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Perception of Early-Career Biology Teachers on the Impacts of Mentoring Modes on Instructional Delivery Effectiveness

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Abstract: ***Advancements in technology have led to virtual mentoring complementing or replacing face-to-face mentoring, but the perceived effectiveness of each by early-career biology teachers remains understudied. This study investigated the comparative effectiveness of on-site and virtual mentoring modes as perceived by early-career biology teachers. Three research questions and two null hypotheses were answered and tested, respectively. A descriptive survey research design was adopted for the study. The study involved 80 early-career biology teachers with less than five years of teaching experience, divided into on-site (n=40) and virtual (n=40) mentoring groups. Data was collected through a validated questionnaire having a reliability coefficient of 0.81. Percentages, means, standard deviations, and t-tests were used for data analysis. The findings revealed that on-site mentoring was perceived to significantly improved content knowledge, instructional strategies, and professional rapport. In contrast, virtual mentoring fostered reflective practice and provided extensive resource access but faced challenges such as scheduling conflicts and technological barriers. Significant differences in perceived effectiveness and challenges between the two modes of mentoring led to the rejection of both null hypotheses. On-site mentoring was perceived as more effective due to its immediate, hands-on support, while virtual mentoring offered valuable flexibility and resource access despite its challenges. A blended mentoring approach was recommended to combine the strengths of both modes for early-career biology teachers.***

Keywords: ***Early-Career Biology Teachers, On-Site Mentoring, Virtual Mentoring, Instructional Delivery, Professional Development.***

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1. INTRODUCTION

As a senior secondary school subject, biology provides essential knowledge about the living world and its processes (Matazu & Isma'il, 2024). Good performance in the subject is fundamental for students' learning outcomes as it serves as a prerequisite for admission to medical and related field. Therefore, secondary school biology teachers must be effective in teaching the subject, cultivate scientific inquiry among students, and manage laboratory activities. However, early-career biology teachers face challenges such as effectively delivering complex and abstract biology content, managing classrooms, and engaging students in inquiry-based learning and laboratory experiments. These challenges can lead to high stress and attrition rates among novice teachers. While mentoring is recognized as a support mechanism, the variability in mentoring modes, quality and mentor-mentee relationships often limits its effectiveness. The unique needs of early-career biology teachers in conveying complex concept, bulky content and conducting laboratory activities necessitate wise choice mentoring strategy.

These demands of early-career biology teachers, as noted by Ayeni (2011), Barnett and Friedrichsen (2015), and Sodangi et al. (2022), necessitate specialized professional development approaches that focus on subject-specific pedagogies and content knowledge. A substantial body of professional development literature (e.g., Barnett & Friedrichsen, 2015; Binmohsen & Abrahams, 2020; John et al., 2023; Tobin, 2018; Sodangi et al., 2022) indicates that mentoring programmes specifically designed for science teachers can significantly improve instructional effectiveness. Isma'il and Matazu (2024) emphasize the importance of components such as co-teaching, collaborative lesson planning, and observation of experienced mentors in the professional development of science teachers. These components provide beginning teachers with practical understandings into effective science teaching practices and help them build confidence in their instructional abilities.

Furthermore, challenges related to the mode of mentoring such as insufficient mentoring time, lack of clear goals and expectations (Lau, 2021), and variability in mentor expertise may affect the perception of early-career teachers. These challenges can lead to dissatisfaction with mentoring modes and limit their impact on instructional effectiveness. The perceptions of early-career teachers are also influenced by the overall school culture and climate (Singer et al., 2023; Bressman et al., 2018). Schools that encourage a collaborative and supportive professional environment are more likely to have successful mentoring programmes (Lerman, 2020). In such environments, early-career teachers may feel more comfortable seeking advice and sharing their challenges with mentors and colleagues. Conversely, in schools with a less supportive culture, mentoring may be perceived as a compliance activity rather than a meaningful professional development opportunity.

However, a research gap exists in understanding early-career biology teachers' perceptions or preferred mentoring modes on their instructional delivery effectiveness. Thus, this study investigated the perceptions of early-career biology teachers on the impacts of on-site and

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virtual mentoring on their instructional delivery effectiveness in the Zaria Education Zone, Kaduna State Ministry of Education in Nigeria.

