



The Impact of the OER Module ‘Force and Motion’ on Physics Teachers’ Knowledge and Practices

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Abstract

Students' performance in STEM subjects is a growing concern globally, with coinciding factors cited, as ineffective teaching methods, students' lack of interest, and the abstractness of STEM content. This study in particular investigated the impact of an Open Educational Resource module on teachers' understanding of Force and Motion. The goal was to enhance the professional efficacy of Secondary School Science and Mathematics teachers, promoting an inclusive and equitable higher-order learning in their classrooms with the help of OER. A mixed-methods approach was employed, involving 36 teachers from 32 different schools. Data collection included pre-tests and post-tests, evaluations of lesson plans and reflections, assessments of teacher participation in a community of practice and the Moodle platform, and interviews. Findings indicated a modest yet positive shift in teachers' content knowledge, with an increase in the number of participants classified as 'accomplished' in post-test assessments. While teachers demonstrated the improved awareness of their students' needs and engagement strategies, challenges still remain in effectively integrating Universal Design for Learning principles and diverse assessment methods. The study highlights the importance of ongoing professional development and clearer guidelines to support teachers in implementing these practices. Recommendations for future research include longitudinal studies to assess the long-term effects of OER modules on teaching practices and student outcomes.

Keywords: Open Educational Resource, Community of Practice, module, Universal Design for Learning, learners, content, teaching and learning

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Introduction

Students' performance in STEM subjects is an international concern and Bhutan is no exception. There are numerous reasons cited for the poor performance amongst which the most prominent ones are the ineffective teaching methods used (Erinosho, 2013), students' lack of interest towards the subject (Gudyangal & Kurup, 2017) and the poor mathematical knowledge (Hamel, 2016). Beside these, other causes cited for Bhutanese students' poor performance are the abstract nature of STEM subjects (Dorji et al., 2023) and negative attitude towards the subjects (Wangchuk, 2022). The Connected learning for Science Technology Engineering and Mathematics (CL4STEM) Project, 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), Bhutan, and Open University, Tanzania (OUT), with the Tata Institute of Social Sciences, India (TISS) serving as the technical consultant, aimed to enhance the capacities of secondary school teachers in science and mathematics, promoting inclusive and equitable higher-order learning in their classrooms through the use of Open Educational Resources (OER). As part of the project, three OER modules each were developed in Physics, Chemistry, Biology, and Mathematics. In each subject, a partner country led the creation of one module and other partner countries adapted these modules to fit their local contexts. The modules were offered to select schools in respective countries as part of the project implementation in 2022. To study the outcome of this implementation, an impact study by Utha et al. (2024) was carried out. Though there were positive findings, they reported several limitations out of which one important limitation was that the implementation took place only on 20 teachers in 7 different schools. Out of these, 10 were pre-service teachers who were on field practicum and they could barely manage time. Hence, the study findings could not be generalised.

The project expanded its reach by implementing revised modules to other teachers of secondary schools in Bhutan. Based on the feedback received from the first phase implementation in seven secondary schools, the module was reviewed and updated to align with the latest National (Bhutan) Science Curriculum Framework. The review simplified the module and enhanced its effectiveness by:

- clearly articulating competency-based teaching and learning objectives for each lesson;
- reducing the number of lesson plans and reflections requirement;
- integrating online components of assessments within activities for easy evaluation and quick feedback;
- multiple opportunities for participants to attempt activities and receive instant feedback; and
- opportunity to undertake peer assessment.

The revised module comprises of four units designed to enhance teachers' Subject Matter Knowledge (SMK), Pedagogical Content Knowledge (PCK), and General Pedagogical Knowledge (GPK). The module includes activity-based learning with the framework of technology integration, Universal Design for Learning (UDL) principles and Design Thinking. Before implementation, all participating teachers received professional development on the principles of UDL, the Design Thinking approach, and the integration of technology in the teaching, learning, and assessment processes. They were introduced to the peer assessment process on the Moodle platform. The Heads of Departments (HoDs) and selected subject experts were

trained in conducting classroom observations. This study examined the impact of the implementation of the "Force and Motion" module in secondary schools in Bhutan during the scaling-up phase, by focusing on the following research question: How has the implementation of the OER module on Force and Motion impacted physics teachers' knowledge across the categories Learners, Content, and Teaching and Learning?

