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The Impact of Open Educational Resources Based Professional Development on the Bhutanese Secondary Biology In-service and Pre-Service Teachers

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Abstract

This study examined the impact of Open Educational Resources (OER) based professional development of secondary school biology teachers in Samtse Dzongkha in Bhutan. It highlights the importance of teaching and learning biology in secondary classrooms, emphasising its relevance to students' understanding of science, the environment, and their future academic and career choices. Recognising the challenges faced by teachers and students in biology education, STEM teacher educators from Samtse College of Education underwent professional development using OERs and online sessions facilitated by experts from Tata Institute of Social Sciences (TISS) in India. These educators collaborated with peers from Tanzania, Nigeria, and TISS to develop six-week-long OERs on specific biology topics, which were then shared with selected in-service and pre-service biology teachers in Bhutan through Moodle platform. Additionally, an online Community of Practice (CoP) was established on Telegram to support the ongoing professional development. The study employed a mixed-methods approach, utilising pre and post-test scores, lesson plans, reflections, and interviews to assess the impact of the OERs on teachers. The CoP network was also analysed to understand communication patterns and knowledge sharing within the community.

The results from pre-test and post-test assessments across these modules showcased marginal improvements in teachers' subject content knowledge. Detailed analysis of lesson plans and reflections revealed evolving proficiency in various pedagogical domains. Notably, many teachers sought technological integration, demonstrating an eagerness to utilize digital tools for enhancing student engagement. Despite these positive trends, a significant gap in high expertise levels among teachers was observed, particularly in the Genetics module. This hints at an underlying need for enriched professional development opportunities in specific content areas. Therefore, findings of this study concludes by recommending educational institutions to support continuous professional development for biology teachers through the integration of OERs, thereby improving the quality of biology education.

Keywords: Biology, open educational resources, community of practice, technology, subject matter knowledge, pedagogical content knowledge, general pedagogical knowledge

Introduction

In the current times we need to consider that the need for ICT does not limit itself simply to the process of acquiring an education but also spills over into life post-education. For example, Beetham and Sharpe (2007) claim that the information economy today demands that job seekers have information literacy as a core requisite rather than just a stable body of knowledge. Holliman and Scanlon (2004) point out that one of the positives about using ICT is that it provides a wide range of communication in the teaching and learning process and is not limited to the classroom but rather extends to the global world. Lloyd has stated that ICT integration enables teachers "to improve and increase the quality, accessibility and cost-efficiency of the delivery of education" (2005, p. 1). The findings from a case study by Tamang et al. (2021) indicate that there is enhanced learning achievement in biology lessons when taught using digital tools. The activity-based learning approach draws deep inspiration from the experiential learning theory of Klob (1984) which focuses on learning by doing.

Open Educational Resources (OER) are digitised materials offered freely and openly for educators, students and self-learners to use and re-use for teaching, learning and research (Hylen, 2006, p. 2). According to Das (2011) OERs is a recent innovation that are especially relevant for achieving equitable access to quality education and stressed that resources created by educators and researchers should subsequently be open for anyone to use and reuse with an intent that the OERs will be reached to lifelong learners across the professions and occupations. The HOTIE framework aimed to make explicit the combination of foundational research ideas from Pedagogical Content Knowledge such as Ball et al. (2005), Shulman (1987), Grossman (1990), Kind (2009), and Universal Design of Learning (UDL) such as CAST (2018). It comprises three broad themes: Subject Matter Knowledge (SMK), Pedagogical Content Knowledge (PCK), and General Pedagogical Knowledge (GPK).

SMK: Knowledge of Science and Mathematics, Nature of Science/ Mathematics.

PCK: Instructional Strategies, Students Misconceptions, Representation of content, Context of Learning, and Curriculum Knowledge.