Research Questions

1. What specific aspects of mentoring do early-career biology teachers find most beneficial for instructional delivery?
2. How do on-site and virtual mentoring differ in their perceived impact on early-career biology teachers' instructional delivery effectiveness?
3. What challenges do early-career biology teachers face during on-site and virtual mentoring processes?

Null hypotheses

$H0_1$: There is no significant difference in the perceived effectiveness of mentoring between early-career biology teachers who received virtual mentoring and those who received on-site mentoring.

$H0_2$: There is no significant difference in the challenges faced by early-career biology teachers during the on-site mentoring process and those faced during the virtual mentoring process.

2. RELATED WORKS

Teaching presents some challenges for early-career science teachers, who often face numerous obstacles during their transition into the profession. To route this new environment and their responsibilities effectively, these teachers require guidance from experienced mentors (Dahal, 2023). Mentoring is an important component of professional development, especially for those in the early stages of their careers. The shift from pre-service education to actual classroom teaching can be fraught with difficulties that adversely affect instructional effectiveness (Hong & Matsko, 2019; Ingersoll & Strong, 2011; Smith, 2021). This induction phase is fundamental because it shapes the trajectory of a teacher's career. Structured mentoring during this important period supports early-career teachers by improving their professional practices (Kutsyuruba et al., 2019).

Research indicates that mentoring significantly influences the instructional practices of early-career teachers, leading to improved teaching efficacy and better student outcomes (Lerman, 2020; Li et al., 2023; Mary & Cha, 2021; Peila, 2020; Wang & Hartley, 2020). Effective mentoring programmes offer guidance, feedback, and support, enabling beginner teachers to grasp classroom management, curriculum implementation, and student engagement (Admiraal et al., 2023; Alemdag & Erdem, 2017; Bressman et al., 2018; Isma'il & Olatunbosun, 2024; Kutsyuruba et al., 2019; Yoon et al., 2020). In practice, mentoring involves interactions between mentors and mentees to develop understanding and skills through collaborative sessions (Dahal, 2023). Mentors, typically experienced teachers or education specialists, model best practices, provide emotional support, and encourage reflective practices among early-career teachers (Barnett & Friedrichsen, 2015; Peila, 2020).

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According to Admiraal et al. (2023), effective mentoring helps early-career teachers adopt best teaching practices and integrate them into their routines. More so, mentoring promotes reflective practice (Lau, 2021; Smith, 2021), allowing early-career teachers to evaluate their methods and make informed adjustments (Hong & Matsko, 2019). This process of reflection supports the development of adaptive expertise, essential for teaching in diverse classroom environments and promoting continuous professional growth. Kutsyuruba et al. (2019) argue that mentoring facilitates access to vital professional development resources and communities of practice, which is particularly important in dynamic fields like biology where staying abreast of advancements is essential.

Numerous studies have reported the effectiveness of both on-site and virtual mentoring for the professional development of early-career teachers. Literature (e.g. Peila, 2020; Sodangi et al., 2022) indicates that mentoring is generally beneficial, but perceptions vary greatly depending on whether it is done on-site or virtually. Some research findings (e.g. Anyanwu & Abe, 2023; Smith et al., 2019; Wey-Amaewhule & Udofia, 2022) revealed that, on-site mentoring provides direct, hands-on guidance to help teachers design and implement instructional strategies, manage laboratory activities, and assess student learning. Nielsen et al. (2022) reported that, virtual mentoring makes it easier to incorporate technology into teaching, such as the use of virtual laboratories, simulations, and argumentation, all of which are becoming increasingly important in science education. Hong and Matsko (2019) reported that, both mentoring modes contribute to effective classroom management, instructional strategies, and an understanding of student assessment practices.

The integration of technology, such as virtual laboratories and simulations, is becoming increasingly important in science education (Ismail et al., 2024; Nielsen et al., 2022). Mentored teachers are more likely to utilize these technologies to enhance their classroom management skills (Hong & Matsko, 2019), instructional strategies, and understanding of student assessment practices. While mentoring is generally perceived as beneficial by early-career teachers, their experiences and perceptions can vary significantly depending on individual and contextual factors (Hong & Matsko, 2019; Peila, 2020; Sodangi et al., 2022). They frequently report that mentoring helps them gain a better understanding of subject-specific pedagogies and instructional strategies (Barnett & Friedrichsen, 2015), and they appreciate the emotional support and encouragement they receive from mentors, which can boost confidence and motivation.

