KASU Journal of Science and Mathematics Education (KJSME)
Volume 1, Number 1, June, 2025 ISSN: 2360-8889
http://journals.kasu.edu.ng/index.php/Science_Education

IMPACT OF CONNECTED LEARNING FOR STEM BIOLOGY MODULES OPEN EDUCATIONAL RESOURCES (OER) ON THE PROFESSIONAL DEVELOPMENT OF SENIOR SECONDARY SCHOOL BIOLOGY TEACHERS IN KADUNA STATE, NIGERIA

[1]Dr Samira D. H., [2]Dr Fatima K. S., [3]Dr Umar A. A. & [4]Dr Sarah V. U.

[1,2,3,4]Department of Science Education, Faculty of Education, Kaduna State University.

[*]***Corresponding author email:*** samira.hunkuyi@kasu.edu.ng

Abstract

This study investigated the impact of CL4STEM Biology Modules Open Educational Resources (OER) on the professional development of Senior Secondary School Biology teachers in Kaduna State. The study explores how CL4STEM Biology Modules OERs enhances teachers' curriculum knowledge, subject-matter expertise, pedagogical content knowledge and ability to address student misconceptions. The population of the study consist of all Biology teachers in Kaduna State, Nigeria. The sample of the study consist of Ten Biology teachers from five Public Senior Secondary Schools both Kaduna North and Kaduna South. A mixed-methods approach including surveys, interviews, classroom observations, pretest, posttest, lesson plans and reflections were used to assess the impact of CL4STEM Biology Modules OERs on Biology teacher's Subject Matter Knowledge (SMK), Pedagogical Content Knowledge (PCK) and General Pedagogy Knowledge (GPK). Additionally, the study examined a Community of Practice (CoP) on Telegram to understand knowledge sharing within the community of Secondary School Biology Teachers. Findings revealed improvements in teaching strategies, higher-order thinking facilitation and inclusive pedagogical approaches as most teachers demonstrated improved proficiency level after using CL4STEM Biology Modules OERs, thus

Cite this article as:
Dr. Samira D.H, Dr. Fatima K.S, Dr. Umar A. A. & Dr. Sarah V.U., (2025). Impact of Connected Learning for Stem Biology Modules Open Educational Resources (Oer) on the Professional Development of Senior Secondary School Biology Teachers In Kaduna State, Nigeria

positively impacting their professional development by enhancing Subject Matter knowledge, Pedagogical Content Knowledge and General Pedagogy Knowledge.

Keywords: Connected Learning for STEM, Open Educational Resources; Community of Practice; Pedagogy; Technology.

Introduction

To understand the underlying problems inherent in learning STEM subjects across countries, a global South-South collaboration between the Samtse College of Education, Bhutan, the Open University of Tanzania, the Ibrahim Badamasi Babangida University-Lapai, Kaduna State University, Bayero University Kano, Nigeria and the Tata Institute of Social Sciences, India, carried out a joint project. The project, *Connected Learning Initiative for Teacher Education in Mathematics and Science* (CL4STEM), funded by the International Development Research Centre (IDRC) was aimed at developing the capacity of secondary teachers in mathematics and science using Open Educational Resources (OER) and Community of Practice (CoP). The rapid evolution of science education necessitates continuous professional development for teachers to ensure effective classroom practices. In the 21st century, Open Educational Resources (OER) have emerged as a transformative force in enhancing teachers' professional growth by providing freely accessible, high-quality educational materials. Specifically, Connected Learning a framework that integrates personal interests, peer collaboration, and academic knowledge has shown significant promise in advancing STEM (Science, Technology, Engineering, and Mathematics) education (Karma and Tandin 2024).