GPK: Equity and Inclusion, Classroom Management, and Assessment

Communities of Practice (CoP) are a concept of social, situated and professional learning through the regular interaction of the community members (Wenger, 1998). They draw on the idea of situated learning (Lave & Wenger, 1991) that states that professional learning happens by participation in social processes that are situated within specific socio-cultural contexts. Research shows that the application of teacher professional knowledge is contextual and value-based, where teacher learning is social and situated in nature (e.g., Cochran-Smith & Lytle, 1999, Sarangapani, 2011; Winch, 2004). Additional research has shown that there is a strong influence of teacher social networks on teacher participation, attitudes towards the professional development opportunities, and ability to understand and implement these ideas (Baker-Doyle & Yoon, 2010). Professional development for teachers happened through the two-pronged nature of CoP: participating in the Telegram CoP' "activities, discussions, conversations, and reflections" and secondly through sharing of artefacts, such as teaching resources, evidence of teacher practice, strategies to teach common concepts etc (Thirumalai et al., 2019).

Ten in-service secondary school biology teachers from seven schools (five higher secondary & two middle secondary[1]) in Samtse District were enrolled as participants. Nine pre-service teachers were included as participants in the study. The learnings and experience from the OERs were expected to empower the

[1] All secondary schools in Samtse district participated in the CL4STEM project. Due to COVID restrictions the participation was contained to only Samtse district, instead of multiple districts in Bhutan as envisioned earlier.

participants in subject content, emerging pedagogy, and technology knowledge and skills. This research focused on examining the impact of OER-based professional development on pre and in-service biology teachers' knowledge, attitudes and practices. It is important to note here, that while the professional development model focused on both OERs and CoP in tandem, this research paper only looks at the teachers' participation in OERs. There are two sub-research questions that will be answered to explore the impact of OERs on teachers' KAP,

1. What was the impact of the OERs on teachers' KAP?
2. How did the biology teachers' practices evolve by participating in CL4STEM OER?

Study context

Connected Learning for STEM (CL4STEM) is a project funded by the International Development Research Centre (IDRC). The project is aimed at developing the capacity of middle and secondary teachers, including Newly Qualified Teachers (NQTs) in mathematics and science. CL4STEM attempted to pilot the CLIx (Connected Learning Initiative, 2020) strategy of teacher professional development using high-quality OERs and CoP. CLIx has been successfully implemented at scale in India and was developed by the Tata Institute of Social Sciences (TISS) in collaboration with the Massachusetts Institute of Technology. CL4STEM is a global South-South collaboration between the Samtse College of Education (SCE), Bhutan, the Open University of Tanzania (OUT), the Ibrahim Badamasi Babangida University-Lapai (IBBUL), Nigeria and the Tata Institute of Social Sciences (TISS), India.

One of the major activities of the project was involving the STEM teachers in the use of curated, interactive OERs in the form of online modules developed by the STEM teacher educators of SCE. Eighteen STEM teacher educators from SCE underwent professional development using the CLIx OERs platform organised and led by TISS experts on areas such as Reflective Teaching using ICT for STEM subjects, Universal Design for Learning, and Design Thinking. As an outcome of the professional development, each STEM discipline (Biology, Chemistry, Physics and Mathematics) designed and curated a subject-specific OERs module and also developed one common pedagogy module together.

The Biology module was created on the topic of Genetics and hereditary, as teachers expressed difficulty in teaching evolution, genetics and inheritance, through a quick survey with the secondary school biology teachers through Telegram. The Bhutanese school curriculum for classes IX and X was also taken into consideration during the selection and decision of contents for the module. Therefore, upon deliberation amongst the biology academics at SCE, it was decided that the OERs on Introduction to Genetics and Hereditary would be designed to be offered to the secondary school biology teachers of Samtse District.

Along with the aspiration of enhancing the teachers' biology pedagogical content knowledge, the module was curated with the framework of technology integration, inclusion of UDL principles and design thinking. From the inception till the implementation rigorous vetting was done during the weekly project meetings. In addition to the home module "Introduction to Genetics and Hereditary", the biology teacher educators also contextualised the biology modules designed by OUT and IBBUL teacher educators to align them to the Bhutanese context, namely, Cell Structure and Organisation, and Ecology.

