 5114* uses inquiry-based activities with real-life examples, simulations, and hands-on tasks.

Teacher participant 5088, 5103 and 5115 use active participation through experiments, open-ended questions, and student inquiry.

Theme P3.2: Use multiple representations of content

The performance of teacher-participants in this theme has a "Large impact" impact of the OER module with (*M*=1.53; *SD* =0.25) as shown in Table 3.6. This indicates that the majority of teacher-participants are able to present information of the lesson in different ways through the use a variety of methods: visual aids, simulations, diagrams, and hands-on materials to represent concepts and address different learning styles, helping students grasp complex ideas more effectively. Some examples are as follows:

Teacher participants *5077, 5083, 5085, 5090, 5102, 5111* uses simulations and diagrams (PhET, PPTs, whiteboards) to visualise concepts.

Teacher participants *5081, 5086, 5104, 5106, 5115 u*se of animations, charts, and visual representations (electromagnetic spectrum charts, diagrams).

Teacher participants *5095, 5096, 5108, 5113* use practical demonstrations (motors, physical apparatus), videos, and real-life examples to reinforce content.

Theme P3.3: Create opportunities for multiple modes of expression

The performance of teacher-participants in this theme has a “Medium” impact of the OER module with (M=1.42; *SD* =0.24) as shown in Table 3.6. This indicates that the teacher-participants provide students to express their understanding through multiple modes such as verbal discussion, written tasks, and group activities. This allows diverse forms of participation and deeper engagement with the content.

Some of the examples are as follows:

Teacher participants *5077, 5080, 5097, 5107 and 5110* use presentations, oral responses, and sharing observations.

Teacher participants *5081, 5095, 5102 and 5114* make use of question-and-answer sessions, written assignments, and homework tasks.

Teacher participant *5084, 5098, 5109, 5111 and 5113 use p*ractical tasks and written observations to demonstrate knowledge.

Theme P3.4: Use locally available materials

The performance of teacher-participants in this theme has a “Medium” impact of the OER module with (M=1.15; *SD* =0.44) as shown in Table 3.6. This indicates that the teacher-participants integrate accessible, locally sourced materials, such as magnets, coils, and batteries, for experiments and demonstrations, but some rely more on digital resources.

Following are evidences to support this

Teacher participants 5080, 5095, 5107, 5111, 5113 make use of magnets, wires, batteries, and other everyday items to conduct experiments.

Teacher participants *5084, 5091, 5103, 5109, 5115* rely on locally sourced and classroom-based physical materials (e.g., nails, paper pins).

Teacher participants *5102, 5108, 5114* emphasize on ICT tools and simulations (PhET) rather than local materials or when the materials are not available.

Theme P3.5: Link conceptual content to students' everyday life experiences and prior knowledge

The performance of teacher-participants in this theme has a "Medium" impact of the OER module with (M=1.18; *SD* =0.43) as shown in Table 3.6. This indicates that the teacher-participants occasionally connect lesson content to students' daily experiences, especially in topics such as electromagnetic induction and real-world applications, though there may be more opportunities to deepen these connections.

Supporting evidence are as follows:

Teacher participants *5077, 5087, 5100, 5106 and 5114* make use of real-life applications of electromagnetic induction in generators, transformers, and mobile technology.

Teacher participants *5095, 5098 and 5110* use discussion of devices and concepts related to daily life (e.g., motors, household appliances).

3.7 Social learning in Community of Practices (CoPs) on telegram platform

3.7.1 Frequency of posts

Table 3.9: *Frequency of posts by participants*

Role	**Number of posts**
Teacher- Participants	151
Teacher- Educators	97
Total	**248**

The interactions among three teacher-educators and 36 teacher-participants in the physics group's CoP on Telegram platform, "CL4STEM_TOT_Physics," from 16th July to 5th September 2024 as shown in Table 3.9, indicate that the total number of posts by teacher-participants is lower compared to those by teacher-educators.