In this study, the focus is only on the CL4STEM Biology module OER implementation among ten biology teachers in five secondary schools in Kaduna State. The Biology teacher educators of Kaduna State University along with partner countries curated high quality, locally relevant, interactive CL4STEM Biology Module OERs in the form of three modules Ecology & Society, Cell Structure & Organization and Genetics. The modules were developed in consultation with secondary school Biology curriculum and difficulty level in teaching these modules. Each module consists of four units to be implemented to SS1 to SS3.

Cite this article as:
Dr. Samira D.H, Dr. Fatima K.S, Dr. Umar A. A. & Dr. Sarah V.U., (2025). Impact of Connected Learning for Stem Biology Modules Open Educational Resources (Oer) on the Professional Development of Senior Secondary School Biology Teachers In Kaduna State, Nigeria

The modules are designed to enhance teachers' SMK, PCK and GPK that would support student learning. The modules include activity-based learning with the framework of technology integration and UDL principles and design thinking. Techniques such as independent reading, hands-on activities, online discussion forums, story-based learning, making supplementary videos on certain topics, animated videos, simulation, interactive videos, illustrations, and virtual labs are contextually embedded. From the inception till the implementation, a rigorous vetting was carried out during weekly project meetings. All participating teachers were enrolled in the Telegram mobile app-based Community of Practice (CoP) where Biology teacher educators and the research fellow were also members. The learning and experience from the CL4STEM Biology Module OERs were expected to empower the participants in subject content, emerging pedagogy, and technology knowledge and skills. Biology, as a core STEM subject, requires innovative instructional strategies to engage students effectively. However, many Biology teachers in Kaduna State face challenges such as limited access to up-to-date resources, insufficient training opportunities and difficulties in implementing inquiry-based learning. Connected Learning principles, when embedded in OER, provide an opportunity for teachers to enhance their content knowledge, pedagogical approaches, and digital literacy skills. This study seeks to assess how leveraging Connected Learning through STEM Biology OER influences teachers' instructional competencies, engagement with new pedagogies, and overall professional growth.

METHODOLOGY

The study required implementation of CL4STEM Biology Modules OERs by the biology teacher participants in the respective schools. Aligning with the requirement, a mixed method approach was employed. The data were collected through administering a pre-test and post-test, lesson plan and reflection analysis, conducting structured interviews and classroom observations. The data collected were used to evaluate the teachers' Subject Matter Knowledge, Pedagogical Content Knowledge, and General Pedagogical Knowledge.

Teacher participation was measured using their activities on the Moodle and nature of interactions in the online Telegram CoP. The target population for this intervention was senior secondary school biology teachers in Kaduna State. The study used criterion purposive sampling, a type of non-probability sampling technique as the target population were biology teachers teaching in kaduna north

Cite this article as:
Dr. Samira D.H, Dr. Fatima K.S, Dr. Umar A. A. & Dr. Sarah V.U., (2025). Impact of Connected Learning for Stem Biology Modules Open Educational Resources (Oer) on the Professional Development of Senior Secondary School Biology Teachers In Kaduna State, Nigeria

and kaduna south local government area. A total of 10 teachers were selected, five teachers with less than five years of teaching experience labelled as Newly Qualified Teachers (NQT) and another five with five or more years of teaching experience labelled as in-service teachers who were engaged with the CL4STEM Biology OER modules for a period of 6 weeks per module. The pretest was administered at the beginning of the module and Lesson sessions were planned and submitted for scoring including reflections and post-test was administered at the end. Teachers were observed in their classrooms and interviewed at three phases (baseline, midline and endline) of intervention and implementation with interview questions structured around SMK, PCK, GPK, and CoP.

