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Investigating the Impact of the Continuous Professional Development in Educational Mentoring and Coaching for STEM Teachers on Biology Teacher's Classroom Practices in Public Schools of Kamonyi District, Rwanda

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Abstract: *Rwanda has adopted continuous professional development (CPD) in education as one of the adequate methods for improving teacher's knowledge towards the biology teacher's classroom practice. This study's aim was to examine effects of CPD in educational mentoring and coaching for STEM teachers on biology teacher's classroom practices in Kamonyi district, Rwanda. The study was mixed research and the population of this study was 184 biology teachers while the sample size was 123 biology teachers. Data were gathered using questionnaires, observation with Excel and SPSS being used for statistical computing. Chi-square test and Pearson correlation were used. Findings showed that the impact of CPD in educational mentoring and coaching for STEM teachers on biology teacher's classroom practices scored at 96.5%, with a good relationship between CPD program and biology teachers classroom practice (p-value = 1.23e-07).The CPD impacts were inferred as follows: improving teacher's competence (15%),time management(14%).Barriers were revealed as: The shortage of teaching materials (60.6%), insufficient internet connection (19.7%), The purpose of the study was to examine the effects of CPD in educational mentoring and coaching for STEM teachers on biology teachers' classroom practices in Kamonyi district. Despite some barriers that persisted, CPD activities have shown better significance towards biology teachers' classroom practices.*

Keywords: *Continuous Professional Development, Biology teaching practices, Coaching and mentoring.*

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1. Introduction

The investigation on the impact of the continuous professional development in educational mentoring and coaching for STEM teachers on biology teacher's classroom practices in Kamonyi district of Rwanda is strongly necessary, since CPD program helps biology instructors to improve their professional abilities, knowledge and skills (Martin, 2015). Rwanda acknowledged CPD programs in public schools for enhancing science teaching and learning outcomes (REB, 2015). Rwanda shifted from knowledge and skills acquisition learning to critical thinking, creation and innovation, research and problem solving, communication, cooperation, interpersonal life skills and lifelong learning competencies (Ling &Mackenzie, 2015). So, the changes embed biology teachers constantly

updating their skills and knowledge through CPD programs (Darling-Hammond et al., 2009).

The CPD programs are valued for involving biology instructors in dynamic learning, which is aligned with Rwanda's aspirations for the next generation and the effectiveness of the educational system (REB, 2015). In USA and France, the CPD is valued for raising standards for the skills required at the international level and for assisting biology instructors in overcoming obstacles they confront in their teaching profession (Powell et al., 2010). In Zimbabwe and Ghana, CPD programs were designed as a strategy for fulfilling its population's goals to satisfy their needs through a better educational system (Opfer & Peder, 2011). Seven years after the Rwandan government made the decision to do so, there is information available regarding the adoption of CPD programs across educational system (REB, 2015). It is essential to evaluate the existing situation in order to determine the potential and barriers related to its implementation and to construct mitigations (Gersten et al., 2010). This study responds to the knowledge gap and presents previously unpublished data on the biology teachers' perception towards CPD programs in public schools of Kamonyi district, Rwanda. It aims to respond to the following research question in particular: How are CPD impacts carried out at the school level in Kamonyi District?

2. Literature Review

The CPD programs were considered as the best way for teachers to strengthen their knowledge and abilities as long as knowledge is shared and applied via CPD activities in academic environment (Bandura, 1977). In the Canada, United Kingdom, New Zealand, German and Australia, CPD programs began in 1970s and they were used to empower teachers towards improving educational outcomes (Dede et al., 2009). Africa's CPD programs have also been embraced by nations including Rwanda, Zambia and Tanzania (Desimone et al., 2002). The majority of developing nations adopted CPD systems from rich nations and modified them to improve science teaching outcomes, including biology subjects (Garet et al., 2008).

