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## **Impact of CL4stem Project Mobile Communities of Practice on Science and Mathematics Teachers' Capacity Building Towards Piloting Curated Subject-Specific Oers in Nigerian Secondary Schools**

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**Abstract:** Connected Learning for STEM (CL4STEM) is an innovative project aimed at teacher capacity building in science, technology, engineering, and mathematics involving communities of practice as its component to developing teachers' ability to adopt an innovative approach to science instruction and to implement a novel curriculum. Hence, this study investigated the impact of CL4STEM project mobile communities of practice on science and mathematics teachers' capacity towards piloting curated subject-specific OERs in Nigerian secondary schools and to enhancing subject matter knowledge, pedagogical knowledge and practice for achieving Higher-Order Thinking, Equity and Inclusion (HOTIE) in their classroom. The study adopted a survey research design involving documentary content analysis and a one-group pre-test-posttest design to collect qualitative and quantitative secondary data to achieve the objectives of the research. The population of the study involves all science; biology, chemistry, and physics teachers in senior secondary schools in selected states in Northern Nigeria. Purposive sampling was used to select one newly qualified biology, chemistry, physics and mathematics teacher per subject area from twenty sample schools in the population, thus a

sample size of 80 science and mathematics teachers, 20 each per subject but less due to attrition. Content analysis of the science teachers' participation in telegram social network communications was used to obtain qualitative data on their CoP practices. While the Pre-test and Post-test on the teachers' subject matter and pedagogical content knowledge was the instrument for quantitative data collection. The instruments were validated by science and mathematics education experts. Four research objectives and four corresponding research questions guided the study. Descriptive narrative, descriptive content analysis and descriptive statistics were used to analyze the data on teachers' participation in the online telegram platform to provide answers to research questions. The study revealed that online CoP has creditably impacted on teachers' subject matter and pedagogical content knowledge. The implications for continuous teacher professional development policy and teacher education curriculum in Nigeria were highlighted

**Keywords:** CL4STEM, OERs, Mobile/online CoP

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## Introduction

Weak initial teacher education programmes and ineffective professional development programmes leaving teachers with weak content and pedagogical knowledge and classroom skills (including instructional practices) have been found in the literature as a factor affecting teachers' quality and students' learning (CLIX, 2019). In Nigeria, the teaching of STM in all the nation's schools has been described as generally ineffective and the student's achievement in terms of knowledge and skills are yet to meet the expectation (Adedokun, 2018; Ayeni, 2021). Several literature has implicated the teacher, and how science is taught as part of the problems (Olawuwo, 2015; Ayeni, 2021). It is reported that many science and mathematics teachers are not familiar with those effective teaching strategies, nor could they demonstrate the knowledge and competencies required to use inquiry-based teaching in implementing the Nigeria STEM curriculum (Mustapha, 2013;). Also, a good number of teachers in the school system are far from being computer literate and are incapable of applying technology in teaching science (FMOE, 2013; Tukura, 2019). Researchers have also reported that most teacher education courses at the pre-service level do not provide meaningful contexts for applying ICT to enhance teaching and learning and that even though ICT is included in teacher education programme, teachers are not sufficiently trained to use ICT in instructional setting (Tayo, 2015) From this standpoint, it is obvious that newly qualified teachers (NQTs) and generally STEM teachers in Nigeria need to be provided with capacity building in new pedagogical practice and in the method of integrating ICT in teaching and learning. The connected learning for

STEM (CL4STEM), a project aimed at teacher capacity building in STEM offers the opportunity to address this gap.

The Connected Learning for STEM (CL4STEM) project is an offshoot of the connected learning initiative CLIX developed by TISS, India to strengthen secondary STEM learning, pedagogic content knowledge of science teachers and their practice at scale in four states in India with proven effectiveness and as the award of winning project of the UNESCO-King Hamad Prize for the use of ICTs in Education in 2018 and the OER award for Excellence in Collaboration-2019 (<https://clix.tiss.edu>, <https://clixoer.tiss.edu>). The CLIX project is now being scaled through a process of knowledge diffusion and adaptation as CL4STEM to a new country context based on a South-South collaboration among higher education institutions involving Nigeria, Bhutan, and Tanzania.