Despite the benefits of mentoring programmes, they do face challenges that can undermine their effectiveness (Lau, 2021). Isma'il and Olatunbosun (2024) maintain that variability in programmes design and implementation for biology teachers can lead to considerable differences in effectiveness, depending on mentoring mode, mentor selection, and mentoring interaction structure. Similarly, Bressman et al. (2018) express that, mentors may not always have the necessary skills or motivation to provide adequate support, resulting in less than ideal mentoring experiences for mentees. The quality of the mentor-mentee relationship also plays an important role in the success of mentoring programmes (Johnson et al., 2018). Castanheira (2016) and John et al. (2023) supported this argument by asserting that, mentors sometimes

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impose their teaching styles on mentees, rather than nurturing the development of the mentees' instructional approaches. Based on this, Gakonga and Mann (2022), Kutsyuruba et al. (2019) and Peila (2020) assert that, a strong, trusting relationship is essential for effective mentoring. Personality mismatches, differing teaching philosophies, or communication style disparities can hinder the development of these relationships.

Time constraints and workload pressures also significantly challenge effective mentoring. Early-career biology teachers must balance multiple responsibilities, such as lesson planning, grading, and extracurricular activities, which can limit their time for mentoring interactions (Isma'il & Olatunbosun, 2024). Mentors may also struggle to balance their mentoring roles with regular teaching responsibilities, resulting in little or rushed sessions that reduce the overall effectiveness. Likewise, the mode of mentoring (on-site or virtual) influences the accessibility and flexibility of interactions. On-site mentoring offers face-to-face engagement and hands-on guidance (Mulaimović et al., 2024; Terrazas-Arellanes et al., 2016; Yoon et al., 2020), while virtual mentoring provides flexibility and access to more resources. However, according to Isma'il and Olatunbosun (2024), both modes present distinctive challenges, such as scheduling conflicts and technological barriers as associated with virtual mentoring. Understanding early-career biology teachers' perceptions regarding the impacts of on-site and virtual mentoring on their instructional delivery effectiveness is both essential and necessary. Challenges related to mentoring modes, such as insufficient time, unclear goals and expectations (Lau, 2021), and variability in mentor expertise, may affect early-career teachers' perceptions. These challenges can lead to dissatisfaction with mentoring modes and limit their impact on instructional effectiveness. Moreover, perceptions are influenced by the overall school culture and climate (Singer et al., 2023; Bressman et al., 2018). Supportive and collaborative school environments are more likely to foster successful mentoring programmes (Lerman, 2020). In such settings, early-career teachers may feel more comfortable seeking advice and sharing challenges with mentors and colleagues. Conversely, in less supportive cultures, mentoring may be viewed as a mere compliance activity rather than a meaningful opportunity for professional development. Against this backdrop, this study investigated the perceptions of early-career biology teachers regarding the impacts of on-site and virtual mentoring on their instructional delivery effectiveness within the Zaria Education Zone, Kaduna State Ministry of Education in Nigeria.

3. METHODOLOGY

Research Design

This study adopted a survey research design to examine the perceptions of early-career biology teachers regarding the impact of mentoring on their instructional delivery effectiveness following a 12-week on-site and virtual mentoring intervention.

Population

The population for this study comprised early-career biology teachers with less than five years of teaching experience in public secondary schools in the Zaria Education Zone, Kaduna State.

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Sample and Sampling Technique

A total of 80 early-career biology teachers who participated in mentoring professional development were used for the study. The Virtual Mentoring Group consisted of 40 teachers who received mentoring through online platforms, while the On-Site Mentoring Group included 40 teachers who received face-to-face mentoring at their respective schools. Purposive sampling technique was used by Isma'il and Olatunbosun (2024) for the selection and the assignment of the teachers into the groups.

Research Instrument

The instrument for data collection for thus study was a structured questionnaire designed to obtain participants' perceptions of mentoring effectiveness. The questionnaire consisted of three main sections: Section 1: Demographic information. Section 2: Perceptions of mentoring effectiveness, with 8 items measured on a Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). Section 3: Specific aspects of mentoring perceived as beneficial, with 8 items measured on a Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). Section 4: Perceived differences in mentoring effectiveness based on mentoring style and delivery mode, with 8 items measured on a Likert scale (1 = Strongly Disagree to 5 = Strongly Agree).