The Cell Structure and Organisation module was designed and curated by the Tanzania team to prepare teachers to teach this particular area for grade IX students. The concepts used in the module were chosen and thought of as a foundational module for students. The goal of the module besides providing basic concepts of cells is to produce well-informed students capable of understanding, engaging, problem-

solving, and appreciating the interconnectedness of different cell structures and their complex organisation.

The Ecology module was designed and curated by the Nigeria team, for teachers teaching grade IX students. The concepts used in the module were chosen and thought of as basics of introductory Ecology for students. The goal of the module was to produce well-informed students capable of understanding, engaging, problem-solving, and making decisions about the natural world around us. The Bhutan biology team contextualised it to be used by the Bhutanese participants, aligning for local names, ensuring availability of resources, and using local examples.

Lastly, all participating biology teachers were enrolled in the Telegram mobile app-based CoP. Teacher educators and researchers were also members of this CoP. The purpose of this CoP was to share information, guidance, and encouragement for the teachers to continue participation and share practices as they engaged with the OERs. Teachers used this forum to ask questions, clarifications and doubts to the teacher educators about the content of the OERs and their experience of participating in the same, share the implementation of their lessons in the classroom, and general teacher practice.

Significance

This study is significant, as it is a first of its kind in the Bhutanese context. Teachers were engaged in online teacher professional development where they not only developed their theoretical knowledge and specific aspects of PCK but also implemented and reflected on self-designed lesson plans. This is even more significant when coupled with the fact that the OERs were both developed and curated by their local teacher education experts, the Bhutanese teacher educators. Thus, teachers were supported by the experts from their context. The online CoP served as a space for teachers to ask questions, showcase their practice, and seek and provide support to their peers. Thus, this could serve as a model of continuous teacher professional development, where in-service teachers can get contextual support from the university experts on ideas related to their practice.

Methodology

The study employed purposive sampling, a non-probability sampling techniques. The participants included 5 in-service teachers with less than five years of experience, termed as Newly Qualified Teachers (NQT). Additionally, 5 teachers with over five years of experience were categorised under the Intervention Focus Group. Furthermore, 9 pre-service teachers enrolled in the Postgraduate Diploma in Education (PgDE) at Samtse College of Education were also part of the sample.

The participants engaged with each OER module for a period of 6 weeks per module. Aligning with the requirement of an intervention study, a pre-test at Baseline in June 2023 and a post-test at Endline in December 2023 was administered. The pre-test and post-test aimed to evaluate teachers' Knowledge and Attitudes towards teaching for Higher Order thinking with Inclusion and Equity (HOTIE). Teacher practice was evaluated by assessing the lesson plans and reflections that the teachers submitted as part of engaging with the online OERs. All evaluations of teacher knowledge, attitudes, and practice were done using the HOTIE framework (CETE, 2022) of teachers' Knowledge, Attitude and Practise for Higher Order Thinking with Inclusion and Equity.

While the CoP data has not been explored in detail in this paper, tutors' observations on the participants' engagement in the CoP and modules were recorded and analysed to triangulate the pre and post-test analysis.

Data Analyses and Observations

This section presents the results derived from the previously stated research questions. The findings are organised, starting with results from the OER-based pre-test and post-test, followed by insights from the lesson plans and reflections.

A. Pre-test and Post-test Scores

The subject content knowledge of the participating biology teachers in three OER biology modules were assessed using pre-test and post-test scores.

1. **Introduction to Genetics Module:** The comparison between the pretest and posttest results for the 'Introduction to Genetics' module revealed only a marginal increase in the average scores, moving from 12.42 to 12.89. This suggests that participating biology teachers' understanding of the subject content remained relatively constant before and after the intervention.
2. **Ecology Module:** In the ecology module, there was a marginal improvement in the mean scores, increasing from 8.74 in the pretest to 9.16 in the posttest. This might hint at a small positive influence of the intervention on participants' content knowledge.
3. **Cell Structure and Organisation Module:** For the 'Cell Structure and Organisation' module, participants' mean scores exhibited a minor rise from 8.0 in the pretest to 8.37 in the posttest, indicating a slight enhancement in their grasp of the subject.