The CL4STEM project being piloted in selected Nigeria secondary schools involving newly qualified teachers (NQTs) who have been given orientation training for piloting curated OER modules and to develop new pedagogical practice and in the method of using ICT in implementing curated subject-specific OERs. CL4STEM is aimed at bringing about educational changes that improve teacher subject content and pedagogical knowledge and teaching. Online CoP is one of the component features of the CL4STEM. It harnesses ICT and online CoP to give academic support during the piloting phase of the project. In the context of the CL4STEM project CoP, the expert teacher educators provide academic and technical support for NQTs to take active pedagogy and UDL principles into STEM classrooms in piloting the subject modules.

The CoP is a model for continued professional development or training where teachers are engaged with one another and teacher educators to gain new knowledge and understanding of the new pedagogical practices. It enables teachers to create a network amongst themselves with a goal for collective learning.

Basically, the project adoption of online CoP is to enable teachers interact and share knowledge and experiences and, and to discuss their experiences and challenges and discuss solutions that could lead to more effective ways to pilot the innovative that will enable them implement an innovative subject based OERs modules. The interaction is believed would help the teachers to develop content knowledge, and inclusive pedagogical principle in their classroom practice. The CL4STEM online CoP model is represented as shown in fig. 1

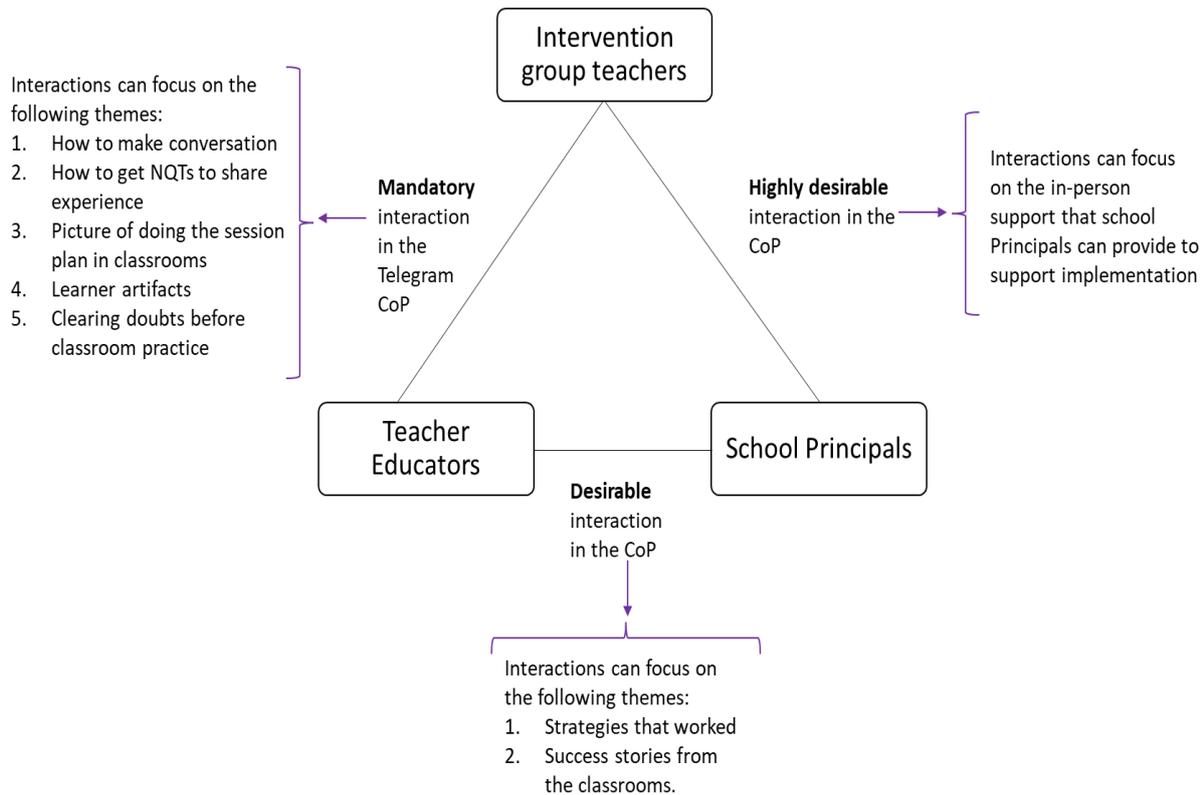
This study focuses on the NQTs and Teacher educators as the principal actors in the CoP

