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Impacts of Virtual and on-Site Mentoring on Instructional Delivery Effectiveness of Secondary School Biology Teachers in Ecology

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Abstract: The study aimed to assess the impact of virtual and on-site mentoring interventions on the instructional delivery effectiveness of secondary school biology teachers in teaching ecology. The study adapted a quasi-experimental design with structured observations, incorporating interventions within two designated groups, with non-random assignment of participants. Through purposive sampling, 40 early-career biology teachers were assigned to both the virtual and on-site mentoring groups. The study raised and addressed three research questions. The research instrument utilized for data collection was Instructional Delivery Effectiveness Scale (IDES). A panel of three experts validated the IDES, and its inter-rater reliability was assessed using Cohen's kappa coefficient, yielding a correlation coefficient of 0.85. Virtual mentoring sessions were conducted online via Zoom video conferencing platforms, while on-site mentoring sessions took place face-to-face at teachers' respective school locations. Classroom observations during ecology instruction sessions served as the method of data collection. Data collected were analyzed descriptively using frequency, summation, means, and standard deviations. The findings revealed that both virtual and on-site mentoring interventions contributed to improvements in instructional delivery effectiveness of early-career biology teachers. Substantial decrease in the frequency of Poor and Fair ratings were observed in both interventions, indicating decline in previously identified inadequacies and inefficiencies in instructional delivery. However, on-site mentoring group exhibited a more impactful change in instructional effectiveness in teaching ecology. Some recommendations made include engaging in continuous professional development and advocating for policies that promote the professional growth of biology teachers.

Keywords: Virtual Mentoring, On-Site Mentoring, Biology Teachers, Instructional Delivery Effectiveness, Professional Development.

Research Paper

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INTRODUCTION

Instructional delivery encompasses the process by which teachers transmit knowledge, skills, and values to students within educational settings. It involves various elements such as lesson planning, content delivery, assessment, and classroom management, all aimed at facilitating effective learning experiences. As described by Battioala (2014), instructional delivery entails dynamic interactions among students, teachers, content, and instructional materials, fostering engagement and collaboration in the learning process. Effective instructional delivery relies on the competencies and skills of teachers, which encompass a range of areas including classroom management, teaching methods, assessment practices, among others. Teachers must possess the ability to create engaging learning environments, employ innovative teaching strategies, provide constructive feedback, and leverage technology tools effectively to enhance instructional delivery (Oriji & Amadi, 2018). Mastery of these competencies enables teachers to adapt their instructional approaches to meet the diverse needs of students and maximize learning outcomes.

Biology teachers play a central role in implementing the secondary school biology curriculum through instructional delivery, exerting considerable influence on the quality of educational outcomes in the subject. As Ayeni (2011) asserts, teachers play an important part in facilitating effective and efficient learning and teaching processes. He further asserts that teachers are tasked with providing essential services,

including lesson planning, delivering lessons effectively, and conducting thorough monitoring and evaluation of students. Early-career biology teachers, referred to as beginning teachers by scholars (e.g. Anyanwu & Abe, 2023; John *et al*., 2023), frequently encounter unique challenges as they try to route the complexities of classroom instruction. Recognizing these challenges encountered by early-career teachers and the importance of effective instructional delivery in improving student learning outcomes, Anyanwu and Abe (2023) strongly advocate for the serious implementation of mentoring programmes in secondary schools to support instructional service delivery.

The field of education is continually evolving with the emergence of new technologies and methodologies, which significantly impact teaching and learning practices. Among these advancements, mentoring has emerged as a means for teacher professional development (Darling-hammond *et al*., 2017), particularly in secondary school education.

In recent years, the integration of virtual mentoring alongside traditional on-site mentoring has gained prominence due to its potential to improve teacher effectiveness in instructional delivery (Ejekwu & Worlu, 2021; Irby, 2020; Sankar & Sankar, 2010; Singer *et al*., 2023; Vargas *et al*., 2023; Williams *et al*., 2012). Castanheira (2016) argued that defining mentoring proves to be a challenging task. Nevertheless numerous authors whose papers were reviewed in this study contend that, mentoring is a professional relationship in which an experienced individual helps a less experienced person grow and develop, has long been recognized as an effective mechanism for teacher development (Boreen *et al*., 2011; Maor & McConney, 2015; Mijares *et al*., 2013; Vargas *et al*., 2023; *Williams et al*., 2012).