The CPD program is viewed as a combined and integrated learning setting that combines information, practices, and attitudes that can be identified via experience and action (Guskey, 2002). In this sense, instructors use competence as a crucial organizational resource to obtain a competitive edge in their thinking and actions (Kazemi & Hubbard, 2008). One way to connect education to the modern workplace is through CPD programs, which can help students who perform poorly in biology classes because they lack the skills required for the subject's teaching and learning methods (Lam, 2015). The CPD program in Rwanda is oriented on higher order and critical thinking abilities that foster understanding and facilitate efficient biology learning, where learning objectives employ more difficult and active verbs that can encourage biology teachers to engage in in-depth thought (REB, 2015). The CPD program also attempts to help biology teachers shift from memory and recall to higher level thinking that contributes to deep and long-lasting learning (Likisa, 2018). The main goal of the CPD program is for biology instructors to become proficient in the subject matter they teach and transition from rote memorization and information recall to knowledge and biology application of learning in real-world contexts (Hill et al., 2013). Therefore, CPD activities provide a biology teaching and learning environment which is properly integrated, they become problem solvers in society (Little, 1993). This study attempts to identify the impact of the continuous professional development in educational mentoring and coaching for STEM teachers on biology teacher's classroom practices in public schools of Kamonyi district, Rwanda.

2.1. The innovative teaching methods for science and mathematics acquired by teachers trained during the tenure of continuous professional development in educational mentoring and coaching for STEM teachers

Models for skill application can be built in a variety of ways and with a variety of backgrounds. The majority of continuing professional development (CPD) events can be thought of as a way to introduce or develop information, skills, attitudes, and knowledge assumptions (Ball, 1995). According to Apple (2001), the most important aspect of CPD is the sort of professional knowledge received, the context in which it is acquired, and how it is applied to comprehend the nature of the knowledge. Teachers can use the skill application model to help them understand professional knowledge and professionalism. Outside of the institutional environment, Apple (2001) does not explicitly explore the importance of informal professional discussions and assessments. However, this informal context is indeed most relevant to continuing professional development. The models presented in this part reflect the differing degrees of importance in each context as prospective sites of knowledge acquisition, as well as their consideration in examining professional competency development programs across the models (Sherry & Gibson, 2002).

These models can then be used as the basis for creating a new model that is more suitable. Professional

competency development can take nine different forms or programs in general: 1) training; 2) certification; 3) deficiency; 4) reflective dissemination; 5) benchmarks-based; 6) mentoring; 7) working group; 8) action research; and 9) transformative and thus the training model in general, is still dominant in the development of teacher professionalism (Avalos, 2011). This model supports the idea of skills-based and technocratic teaching and it also allows teachers to update skills to improve their competence (Barber & Mourshed, 2007). Therefore, the training is usually carried out outside the institution and the use of that model using external speakers off-site has sparked criticism because it can be arguably implemented in the institution itself (Bautista et al., 2015). Unfortunately, the training program is often unrelated to the participants' (teachers') actual classroom situation (Borko, 2004). The awarding model emphasizes completing a period of service to qualify for t an award.

An example in Indonesia is the awarding of the Lencana Karya Satya (Satya's badge) after serving a certain period of service. It is conducted by validating the individual's effective service in a work area. In practice, this model also serves as a reference or limitation for the potential granting of other awards (Bautista et al., 2015). This award model is part of educational practice and applied to a teaching career to measure the teachers' integrity aside from their professional competency (Borko, 2004). The deficit model is specially developed to address performance management inadequacies in teachers. Avalos (2011) suggests that performance management is a means to improve performance standards. Government involvement in improving efficiency, effectiveness, and accountability is sometimes referred to as performance management (Burnaford et al., 2007). Thus, performance supervisors manage and evaluate teachers' performance and are also responsible for enhancing a teacher's individual performance in weak areas (Carpenter et al., 1989). The reflection dissemination model provides an opportunity for a teacher to participate in workshops (Avalos,2011). Following this, the teacher disseminates the workshop results to fellow teachers (Darling-Hammond, 2010). This model tends to be chosen as an alternative when financial resources are limited but is not very popular in Indonesia. says that This cascade model tends to be used by a group of teachers in order to share their learning model (Borko, 2004). They share what they've learned, with participation, collaboration, and ownership values guiding the process (Darling-Hammond et al., 2010). The standards-based model highlights the idea that teaching is a complicated political policy (REB, 2015). It aims to create a learning and teaching system by teachers that can empirically prove the relationship between the effectiveness of teacher performance and student learning processes in certain situations (UN, 2016).