Literature Review

The literature review is broadly presented under three themes namely STEM and its associated challenges, Open Educational Resources and its benefits, and Community of practice.

STEM and its Associated Challenges

Students' engagement, interest and performance in school science and mathematics is an international concern (Renninger, Nieswandt, & Hidi, 2015). In Bhutanese secondary schools too, majority of the students are reported to face challenges in learning science and mathematics (Dorji et al., 2023) and physics is said to be the most difficult and least interesting due to its abstract nature, and numerous calculations requiring mathematical knowledge (Utha et al., 2023; Zangmo, 2016). Wangchuk, (2022) reported that there is a common preconception among students, teachers and the public in general that a science subject especially physics is difficult. The numerical problem solving which requires mathematical knowledge was also tinted as a challenge in learning physics by Hamelo (2016) who studied the students' interest towards physics in Ethiopia. Besides, students' poor attitude towards physics, lack of motivation, lack of teaching and learning resources, and the type of teaching methods implemented by the teacher were also reported to be the reason for students' poor learning in Physics as early as 2013 (Erinosho, 2013). Gudyangal and Kurup (2017) further reported that the attitude towards physics is dependent on the interest towards the subject. Their study on the Zimbabwean female participation in physics reported that those students who have interest towards physics develop positive perspective towards learning physics, and vice versa. They also reported that the female students develop the opinion that the subject is irrelevant for their future, difficult and masculine in nature causing them not to opt physics to study. Besides, teachers are often said to adapt traditional teaching approach even in the digital era. Often practical issues like network connectivity, lack of engagement, infrastructure and adaptability were cited for it (Verma & Verma, 2022). Other issues cited are the STEM concepts being not relatable and observable leading to difficulty in learning (Utha et al., 2023). It is also reported that STEM activities are difficult to design (Sangue et al., 2023).

Open Educational Resources and its Benefits

It is defined as teaching, learning, and research resources that reside in the public domain or have been released under an intellectual property license that permits their free use and re-purposing by others (William and Flora Hewlett Foundation, 2013). They are freely accessible educational materials designed for teaching, learning, and research, which was first introduced in 2002, UNESCO Forum on the Impact of Open Courseware for Higher Education in Developing Countries (UNESCO, 2002). The primary goal of OER was to empower the educators and learners by providing quality, adaptable resources that will be free of cost, and also universally accessible. Besides being cost-effective, both educators and students reported the importance and perks of having access to the learning resources immediately (Willer, 2015). Hilton (2016) in his review of

literatures on OER, indicated that learners preferred engaging with OER over traditional textbooks though there wasn't much difference in the learning outcome.

In terms of benefits of subject specific OER, research is limited. Research indicates that the use of OER can lead to improved student performance, especially in subjects such as mathematics and biology (Hilton, 2016). For instance, some studies demonstrate higher passing rates and better overall grades when OER materials are utilised compared to traditional textbooks (Colvard et al., 2018). Utha et al. (2024) in their study on implementation of physics OER modules reported that participating teachers have developed a varied levels of Subject Matter Knowledge, Pedagogical Content Knowledge and General Pedagogical Knowledge which could positively influence their ability to effectively teach the subject matter.

Community of Practice

Originating from the work of Etienne Wenger and Jean Lave, Community of Practice (CoP) emphasises the importance of social interaction in learning processes. Wenger (1998), outlines the key elements of CoP as a shared domain of interest, a community of individuals that engages in mutual learning, and a practice that evolves through shared experiences and resources. This framework positions CoPs as essential not only in educational settings but also within organisations, where it can enhance innovation and foster a culture of continuous learning. Abigail (2016) in his study indicated that CoP could make a difference to the educators' practices through actual application of knowledge, tools and social relationships. The collaborative nature of OER supports the development of communities of professional learning among the educators. This community aspect encourages teachers to share experiences and best practices, leading to improved instructional methods (Pitt, 2015). Further, there is a strong influence of teachers' social networks on teacher participation, attitudes towards the professional development opportunity, and ability to understand and implement these ideas (Baker-Doyle & Yoon, 2010).