Mentoring programmes have been implemented in the field of education to provide early-career teachers with guidance, support, and feedback, assisting them in adjusting to the profession and improving their instructional skills (Barnett & Friedrichsen, 2015; Bullough, 2011; Singer *et al*., 2023). Traditionally, mentoring in education has been carried out through face-to-face interactions (Clement, 2018; Sankar & Sankar, 2010; Singer *et al*., 2023), with mentors and mentees meeting on a regular basis and conducting observations in the school setting (Yob & Crawford, 2012). However, the advent of digital technologies has revolutionized mentoring practices, giving rise to virtual mentoring platforms that facilitate remote communication and collaboration between participants (Rockinson-Szapkiw *et al*., 2013). Virtual mentoring offers many benefits and opportunities (Redmond, 2015) such as flexibility in scheduling (Clement, 2018; Kutsyuruba *et al*., 2019; Williams *et al*., 2012) and eliminates geographical constraints (Kutsyuruba *et al*., 2019; Redmond, 2015), allowing for broader participation and access to expertise (Eby *et al*., 2013; Vargas *et al*., 2023).

In the specific perspective of biology instruction in secondary school, effective instructional delivery is central in engaging students in order to improve their learning outcomes (Ejekwu & Worlu, 2021; Stinson & Wang, 2013). Given the complexity and interdisciplinary nature of concepts inherent in ecology, mentorship becomes indispensable in assisting early-career biology teachers to navigate these challenges. Integrating both virtual and on-site mentoring can provide teachers with the necessary guidance and support to implement innovative instructional strategies. By taking advantages of the expertise of mentors, biology teachers (mentees) can refine their teaching approaches to facilitate deeper understanding and retention of ecological concepts. Building upon this premise, this research aims to explore the effects of virtual and on-site mentoring on the instructional delivery effectiveness of secondary school biology teachers in teaching ecology.

Theoretical Framework

The present study on the impacts of virtual and on-site mentoring on instructional delivery effectiveness of secondary school biology teachers in ecology is deeply connected to the theoretical frameworks of social learning theory, social cognitive theory, and social constructivism. Social learning theory, pioneered by Bandura (1977), posits that individuals learn through observation, imitation, and modeling of behaviours exhibited by others. In the context of education, mentoring is conceptualized as a dynamic and reciprocal relationship between an experienced mentor and a less experienced mentee, fostering professional growth and development (Boreen *et al*., 2011). Social cognitive theory extends these ideas, emphasizing the role of self-efficacy in shaping individuals' beliefs and behaviours (Bandura, 1986). Mentoring interventions aim to enhance mentees' self-efficacy by providing opportunities for skill acquisition, feedback, and reflective practice (Eby *et al*., 2013). More so, mentoring in education is guided by principles of social constructivism propounded by Vygotsky (1978). Social constructivism emphasizes the importance of social interaction and collaboration in knowledge construction. Mentors facilitate learning by creating environments where mentees can actively engage in meaningful experiences and construct new understanding (Boreen *et al*., 2011; Bullough, 2011). These theoretical perspectives directly relate to this research by guiding the design and understanding of the mentoring interventions, which aim to enhance biology teachers' instructional delivery effectiveness through observation, modeling, and collaborative learning processes.

Literature Review

Mentoring has advanced beyond traditional face-to-face interactions to include virtual mentoring,

which makes use of digital platforms and communication technologies. Virtual mentoring otherwise known as e-mentoring (Williams *et al*., 2012), offers several distinct advantages over on-site mentoring. Firstly, it transcends geographical barriers, enabling mentors and mentees to connect regardless of their physical locations (Eby *et al*., 2013). This expanded reach facilitates access to a diverse pool of mentors, fostering cross-cultural exchanges and the sharing of varied perspectives (Castanheira, 2016). Williams *et al*., (2012) observed that while virtual mentoring draws inspiration from traditional mentoring schemes, it evolves uniquely and fulfills distinct needs. It provides flexibility in scheduling, accommodating the busy schedules of teachers and minimizing disruptions to their daily routines. According to Singer *et al*., (2023), online meeting platforms offer a range of communication tools, including video conferencing, email, and instant messaging, which can enhance the frequency and depth of interactions between mentors and mentees. In spite of the advantages it provides, virtual mentoring presents unique challenges that warrant consideration. One such challenge is the potential loss of non-verbal communication cues, which play a significant role in building rapport and fostering trust in mentoring relationships (Kutsyuruba *et al*., 2019; Lach *et al*., 2013). The absence of face-to-face interactions may also hinder the development of personal connections between mentors and mentees, impacting the quality and depth of the mentoring experience (Rockinson-Szapkiw *et al*., 2013; Sankar & Sankar, 2010). Moreover, technological issues such as connectivity issues, software glitches, and compatibility issues may impede the smooth functioning of virtual mentoring programmes (Singer *et al*., 2023). Furthermore, virtual mentoring requires a certain level of digital literacy and technological proficiency, which may pose barriers to participation for some teachers (Williams *et al*., 2012).