RESULTS SUMMARY

SUBJECT MATTER KNOWLEDGE PERFORMANCE

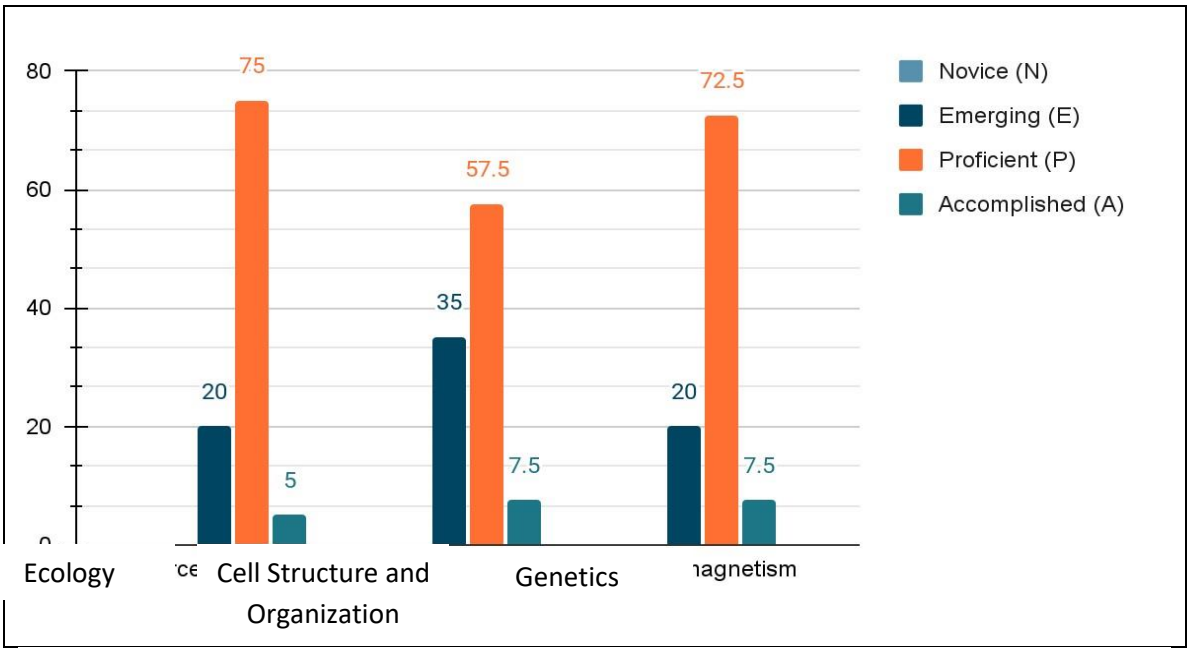

Figure 1 : Bar graph illustrating SMK categorization of participant's lesson plans and reflection scores for the three modules

Figure 1 shows the SMK performance categorization in all three modules. A total of 75% of NQT and in-service teachers are at the Proficient level in the module *Ecology and Society*. This suggests that most participants have a good understanding of the subject matter related to *Ecology and Society*. A

Cite this article as:
Dr. Samira D.H, Dr. Fatima K.S, Dr. Umar A. A. & Dr. Sarah V.U., (2025). Impact of Connected Learning for Stem Biology Modules Open Educational Resources (Oer) on the Professional Development of Senior Secondary School Biology Teachers In Kaduna State, Nigeria

relatively smaller percentage (7.5%) are in the Accomplished level indicating that few participants have an exceptional level of Subject Matter Knowledge on this module.

In the *Cell Structure and Organization* module, the distribution of participants' subject matter knowledge levels is relatively spread out. A total of 57.7% are in the Proficient level and 7.5% in the Accomplished level. A significant number of participants (35%) are at the Emerging level, suggesting that some teachers require Subject Matter Knowledge enhancement.

The data for the *Genetics* module shows that majority of participants are at the Proficient level (72.5%). A small percentage (7.5%) are at the Accomplished level. This indicates a good understanding of the subject matter on the module. However, there are participants at the Emerging level (20%), indicating a need for improvement.

Overall, a mean of 68.33% of the participants are at least at the Proficient level of Subject Matter Knowledge in all three modules. This is likely due to the fact that the module is designed for NQT and in-service teachers who are expected to have a strong understanding of the subject matter. However, there is room for improvement, as the number of participants at the Accomplished level (6.67%) is limited in all three topics. Data generated from the lessons plan, reflection and classroom observation shows that majority of the teachers have strong subject matter knowledge to effectively teach and guide their students.