The challenges associated with maintaining engagement in Communities of Practice (CoP) are also highlighted by Utha et al. (2024), emphasising that these issues persist within the context of Bhutanese secondary school teachers. Commonly cited obstacles include a lack of time and emotional barriers, such as the fear of asking questions that might be perceived by others as overly simplistic.

Methodology

Aligning with the implementation process and evaluation planned, a mixed-method approach was employed to collect data for this study. The data were collected administering a pre-test and post-test, evaluation of lesson plans and reflection, teacher participation on CoP and Moodle, and individual interviews. For evaluation, all the data set used the same three pre-determined categories—Learners, Content, and Teaching and Learning.

The pre-test consisted of 45 multiple-choice questions (MCQs). The same test was used for post-test. The test items were supposed to be completed within the given time limit. The pre-test assessed participants' initial understanding, while the post-test measured progress and the module's effectiveness revolving around the three categories.

All the teacher participants were required to plan two lesson plans, implement in the class and write a reflection. The implementation of first lesson plan was observed by a peer or a focal person (Head of the Department or a senior teacher) who were mandated to grade and also provide feedback. Since, many of the peers were not from the same school, lesson implementation was video recorded and shared. The peers used the peer assessment forum available on the Moodle

Platform-Virtual Learning Environment. The same lesson plans and reflections were also evaluated by the teacher educators. Since the lesson implementation was not observed by the teacher educator, they used the video recorded lesson for grading.

Teachers' participation was qualitatively measured using their activities on the Moodle interface, number of messages sent and nature of interactions in the online Telegram CoP created by the teacher educators. It served as a virtual space for teachers to share their practices without evaluation or judgment. It remained open throughout the duration of the OER offered. Further, interviews were conducted with eight teachers to get an in-depth understanding of the implementation and the effectiveness. The interviews focused on the same themes used for evaluation of lesson plans.

A total of 36 teachers from 32 schools under 15 dzongkhags participated in the study. The teachers teaching in secondary schools were selected based on competitive application process and with a teaching experience of three years and above. Since only a few female physics teachers applied for this module implementation, preference was given to them. In total, 4 female teachers participated in the study.

Findings

All the teacher participants successfully completed the module and its assessment components.

Pre-test and Post-test

Scores from both tests, originally out of 45, were converted to 100. The average score for teacher participants in the pre-test was 59.32%, which increased to 62.01% in the post-test. Although the increase was slight, it suggests that teacher participants' performance improved as a result of undertaking the OER module on Force and Motion. A teacher participant (T5104) aptly expressed this:

One thing is the course, which your college offered. It was informative and I think for many participants, it was eye opening because of lots of activities which we can now use, those resources, which we can duplicate in our classroom. I would like to thank your college for giving such opportunity.

The analysis of the test performance in terms of scores received is as shown in Table 1.

Table 1

Performance of the Teacher-participants in Pre-test and Post-test

Test	Categorisation of teachers as per the score in percentage			
	Novice (0-25%)	Emerging (26-50%)	Proficient (51-75%)	Accomplished (76-100%)
Pre-test	0	11	24	1
Post-test	1	4	24	7

Although the average score increase was small, Table 1 highlights the significant benefits of the OER for teachers. In the pre-test, most teachers fell into the 'emerging' and 'proficient' categories, with only one reaching the 'accomplished' level. By the post-test, the number of teachers in the 'accomplished' category rose to seven, while those classified as 'emerging' decreased from 11 to

four. One teacher dropped to the 'novice' level, likely due to time constraints during the test as some teachers reported on Telegram that network fluctuations prevented them from completing the test.

To further assess changes, the pre- and post-test data were categorised by theme (see Table 2) and analysed by calculating the mean and standard deviation for each theme.