Two experts in science education and one in measurement and evaluation validated the content of the questionnaire, leading to revisions of few items based on their feedback. A pilot study was conducted with a sample of 20 participants from outside the main study area but with similar demographic characteristics. The reliability coefficient obtained using Cronbach's alpha was 0.81. This reliability coefficient indicated acceptable internal consistency of the instrument, thus reliable for the study.

Data Collection Procedure

Data was collected through a survey questionnaire administered to the participants following their 12-week participation in their respective on-site mentoring and virtual mentoring professional development, an interventions administered by Isma'il and Olatunbosun (2024).

Data Analysis

The collected data was analyzed using percentage, mean and standard deviation to address the research questions, while independent samples t-tests were conducted to test the formulated hypotheses.

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4. RESULTS

Key Beneficial Aspects of Mentoring by Delivery Mode

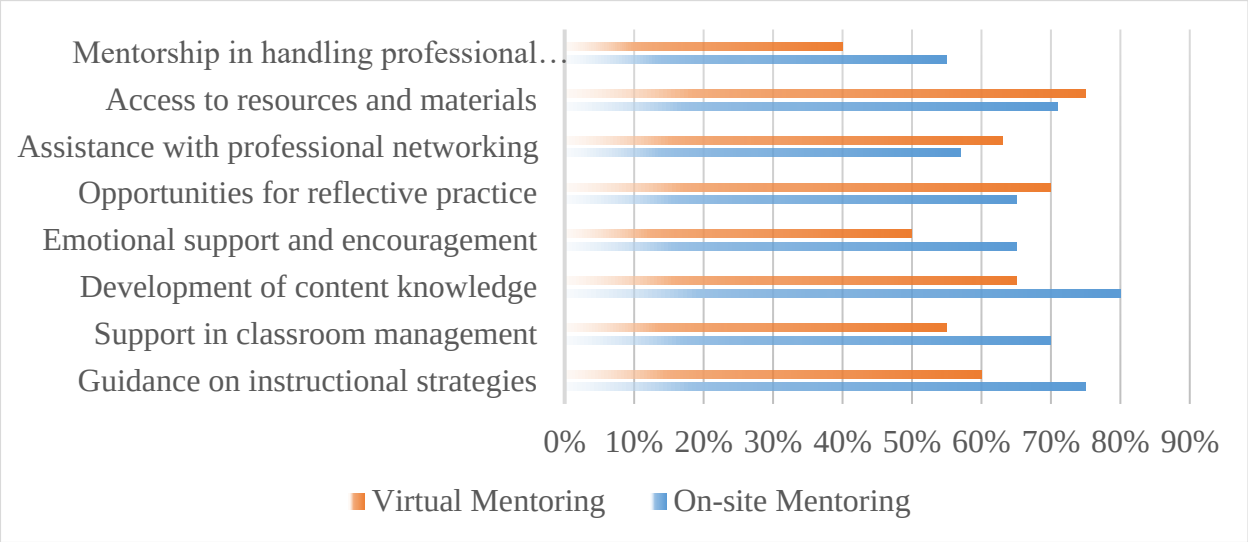

Figure 1. Perceived beneficial aspects of on-site and virtual mentoring

Figure 1 reveal the comparison of perceived beneficial aspects of on-site and virtual mentoring among early-career biology teachers. On-site mentoring is highly valued, with 80% citing its impact on content knowledge development, 75% on instructional strategies, and 71% on access to resources. Conversely, virtual mentoring excels with 70% rating it highly for reflective practice and 75% for access to resources.

Perceptions of Mentoring Effectiveness by Delivery Mode

Table 1. Mentoring effectiveness by delivery mode

Items	On-site Mentoring (n=40)		Virtual Mentoring (n=40)	
	Mean	SD	Mean	SD
Mentoring has helped me improve my instructional delivery skills.	4.2	0.5	4.0	0.6
I feel more confident in managing classroom activities due to mentoring.	4.4	0.6	3.8	0.5
Mentoring has enhanced my ability to engage students in learning activities.	4.1	0.4	3.5	0.4
The feedback received from my mentor has been valuable for my professional growth.	4.3	0.5	3.7	0.5
My mentor provides constructive criticism that helps me improve.	4.0	0.4	3.1	0.5
I have gained new teaching strategies from my mentor.	4.5	0.7	3.9	0.6