Regrettably, this architecture restricts the possibilities for creating alternate skill application models and it also largely relies on a behaviorist learning viewpoint on the causal relationship between teacher competence and the rewards that emerge from it (UNESCO, 2011). A variety of skill application methods based on philosophical principles are included in the coaching/mentoring model and the importance of one-on-one contact between two teachers is a crucial feature of this model (REB, 2015). Coaching focuses primarily on skill transfer, whereas mentoring combines "professional counseling and companionship" aspects (UNESCO, 2002). Mentoring also entails a partnership between inexperienced and experienced teachers (MINEDUC, 2016), and the coaching/mentoring concept is linked to the community of practice model. This style, on the other hand, is nearly the polar opposite of the prior coaching/mentoring model and the primary distinction is that a community of practice is made up of more than two persons and does not involve any level of confidentiality (Borko, 2004). The hierarchical assessment-based model is another type of CPD coaching/assistance model mentioned before (Polit & Beck, 2014).

This concept has little in common with the community practice model. MINEDUC (2016) claims that we are all part of a broad community of learning practices that are characterized by three key processes.: a. Generate productive reciprocal relationships; b. Understand and adapt the work unit of the teacher community; and c. Develop the repertoire, styles, and discourses of the teacher community. The action research model is characterized as a study of social circumstances in which individuals act as researchers to improve the quality of the situation (Nizeyimana et al., 2021). The participant's grasp of the circumstance and execution of the exercise might be deemed the quality of action, and the action research model's proponents (UNESCO, 2011) suggest that involving the community of practice in its actions will have a bigger impact. This is not, however, a need for an action research model. The trans-formative model involves several processes and conditions with aspects taken from various other models including the mix of practices and situations that promote a revolutionary agenda is its defining trait. According to Bush (1984) perspective on this model is to support educational change efforts, and they compare focused knowledge and contextual emptiness models including the contextual emptiness models from the practice model community's context-specific training approach do not always accommodate new kinds of formal knowledge.

3. Methodology

In this research, a mixed method was adopted because it enhanced complementarity between qualitative and quantitative data for having a meaningful conclusion research. The first strategy was conducting an empirical examination based on quantitative research with school biology teachers by means of a questionnaire. In Kamonyi district of Southerrn Rwanda, secondary schools were specifically chosen. Because of the nature of the study, only biology teachers were involved. The study's target population was the Kamonyi District public schools utilising the model formula n=N/(1+N (e)2) obtained from the The Yamane formula (Darling-Hammond et al., 2009).

n = sample size, N = population, and e = error

The sample size was computed as follows at a 95% confidence interval and a population of 184:

$$= \frac{184}{1+184 \times (0.05)^2}$$

Sample size =123 respondents

Thus, the sample sizes of 123 respondents were considered representative of the total population.

The goal of the research was described to respondents during the introduction (Little, 1993), and a consent form was signed in order to assure the confidentiality and relevance of the results. The on-the-spot data collection method was used to collect the data in order to assure accurate responses and effective time management (Abu-Taleb & Murad, 1999). According to Carter's 2014 theory, the second method involved classroom observation in which 5 biology teachers in 5 schools were purposely observed in 5 days for a period of 40min for each participant. The third way involved using documentation as the school's accessible resources.

In a quantitative study, validity is the degree to which a notion is precisely measured. A supervisor reviewed the questionnaire to ensure that there were no errors. There are no ambiguous questions. Grammar and typographical errors flaws were resolved, and the statement's clarity was improved. Thanks to the feedback, I've improved. The extent to which the phenomenon can be quantified, and the outcome is consistent. Reliability is defined as being consistent. This research used a pilot test to assess the reliability of the questionnaire.

In this study, data was gathered through the questionnaire information from interviews was qualitatively analyzed (Cerny & Kaiser, 1977). Thematic analysis was used to evaluate the qualitative data, and SPSS was used to statistically analyze the quantitative data. Prior to conducting the study for all schools, each school's data was analyzed separately. Surveys and interviews were utilized to supplement the data from the resources made accessible (Carter et al., 2014).

4. Results and Discussion

4.1 Introduction

In this study, the collected data are in line with the objectives of the study, and the gathered data was from individual interviews and questionnaires were successful to provide a significant and interesting view of school heads and biology teachers of Kamonyi public schools about the biology teacher’s perception on CPD in twelve secondary schools of Kamonyi district, Rwanda. The presentation and analysis of the data included tables and figures.

4.2 Demographic characteristics of the participants

A total of 123 biology teachers of public schools participated in the survey, which was conducted for the academic year of 2021–2022 in the 32 public schools which has previously implemented CPD activities for biology teachers. (Table1).