In contrast, on-site mentoring which Williams *et al*., (2012) described as face-to-face, offers unique advantages that stem from its physical presence within the school environment. One of the primary benefits is the opportunity for direct observation and modeling of effective teaching practices in real-time. On-site mentors can provide immediate feedback and support, tailored to the specific needs and context of the mentee's classroom (Bullough, 2011; Sankar & Sankar, 2010). This personalized approach allows for targeted interventions and the timely resolution of challenges, improving the mentee's professional growth and efficacy (Eby *et al*., 2013). Additionally, on-site mentoring fosters a sense of belonging and community within the school, strengthening interpersonal relationships and collaboration among faculty members (Kutsyuruba *et al*., 2019; Rockinson-Szapkiw *et al*., 2013). However, on-site mentoring is not without its challenges. One significant limitation is the potential for logistical constraints, such as scheduling conflicts and travel expenses, which may limit the availability and accessibility of mentors (Boreen *et al*., 2011). Moreover, Barnett and Friedrichsen (2015) posited that, the effectiveness of on-site mentoring may be contingent upon the quality of the mentor-mentee match and the mentor's pedagogical expertise. In some cases, mentees may feel apprehensive about being observed and evaluated by their peers, leading to feelings of vulnerability and resistance to feedback (Bullough, 2011). Furthermore, the hierarchical nature of on-site mentoring relationships may inhibit open communication and collaboration, particularly if power differentials exist between mentors and mentees (Rockinson-Szapkiw *et al*., 2013).

Research consistently demonstrates a positive association between mentoring and teacher performance, with mentored teachers exhibiting higher levels of instructional effectiveness and classroom management skills (Barnett & Friedrichsen, 2015). Mentoring interventions have been shown to enhance teachers' self-efficacy, confidence, and motivation, leading to greater job satisfaction (Hartmann *et al*., 2014) and retention within the profession (Clement, 2018; Ehlers, 2019; Kutsyuruba *et al*., 2019). Mentors play a critical role in supporting early-career teachers' transition into the profession, providing them with emotional support, practical guidance, and opportunities for professional growth (Darling-hammond *et al*., 2017; Williams *et al*., 2012). Moreover, mentoring has a direct impact on student learning outcomes, including academic achievement (Elizabeth, 2017), socio-emotional development, and school engagement (Eby *et al*., 2013). Teachers who participate in mentoring programmes are better equipped to meet the diverse needs of their students, adapt instructional strategies to individual learning styles, and create supportive learning environments (Rockinson-Szapkiw *et al*., 2013). By fostering positive teacher-student relationships and promoting a culture of collaboration and continuous improvement, mentoring contributes to a more enriching and inclusive educational experience for all students (Boreen *et al*., 2011).

Several factors have been identified as critical determinants of mentoring effectiveness in education. Firstly, the quality of the mentor-mentee relationship is paramount, characterized by trust, mutual respect, and open communication (Eby *et al*., 2013). Mentors who establish supportive and collaborative partnerships with their mentees are more successful in fostering professional growth and promoting reflective practice (Bullough, 2011). Secondly, the alignment between mentors' expertise and mentees' needs is essential, ensuring that mentoring interventions address specific areas of professional development and instructional improvement (Eby *et al*., 2013). Furthermore, the duration and intensity of mentoring relationships play a significant role in determining their impact on teacher effectiveness and job satisfaction (Hartmann *et al*., 2014). Long-term mentoring engagements allow for sustained support and continuous feedback, enabling

mentees to make meaningful progress towards their professional goals (Boreen *et al*., 2011). Mentoring programmes that incorporate structured training, ongoing supervision, and evaluation mechanisms are more likely to yield positive outcomes for both mentors and mentees (Maor & McConney, 2015).

