



Enhancing Science Teachers' Continuous Professional Development through Digital Mentoring: Advancing Teacher Education for 21st-Century Classrooms

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ABSTRACT

This study investigated the impact of digital mentoring on science teacher continuous professional development in Taraba State, Nigeria, which was aimed towards transforming science teachers' education for the 21st century classroom. The study adopted a survey research design. The population for the study consisted of all secondary school science teachers. The sample size comprised 120 science teachers. Digital Mentoring Questionnaire (DMQ) was the instrument used for data collection. The instrument was found to have a reliability coefficient of 0.71 using Cronbach's alpha. Research questions were answered using the descriptive statistic of mean and standard deviation. The finding showed that digital mentoring is effective for science teacher continuous professional development. The findings also showed that the perception of science teachers on the effectiveness of digital mentoring compared to traditional methods is high. It is evident from the findings of this study to conclude that digital mentoring is effective in science teacher development. Hence, science teachers should be encouraged to use digital platforms for continuous professional development, which will help them to stay updated with emerging technologies and teaching practices to cope effectively with the 21st century classroom/skills.

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INTRODUCTION

Transforming teachers' education and capacity for the 21st century classroom" means fundamentally changing how teachers are trained and developed to effectively utilize technology, promote critical thinking, collaboration, and creativity, while adapting to the evolving needs of modern learners in a digitally integrated learning environment. The key aspects of transforming teacher education for the 21st century classroom involves focusing on the 21st century skills, curriculum design for 21st century learners, student-centered pedagogy, collaboration with industry/community partners, technology integration and continuous professional development. In equipping teachers with the skills

necessary to navigate a classroom where students are actively engaged with technology and learning through inquiry-based approaches can be actualized through adequate innovative and effective mentoring processes.

Mentoring plays a vital role in the professional growth of science teachers as it enables the exchange of knowledge and skills between science teachers in training and those already in service; providing valuable support, guidance, and resources throughout their careers (Cornelius et al., 2020; Yan, 2021). This promotes personal and professional development, provides emotional support, enhances job satisfaction, encourages professional networking and collaboration, and nurtures potential educational

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leaders (Hathazi, 2020; Pandey & Sharma, 2022; Westervelt et al., 2020) among science teachers to enable transforming teacher education for the 21st century classroom using mentoring platforms.

Mentoring has advanced beyond traditional face-to-face interactions to include digital mentoring, which makes use of digital platforms. Digital mentoring otherwise known as e-mentoring, offers several distinct advantages over on-site mentoring which go beyond geographical barriers, enabling mentors and mentees to connect regardless of their physical locations. This proffer facilitates access to a varied pool of mentors, fostering cross-cultural exchanges and the sharing of varied perspectives (Castanheira, 2016). Digital mentoring 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.

Through the use of digital platforms and communication technology, mentoring has moved beyond conventional meetings in person to incorporate digital mentoring. Digital mentoring otherwise known as e-mentoring, offers several distinct advantages over the traditional face-to-face mentoring (Isma'il & Olatunbosun, 2024). Digital mentoring breaks down geographical barriers, no matter where they are physically located, mentors and mentees can connect through to digital mentoring. This expanded reach facilitates access to a diverse pool of mentors (Castanheira, 2016), fostering cross-cultural exchanges and the sharing of varied perspectives via digital mentorship.

The concept of digital mentorship and its significant influence on educational and career growth has been thoroughly examined in previous studies. Digital mentorship platforms have emerged as powerful technology tools for facilitating connections between mentee and mentors (Okolie, 2020; Addai, 2023). These platforms use digital technology to overcome

geographic distances and give science teachers easily accessible ways to get help and support. The key features of digital mentorship platforms include mentor-mentee matching, personalized mentoring, resource libraries and community building (Borup, 2020; Montgomery, 2017). Online communities have revolutionized how people collaborate, engage in learning and personal growth (Çakiroğlu et al., 2022; Li et al., 2023). These digital platforms create a sense of belonging, allowing members to connect, exchange experiences, and support each other (Ren & Qi, 2023). The chief aspects of online communities have peer support networks, knowledge sharing, collaborative learning, network opportunities. Çakiroğlu and Kahyar (2022) asserted that online community-based learning, provide encouragement, advice, and moral support to one another through exchanging ideas, best practices, and valuable insights under knowledge sharing attribute.