3.7.1 Frequency of posts by content and types

Table 3.10: *Frequency of posts by content*

Frequency of posts by content	**Number of posts**
PCK	2
UDL	0
Technical	15
Communication/ Administrative	24
Total	**41**

Table 3.11: *Frequency of posts by type*

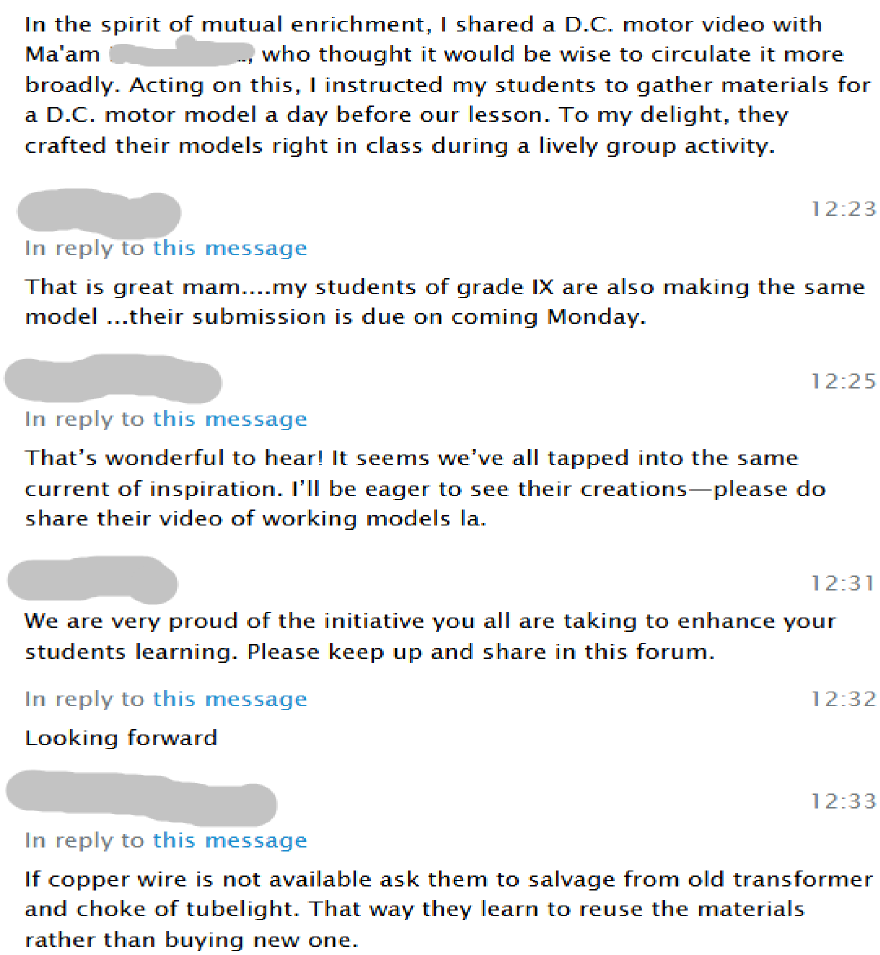
Frequency of posts by types	**Number of posts**
Voice messages	0
Video files	4
Photos	32
Files	5
Total	**41**

Table 3.10 presents the frequency of posts by content during the implementation of the "Electromagnetism" module. In total there are 42 which is lower than total reflected in Table 9. The total message includes all the messages posted by the group members. Only total message of 42 was found to fit in the category given in Table 3.10. The majority of the messages were related to communication and administration followed by technical and PCK. There was no post related to UDL. The majority of the post includes photos or screenshot of the technical problem and the progress of the course. Some videos of the motor designed by the student were shared.

3.8 Qualitative dialogues/ discussion threads

On CoP telegram platform "CL4STEM_TOT_Physics", the teacher-participants 5097 shared a video of dc motor designed by the student as a part of an activity. It has generated the following discussion (Figure 3.3)

Figure 3.3 *CoP discussion*


In the spirit of mutual enrichment, I shared a D.C. motor video with Ma'am .., who thought it would be wise to circulate it more broadly. Acting on this, I instructed my students to gather materials for a D.C. motor model a day before our lesson. To my delight, they crafted their models right in class during a lively group activity.

12:23
In reply to this message
That is great mam....my students of grade IX are also making the same model ...their submission is due on coming Monday.

12:25
In reply to this message
That's wonderful to hear! It seems we've all tapped into the same current of inspiration. I'll be eager to see their creations—please do share their video of working models la.

12:31
We are very proud of the initiative you all are taking to enhance your students learning. Please keep up and share in this forum.

In reply to this message 12:32
Looking forward

12:33
In reply to this message
If copper wire is not available ask them to salvage from old transformer and choke of tubelight. That way they learn to reuse the materials rather than buying new one.

Apart from the discussion in the COP, the teacher-participant also has option to discuss about the concept of electromagnetism using the discussion forum in the module. Teacher participant 5093 posted doubts and question on magnetic field due to current carrying wire (Figure 3.4). Teacher participant 5104 suggested to use of physics Lab simulation.