The teacher educators are expected to provide professional, administrative and possible technical support to the NQTs and to prepare a module level impact report. The NQTs are to actively participate in the Telegram CoP to share their practices and teaching/learning activities, seek support in the implementation of CL4STEM pedagogy in their classrooms and complete and post all module activities/assignment.

The objectives of CL4STEM online CoP are to;

- i. offer the NQTs the opportunity for professional development, to enhance and improve their content knowledge and pedagogical skills and practice,

- ii. empower the NQTs to using ICT (telegram/mobile technology) to link with each other and with expert teacher educators for collaborative learning activities, experience and knowledge sharing, clearing doubts and gaining understanding of different pedagogies, subject matter content of the modules.



## Purpose and Objectives of the Study

This study is aimed at finding out the impact of CL4STEM online CoP on newly qualified teachers on their subject matter and pedagogical content knowledge, and classroom practice for higher order thinking, inclusion, and equity (HOTIE). The specific objectives of this study are;

- Explore professional and academic activities/practices by newly qualified teacher's participation in CL4STEM online community of practice
- Explore how the participation of newly qualified teachers in CL4STEM community of practice has contributed to their professional development.
- Determine the impact of CL4STEM online community of practice on newly qualified teachers' subject matter and Pedagogical content knowledge and practice.
- Find out if the CL4STEM CoP impact differently on the NQTs subject groups

## Research Questions

To achieve the objectives of the study, the following research questions were stated to guide the study:

- What professional and academic activities/practices are carried out by the newly qualified teachers participating in CL4STEM online community of practice?
- Do the practices of newly qualified science and mathematics teachers provide evidence that CL4STEM CoP engagement contribute to their professional development?
- What is the impact of online CoP on the NQTs subject matter and pedagogical knowledge, and practice?
- Is there any perceived difference of the impact of online CoP among the NQTs subject groups?

## Literature Review

Many research studies have established that CoP is useful for teacher professional development (Qi and Wang, 2018, Wesley, 2013), and it is believed that online learning communities can improve instructors' professional development, especially with the growth and accessibility of the internet, thus, erasing time constraints and distance (Rosell-Aguilar, 2018). Qi and Wang (2018) reported that WeChat was effective in enhancing teachers' interaction with one another in both synchronous and asynchronous ways to work and reflect together and share experiences and ideas. COP inspires teacher inquiry and encourages teachers to develop their existing use of the innovation further, and work together and develop shared practices (Goodyear et al. 2014). Similarly, Wesley (2013) identified that CoP built on Twitter promoted activities for members to share ideas and practices.

The COP has the capacity to make certain tasks, activities, or a series of events easier, and alter users' social surroundings (Hoadley 2012). A CoP makes professional development to be more practical, adaptable, and capable of providing just-in-time support for participating teachers (Wang and Lu 2012). Sijia, Xiao, Xinli, & Jiangzhi, (2019) investigated building an online community of practice through WeChat for teacher professional learning. The finding shows positive perceptions about COP using WeChat were identified among participants on joining the teacher group. Moreover, their teaching practices were positively transformed. It also reported in the literature that Online CoPs allow greater flexibility than traditional, face-to-face mentoring, it also enhances members' professional growth through interactions with professional colleagues (Khalid, et al., 2014) Khalid, Joyes, Ellison, and Daud, (2014) investigated the factors influencing teachers' level of participation in online communities. The finding shows that the participating teachers view CoP participation as useful for getting new ideas and enhancing their pedagogical skills. Juandi, and Jupri, (2013) reported that CoP provides the opportunity for group members to share ideas and experiences, and assist each other in adopting innovative strategies and approaches that is more professional. The Cop also enhance the teachers' teaching competence and improve the students' learning outcome and the quality of education (Juandi, & Jupri, 2013).