Teachers instructional delivery task are multidimensional (Anyanwu & Abe, 2023; Ejekwu & Worlu, 2021). The effectiveness of instructional delivery in biology education is crucial for fostering student engagement, comprehension, and retention of key concepts. Research in teaching and learning biology has identified a wide range of instructional strategies that contribute to effective instructional delivery. Student-centred instructional strategies, for example, encourages students to explore scientific phenomena through hands-on investigations, collaborative problem-solving, and critical thinking activities (Greenleaf *et al*., 2011). By engaging students in authentic scientific practices, inquiry-based lessons promote deeper understanding and retention of biological concepts (Stinson & Wang, 2013). Similarly, active learning strategies such as group discussions, concept mapping, and peer teaching have been shown to enhance student participation and knowledge acquisition in biology classrooms (Stinson & Wang, 2013). Mentoring can provide biology teachers with guidance and support in implementing various instructional strategies (Barnett & Friedrichsen, 2015). Moreover, pedagogical approaches play a significant role in shaping instructional delivery effectiveness in biology education. Constructivist approaches, grounded in theories of social constructivism and cognitive psychology, emphasize the active construction of knowledge by students through meaningful learning experiences (Vygotsky, 1978). In biology classrooms, constructivist pedagogy encourages student-centered learning, inquiry-based investigations, and the integration of real-world applications and phenomena (Greenleaf *et al*., 2011). By scaffolding students' learning experiences and providing opportunities for reflection and collaboration, constructivist teaching approaches promote conceptual understanding and scientific literacy (Stinson & Wang, 2013).

Existing research suggests that effective instructional delivery in biology education has a positive impact on student learning outcomes, including academic achievement, scientific literacy, and attitudes towards science (Anyanwu and Abe, 2023; Stinson & Wang, 2013; Wey-Amaewhule & Udofia, 2022). Teachers who employ effective instructional strategies and constructivist teaching approaches are better able to meet the diverse needs of their students, accommodate different learning styles, and foster a deeper appreciation for the natural world (Greenleaf *et al*., 2011). In addition, lessons that incorporate active learning strategies promote student engagement, critical thinking, and problem-solving skills, preparing students for success in future science courses and careers (Stinson & Wang, 2013). However, implementing effective instructional delivery by early-career biology teachers is not without its challenges. Limited resources, time constraints, and curricular requirements may constrain teachers' ability to adopt innovative instructional strategies and pedagogical approaches (Greenleaf *et al*., 2011). Moreover, traditional assessments and standardized testing may prioritize rote memorization over conceptual understanding, leading to a disconnect between intended learning outcomes and instructional practices (Stinson & Wang, 2013). Nonetheless, emerging technologies, interdisciplinary collaborations, and professional development initiatives offer opportunities to overcome these challenges and promote innovation in biology education.

Statement of the Problem

Despite the growing interest in mentoring for professional development, limited research compares the effectiveness of virtual and on-site mentoring, particularly for early-career biology teachers in secondary schools, specifically in teaching ecology. Understanding their differential impacts on instructional delivery effectiveness in ecology is essential for addressing challenges faced by these teachers in the Zaria Education Zone, Kaduna State, Nigeria. Early-career biology teachers in secondary schools encounter difficulties in delivering effective ecology lessons due to the topic's complexities and the lack of related resources. More so, the geographic distribution of schools in the study area poses logistical hurdles, limiting the necessary support and guidance opportunities for early-career teachers and access to centralized support systems from experienced ones for effective instruction. Although the Kaduna State Ministry of Education has implemented initiative of deploying senior staff as mentors, to address challenges face by teachers in instructional delivery, the effectiveness of the effort remains unclear. Therefore, investigating the impact of mentoring interventions, both virtual and on-site, in improving the teaching of ecology among early-career secondary school biology teachers is imperative.

Objectives of the Study

The objectives of the study are to;

1. Assess the impact of virtual mentoring on biology teachers' instructional delivery effectiveness in teaching ecology.
2. Assess the impact of on-site mentoring on biology teachers' instructional delivery effectiveness in teaching ecology.
3. Compare changes in instructional delivery effectiveness between virtual and on-site mentoring for biology teachers teaching ecology.

Research Questions

The study was guided by the following research questions:

1. How does virtual mentoring impact the instructional delivery effectiveness of biology teachers in teaching ecology?

2. How does on-site mentoring impact the instructional delivery effectiveness of biology teachers in teaching ecology?
3. What are the comparative changes in instructional delivery effectiveness between virtual and on-site mentoring for biology teachers teaching ecology?

METHOD

Research Design

The research design adapted for this study was quasi-experimental design with structured observational components, incorporating interventions within two designated groups: virtual and on-site mentoring. The study involved non-random allocation of participants to groups and systematic observation of classroom instruction before and after the interventions. The pretest observations served to establish a baseline assessment of teacher instructional practices, while the posttest observations assessed the impact of the mentoring interventions on enhancing instructional delivery effectiveness. Observational studies are well suited for capturing real-world phenomena as they unfold (Babbie, 2016; Patton, 2015).