Overall Observation: Although none of the modules displayed substantial shifts in the mean scores from pretest to posttest, the consistent small upward trends across all three modules might suggest that the OERs played a role, though limited, in enhancing the content knowledge of the participating school biology teachers. It's promising to see positive progression in each module, and it underscores the potential benefits of further optimising and integrating OERs into the curriculum.

B. Lesson Plan and reflection scoring

Each of the participants was required to upload three lesson plans per module to Moodle as part of engagement with the OERs and implement the lessons in the classroom. Coupled with the lesson plan participants were also required to make one reflection of the implemented lessons and upload that in Moodle as well. The lesson plan template along with the requisites of any general lesson plan also had the following key elements highlighted: learning outcome, pre-requisites, session narrative, and organisation of the class. Likewise, in the reflection they were required to critically describe what went well, what didn’t go well, and what changes they will make in the future lesson. The biology tutors at SCE assessed the lesson plans and the reflections on three themes from the HOTIE framework: SMK, PCK, and GPK with each theme consisting of a specific requirement description. The performance of the participating teachers was categorised into levels of expertise that include (i) Novice (N), (ii) Emerging (E), (iii) Proficient (P), and (iv) Accomplished (A) based on their ability to demonstrate elements of SMK, PCK and GPK in their lesson plan and their ability to articulate it in their reflection.

Tables 1, 2 & 3 present the categorisation of the school biology teacher participants into N, E, P and A based on their scores from lesson plans and reflections, specifically pertaining to three distinct OER

modules. This data elucidates the proficiencies of selected school biology teachers (n=19) across various pedagogical spectrums associated with the modules.

The data analysis yielded significant insights into the competence of school biology teacher participants. For simplicity, the analysis has been segmented into three main themes: SMK, PCK and GPK under which specific performance metrics are discussed. Furthermore, the biology teacher participants are stratified into four levels of expertise (i.e., N, E, P and A) in each of the OER modules.

1. Genetics module

In the quest of assessing the SMK of school biology teachers, two key areas namely. Knowledge of Science and Nature of Science were scrutinised. The analysis revealed that for Knowledge of Science, only 2 teachers were at the novice level, while 9 teachers in emerging, and 8 in proficient level, showcasing an increasing foundational understanding of Genetics. But notably, none achieved the accomplished level (Table 1; Figure 1). A similar trend emerged in the Nature of Science domain, with 4 novices, 8 at emerging, 7 in proficient and zero in accomplished level.

Under theme PCK, most teachers were seen to be proficient with 10 teacher participants followed closely by those at the emerging level with 8 teacher participants in instructional strategies. Regarding "Student Misconceptions & Learning Difficulties", the majority were at the emerging level with 10 participants, while a considerable number were proficient with 6 teacher participants. Similarly in "Representation of Content ", the majority were proficient with 12 teacher participants, while 7 were in emerging level. Context for Learning saw an equal number of teacher participants with 10 each at emerging and proficient levels. Curriculum Knowledge was another area where emerging was predominant with 10 participants followed by proficient with 8 teacher participants. No teacher participants were found to be at an accomplished level.

In GPK, Equity and Inclusion had the highest number of emerging teachers with 13 teacher participants and fewer at the proficient level with 5 teacher participants. Classroom Management showed a majority at the proficient level with 11 teacher participants and 8 participants at emerging level. Interestingly, the Assessment area exhibited a stark disparity with 10 novice teacher participants, implying a significant need for development in this area, followed by 9 participants at the emerging level.