Table 1: Frequencies and percentages of demographic factors of biology teachers

Factors	Description	Frequency (%)
Gender	Male	78
	Female	22
Teaching Experience	1 to 5 years	18.4
	6 to 10 years	75.2
	More than 10 years	6.4
Type of school	Public	28.6
	Government aided	71.4
	Private	0

Source: Primary data, 2023

The report showed that more teachers were experienced 6 to 10 years (75.2%) and 78% were males.

4.3 The impact of the CPD in educational mentoring and coaching for STEM teachers on biology teachers' classroom practice

In this study, biology teachers got involved in as direct beneficiaries of continuous professional development in educational mentoring and coaching for STEM teachers. As shown in the table below, biology teachers provided views on various new methodology approaches acquired in CPD activities. A conceptual understanding test that was administered to 123 biology teachers in Kamonyi district in Rwanda and its aim was to determine whether there is a significant difference the use of skills and knowledge elaborated in STEM CPD for biology teachers in before and after CPD implementation for schools.

4.4 Biology teachers innovative teaching methods elaborated in STEM CPD before they were trained.

The table below summarizes biology views how they used various innovative teaching methods for science and mathematics before they got trained as presented below.

Table 3: Biology teachers views on the innovative teaching methods elaborated in STEM CPD before they were trained.

SN	Pedagogical skills/Factors	Never	Rarely	Often	Always
1	Mentoring and coaching	96.4	2.6	0	0
2	Induction of new teachers	85.3	10.9	0	0
3	Use of 5Es instructional model of teaching to prepare and deliver a lesson	89.2	7.1	0	0
5	Use of Discrepant event to excite learners	87.6	7.3	0	0
6	Use real material or real model to to excite learners	91.8	9.1	0	0
7	Formulation of key question	90.7	5.4	0	0
8	Allow learners to explore new content with a well-chosen real experiment/video/animation diagram(s)3D model/simulation	96.1	3.6	0	0
9	Use of practical activities	96.1	3.9	0	0
10	Use of inquiry-based teaching and learning	95.3	0.8	0	0
11	Use of questioning technique	96.2	3.8	0	0
Average		92.4	5.42	0	0

In order to assess the impact of the CPD in educational mentoring and coaching from STEM teachers, a number of statements were made to the respondents from the questionnaire. The responses were a likert scale ranging from never, rarely, often and always. The results were deduced as follows: pedagogical skills scored in a huge range of 85.3 % to 96.4% and the general aggregate at 92.2%. This inferred that before biology teachers were trained their pedagogical skills were very low. From the table above, it can be deduced that 92.4% of the respondents indicated that before being trained through CPD, they had practically no adequate biology teaching skills.

4.5 Comparative trends innovative teaching methods they learnt in CPD before and after being trained.

A total of 123 biology teachers were interviewed through guided interview, the assessment aim was to track initial pedagogical skills for biology teachers before attending STEM CPD and after being trained. This was also done to show the improvement that happened for knowledge and skills development for biology teachers during classroom teaching practice.