Participants

The target population of the study comprised all early-career biology teachers of public secondary schools in the Zaria Education Zone under Ministry of Education, Kaduna State. Purposive sampling was used to assign 40 early-career biology teachers to both the virtual and on-site mentoring groups having less than five years of teaching experience. This criterion was established to target early-career teachers who may benefit the most from mentoring interventions. In addition, those assigned to the virtual mentoring group were required to have either a smartphone or a laptop to participate in the online mentoring sessions.

Instrument for Data Collection

The research instrument data collection was a structured observation Scale titled "Instructional delivery Effectiveness Scale (IDES). The IDES was adapted from Wieman and Gilbert's (2014) Teaching Practices Inventory (TPI) and observation protocols by Danielson (2013) developed based on established frameworks for assessing teaching effectiveness. The IDES encompassed the following areas; instructional planning, teacher-student interactions, questioning techniques, instructional strategies, accommodation of diverse student needs, utilization of teaching aids, clarity of instructions, objective achievement, teacher content knowledge, classroom management, time management, and lesson presentation sequence. For each area, observers assigned a score indicating the level of effectiveness, ranging from Poor to Very Good, based on the observed performance of the teacher during the lesson. These scores were then tabulated to provide an overall assessment of the teacher's instructional delivery effectiveness.

Validity and Reliability of the Instrument

A panel of three experts validated the instrument to ascertain that it appropriately measures the intended constructs related to instructional delivery effectiveness in secondary school biology classrooms. To assess the instrument's reliability, inter-rater reliability was evaluated as recommended by Taber (2013). Two experienced teachers independently utilized the IDES to observe instructional delivery in classrooms outside the study sample. Subsequently, Cohen's kappa coefficient was calculated, resulting in a correlation coefficient of 0.85, which indicated an almost perfect agreement between observers' ratings.

Interventions

In the virtual mentoring intervention, early-career biology teachers (mentees) engage in remote communication with two mentors via digital platforms. These two mentors provide guidance, share resources, and conduct virtual classroom support for teachers in improving their instructional delivery effectiveness. Regular check-ins and online discussions facilitate ongoing collaboration and reflection, empowering teachers to implement effective instructional strategies tailored to their needs. On the other hand, the on-site mentoring intervention involves face-to-face interactions between four mentors and early-career biology teachers (mentees) within school settings. The four mentors who were physically available observe teachers' biology lessons, provide feedback, and model effective teaching practices. Through mentoring sessions, co-teaching opportunities, and participation in professional learning communities, teacher participants receive personalized support and guidance to improve their instructional skills effectively. Participants in the virtual mentoring group who were unfamiliar with online platforms were quickly introduced to Zoom and other online meeting formats at the beginning, as implemented by Singer *et al*., (2023). The intervention for the both group lasted for 12 weeks.

Data Collection

Data collection for this study involved conducting direct classroom observations during biology instruction sessions. Three assessors (observers), holding the rank of Assistant Lecturer and possessing prior experience in teaching practice supervision, were recruited to conduct pretest and posttest instructional observations in classroom settings for the intervention groups. The assessors were trained in using IDES to avoid bias. The assessors utilized the IDES to systematically record observed behaviours and practices of teachers during instruction. The observation sessions were conducted both before and after the mentoring interventions, serving as pretest and posttest assessments to measure changes in instructional delivery effectiveness. The pretest observations provided a baseline assessment of biology teachers' instructional practices before the interventions, while the posttest observations assessed the impact of the mentoring

interventions on improving instructional delivery effectiveness.

Data Analysis

The data collected were analyzed using descriptive statistics to calculate frequency, summation, mean scores and standard deviations for each dimension of instructional delivery effectiveness.

RESULTS

The study findings are presented in accordance with the research questions that guided the research.

Research Question One: How does virtual mentoring impact the instructional delivery effectiveness of biology teachers in teaching ecology?

Table 1: Biology teachers' instructional delivery effectiveness in teaching ecology before and after virtual mentoring

SN	Instructional Delivery Effectiveness	Virtual Mentoring							
		Pretest Rating (*f*)				Posttest Rating (*f*)			
		Poor	Fair	Good	V. Good	Poor	Fair	Good	V. Good
1	Instructional Planning	14	17	1	8	0	2	21	17
2	Teacher and students interactions	17	8	9	6	4	3	19	14
3	Questioning Techniques employed	11	10	11	8	6	3	19	12
4	Instructional strategies employed	0	5	22	13	0	5	22	12
5	Catering for diverse students' needs	5	10	11	14	2	8	11	19
6	Utilization of teaching aids	21	4	14	1	6	0	22	12
7	Clarity of instructions	1	0	22	17	0	0	18	22
8	Achievement of set objectives	0	4	27	9	0	0	26	14
9	Content Knowledge of the teacher	3	6	17	14	0	6	17	17
10	Classroom management and control	3	4	20	13	0	2	22	16
11	Time management	4	2	23	11	0	0	21	19
12	Sequence of lesson presentation	8	8	15	9	0	6	26	8
Summation (∑)		**87**	**78**	**192**	**123**	**18**	**35**	**244**	**182**
Mean (μ)		**7.25**	**7.33**	**16.00**	**10.25**	**1.5**	**2.92**	**22.00**	**15.17**
SD (σ)		**4.71**	**2.89**	**8.94**	**2.64**	**2.29**	**2.73**	**4.22**	**3.82**