The consistent lack of biology teachers at the accomplished level in all three themes i.e. SMK, PCK and GPK raise questions about the potential external influences. The accomplished level is the highest level of performance in this study. To achieve this level, teachers must have a deep understanding of genetics content, be able to translate this knowledge into effective teaching practices, and be able to apply this knowledge to real-world problems. Lack of accomplished teacher participants in the sample suggests that there is a need for more professional development opportunities for school biology teachers, and these professional opportunities should focus on helping them develop their SMK, PCK and APK in Genetics module.

Across all three themes, the consistent absence of teachers at the accomplished level, the pinnacle of performance in this study, underscores a need for deeper professional development in genetics for these teacher educators. This shortfall suggests a need for enhanced professional development, emphasising genetics, to cultivate deeper understanding and pedagogical effectiveness among school biology teachers. However, data also suggests that teacher participants in this study had a good understanding of general teaching strategies, and how to teach them to students using OER. The more experienced teachers had a better understanding of genetics concepts and teaching strategies than the less experienced teachers.

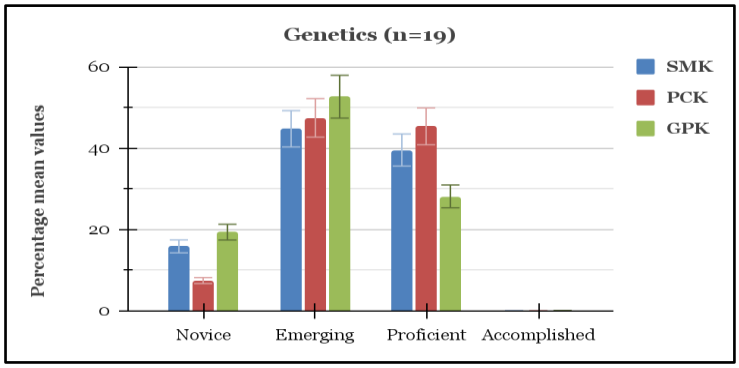
Table 1

Number of Biology Teachers (n=19) in N, E, P, and A Expertise Level from Lesson Plans and Reflections in 'Genetics' Module across SMK, PCK, and GPK Domains

Themes and items	Novice (N)	Emerging (E)	Proficient (P)	Accomplished (A)	Total
SMK					
Knowledge of science	2	9	8	-	**19**
Nature of science	4	8	7	-	**19**
PCK					
Instructional Strategies	1	8	10	-	**19**
Student misconceptions & learning difficulties	3	10	6	-	**19**
Representation of content	-	7	12	-	**19**
Context for learning	2	10	7	-	**19**
Curriculum knowledge	1	10	8	-	**19**
GPK					
Equity and Inclusion	1	13	5	-	**19**
Classroom Management	-	8	11	-	**19**
Assessment	10	9	-	-	**19**

Figure 1

Mean Percentage of Biology Teachers' Expertise Level in the Genetics Module across Three Key Areas of SMK, PCK, & GPK



2. Ecology module

The OER Ecology module data highlighted participants' expertise under the SMK theme. Six participants are novices, needing foundational enhancement. Sixteen are emerging, holding basic knowledge yet needing specific professional growth. Fifteen are proficient, merging theory with practical teaching insights. A single accomplished participant exists (Table 2), who could potentially mentor others. In PCK the school biology teachers were more evenly distributed across the four levels of expertise. However, there were more teachers who were categorised as proficient (11 out of 19) than novice (2 out of 19), suggesting that the teachers have a good understanding of how to teach science concepts to students, but they may need some additional support in areas such as instructional strategies and student misconceptions. Similarly in GPK, data depicts a clear trajectory of professional growth from novice to

expertise. While the teachers are progressing well in classroom management, there seems to be a collective need for further training and support in the domain of equity and inclusion (Table 2: Figure 2).

Overall, the OER Ecology module analysis showed a positive trend in biology teachers' expertise levels, with a significant portion leaning towards emerging and proficient stages. Few teachers exhibited high expertise in certain assessment areas, indicating a solid grasp of ecology knowledge across SMK, PCK, and GPK themes.