Table 2
Category and Theme wise Analysis of Pre- and Post-test

Category	Themes	Pre test		Post test	
		Mean	SD	Mean	SD
Learners	K1.2 Recognise students' prior conceptions and misconception	1.78	1.02	1.92	1.08
	K1.3 Recognise areas of difficulty that students face	2.36	1.38	2.78	1.44
Content	K2.1 Understand nature of science/mathematics	2.72	1.09	3.17	1.18
	K2.2 Explain goals of teaching the subject	4.72	0.66	4.56	1.08
	K2.3 Identify 'Big' ideas, key concepts and theories	3.72	0.97	2.63	1.13
	K2.4 Sequence and connect between concepts within subjects and across grades	3.72	0.97	4.13	0.97
Teaching and Learning	K3.1 Select instructional strategies to support multiple forms of students' engagement	3.19	0.66	3.30	0.92
	K3.2 Evaluate resources for multiple forms of representing content	2.90	0.65	2.63	0.79
	K3.3 Choose multiple tools of assessments to encourage multiple modes of expression	2.42	1.12	2.82	1.06
Total Average		3.06	0.95	3.14	1.07

The mean interpretation of the pre- and post-test is adapted from Alston and Miller (2002) as reflected in Table 3.

Table 3
Mean Interpretation and Distribution of Values

Sl. No	Mean Range	Interpretation
1	1.0 -1.49	Very small effect
2	1.5-2.49	Small effect
3	2.5-3.49	Medium effect
4	3.5-4.49	Large effect
5	4.5-5.00	Very large effect

The findings and discussion from Table 2 is presented category wise as follows.

Learners - For Theme K1.2, there was a small effect observed. The modest increase in mean from $M=1.78$ ($SD=1.02$) to $M=1.92$ ($SD=1.08$) suggests some minor improvement, though not significant enough to indicate a meaningful change in participants' performance or understanding. In the interview, all the teachers expressed that comprehending students' prior knowledge is important and is used in every lesson to connect with the concept to be taught, their importance and use of prior knowledge. In terms of misconceptions, teachers were of the view that it exists in most physics' topic (T5104, T5077, T5108, T5115). Specifically, T5108 expressed, "So, of course misconception is there in every topic". They use simulation, and videos (T5104), concept mapping (T5108), use of life examples and demonstration (T5115) and hand-on activities (T5077). However, additional efforts may be needed to achieve more substantial advancements in this area. Theme K1.3 showed a significant improvement in teacher participants' scores, with the pre-test mean indicating a small effect that increased to a medium effect in the post-test. The interview analysis also showed that teachers were aware of students' difficulties in learning. Besides many difficulties, parents' literacy was mentioned by T5108 and T5115 as one factor whereby educated parents children performed better as their parents prioritised their children's learning by making time and space available for them at home. Another difficulty was to support the students with Special Educational Needs (SEN). A teacher (T5077) mentioned how the module implementation helped to make a positive difference in SEN students learning:

After taking the course by OER, I think it helped me a lot because when I used to plan and teach, I used the same lesson plan and I do not consider their background. So, the new lesson plan format that we had to undertake considered all the backgrounds especially due to the students with learning difficulties. My school is SEN school with around 8 students who have very high learning difficulties. So, for them, I have to plan different activities and modify the activities. When I assign work, I have to give them special attention. I have to change my instruction. So, this modification, adaptations I give so that they understand my lessons. And assessment also I do not use the same assessment for those who are performing and students who are from SEN background. For those students from SEN background, I keep on checking in their works. Now I'm confident and then they are also comfortable with the flow of the lesson.

These reflect a positive shift in teachers' awareness of student difficulties and the implications of the module offered. This suggests opportunities for further enhancement in this area.