## Methodology

The study adopted a survey research design involving documentary content analysis and a one-group pre-test-posttest design to collect qualitative and quantitative secondary data to achieve the objectives of the research. The population of the study involves all science; biology, chemistry, and physics teachers in senior secondary schools in 3 selected states in Northern Nigeria; Niger, Kaduna and Kano states. Purposive sampling was used to select one newly qualified biology, chemistry, physics and mathematics teacher per subject area from twenty sample schools in the population, thus a sample size of 80 science and mathematics teachers, 20 each per subject; biology, chemistry and physics and mathematics teachers provided the data for this study.

### **Data Collection Instrument**

The instruments for data collection are; Teacher educator's module implementation report from July to August, 2022, and the subject-specific pre-test and post-test designed based on the constructs of subject matter and pedagogical content knowledge contents of the curated OER subject modules; biology, chemistry, physics, and mathematics. Each of test instrument contains the specific number of objective test items on each of the constructs. The test instruments were adopted from CL4STEM, OER subject modules and the content was validated by science and mathematics education experts.

### **Data Collection**

Records of CoP teachers' communication/posts and performances in the module assignments were obtained from Cop moodle platform/telegram group and from Teacher Educators module impact reports (secondary sources). The pre-tests were administered to collect the baseline data at the commencement of the piloting of the subject modules. The post-tests were administered at the end of the 6 weeks of the first phase of the module piloting and teachers' participation in the CoP.

### **Findings**

The data were analysed using; descriptive content analysis and descriptive statistics to provide answers to research questions. The results are presented in the tables;

#### **Research Question 1**

What professional and academic activities/practices do newly qualified teachers (NQTs) participate in the CL4STEM online community of practice?

Table 1. Analysis Of Frequency and Types of Professional and Academic Posts

S/No,	Type of Post	Frequency	Percentage
1.	PCK	250	52.6
2.	UDL	130	27.3
3.	Technical	37	7.8
4.	Communication/administration	58	12.2
	Total	475	
	Mode of post		
1.	Text only	246	53.9
2.	Images	190	41.6
3.	External links	20	4.4
	Total	456	

Table 1 revealed the professional and academic posts of the teachers on the CoP platform using ICT (telegram/mobile technology) to link with each other and with expert teacher educators. Teachers posts on PCK (52.6%) UDL (27.3%), the use of text (53.9), and images (41.6) were most frequent professional activities for collaborative learning activities, experience, and knowledge sharing, clearing doubts and gaining an understanding of different pedagogies, subject matter content of the modules. Although, technical posts were less frequent (7.8%) the NQTs were faced with technical challenges due to unstable internet connectivity, module access, lack of skill in the use of telegram etc were mostly the content of the post.

## Research Question 2

- Do the practices of newly qualified science and mathematics teachers provide evidence that CL4STEM COP engagement contribute to their professional development?

Analysis of CL4STEM COP contributions to NQTs professional development relative to subject matter and pedagogical content knowledge for each of the subject group are given in the tables 3-5

Table 2. Cop Contributions to Knowledge and Practice: Subject Group 1

Criteria	Number of teachers				Total
	Novice	Emerging	Proficient	Accomplished	
<b>A. Subject Matter Knowledge</b>					
1. Knowledge of Subject Matter		2(18.18%)	6(54.55%)	3(27.27%)	11
2. Nature of Science/ Mathematics		1(9.09%)	6(54.55%)	4(36.36%)	11
<b>B. Pedagogical Content Knowledge</b>					