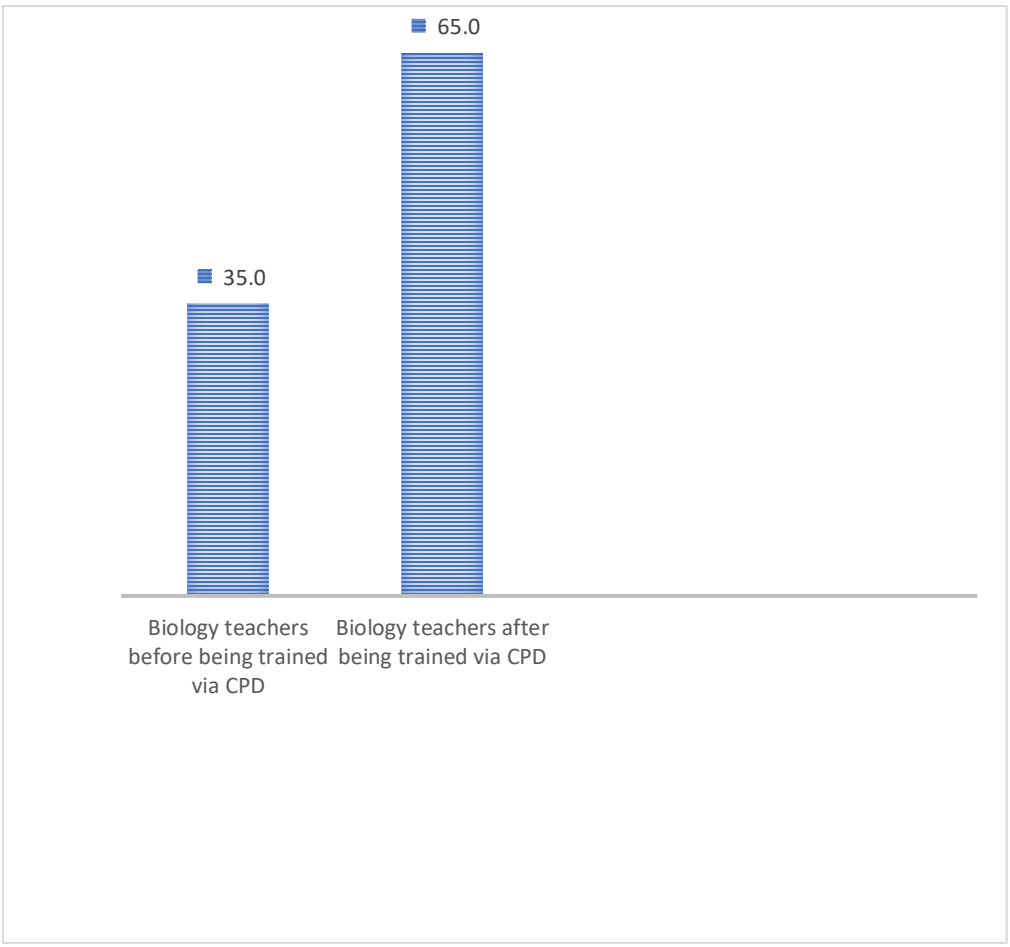

Figure 1: Comparative analysis for the innovative teaching methods identified before and after training.

A positive change on the use of knowledge and skills learnt through STEM CPD in biology classroom teaching practice was observed by comparing pedagogical skills of biology teachers before and after training (Fig 1). CPD influences biology teaching practice in public schools. P-value: 5.412e-06. The $p < 0.05$, indicates that CPD has significant influence on biology classroom teaching practice as shown by the figure as CPD increased it enhances biology teaching also. It has been noted that the use of knowledge and skills for biology teachers was at 35% and after being trained skill enhanced to 65% in Public schools of Kamonyi district.

4.6. CPD advantages towards biology teaching practice

Throughout questionnaire and observation approaches, some advantages were raised as a motivation for effective CPD in biology teaching practice in public schools. Results are presented as follows in bellow figures (2).

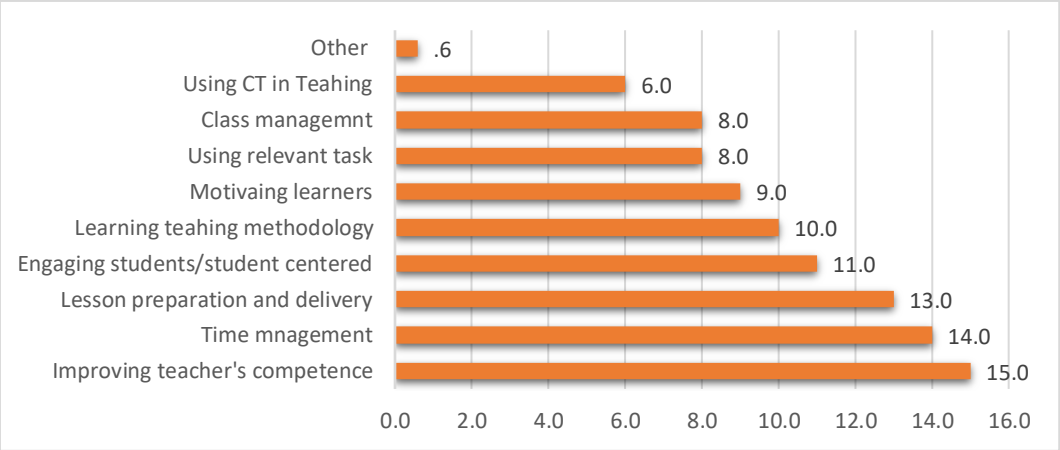

Figure 2: CPD advantages towards biology teaching practice

The findings of CPD advantages in the above table are reported as follows: improving teacher's competence (15%), time management(14%), lesson preparation and delivery (13),engaging students(11%), learning teaching methodology (10%), motivating learners (9%),using relevant tasks(8%), class management(8%) and using ICT in teaching (6%). This inferred that CPD is very crucial in biology classroom practice.