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Mentoring has positively influenced my overall job satisfaction.	4.2	0.5	3.4	0.3
I am more motivated to continue teaching because of mentoring.	4.3	0.5	3.7	0.5
Grand Mean ± SD	**4.25 ± 0.51**		**3.63 ± 0.49**	

Table 1 compares the perceived impact of on-site and virtual mentoring on early-career biology teachers' instructional delivery effectiveness. On-site mentoring participants consistently reported higher mean scores across all items compared to virtual mentoring participants. Specifically, on-site mentoring had higher mean scores in areas such as improvement in instructional delivery skills (4.2 ± 0.5 vs. 4.0 ± 0.6), confidence in managing classroom activities (4.4 ± 0.6 vs. 3.8 ± 0.5), and gaining new teaching strategies (4.5 ± 0.7 vs. 3.9 ± 0.6). The grand mean further indicates that participants in on-site mentoring perceive a higher overall impact (4.25 ± 0.51) than those in virtual mentoring (3.63 ± 0.49).

Table 2. Summary of independent samples t-test for effectiveness of mentoring modes

Group	**N**	**Mean**	**SD**
Virtual Mentoring	40	3.63	0.49
On-Site Mentoring	40	4.25	0.51
Difference	0.62		
t-Value	6.15		
df	78		
Crit t-Value (α = 0.05, two-tailed)	1.99		
p-Value	< 0.001		
Decision	Reject the null hypothesis		

Table 2 compare the perceived effectiveness of mentoring between early-career biology teachers who received virtual mentoring and those who received on-site mentoring. The results showed a statistically significant difference between the two groups ($t_{(78)} = 6.15$, $p < .001$). The mean rating for on-site mentoring (M = 4.25, SD = 0.51) was significantly higher than that for virtual mentoring (M = 3.63, SD = 0.49). Therefore, we reject the null hypothesis that there is no significant difference in the perceived effectiveness of mentoring between the two groups. This indicates that on-site mentoring is perceived as more effective than virtual mentoring among early-career biology teachers.

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Challenges Faced in On-Site and Virtual Mentoring

Table 3. Challenges in mentoring modes for early-career biology teachers

Challenges	**On-site Mentoring (n=40)**		**Virtual Mentoring (n=40)**	
	Mean	SD	Mean	SD
Difficulty in scheduling regular mentoring sessions due to time constraints.	2.5	0.6	3.0	0.5
Limited opportunities for hands-on guidance and observation in the classroom.	2.1	0.5	2.6	0.4
Challenges in building a rapport with mentors.	2.3	0.7	3.2	0.6
Inadequate access to resources and materials needed for effective mentoring.	2.9	0.6	3.1	0.5
Difficulty in receiving timely feedback and support from mentors.	3.0	0.5	3.2	0.5
Technological issues and barriers in mentoring sessions.	2.2	0.6	3.3	0.5
Feeling isolated or unsupported during the mentoring process.	1.8	0.6	2.9	0.4
Difficulty in balancing mentoring activities with other professional responsibilities.	2.2	0.5	1.9	0.4
Grand Mean ± SD	**2.37 ± 0.57**		**2.90 ± 0.47**	

Table 3 presents perceived challenges in on-site and virtual mentoring for early-career biology teachers. On-site mentoring participants generally reported lower mean scores across various challenges compared to virtual mentoring participants. Virtual mentoring showed higher mean scores in several areas such as scheduling constraints (3.0 ± 0.5), limited hands-on guidance (2.6 ± 0.4), and technological barriers (3.3 ± 0.5). The grand mean highlights that, on average, participants in virtual mentoring perceive higher overall challenges (2.9 ± 0.5) compared to on-site mentoring (2.4 ± 0.5).

Table 4. Summary of independent samples t-test for challenges in mentoring modes

Group	**N**	**Mean**	**SD**
Virtual Mentoring	40	2.90	0.47
On-Site Mentoring	40	2.37	0.57
Difference		0.53	
t-Value		-4.94	
Degrees of Freedom		78	
Critical t-Value		1.99	
p-Value		0.00001	
Decision		Reject the null hypothesis	

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The results in Table 4 indicate a significant difference in the challenges faced by early-career biology teachers during on-site and virtual mentoring processes. The mean score for virtual mentoring challenges (M = 2.90, SD = 0.47) was higher than that for on-site mentoring (M = 2.37, SD = 0.57). The t-test revealed a t-value of -4.94 with 78 degrees of freedom and a p-value of 0.00001, which is less than the critical t-value (1.99) at $\alpha = 0.05$. Therefore, we reject the null hypothesis, concluding that there is a significant difference in the perceived challenges between on-site and virtual mentoring. This indicate that virtual mentoring is associated with greater perceived difficulties.