Content - Theme K2.1 showed significant improvement post-intervention, reflecting a positive change in teachers' understanding. Conversely, Theme K2.2 revealed a slight decline in the mean suggesting that the intervention may not have effectively enhanced their existing knowledge. In the interviews also, most teachers gave very basic objectives of teaching physics like it is important as it tell us how nature works. In Theme K2.3, which focuses on identifying key concepts and theories, the mean score fell significantly from 3.72 (SD=0.97) to 2.63, indicating that some teachers struggled more after the intervention. However, Theme K2.4 demonstrated improvement, with the mean score rising from 3.72 (SD=0.97) to 4.13 (SD=0.97), indicating substantial enhancement in teachers' abilities to connect concepts effectively.

Teaching and Learning -The analysis of teaching and learning themes revealed some mixed outcomes. In Theme K3.1, the mean score showed small improvement suggesting a modest enhancement in teachers' ability to select effective strategies. While in the interview some teachers mentioned using UDL principles and Design Thinking approaches shared to them as professional development before the implementation, almost all the lesson plans lacked mention of it. In Theme K3.2, the mean score decreased from 2.90 (SD=0.65) to 2.63 (SD=0.79), indicating a decline in understanding, while the increased variability suggests that some teachers struggled more. However, most teachers mentioned using online resources like videos and simulation which are freely available online. Some of the criteria they used in evaluating the effectiveness of the resources are its standard, content, and preciseness in explanation as expressed by T5104:

When I look for the resources, I always see the one is the standard. If I want to teach in Class 9, I always see that that content whether the content is in that level or not. Then another criterion which I always look is based on the objective, whether that content is really helpful to fulfil my objective or not. These are some of the two these which I look... I have some few sites which I understand like Khan academy. In terms of video, in terms of concept that was very precise and I always look for that one thing. Another, I have a few authors in YouTube, who can explain that concept very precisely, especially for class 12, at least look for.

The Theme K3.3, focusing on choosing multiple assessment tools, showed slight improvement, with the mean score rising from 2.42 (SD=1.12) to 2.82 (SD=1.06). This change reflects a small enhancement in understanding, although it did not result in widespread changes in practice among teachers. In the interviews, most teachers mentioned the use of questioning as assessment tools only.

Lesson Plans and Reflection

The analysis of lesson plans and reflection was carried out using the mean and standard deviation for each theme under each category as reflected in Table 4.

Table 4
Analysis of Grading Sheet on Lesson 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
	P2.1 Use processes on science and mathematics	1.29	0.37	Medium
	P2.2 Facilitate higher order thinking	1.30	0.29	Medium
2.Content	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
	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
3.Teaching and Learning	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 5. It is based on the general project team agreement.

Table 5
Interpretation of mean value

Mean value(x)	Meaning
$x < 0.50$	Very small impact
$0.50 \leq x < 1.00$	Small impact
$1.00 \leq x < 1.50$	Medium impact
$x \geq 1.50$	Large impact

As shown in Table 4, all the themes under the three categories showed that the OER module had positive medium impacts on the teachers. The theme wise analysis under three categories is explained below.

Learner - This category has an average mean of 1.22 (SD= 0.42) indicating a medium impact. The theme “Promote Inclusion and Equity” focused on teachers’ abilities to create inclusive opportunities for all students and had a mean of 1.20 (SD= 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. Many of the teachers used group work to encourage collaboration and interactions among students, with some using mixed-gender grouping (T5115, T5111, T5097). Some provided specific support, like helping anxious students (T5091), and using the ClassPoint app for individual care (T5086).

The theme "Build on students’ prior conceptions" had a mean of 1.33 (SD=0.32), indicating a positive but moderate effectiveness. All teachers recapitulated previous lessons or what was learnt in lower grades through questioning. For example, teacher 5094 engaged students by linking new lessons to previously learned concepts like Newton's laws, while teacher 5092 discussed everyday experiences of push and pull to activate prior knowledge.

The theme "Address misconceptions and areas of difficulties" had a mean of 1.13 (SD=, 0.57), indicating a medium impact. While teachers recognise the need to address misconceptions, many (T5109, T5107, T5106, T5098, T5096, T5084, T5080) struggle to effectively integrate this focus into their lessons. Four teachers scored '0' in this area. They noted misconceptions but did not provide strategies for addressing them. Few employed discussions and questions to clarify misunderstandings.