4.7. CPD Challenge towards biology teaching classroom practice

Throughout questionnaire and observation approaches, some challenges were raised as hindrance to effective CPD in biology teaching practice in public schools. Results are presented as follows in bellow figures (3).

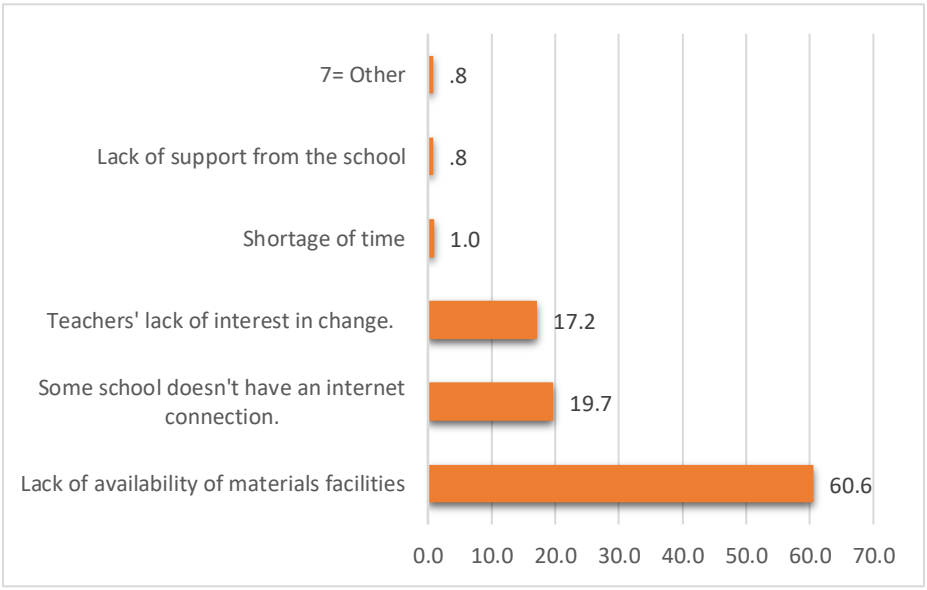

Figure 3: The barriers in CPD activities towards biology classroom teaching practice in public schools of Kamonyi district.

In this study, the challenges for CPD activities towards biology teaching and learning were outlined in the above figure by the biology teachers and head teachers as follows:

- 60.5% reported that CPD is hindered by lack of availability of materials.
- 19.7% Some schools do not have internet connection.

- 17.2 % reported that CPD lacks interest in change.
- 1.1% shortage of time
- 0.8% of school support and 0.08% for others

The challenges inferred that several barriers for CPD towards teaching biology practice in public schools is persisting as shown by biology teachers of Kamonyi district. The shortage of biology teaching and learning materials (60.5%) is predominant and followed by insufficient internet connection (19.7%).

4.8 Strategies to tackle barriers to CPD implementation

This study involved 123biology teachers to identify different strategies which could be used to handle barriers to CPD implementation in Kamonyi district public schools. The list provided in table 2 is not exhaustive since the research sample was limited to 123 respondents instead of all biology teachers public schools of Kamonyi district.

Table 2: Proposed Strategies

Strategies to overcome presented barriers	Frequency	Percentage (%)
To reduce teaching workload for SBMs & SSLs	123	100.0
To engage teachers at every stage of their professional learning	98	79.8
Setting a termly action plan for CPD	104	84.8
Education partnership and collaboration	86	65.5
Adopt new habits of making biology teaching and learning aids locally based	112	90.9

Source of data: Primary data collected in May 2023

Talking about strategies to tackle barriers to CPD implementation, all participants involved in the sample proposed reducing School based Mentors (SBM) and School subject leaders (SSL) workload as the most successful approach of solution when 98 out of 123 participants (79.8%) claimed that engaging teachers at every stage of their professional learning could be an additional approach. Thus, for 104 participants among 123 (84.8%) found that setting termly action plan for CPD might improve CPD impact on teaching and learning while 86 out of 123 participants (65.5%) proposed partnership and collaboration as another way of handling barriers under discussion. For the problem of time mismanagement, 112 respondents that is 90.9% viewed that the adoption of new habits towards time management could be one of possible solutions to such a barrier.