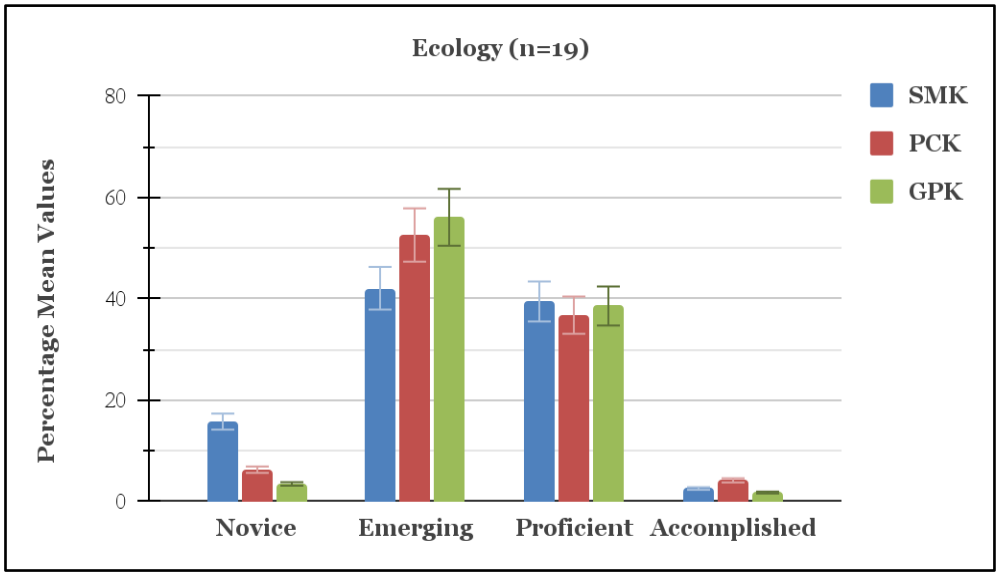
Table 2

Number of biology teachers (n=19) in N, E, P, and A expertise level from lesson plans and reflections in 'Ecology' module across SMK, PCK, and GPK domains.

Themes and items	**Novice (N)**	**Emerging (E)**	**Proficient (P)**	**Accomplished (A)**	**Total**
SMK					
Knowledge of science	4	7	7	1	**19**
Nature of science	2	9	8	-	**19**
PCK					
Instructional Strategies	2	5	11	1	**19**
Student misconceptions & learning difficulties	1	13	5	-	**19**
Representation of content	2	7	8	2	**19**
Context for learning	1	12	5	1	**19**
Curriculum knowledge	-	13	6	-	**19**
GPK					
Equity and Inclusion	1	13	5	-	**19**
Classroom Management	1	8	9	1	**19**
Assessment	-	11	8	-	**19**

Figure 2

Mean percentage of biology teachers' expertise level in the Ecology module across three key areas of SMK, PCK, & GPK.



3. Cell Structures and Organisation module

In the Cell Structure and Organization module, most biology teachers exhibit proficient skills in the SMK theme, especially in the knowledge of science. For example, most teachers, 12 out of 19 biology teachers were proficient in their knowledge of science. However, there was one novice teacher and one emerging teacher. Similarly, the majority of biology teachers (11 out of 19) were proficient in their understanding of the nature of science. However, there were three participants who were emerging, and three teachers who were novices (Table 3; Figure 3). Under PCK, instructional strategies are the strongest, with a majority of teacher participants (13 out of 19) being proficient (Table 3). However, there is a notable emerging level of expertise when it comes to areas such as student misconceptions and learning difficulties (9 out of 19), and the representation of content (9 out of 19). This suggests that while they might be good with strategies, there is room for improvement in understanding student challenges and how content is presented. Similarly in GPK, teachers are generally proficient especially in the aspects of equity and inclusion (9 out of 19), classroom management (9 out of 19), and assessment (10 out of 19) (Table 3). There's a relatively balanced distribution between emerging and accomplished expertise, suggesting a more spread out skill set.