Content - This category focused on the use of processes in science and mathematics, fostering higher-order thinking, and planning to enhance students' competencies in achieving educational goals in the subject. With a mean of 1.29 (SD= 0.37), this category suggests a medium impact of OER on teachers. All the three themes individually also had a medium impact. The theme "Use processes on science and mathematics" focusing on teachers encouraging students to hypothesise or draw conjecture while teaching concepts, some teachers broadly mentioned using experimentation and problem-solving, others provided specific examples. For instance, teacher 5102 encourages students to observe and test hypotheses through real-life demonstrations, asking questions like, “What would happen if there were no friction?”, and Teacher 5103 had students design group activities to demonstrate Newton's second law. On the theme "Facilitate higher order thinking", students higher order thinking skills were facilitated through problem solving, graph interpretation and connecting the concepts with everyday life examples (T5095, T5104, T5090, T5088, T5087). A teacher also used extended activity to activate the students’ higher order thinking (T5096). The theme "Plan to build students’ competences to meet the goals of teaching science/mathematics" received a slightly lower mean compared to the other themes indicating 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.

Teaching and Learning - This category includes themes on the use of instructional strategies for active learning, use multiple representations of content, creating opportunities for multiple modes of expression, use of locally available materials, and linking conceptual content to students’

everyday life experiences and prior knowledge. It had an overall mean of 1.31 (SD= 0.40) indicating a medium impact. All the individual themes also had medium impact.

On the teachers' use of instructional strategies for active learning, almost all the teachers used group work. Few teachers used other strategies like gamification (T5106), guided learning (T5103), experiential learning (T5099), and 5E model (T5097). Before implementing the OER, the teachers were introduced to strategies like Design Thinking and Inquiry learning. However, the implementation of these strategies was not successful. This has been pointed out by Krelja Kurelovic (2016) in his study on the advantages and limitations of usage of OER, that spreading of OER is hindered by teachers' educational practice which is mostly founded on traditional teaching and learning methods.

On the use of multiple representations of content, teachers are somewhat positively influenced by the module to incorporate various ways of presenting information. While many teachers provided opportunities to some students to either answer questions or make a presentation, not every student seems to have got an opportunity. On the use of locally available materials, the teachers' use of materials was more of what is available in the science laboratory or what they owned rather than what would be available locally. For example, some resources used were weights, a stopwatch, graph paper, mobile phones, etc. However, there are ample use of simulation and videos.

The theme "Link conceptual content to students' everyday life experiences and prior knowledge" though had a medium impact, it received the lowest mean of 1.15 (SD= 0.51) among other themes in the same category suggesting that teachers are incorporating this practice into their instruction. In the interview, it was mentioned that student's prior knowledge is used in almost all the lessons.

Teacher Participation on CoP and Moodle

Participation on Community of Practice - Table 6 details the frequency of posts made by 36 teachers and 3 teacher educators, showing a total of 392 posts, with educators contributing 245 and teachers 147.

Table 6
Frequency of Post by Teachers and Teacher Educators

Role	Number of posts
Teachers	147
Teacher educators	245
Total	392

The posts were categorised into PCK, UDL, technical issues, and administrative communication (Table 7).

Table 7
Frequency of Post by Content

Type of Posts	Number of posts
PCK	2
UDL	0
Technical	61
Administrative Communication	582
Total	645

Most posts were related to administrative matters (582), followed by technical posts (61), while PCK had only 2 posts and UDL had none, indicating teachers faced minimal challenges in module implementation. Some teachers, however, did seek clarification on specific issues through personal Telegram chats with educators. Though the UDL was offered as PD before the implementation of the OER, their use is hindered by the educational practice which is mostly founded on traditional teaching and learning methods.