Table 1 shows Biology teachers' instructional delivery effectiveness in teaching ecology before and after virtual mentoring. Substantial improvements in post-mentoring are observed across various instructional aspects. Markedly, there are substantial increases in the frequency of Very Good category for Instructional Planning, from 8 to 31, and Achievement of Set Objectives, from 9 to 26. Progress is also observed in the Very Good categories for Questioning Techniques, 8 to 12. Instructional Strategies Employed improve in the Good category, remaining at 22. Enhancements are noted in the Good and Very Good categories for Adaptation of Instruction, from 11 to 11 and 14 to 19, and Utilization of Teaching Aids, from 14 to 22 and 1 to 12, respectively. Classroom Management and Control show progress in the Fair and Very Good categories, from 4 to 22 and 13 to 16, while Time Management improves in the Very Good category, from 11 to 19. Before mentoring, mean ratings for Poor, Fair, Good, and Very Good were 7.25, 7.33, 16.00, and 10.25, respectively, with standard deviations ranging from 2.64 to 8.94. Following mentoring, mean ratings changed substantially, decreasing from 7.25 and 7.33 to 1.5 and 2.92 for Poor and Fair, respectively, while increasing from 16.00 and 10.25 to 20.00 and 15.17 for Good and Very Good. Standard deviations showed a narrower range, from 2.29 to 3.82, indicating improved consistency post-mentoring, particularly evident in the Very Good category in Biology teachers' instructional delivery effectiveness in teaching ecology

Research Question Two: How does on-site mentoring impact the instructional delivery effectiveness of biology teachers in teaching ecology?

Table 2: Biology teachers' instructional delivery effectiveness in teaching ecology before and after On-site mentoring

SN	Instructional Delivery Effectiveness	On-Site Mentoring							
		Pretest Rating (*f*)				Posttest Rating (*f*)			
		Poor	Fair	Good	V. Good	Poor	Fair	Good	V. Good
1	Instructional Planning	12	17	3	8	0	2	11	27
2	Teacher and students interactions	21	9	5	5	0	8	19	13
3	Questioning Techniques employed	15	9	9	7	2	9	18	11
4	Instructional strategies employed	2	7	19	12	0	0	14	26
5	Catering for diverse students' needs	7	17	10	6	2	1	14	23
6	Utilization of teaching aids	30	2	6	2	0	0	19	21

SN	Instructional Delivery Effectiveness	On-Site Mentoring							
		Pretest Rating (*f*)				Posttest Rating (*f*)			
		Poor	Fair	Good	V. Good	Poor	Fair	Good	V. Good
7	Clarity of instructions	1	4	18	17	3	1	13	23
8	Achievement of set objectives	0	6	16	18	0	0	14	26
9	Content Knowledge of the teacher	3	6	17	14	1	2	11	26
10	Classroom management and control	4	4	22	10	0	2	9	29
11	Time management	8	2	14	16	0	0	22	18
12	Sequence of lesson presentation	7	9	14	10	0	0	19	21
Summation (∑)		110	92	153	125	8	25	183	264
Mean (μ)		9.17	7.67	12.75	10.42	1.23	2.08	14.42	24.5
SD (σ)		8.43	4.92	5.73	4.89	2.92	2.71	4.02	5.74