Cite this article as:
Dr. Samira D.H, Dr. Fatima K.S, Dr. Umar A. A. & Dr. Sarah V.U., (2025). Impact of Connected Learning for Stem Biology Modules Open Educational Resources (Oer) on the Professional Development of Senior Secondary School Biology Teachers In Kaduna State, Nigeria

PEDAGOGICAL CONTENT KNOWLEDGE PERFORMANCE

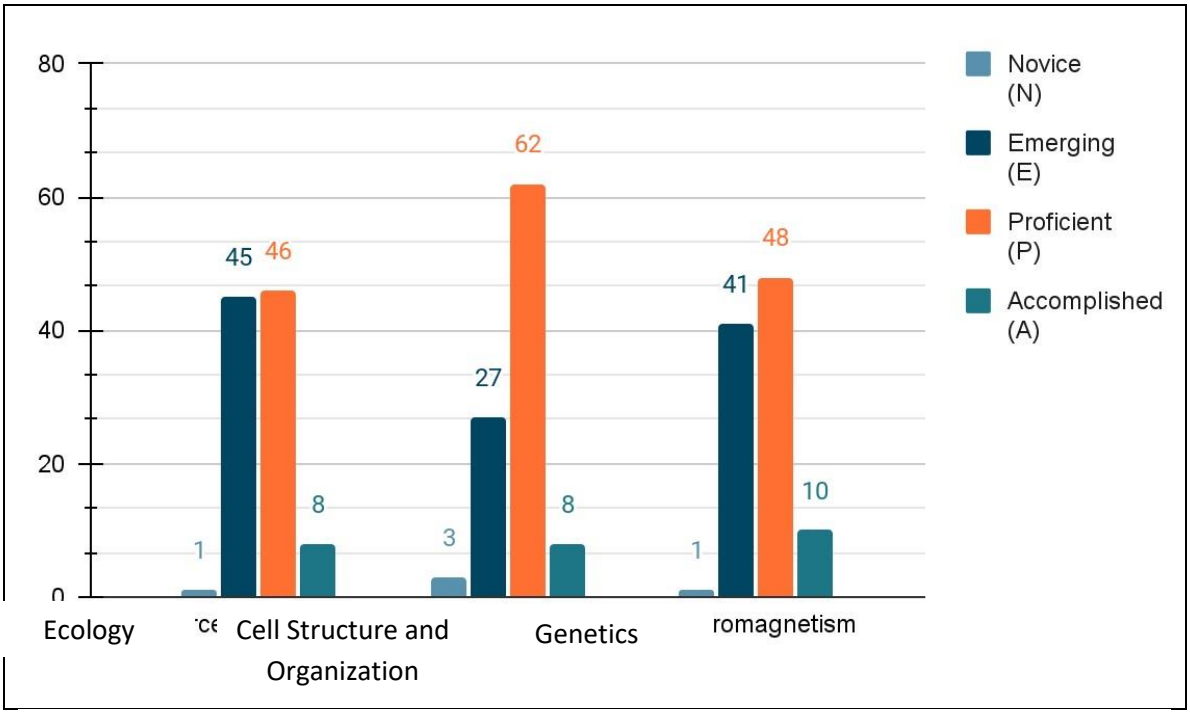

Figure 2 : Bar graph illustrating PCK categorization of participant's lesson plans and reflection scores for the three modules

Figure 2 shows the categorization of participants based on their pedagogical content knowledge (PCK). The distribution of proficiency levels is consistent across the three modules, with the majority of participants at the proficient level, followed by the emerging level and the accomplished level. A small number of participants are at a novice level of knowledge in all the modules.