Participation on Moodle - Teachers displayed strong engagement on Moodle, aided by their prior experience with the first OER module, which equipped them with essential skills for lesson planning, video recording, and peer assessment. This familiarity fostered confidence and allowed them to focus effectively on new content in the second module. Further, each educator supported a group of 12 teachers, facilitating personalised assistance and regular communication, maintaining regular participation. They provided reminders and were responsive to queries, which contributed significantly to the overall success of the engagement. However, time constraints emerged as a central challenge for all. Teachers struggled to balance module activities with regular teaching responsibilities, impacting their engagement with content and deadlines. Educators had the ongoing task of monitoring participation and sending reminders, requiring a careful balance of persistence and understanding. Additionally, the peer assessment process proved stressful due to the requirement for timely submission of lesson plans, which sometimes led to delays and added pressure on both teachers and educators. The peer feedback on lesson plans was often limited to grades rather than detailed comments, reducing the effectiveness of peer reviews. The requirement to video record lessons and compress files further complicated matters, as many participants were unfamiliar with the necessary technical skills, highlighting a need for clearer guidelines and support. Furthermore, using personal mobile phones for video recordings often failed to capture comprehensive classroom interactions, suggesting a need to streamline these requirements for a better learning experience.

Discussion

The findings indicate a modest yet positive impact of the OER module on teacher participants' understanding of Force and Motion. The categorisation of teachers also shifted: while most were classified as 'emerging' or 'proficient' in the pre-test, the number in the 'accomplished' category rose from one to seven in the post-test, indicating effective support for some teachers in advancing their understanding. This improvement suggests that engagement with the OER content facilitated some degree of learning, consistent with findings from Weller et al. (2015) that highlight the absence of negative effects from OER on performance. However, the experience of one teacher dropping to the 'novice' level probably due to network instability underscores the challenges that can arise during assessment, highlighting the need for reliable infrastructure to facilitate effective learning experiences (Konkoi et al., 2021; Verma & Verma, 2022).

The discussion of the findings is further organised according to three predetermined categories: Learners, Content, and Teaching and Learning, along with an analysis of teacher engagement in the CoP and the Moodle platform.

Learner - The analysis of both pre- and post-test data, and lesson plans and reflections under the learners' category reveal important insights into teachers' understanding of their students' needs and the effectiveness of instructional strategies. The findings indicate a modest improvement in teachers' understanding of students' prior knowledge. There is not only a growing awareness among teachers of the importance of connecting new concepts to students' existing knowledge, they are found to actively found to engage students by recapping prior lessons and relating new ideas to everyday experiences.

Teachers faced challenges in effectively integrating strategies to confront student misconceptions. While many teachers recognised the existence of misconceptions, some struggled to implement targeted strategies in their lessons. This pinpoints to a critical area for professional development, emphasising the need to develop more robust strategies for identifying and remediating misconceptions, which is essential for enhancing student comprehension in physics. The findings indicate a medium impact in promoting inclusion and equity within the classroom, with teachers making efforts to create an inclusive environment, highlighting a growing awareness of the challenges their students face, particularly regarding parental involvement and support for diverse learners. Strategies such as group work and mixed-gender grouping were employed to enhance collaboration, and some teachers provided targeted support for anxious students, demonstrating a commitment to equity. However, there remains significant room for improvement in systematically addressing the diverse needs of all learners. The UDL principles were offered as part of professional development to support inclusion and equity—by emphasising multiple means of engagement, representation, and action and expression—implementation of these strategies appeared limited in practice with a lone teacher adapting the lesson plans to better accommodate the Special Educational Needs learner as a result of OER module. UDL enables teachers to tailor their instruction to accommodate varied learning preferences, ensuring all students can participate meaningfully in the learning process. To fully realise the benefits of UDL, ongoing support and training are essential for helping teachers effectively integrate these principles into their lesson planning and instruction. This positive shift underscores the module's effectiveness in enhancing teachers' understanding of learner challenges and suggests that continued professional development in this area could yield even greater benefits.