By efficiently matching mentors with mentees based on their interests, objectives, and abilities, artificial intelligence and other technological advancements have transformed personalized mentoring (Montgomery, 2017). Various studies have found significant positive impact of mentorship on academic achievement, career advancement and personal growth (Okolie, 2020). Okolie et al. (2020) emphasized on mentorship program that provides guidance, support, and role modelling, helping individuals to navigate challenges and explore opportunities throughout their educational and career journeys.

Similarly, Montgomery (2017), Pena et al. (2022), and Shah et al. (2023) on their different related studies examined the role of networking platforms in facilitating mentorship relationships, knowledge sharing, and career advancement within professional networks. Their studies showed that this facility is anticipating a new horizon to the academic and professional field. Furthermore, mobile applications have emerged as convenient and personalized tools for mentorship and skill development. Investigation on the effectiveness of apps like CareerVillage, Pathrise, and MentorCruise shows that these applications tailor support and guidance to the



users as they navigate their educational and professional journeys (Okolie, 2020). Tools like LinkedIn and Slack are essential for professional networking and community involvement, offering real-time communication and collaboration capabilities (Pena, 2022). Hence, digital mentorship platforms could emerge as powerful technology tools for science teacher development in for the 21st century classroom.

Statement of the problem

The integration of technology in education has garnered significant attention in recent years, with digital mentoring platforms emerging as a potential solution to enhance the professional development of teachers, particularly in science education. Despite this shift, there remains a lack of empirical evidence regarding the effectiveness of these digital mentoring initiatives, especially in less urbanized regions like Taraba State. Science teachers in Taraba face unique challenges, including limited access to professional development opportunities, inadequate resources, and traditional mentoring methods that may not effectively address their specific needs. Specifically, the time constraints of the mentors and science teachers hinder their ability to engage in meaningful mentoring activities.

Heavy workloads and packed schedules leave little room for regular mentoring sessions for effective professional development. While digital mentoring platforms offer flexibility and accessibility, their impact on teachers' pedagogical skills, classroom management, and overall teaching effectiveness is not well understood; hence the knowledge gap.

This gap in knowledge raises critical questions: How do science teachers perceive and utilize digital mentoring platforms in their professional development? What specific outcomes arise from their engagement with these platforms, and how do these outcomes compare to those derived from traditional mentoring methods. Addressing these questions is vital for developing effective science teacher education policies and programs in Taraba State. A comprehensive understanding of the impact of digital mentoring platforms will not

only inform educational stakeholders, but also contribute to enhancing the quality of science education for the 21st century classroom.

Purpose of the study

1. To evaluate the professional development outcomes of science teachers, experience through digital mentoring geared towards transforming science teachers' quality and skills for the 21st century classroom.
2. To compare the effectiveness of digital mentoring compared to traditional methods.

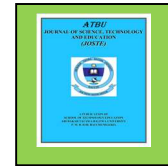
Research Questions

The following research questions were raised to guide the study:

1. What professional development outcomes of science teachers experience through digital mentoring?
2. How do science teachers perceive the effectiveness of digital mentoring compared to traditional methods?

The theoretical frameworks that also guided the study are social learning theory, social cognitive theory, and transformative learning theory. 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. More so, mentoring in education is guided by transformative learning theory, introduced by Jack Mezirow in 1978 which provides a valuable framework for understanding how mentoring can facilitate significant growth in new teachers.

These theory emphasizes critically examining assumptions and biases, a process that can be powerfully catalyzed through thoughtful mentoring conversations. These theoretical perspectives directly relate to this research by guiding the design and understanding



of the mentoring interventions, which aimed to enhance science teacher development for the 21st-century classroom.