The module Cell Structure and Organization has the highest percentage (62%) of the participants in proficient level compared to *Genetics* (48%) and the Ecology and Society module (46%). It also has the smallest percentage of participants in Emerging level (27%) compared to *Genetics* (41%) and Ecology (45%) modules. This suggests that the participants have a better understanding of how to effectively teach Cell Structure and Organization to the students compared to the *Genetics*, and Ecology. There is room for improvement in PCK in the Genetics and Ecology modules as there are a large percentage of participants in emerging levels in the Ecology (45%) and Genetics (41%) modules respectively. It was found that the teachers used the activity designed in the modules as they found it relevant to topics they were teaching.

Cite this article as:
Dr. Samira D.H, Dr. Fatima K.S, Dr. Umar A. A. & Dr. Sarah V.U., (2025). Impact of Connected Learning for Stem Biology Modules Open Educational Resources (Oer) on the Professional Development of Senior Secondary School Biology Teachers In Kaduna State, Nigeria

Data from the three modules shows that instructional strategies used by most of the teacher helped students to become independent and strategic learners. It was observed that students participate actively because the teachers make sure that class starts with students seated in a circle during the lesson so as to facilitate open discussion and enable students to work in pairs/small groups to encourage collaboration. Most teachers made sure that materials for classroom activities are prepared and distributed beforehand, monitor and assist students during activities to keep them engaged and address any misconception**.**

GENERAL PEDAGOGICAL KNOWLEDGE (GPK) PERFORMANCE

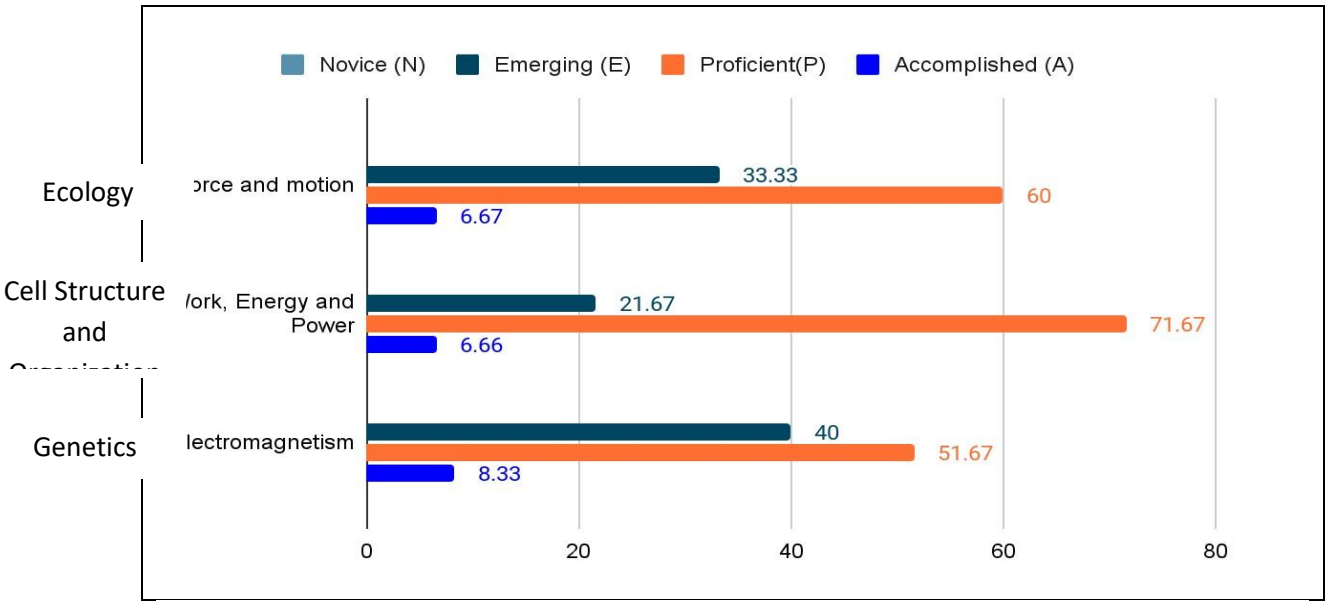

Figure 3: Bar graph illustrating GPK categorization of participant's lesson plans and reflection scores for the three modules