Content - The findings indicated a positive impact on teachers' content knowledge, particularly in understanding the nature of science and mathematics, which improved significantly through the OER module. This highlights the module's effectiveness in enhancing comprehension of fundamental scientific principles. Additionally, there was a positive shift in teachers' ability to connect concepts across the curriculum, suggesting that the module successfully fostered deeper connections among scientific concepts. Teachers are increasingly encouraging higher-order thinking through inquiry-based approaches, engaging students in experiments and problem-solving activities. Strategies that promote problem-solving and conceptual connections were effectively implemented, with many teachers using extended activities and real-life examples to enhance cognitive engagement. This indicates a growing commitment to fostering a more interactive and effective learning environment.

However, there remains a need for improvement in articulating teaching goals, as well as in planning to build students' competencies to meet educational objectives. Some teachers may lack concrete strategies or evidence in their lesson plans to fully support this aim.

Teaching and Learning - The teaching and learning category revealed a variety of outcomes, indicating both progress and areas needing improvement. Teachers showed a small improvement in adopting effective instructional strategies, suggesting a shift toward more engaging practices, particularly through group work. However, despite awareness of UDL and Design Thinking principles, these frameworks were not consistently applied in lesson plans. The issue of teachers not willing to adapt their teaching approach was highlighted by Verma and Verma (2022) in their study too.

In terms of resource utilisation, there was a noted decline in teachers' ability to assess and effectively use available materials. While many engaged with online resources, demonstrating thoughtful evaluation, this awareness did not consistently translate into practical application in lesson design. Similarly, there was a slight improvement in understanding assessment strategies, yet most teachers still relied heavily on questioning as their primary assessment tool, indicating a need for professional development in diverse assessment methods that encourage varied modes of expression.

Teacher Participation on CoP and Moodle - The analysis of teacher participation in the CoP and Moodle highlights key patterns in engagement and areas for improvement. The significant volume of administrative posts (582) indicates that while logistical matters dominated discussions, there was minimal dialogue around PCK and UDL. Research shows that while teachers exchange their teaching material with colleagues within their own organisations informally or share with their students, they often do not share through the formal channels (Krelja Kurelovic, 2016). This suggests a potential gap in the collaborative exchange of pedagogical strategies and indicates that teachers may still rely heavily on traditional methods, limiting the integration of innovative practices.

On Moodle, teachers demonstrated strong engagement, likely bolstered by their prior experience with the first OER module, which fostered confidence and skill development. The supportive organisational strategies employed by teacher educators, such as personalised assistance and timely communication, were critical in facilitating this engagement. However, time constraints emerged as a significant challenge, impacting teachers' ability to balance module activities with their regular teaching responsibilities. This imbalance, alongside the pressures of

the peer assessment process and technical requirements for video recording, underscores the need for clearer guidelines and additional support to enhance the learning experience.

Conclusion

The findings from the study illustrate a modest yet encouraging impact of the OER module on teachers' understanding of Force and Motion. The increase in the number of teachers classified as 'accomplished' and "proficient" following the intervention suggests that the OER module effectively supported professional development. Despite these positive shifts, challenges such as network instability and the reliance on traditional teaching practices remain evident. Furthermore, while teachers have begun to recognise the importance of addressing student misconceptions and promoting inclusion, the implementation of effective strategies in these areas has been inconsistent.

In the categories of Learners, Content, and Teaching and Learning, teachers displayed improvements in understanding students' needs and engaging with higher-order thinking strategies. However, gaps persist in articulating teaching goals and utilising diverse assessment methods. Teacher participation in the Moodle showed strong engagement, particularly due to prior familiarity with OER content; yet, engagement in CoP often focused more on administrative issues than on pedagogical strategies, indicating a need for enhanced collaboration among educators. To maximise the benefits of the OER modules, it is essential to provide ongoing professional development focused on effectively implementing UDL principles and diverse assessment strategies, emphasising practical applications and support for teachers as they adapt their instructional practices. Additionally, establishing clearer guidelines and offering enhanced technical support for teachers—particularly regarding peer assessments and video recording processes—can help alleviate the challenges they face. Finally, future research should focus on longitudinal studies that track the long-term impacts of OER modules on both teacher practices and student outcomes, identifying effective strategies and areas for further enhancement.

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