Overall, the data shows that the majority of school biology teachers have a proficient level of expertise in the Cell Structure and Organisation module. However, there is still some room for improvement, particularly in the areas of student misconceptions and learning difficulties, representation of content, and equity and inclusion.

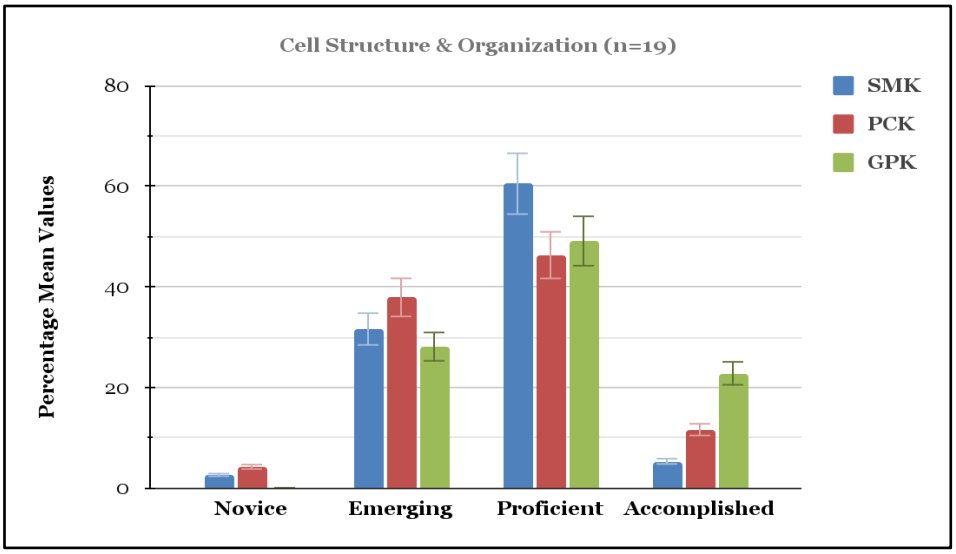
Table 3

Number of biology teachers (n=19) in N, E, P, and A expertise level from lesson plans and reflections in 'Cell Structure and Organization' module across SMK, PCK, and GPK domains.

Themes and items	**Novice (N)**	**Emerging (E)**	**Proficient (P)**	**Accomplished (A)**	**Total**
SMK					
Knowledge of science	-	7	12	-	19
Nature of science	1	5	11	2	19
PCK					
Instructional Strategies	-	4	13	2	19
Student misconceptions & learning difficulties	1	9	5	4	19
Representation of content	-	9	5	5	19
Context for learning	1	7	11	-	19
Curriculum knowledge	2	7	10	-	19
GPK					
Equity and Inclusion	-	5	9	5	19
Classroom Management	-	5	9	5	19
Assessment	-	6	10	3	**19**

Figure 3

Mean percentage of biology teachers' expertise level in the Cell Structure and Organization module across three key areas of SMK, PCK, & GPK.



General Discussion

In three OER biology modules – Genetics, Ecology, and Cell Structure and Organization – distinct patterns of teacher proficiency emerged:

In this comprehensive study examining the influence of OERs on the proficiency of school biology teachers in Bhutan, three core modules were evaluated: Genetics, Ecology, and Cell Structure and Organisation. The intent was to gauge not only the content understanding but also how teachers plan, reflect, and employ pedagogical practices in their teachings.

From the pretest and posttest comparisons, it is evident that while there were no significant shifts in content knowledge across the three modules, there was a small yet consistent positive trend. This finding suggests that OERs may have a modest role in enhancing teachers' knowledge, and there is potential value in further refinement and integration of these resources into their classroom teaching.