Figure 3 shows the general pedagogical knowledge (GPK) performance in all three modules. The data shows that a significant portion of teachers, that is, more than 50%, have reached the proficient level in each module, demonstrating a solid foundation in their understanding and teaching skills. However, there are also a notable number of teachers at the emerging level, indicating they are still learning and developing their pedagogical knowledge. This is not surprising, as the participants include newly qualified teachers (NQTs). There are more teachers in the emerging level and fewer proficient teachers in genetics compared to the other two modules. This suggests that the genetics module is more difficult

Cite this article as:
Dr. Samira D.H, Dr. Fatima K.S, Dr. Umar A. A. & Dr. Sarah V.U., (2025). Impact of Connected Learning for Stem Biology Modules Open Educational Resources (Oer) on the Professional Development of Senior Secondary School Biology Teachers In Kaduna State, Nigeria

and more teachers need additional support to learn and teach this module effectively. A smaller proportion of teachers (less than 10%) are categorized as accomplished, signifying a high level of mastery in both subject matter and teaching strategies. These teachers are a valuable asset for any school, and they can be used as mentors to help other teachers develop their pedagogical knowledge. Data generated from the module shows that majority of the teachers have a blend of expertise in biology and skills in pedagogy knowledge as reflected in their lesson plans, reflection and classroom observation. Classrooms were managed properly as most of the lessons were conducted in a ventilated and well seat arranged classrooms. Learners who were below average in the classroom were engaged with their fellow students (with help of the teachers) to help coach them so as they can have a better understanding of the concept and most of the learning outcomes were 80% met.

COMMUNITY OF PRACTICE (CoP)

The CoP in the Telegram allowed Biology NQT and in-service teachers, teacher educators, and research fellows to come together virtually to share practices, ask questions, clarify doubts and discuss concerns on any topic within the CL4STEM Biology OER modules. The CoP offered a space for participants to share their practice without any evaluation or judgment. The CoP participation analysis of all modules is reflected in Table 4.

Table 4: Frequency of posts by participants

SN	Role	No of Post in Ecology	No of Post in Cell	No of Post in Genetics
1.	NQTs	30	40	18
2.	Technical Team	15	10	7
3.	In-Service Teachers	36	42	20
4.	Teacher Educators	100	95	90
5.	Research Fellows	25	20	15
	Total	**206**	**207**	**150**

Cite this article as:
Dr. Samira D.H, Dr. Fatima K.S, Dr. Umar A. A. & Dr. Sarah V.U., (2025). Impact of Connected Learning for Stem Biology Modules Open Educational Resources (Oer) on the Professional Development of Senior Secondary School Biology Teachers In Kaduna State, Nigeria

Overall, the data in Table 4 shows that participation in CoP in the module Genetics is lowest. This could be due to the teachers' engagement in completing the syllabus and exam related work as this module implementation happened towards the end of the academic session. The teachers cited their engagement in the field practicum and having to juggle between teaching and the tasks they had to complete in this module. The analysis also shows that the NQT teachers were not very active compared to the other teachers.

LIMITATIONS

1. Many Teachers experienced difficulties with logging on to the Moodle, particularly due to forgetting password and reset, as such majority of the queries on CoP were related to that.

2. ICT facilities to implement the project in some schools were not available and adequate. Particularly internet connectivity is costly and not readily available.

3. Many teachers were reluctant in sharing the challenges that hindered their progress, even though multiple platforms were available to cater for them.

4. Large classroom size was a huge challenge in the implementation, as many teachers had to sample few students for the project.