Discussion

This part provides discussions and conclusion of the study together with recommendations related to the findings of the study. Thus, it merely entails and reflects on the objective of the study which is to investigate impact of continuous professional development in educational mentoring and coaching for STEM teachers on biology teacher's classroom practice in public schools of Kamonyi district, Rwanda.

The impact and advantages of continuous professional development in educational mentoring and coaching for STEM teachers on biology teacher's classroom practice.

This study showed CPD program impacts and advantages towards biology classroom teaching biology in public schools, which were numerously deduced by biology teachers, and similarly stipulated by Dede (2009). The results from the observation revealed that all observed biology teachers were equipped with innovative teaching methods in biology classroom practice in the range of 65% to 91% which is also a higher level. This is aligned with the MINEDUC findings which argued that CPD is a relevant weapon for enhancing teachers innovating teaching skills towards science teaching classroom practice in schools (MINEDUC, 2017).Thus, the findings of this study also deduced a list of common advantages and statistical rating as follows:(1) improving teacher's competence (15%), (2) time management(14%), (2) lesson preparation and delivery (13%), (3) engaging students(11%), (4) learning teaching methodology (10%), motivating learners (9%), (5) using relevant tasks(8%), (6)class management(8%) and using ICT in teaching (6%), etc. This is also consistent to the UNESCO (2002) findings which argued that those advantages were

discovered during CPD implementation towards improving science teaching and learning outcomes in primary and secondary schools.

Barriers in CPD activities towards biology teachers' classroom practice in public schools that and strategies to overcome them

The study's finding has deduced the barriers that hinder CPD programs towards teaching biology in public schools of Kamonyi district, Rwanda. The biology teachers produced a long list of common barriers indicated that the shortage biology teaching and learning materials (60.5%) is predominant and followed by insufficient internet connection (19.7%). In addition, 60.5% reported that CPD is hindered by lack of availability of materials facilities, 19.7% Some school does not have internet connection, 17.2 % reported that CPD is lack of interest in change, 1.1% shortage of time, 0.8% of school support and 0.08% for others. This is in same the view of Bautista (2015), who has similarly discovered the barriers during CPD implementation towards teaching and learning outcomes in schools. Thus, in this research, 100% of biology inferred the strategies to tackle barriers during the CPD implementation is reducing SBM and SSL's teaching workload would be the most successful strategy, and it should be followed by adopting new habits of making biology teaching and learning aids locally based asserted at 90.9%. This is consistent to the REB (2015) findings which revealed that having mentors in schools and promoting the culture of making teaching materials were highly advised to the schools.The remedials strategies were proposed such or solutions as follows: **Barrier 1:**Lack of internet connection (17.2%) and chemical reagents (12.7%) for STEM subject in public schools in Rwanda and particularly in Kamonyi district where CPD should be carefully implemented at different levels, and this was often reported MINEDUC findings in public schools (MINEDUC, 2017).**Strategy**: To enable digital teaching on STEM subject including biology and it was noted that collaboration for schools or ministry of education with education partners for the support as advocacy and fund funding where applicable (REB, 2015).

Barrier 2: Lack of time: the timetable biology teachers is often packed on a daily basis, sometime CPD activities oblige them to travel to other settings. Our most precious resource as teachers is time, yet distance should not be an obstacle in this situation (Tan &Dimmock,2014). **Strategy:** Including CPD in teachers' timetable/action plan for CPD: Some of the better CPD experiences for me included team teaching and watching with professionals in other settings (Scott & Morrison, 2006).

5. Conclusions and Recommendations

5.1 Conclusion

According to the findings, CPD significantly impacts how biology is taught in schools. CPD workshops are widely believed to be essential to enhancing the process of innovative teaching methods towards improving biology teachers' classroom practice in Kamonyi District.

5.2 Recommendations

Teachers and school administration should take the initiative to overcome impediments and ensure that CPD sessions are conducted successfully and efficiently. The quality of the teaching at a school depends on the quality of its teachers because they are the architects of society and the foundation of the educational system. The study strongly recommended public and private sectors, school administrators and teachers, researchers, education partners to acknowledge CPD activities efficiently and efficiently.

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