Analysing lesson plans and reflections offered deeper insights. In the Genetics module, while teachers displayed foundational knowledge, the absence of accomplished-level educators across all domains was glaring. This revealed a potential gap in the depth of understanding or pedagogical practices specific to genetics. In contrast, the Ecology module displayed a spread of expertise levels among biology teacher educators with many showing significant expertise, and a potential mentorship avenue from the sole accomplished participant. Lastly, in the Cell Structure and Organisation module, while many teachers demonstrated proficiency, specific areas such as addressing student misconceptions and optimising content presentation stood out as potential growth areas.

The progressive transformation and attaining empowerment in PCK and GPK were also be supported from qualitative data with a view from one of the tutors that states:

My perception of the introduction of three OER biology modules to the field teacher. Ever since College got the opportunity to introduce OER to field teachers through the CL4STEM project. It gave me the opportunity to observe and study the progress of each participant in terms of the content advancement, pedagogical advancement and technological advancement of teachers through months of interactions. I had many interactions with participants both from in-service and pre-service. The focus of the interaction

was always on technology, using technology for effective teaching as simple as how to make it interactive and engaging for learners. For example, two of the in-service teachers were interested in making their lesson interactive. Two of them asked how to engage learners in teaching the Krebs cycle and interactive video content. Some of the participants were also eager to learn to insert the quizzes in their lesson content to engage their learners. Most of them were interested in making lessons engaging using Google quizzes. It was evident in their lesson plan that they used online quizzes but not specifically mentioned Google quizzes. Another tool was simulation was evident in many lesson plans. So my observation was that there was hardly one who sought content and pedagogies support but there were many who were curious to learn and make a difference in student learning using technology. It is evident from the questions they asked in the CoP and from their response shown on the VLE module.

Bhutan's emphasis in improving the quality of STEM education (Royal Education Council [REC], 2012), in particular since scientific knowledge and education, is critical for the development of any country. Bhutan considers teachers as the cornerstone of the education system and they need to be constantly updated with the latest knowledge and teaching pedagogies. The Bhutan Education Blueprint 2014-2024, states that teachers need to use ICT pervasively in their teaching to improve the quality of education (Ministry of Education [MoE], 2014). Generally teachers have not studied ICT in their school/college/teacher training period, there was a need to undertake professional development programmes focused on ICT enabled teaching to enhance their knowledge and skills (Utha et al., 2023). According to Tamang et al. (2021), though teachers in schools and colleges employed various ICT tools to develop and deliver online lessons they still lack adequate skills and knowledge about ICT tools and techniques. Among others though teachers constantly are making attempts to integrate ICT and employ various teaching strategies the lack of adequate resources, competence, and teacher workload was found as a hindrance (Utha et al., 2023). Opportunities to attend and participate in regular ongoing professional development programmes are critical to enable teachers to continuously update their academic content knowledge and enhance pedagogical practices (Utha et al., 2023).

In the current study, though there has not been a significant shift between the pre and post-test results for all the three modules. However, the lesson plan and reflection analysis indicated a progressive change in the teachers' planning and practice as they progressed from the first to the last module. This study also brought to light the eagerness among educators to employ technology to make lessons more engaging. Their consistent inclination towards ICT tools, such as online quizzes and interactive videos, denotes a shift towards a more tech-savvy teaching paradigm. However, the need for more support, both in terms of content and pedagogical strategies, is evident.

Conclusion

Overall, the finding of this study suggests that the participants have developed some level of knowledge and experience related to pedagogy and technology for teaching, there are also some levels of instances with some participants having achieved a higher level of expertise than the rest. This indicates that the participants in the study have developed varied levels of PCK and technological knowledge which could impact their ability to effectively teach the subject matter.

While OERs show promise in bolstering content and pedagogical knowledge, their current influence appears to be mild. However, the shift towards digital learning avenues and the evident interest of teachers in this direction underscore the importance of ongoing professional development, both in content areas

and in ICT tools and techniques. Through regular training and resource optimisation, Bhutan can pave the way for a more proficient, tech-savvy, and effective teaching workforce.

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