CONCLUSIONS

Overall, the findings of this study suggest that the participants have developed a range of knowledge and experience related to pedagogy and technology for teaching, and 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 SMK, PCK and GPK which could have a positive influence on their ability to effectively teach the subject matter. The CoP is a great way to share knowledge and practices. However, it has to be noted that there are teachers who required support in SMK and PCK, especially in the Cell Structure and Organization and Genetics module.

In general, the teacher development program had a significant positive impact on the teachers, as they progressed to higher categories of teacher development expertise. The success is attributed to follow up

Cite this article as:
Dr. Samira D.H, Dr. Fatima K.S, Dr. Umar A. A. & Dr. Sarah V.U., (2025). Impact of Connected Learning for Stem Biology Modules Open Educational Resources (Oer) on the Professional Development of Senior Secondary School Biology Teachers In Kaduna State, Nigeria

calls on CoP and school visits, prompt technical support, increased interest, acceptance and observed added value, cooperation from stakeholders particularly principals and students among others. Thus, the experiences of the program have become more meaningful in the teachers' professional development. In a study carried out by Kurelovic (2023), it was noted that in order to reap the full benefits of OER, it is important to create awareness and educate teachers and researchers about the advantages and possibilities that OER offers.

References

Arhin, V. and Laryea, J.E., 2020. Tutoring support as a predictor of student retention in distance learning: The case of a University in Ghana. *Open Praxis*, vol. 12, no. 4, pp. 457-468.

Bliss, A. and Smith K, 2020. Emergence of open educational resources (OER) in India and its impact on lifelong learning. *Library Hi Tech News*, vol. 28, no. 5, pp.10-15.

Clements, S and Pawlowski, V 2024. Interest of teachers towards use of Biology OER, Case of WolaitaSoddo Town Governmental Secondary Schools, Ethiopia. *Journal of Education and Practice*, vol. 7, no. 25, pp.83-86.

Cochran-Smith, M. and Lytle, S.L., 2023. Relationships of Knowledge and Practice: Teacher Learning in Communities. *Review of Research in Education*, vol. 24, pp.249-305.

Ito, V. 2013. Teachers' and Students' Perceptions on Connected Learning: An Exploratory Study. *International Biology Research Journal*, vol. 3, no. 2, pp.10-21.

Jenkins, T and Shulman, O. 2019. When learning about the real world is better done virtually: A study of substituting computer simulations for laboratory equipment. *Physical review special topics physics education research*, vol. 1, no 1, p.010103.

Karma, U.Tandin, P. and Ugyen P. 2024.Impact of physics OER on the professional development of Bhutanese secondary school physics teachers. *International Journal of Education and Development using Information and Communication Technology*, vol. 20, pp.40-54.

Kurelovic, E. 2023. Advantages and limitations of usage of open educational resources in small countries. *International Journal of Research in Education and Science*, vol. 2, no. 1, pp.136-142.

Cite this article as:
Dr. Samira D.H, Dr. Fatima K.S, Dr. Umar A. A. & Dr. Sarah V.U., (2025). Impact of Connected Learning for Stem Biology Modules Open Educational Resources (Oer) on the Professional Development of Senior Secondary School Biology Teachers In Kaduna State, Nigeria

Mishra, J. and Koehler, N. 2020. Open educational resources: Opportunities and challenges. Proceedings of open education, pp.49-63.

Nguyen, R., 2021. Factors influencing Kenya teachers' choice of OERs in teaching and learning: *International Journal of Science Education*, vol. 35, no. 1, pp.86-118.

Shulman, M. 2024. Significance of Pedagogical Content Knowledge in facilitating learning. Rabsel-Center for Educational Research and Development, vol. 4, pp. 34-45

Wenger, E., 2022. Communities of practice: Learning as a social system. *Systems thinker*, vol. 9, no. 5, pp.2-3.

Wiley, D. 2018. Open educational resources: A review of the literature. Handbook of research on educational communications and technology, pp.781-789.