Table 2 shows the effectiveness of on-site mentoring in enhancing the instructional delivery of biology teachers in teaching ecology. In the post-mentoring phase, substantial decreases in the frequency of Poor and Fair ratings were observed across multiple instructional aspects, indicating improvements in instructional delivery. For example, in Instructional Planning, the frequency of Poor ratings dropped from 12 to 0, and Fair ratings decreased from 17 to 2. Similarly, in Questioning Techniques employed, the frequency of Poor ratings reduced from 15 to 2. Furthermore, in Classroom Management and Control, the frequency of Poor ratings decreased from 4 to 0, and Fair ratings dropped from 4 to 2. Conversely, there were substantial increases in the frequency of Good and Very Good ratings post-mentoring. For instance, in Teacher and Student Interactions, the frequency of Good ratings surged from 5 to 19, and Very Good ratings increased from 5 to 13. Similarly, for Utilization of Teaching Aids, the frequency of Good ratings increased from 6 to 19, and Very Good ratings climbed from 2 to 21. In Content Knowledge of the Teacher, the frequency of Very Good ratings increased from 14 to 26. Further analysis reveals that, for post-mentoring, the mean ratings for Poor and Fair decrease from 9.17 to 1.5 and from 7.67 to 2.92, respectively. While the mean ratings for Good and Very Good increase from 12.75 to 22 and from 10.42 to 26.42, respectively.

Research Question Three:

What are the comparative changes in instructional delivery effectiveness between virtual and on-site mentoring for biology teachers teaching ecology?

Table 3: Mean Rating Comparison of Pretest and Posttest for Virtual and On-Site Mentoring Groups

Groups	Stats	Pretest				Posttest			
		Poor	Fair	Good	V. Good	Poor	Fair	Good	V. Good
Virtual Mentoring	Mean (μ)	7.25	7.33	16.00	10.25	1.5	2.92	22	15.17
	SD (σ)	4.71	2.89	8.94	2.64	2.29	2.73	4.22	3.82
On-Site Mentoring	Mean (μ)	9.17	7.67	12.75	10.42	1.23	2.08	14.42	24.5
	SD (σ)	8.43	4.92	5.73	4.89	2.92	2.71	4.02	5.74

Table 3 compares the changes in instructional delivery effectiveness between virtual and on-site mentoring for biology teachers teaching ecology. Posttest results reveal a substantial decrease in the mean ratings of Poor and Fair categories in both groups compared to the pretest, indicating significant improvement in instructional delivery. Specifically, in the virtual mentoring group, the mean rating for Poor decreased from 7.25 to 1.5, and for Fair decreased from 7.33 to 2.92. Similarly, in the on-Site mentoring group, the mean rating for Poor decreased from 9.17 to 1.23, and for Fair decreased from 7.67 to 2.08. Conversely, there were significant increases in the mean ratings of Good and Very Good categories in both groups posttest compared to pretest, signifying an improvement in instructional effectiveness. In the virtual mentoring group, the mean rating for Good increased from 16.00 to 22, and for Very Good increased from 10.25 to 15.17. Likewise, in the on-site mentoring group, the mean rating for Good increased from 12.75 to 14.42, and for Very Good increased from 10.42 to 24.5. In comparison to the virtual mentoring group, the on-site mentoring group showed greater increases in mean ratings for the Good and Very Good categories, as well as a decrease in Poor and Fair ratings in posttest compared to pretest.

DISCUSSION

The study delved into the impacts of virtual and on-site mentoring on the instructional delivery effectiveness of secondary school biology teachers in teaching ecology. The results of the study revealed improvement in the instructional delivery effectiveness of early-career biology teachers in teaching ecology following two mentoring interventions.

The research question one explored the impact of virtual mentoring on the instructional delivery effectiveness of biology teachers in teaching ecology. The findings, as evidenced in Table 1, revealed major

improvements across various aspects of instructional practices following virtual mentoring interventions. Notable improvements were observed in aspects such as Instructional Planning, Questioning Techniques, and Achievement of Set Objectives, with a marked increase in the frequency of Very Good ratings. Possible reasons for the observed improvements could be attributed to the individualized support offered through virtual platforms, enabling teachers to receive targeted feedback to their specific needs as pointed out Osborne *et al*., (2019). More so, the interactive nature of virtual mentoring promotes reflective practice and encourages teachers to experiment with innovative instructional strategies as reported by Tobin (2018). More so, it could be due to the fact that the virtual modality allows for personalized feedback and guidance, overcoming geographical constraints and fostering continuous professional development. The study by Ejekwu and Worlu (2021) supports the potential of online training to facilitate professional development opportunities for teachers. Their findings emphasize the importance of digital devices and internet access in enhancing instructional delivery effectiveness. The findings also resonate with the study of Smith *et al*., (2019), which reported the efficacy of virtual mentoring in providing accessible and flexible support to teachers. The findings of the present study are also in line with Wang and Hartley's (2020) report on the positive impact of virtual mentoring on teacher self-efficacy and instructional practices.