3. Instructional Strategies	5(45.45%)	6(54.55%)	11
4. Students' misconceptions & Learning Difficulties	4(36.36%)	7(63.64%)	11
5. Representation of the Content	3(27.27%)	8(72.73%)	11
6. Context for Learning	3(27.27%)	8(72.73%)	11
7. Curriculum knowledge	3(27.27%)	8(72.73%)	
<b>C. General Pedagogical Knowledge</b>			
8. Equity and Inclusion	3(27.27%)	8(72.73%)	
9. Classroom Management	2(18.18%)	<b>9(81.82%)</b>	11
10. Assessment	4(36.36%)	7(63.64%)	11
<b>Total</b>			

Table 3. Cop Contributions to Knowledge and Practice: Subject Group 2

Criteria	Number of teachers				Total
	Novice	Emerging	Proficient	Accomplished	
<b>A. Subject Matter Knowledge</b>					
1. Knowledge of Subject Matter		2 (10%)	<b>5(25%)</b>		7(35%)
2. Nature of Science/ Mathematics		1 (5%)	5(25%)		6(30%)
<b>B. Pedagogical Content Knowledge</b>					
3. Instructional Strategies			6 (30%)		6(30%)
4. Students' misconceptions & Learning Difficulties		6 (30%)			6(30%)
5. Representation of the Content		6(30%)			6(30%)

6. Context for Learning		5(25%)	1(5%)		6(30%)
7. Curriculum knowledge		1(5%)	2 (10%)	3 (15%)	6 (30%)
<b>C. General Pedagogical Knowledge</b>					
8. Equity and Inclusion	1 (5%)		5 (25%)		6 (30%)
9. Classroom Management	1 (5%)			5 (25%)	6 (30%)
10. Assessment		5 (25%)	1 (5%)		6(30%)
<b>Total</b>					

Table 4. Cop Contributions to Knowledge and Practice: Subject Group 3

Criteria	Number of teachers				Total
	Novice	Emerging	Proficient	Accomplished	
<b>A. Subject Matter Knowledge</b>					
1. Knowledge of Subject Matter		2(10%)	6(30%)	5(25%)	13
2. Nature of Science/ Mathematics		1(5%)	6(30%)	6(30%)	13
<b>B. Pedagogical Content Knowledge</b>					
3. Instructional Strategies		2(10%)	5(25%)	6(30%)	13
4. Students' misconceptions & Learning Difficulties			5(25%)	8(40%)	13
5. Representation of the Content			6(30%)	7(35%)	13
6. Context for Learning		1(5%)	5(25%)	7(35%)	13
7. Curriculum knowledge		1(5%)	4(20%)	8(40%)	11
<b>C. General Pedagogical Knowledge</b>					

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8. Equity and Inclusion	2(10%)	5(25%)	6(30%)	11
9. Classroom Management	2(10%)	4(20%)	<b>7(35%)</b>	
10. Assessment		6(30%)	7(35%)	
<b>Total</b>	11	52	67	<b>130</b>

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Tables 3-5 show the content analysis of Teacher Educators module implementation reports relative to lesson plans, subject matter knowledge, pedagogical content knowledge, and general pedagogical knowledge of the NQTs. revealing also the professional progression of the NQTs'. The analysis provides the data to answer research question 2

#### **Narrative of evidence from the TE reflections and reports**

The lesson plans are generally activity and learner-centred, complemented with illustrations and integrated with the use of technologies, adoption of UDL principles with students to work in groups and promoting cooperative learning, adoption of different instructional strategies and use of variety of assessment modes that could prompt high order thinking and fostered development of Cognitive Skills, Inclusion, and Equity in the Classrooms. Teacher educators' reflections on the subject matter knowledge of the teachers and data generated from lesson plans indicate that the teachers understood the subject matter deeply and were able to develop students' conceptual knowledge and address misconceptions.