5. DISCUSSION

Key Beneficial Aspects of Mentoring by Delivery Mode

The results for research question one show that early-career biology teachers highly value on-site mentoring for its impact on content knowledge and instructional strategies, while virtual mentoring is perceived effective in improving reflective practices and offering diverse digital resources. This dual benefit suggests that both mentoring modes offer complementary advantages. The benefits of on-site mentoring can be attributed to the direct, personalized feedback and hands-on support it provides. This mode allows for immediate, contextual assistance, which is crucial for the practical application of teaching techniques and resources. Conversely, the benefits of virtual mentoring in improving reflective practices is likely due to its flexibility and the ability to engage in continuous, asynchronous communication. This format facilitates ongoing reflection and access to a broader range of digital resources, supporting the development of teaching practices in a less constrained environment. This is consistent with previous research by Mulaimović et al. (2024), Smith (2021), and Gakonga and Mann (2021). which stress on the benefit of on-site mentoring in providing personalized, practical support, while the strengths of virtual mentoring lie in offering flexible, resource-rich environments for reflective practice. These findings suggest that both mentoring modes offer complementary advantages.

Perceptions of Mentoring Effectiveness by Delivery Mode

Data analyses regarding research question two and the corresponding null hypothesis one indicated that, on-site mentoring profoundly increases perceived instructional delivery effectiveness. The direct interaction and immediate feedback provided in on-site settings appear to better support professional growth and instructional skills of early-career biology teachers compared to virtual mentoring. This is consistent with the findings of Mulaimović et al. (2024) where teachers rated face-to-face professional development and virtual modes highly in effectiveness, but slightly favored the face-to-face mode. Terrazas-Arellanes et al. (2016) also found that teachers rated on-site professional development as highly effective compared to virtual model. This could be attributed to the fact that, on-site mentoring offers real-time demonstrations and corrections, which can be crucial for mastering complex instructional strategies. The opportunity for immediate, personalized feedback allows mentees to quickly identify and address areas for improvement, leading to more rapid professional development. This direct and interactive approach creates an engaging and dynamic learning environment that is difficult to replicate virtually. The more pronounced difference in effectiveness found

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in this present study contradicts previous research by Yoon et al. (2020), who found no significant differences in terms of biology teachers' positive perceptions of the two modes of mentoring. This inconsistency may reflect changes in mentoring practices or advancements in technology since this study, suggesting a need for updated perspectives on virtual mentoring's role.

Challenges Faced in On-Site and Virtual Mentoring

In terms of challenges related to the two mentoring modes addressed by research question three and null hypothesis two, virtual mentoring presents more difficulties, such as scheduling constraints, limited hands-on guidance, and technological barriers or hitches. The significant challenges perceived by early-career biology teachers in virtual mentoring found in this study were also identified in prior research by Ingersoll and Strong (2011), Lau (2021), and Yoon et al. (2020), which acknowledged the logistical and technical hurdles that virtual mentoring must overcome. Scheduling conflicts may arise due to differences in timing convenience or availability, while the lack of physical presence can limit the effectiveness of practical, hands-on guidance. Technological issues such as internet connectivity problems and platform malfunctions can further disrupt the virtual mentoring process. Despite these challenges, early-career biology teachers perceived the flexibility and resource access offered by virtual mentoring remain valuable. This might be because virtual mentoring allows mentees to access a diverse pool online instructional resources that may not be available in their immediate vicinity. Earlier research often focused on the flexibility and convenience of virtual mentoring, whereas these present findings suggest that these benefits come with notable difficulties as perceived by mentees (early-career biology teachers), emphasizing the need for improved strategies to address these issues and enhance virtual mentoring effectiveness.

6. CONCLUSION

The study concluded that, early-career biology teachers perceived on-site mentoring as more impactful than virtual mode. They reported significant improvements in instructional skills, confidence, and job satisfaction. Significant differences were found in both the perceived effectiveness and challenges of the two mentoring modes, with virtual mentoring perceived as presenting more challenges than on-site mentoring.

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Conflict of Interest

The authors declare that they have no competing interests

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