Research question two investigated the impact of on-site mentoring on the instructional delivery effectiveness of biology teachers in teaching ecology. The results, as presented in Table 2, revealed substantial improvements across various instructional aspects following to on-site mentoring interventions. The findings are consistent with of the study by Anyanwu & Abe (2023) which supported the effectiveness of one-on-one mentorship programmes in enhancing teachers' service delivery, particularly for beginning teachers. The findings are also in line with Johnson *et al*., (2018) emphasis on the crucial role of on-site mentors in providing hands-on support and personalized guidance to teachers. The physical presence of mentors enables immediate feedback and modeling of effective teaching practices, thereby facilitating professional development among teachers. Moreover, the study of Sankar & Sankar (2010) established the positive impact of on-site (face-to-face) mentoring on teacher confidence and instructional strategies. The observed improvements in instructional delivery effectiveness can be attributed to the contextualized support offered by on-site mentors, who have the opportunity to firsthand observe classroom instructions of the mentees and provide immediate needed feedback as stated by Davis *et al*., (2017). The findings resonate with John's *et al*., (2023) report that the collaborative nature of on-site mentoring fosters trust and rapport between mentors and teachers, creating an environment conducive to professional growth.

The findings of research question three revealed the comparative changes in instructional delivery effectiveness between virtual and on-site mentoring for biology teachers teaching ecology. Table 3 presents a comparison of mean ratings between pre-test and post-test for both virtual and on-site mentoring groups. The results revealed substantial improvements in both groups post-mentoring, with decreases in the mean ratings of Poor and Fair categories and increases in the mean ratings of good and Very Good categories. These findings are consistent with previous research by Wang and Hartley (2020), which demonstrated the efficacy of both virtual and on-site mentoring in enhancing teacher self-efficacy and instructional practices. Possible reasons for the observed improvements include the personalized support and guidance provided by mentors in both virtual and on-site settings. The finding resonates with Osborne's *et al*., (2019) findings that, virtual mentoring offers flexibility and accessibility, allowing teachers to engage in professional development activities remotely. On the other hand, on-site mentoring provides direct observation and immediate feedback, promoting reflective practice and skill development as reported by Tobin (2018). The research by Sankar and Sankar (2010) provides evidence against the notion that online training alone is sufficient to improve teacher confidence in instructional delivery. Their findings suggest that while online training can improve teacher knowledge, face-to-face (on-site) interactions are more effective in boosting confidence. The comparative analysis suggests that while both virtual and on-site mentoring are effective in improving instructional delivery effectiveness, on-site mentoring may offer additional benefits in terms of immediate support and interaction.

Implications of the Findings for Mentoring Practices in Biology Pedagogy

The findings of the study have important implications for mentoring practices in biology pedagogy. Firstly, they emphasize the significance of creating mentoring support for the instructional needs of biology teachers. Virtual mentoring interventions are particularly effective at addressing fundamental instructional challenges, whereas on-site mentoring provides more in-depth guidance in refining specific teaching practices. Secondly, the comparative effectiveness of virtual and on-site mentoring indicates the importance of combining the two approaches to provide comprehensive support. Finally, the study demonstrates the importance of evidence-based mentoring practices and ongoing evaluation to meet the evolving needs of biology teachers and students. These implications stress the value of specific mentoring approaches for assisting biology teachers' professional development and improving instructional practices.

CONCLUSION

The findings of the study revealed the impact of mentoring interventions on the instructional delivery effectiveness of secondary school biology teachers in

teaching ecology. Both virtual and on-site mentoring interventions led to significant improvements across various aspects of teaching practice. In the pretest and posttest mentoring phases, substantial decrease in the frequency of Poor and Fair ratings were observed, indicating a striking reduction in previously identified inadequacies and inefficiencies, alongside a substantial increase in the frequencies of Good and Very Good ratings in instructional delivery. Even though both virtual and on-site mentoring contributed to these improvements, on-site mentoring emerged with slightly greater observable impacts. The findings indicate the positive impact of the both mentoring approaches in supporting professional growth through the refinement of instructional practices among beginning biology teachers.

RECOMMENDATIONS

Based on the study findings, the following recommendations were made:

1. Biology teachers should engage in continuous professional development opportunities, such as workshops and seminars, to stay updated on the latest advancements in teaching and learning of biology.
2. Biology teachers should actively seek out mentorship relationships with experienced biology teachers or participate in peer mentoring programmes to receive guidance, support, and feedback on teaching practices.
3. Ministry of Education at state level should establish structured mentorship programmes for biology teachers, providing them with access to experienced mentors who can offer guidance and support in improving their instructional practices.
4. Teachers professional bodies should offer mentorship programmes specifically tailored for biology teachers, providing opportunities for them to connect with experienced teachers who can offer guidance and support in their professional development.

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