The data generated on General Pedagogical Knowledge of the teachers as reflected in the lesson plan indicate that classrooms space and time, equity and inclusion, the ability of the teacher to use multiple means of engagement, representation, action, and expression for creating learning experiences that met the needs of diverse learners were taken into consideration. The reflection on the teachers' pedagogical content knowledge, teacher educators indicated that the teachers could relate content to appropriate pedagogy and technology; videos, internet links and pictures, and online diagrams are evident in the instructional strategies employed by the teacher and as reflected in the structure of their lesson plans.

Further the following were revealed from the module report; improved technical knowledge and skills in use of telegram and the use of videos, pictures, illustration technology-mediated activities, using cultural context and local language to clarify difficult concepts and misconceptions, teachers have learned to use more online interactive videos.

All these are evidence that CLASTEM COP engagement contributes to the NQTs professional development and have enhanced their professional progressions

### Research Question 3

- What is the impact of online CoP on the NQTs subject matter and pedagogical knowledge, and practice?

On the Impact of CL4STEM COP engagement on the NQTs subject matter and pedagogical content knowledge are given for each of the subject group in Table 6-9

Table 6. Cop Impact Analysis: Subject Group 1: Mathematics

		<b>Post Test 10.25</b>			
<b>Number of teachers</b>		Novice	Emerging	Proficient	Accomplished
<b>Pre test</b> 6.95	0-25% Novice				1 (5%)
	26-50% Emerging		7 (35%)		1 (5%)
	51-75% Proficient			6 (30%)	1 (5%)
	76-100% Accomplished				3 (15%)

Table 7. Cop Impact Analysis: Subject Group 2: Chemistry

		<b>Post Test: 12.61</b>			
<b>Number of teachers</b>		Novice	Emerging	Proficient	Accomplished
<b>Pre test</b> 6.95	0-25% Novice	2(10.53%)			
	26-50% Emerging	8((42.11%)	1 (16.67%)		
	51-75% Proficient	8(42.11%)			
	76-100% Accomplished	1(5.26%)			5(83.33%)

Tables 6-8 all revealed the average total post-test score of each subject group to be higher than the pre-test score. This indicates NQTs gain in subject matter knowledge and pedagogical content knowledge and general pedagogical knowledge as a result of the engagement in the CL4STEM CoP. Consequently, the teachers have all transited from the greater majority of being a novice to higher statuses of proficient and accomplished except for

Table 7 subject group 2 where more of the NQTs are at the novice status, and only a few at the emerging status and none at the proficient and accomplished.

Table 8. Cop Impact Analysis: Subject Group 3: Biology

		<b>Post Test: 8.56</b>			
<b>Number of teachers</b>		Novice	Emerging	Proficient	Accomplished
<b>Pre test</b> 7.58	0-25% Novice			1	
	26-50% Emerging		1	4	1
	51-75% Proficient		1	9	
	76-100%				
	Accomplished		1	1	

From the findings of this study, it is summarised that the teachers' participation in the online CoP platform using ICT (telegram/mobile technology has enhanced the teacher's engagement in professional and academic activities online and has also impacted remarkably on the NQTs' PCK in teaching science and mathematics and PK in enhancing professional practice and SMK to understanding the contents of the modules resulting on NQTs professional progression from novice to gradually becoming proficient and accomplished teachers. These findings are consistent with Qi and Wang (2018); and Rosell-Aguilar (2018) whose studies have established that CoP is useful for teacher professional development and that online learning communities can improve instructors' professional development,

## Conclusion

The findings have implications for continuous teacher professional development policy and teacher education curriculum in Nigeria discussed. It is therefore recommended that online CoP be adopted as an orientation framework for newly qualified teachers and as an approach to the implementation of new programme teaching, and for continuous teacher professional development. The finding also strongly suggests that teacher training institutions should adopt the online CoP into their pre-service teacher education teaching practice as the online CoP approach can be more beneficial in providing field support to pre-service teacher professional development (TPD) than the traditional training model of school visits teaching practice supervision model. The online Cop will help promote greater links and interactions between the teacher educator/supervisors and the teaching practice students thereby erasing constraints of time and distance.

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