Figure 3.4 *Use of discussion forum*

DOUBTS AND QUESTIONS
by Teacher participant 5093 - Sunday, 28 July 2024, 8:34 PM

Doubts and Questions

1. Influence of Wire Thickness and Material: How does the thickness and material of the wire affect the strength and distribution of the magnetic field around it?

2. Earth's Magnetic Field Interference: How does the Earth's magnetic field influence the observations in Oersted's experiment? Is there a way to minimize this interference?

3. Field Lines Visualization: Are there methods or tools to better visualize the magnetic field lines around a current-carrying conductor in a classroom setting?

Re: DOUBTS AND QUESTIONS
by Teacher participant 5104 - Sunday, 4 August 2024, 8:16 AM
3- Use Ophysics Lab simulation

The discussion forum was also created in the module for the teacher participants to share the DC motor designed by their student. Variety of motor were shared in the forum. Figure 3.5 show the dc motor designed by students of teacher participant 5099, 5077, 5088, 5097, 5115, 5091, 5095 and 5086.

Figure 3.5. *DC motor design submitted by participant teacher.*

There was also discussion on confusion of using Right Hand Palm Rule and Fleming Right Hand rule given in Figure 3.6.

Figure 3.6. *Forum discussion on Right Hand Palm Rule and Fleming Hand Rule.*

Electromagnetism

Re: Electromagnetism

by Teacher participant 5091 - Tuesday, 20 August 2024, 10:20 PM

It's common for students to find the right-hand palm rule and Fleming's right-hand rule confusing, as they involve similar hand movements but apply to different situations in electromagnetism. By breaking down when and how to use each rule, students are more likely to grasp the differences and apply them correctly. For example, you could have students physically demonstrate the rules using their hands while working through specific problems.

Re: Electromagnetism

by Teacher participant 5081 - Sunday, 18 August 2024, 11:42 AM

As per my observation, students understand more when RHPR is used instead of Fleming's left-hand rule

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

3.9.1 Participation of teacher-participants

The implementation of this module was somewhat challenging at the beginning because the teacher-participant were engaged in preparing the mid-term results. Few of teacher participants had difficulty completion of the module on time but with time extension, they were able to complete the module. The module was designed to be interactive in nature with immediate feedback provided on their learning activities through lesson, interactive videos (H5P), online quiz questions, peer assessments and discussion forum. The OER module was designed so that participants could resubmit their answers until they got them correct, allowing them to progress to the next lesson. This approach encouraged participants to clarify their mistakes and experience a sense of accomplishment. However, teacher participant 5099 preferred the content to be kept open without any restrictions. Teacher participants 5110, 5099 and 5109 found the activities/ experiment interesting and enriching.

Though, a discussion forum was created on the Moodle platform for each unit, it was not fully utilised as intended. The CoP Telegram platform facilitated daily communication between teacher-educators and teacher-participants regarding module progress, announcements, reminders, concerns, good practices, and any issues related to the module. All teacher-educators and teacher-participants actively engaged in these discussions, in addition to personal chats. This ensured that the good progress of module.

3.9.2 Challenges

There following challenges were faced during the implementation of this OER module.

1. Timely completion of the course

Some teacher participants had difficulty completing the course on time. A time extension was given for the teacher participants to complete the course. These teacher participants had to be reminded on the CoP time and again.

2. Workshop feature (Peer-review)

The workshop feature on Moodle for peer assessment is good for randomly assigning, reviewing and grading peer's lesson. There is no provision to incorporate two types of observers/evaluators (face-to-face and online) into the workshop feature. Face-to-face observers/evaluators are the focus group's supervisors in the schools, whereas online observers/evaluators are the peers assigned on Moodle who grade their peers' lessons by watching the teaching videos shared. This could be solved by enrolling external evaluator or observer to the course.

3.9.3 Surprises

1. Not much of discussion on PCK and UDL on CoP compared to the previous implementation.

There were not many posts on CoP on PCK and UDL. The posts are mostly related to technical problem faced in the module. However, there were few discussions on the Discussion forum in the module. To ensure the teacher participant actively engage in discussion, the discussion could be mandatory in the subsequent course.

3.9.4 Any changes required in the module design

This module requires no major changes in the activities. However, to address the issue raised by teacher participant 5099, the setting of lesson can be changed to allow free navigation in the activity and also to allow multiple attempts.