METHODOLOGY

The study adopted a survey research design. The population for the study consist of 854 secondary school teachers from the 43 public secondary schools in Jalingo Education Zone of Taraba State. According to the planning and statistics unit, the population of secondary school teachers in 2023/2024 academic session the population was made up of 226 females and 628 males. The sample size comprises 120 science teachers were drawn using purposive sampling. These 120 science teachers comprise of 40 Biology teachers, 40 Chemistry teachers and 40 Physics teachers only. Digital Mentoring Questionnaire (DMQ) was the instrument used for data collection. DMQ contains 22 multiple choice

objective items. DMQ was validated for face and content by two experts from Measurement and Evaluation, all from the Faculty of Education, based on the comments and suggestions of the experts, corrections and modifications were made to the final instrument. The instruments DMQ was subjected to a pilot testing. The instrument was found to have a reliability coefficient of .71 using Cronbach's alpha; which is considered good and suitable for data collection. The data collected, was analyzed using descriptive statistics of mean and standard deviation to answer all the research questions raised to guide the study.

RESULTS

Research Question One: What professional development outcomes of science teachers experience through digital mentoring?

Table 1. Mean Ratings & Standard Deviation Scores on professional development outcomes of science teachers experience through digital mentoring

SN	Items	Mean	SD	Decision
1	Digital mentoring has improved my teaching practices	2.66	1.10	Agreed
2	I feel more confident in my teaching skills due to digital mentoring	3.50	0.65	Agreed
3	Digital mentoring has helped me to better manage my classroom	2.40	1.07	Disagreed
4	I have gained new teaching strategies through digital mentoring	3.55	0.66	Agreed
5	Digital mentoring has increased my engagement with students	2.99	1.11	Agreed
6	Digital mentoring positively impacts student learning in your science classes	3.19	0.99	Agreed
7	Digital mentoring has improved my ability to use technology effectively in my classroom	3.51	0.72	Agreed
8	Digital mentoring has helped me to stay up-to-date with the latest developments in science education	3.48	0.76	Agreed
9	I have developed stronger relationships with other science teachers through digital mentoring	3.27	0.68	Agreed
10	Digital mentoring has increased my motivation to continue professional development	3.30	0.81	Agreed
11	I am more confident in my ability to differentiate instruction for diverse learners due to digital mentoring	3.19	0.74	Agreed
Grand Mean:		3.185	0.845	

Criterion mean: $\bar{x} \geq 2.50$ = Agreed; $\bar{x} < 2.50$ = Disagreed, n=120

The results shown in Table 1 reveals that the mean scores of the respondents for Items 1, 3, 4, 5, 6, 7, 8, 9, 10 and 11 are all above the cut off mean of 2.50, indicating an agreement with

the items on professional development outcomes of science teachers experience through digital mentoring. In contrast, the mean score of Item 3 is below 2.50, showing disagreement with the item. This indicates disagreement that digital mentoring

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helped science teachers to better manage their classrooms. The standard deviation scores ranged from 0.65 to 1.11, indicating homogeneity amongst responses and a similar consensus of opinion. The cluster mean of 3.19 and SD of 0.85 is greater than the criterion mean which indicates

that digital mentoring is effective in science teacher development.

Research Question Two: How do science teachers perceive the effectiveness of digital mentoring compared to traditional methods?

Table 2. Mean Ratings & Standard Deviation Scores on effectiveness of digital mentoring

SN	Items	Mean	SD	Decision
12	Digital mentoring is more effective compare to traditional mentoring in terms of professional growth	3.35	0.77	Agreed
13	Compared to traditional methods, digital mentoring is more flexible	2.74	1.02	Agreed
14	compared to traditional methods, digital mentoring is more accessible	3.13	0.86	Agreed
15	Resources for digital mentoring are always available than that of the traditional method	2.82	1.01	Agreed
16	Peer support in digital mentoring is more achievable than the traditional method	2.93	0.97	Agreed
17	There are limited interaction with mentors in digital mentoring as compared to the traditional method	3.28	0.82	Agreed
18	Digital mentoring offers more diverse perspectives compared to traditional mentoring in professional development	3.08	0.92	Agreed
19	Compared to traditional methods, digital mentoring facilitates more immediate feedback for science teachers	3.29	0.87	Agreed
20	Digital mentoring provides more opportunities for global collaboration with science teacher than traditional mentoring does	3.02	0.93	Agreed
21	Compared to traditional methods, digital mentoring enhances technology integration in teaching practices	3.30	0.83	Agreed
22	Digital mentoring fosters a greater sense of community among educators compared to traditional methods	2.67	1.00	Agreed
Grand Mean:		3.055	0.909	

Criterion mean: $\bar{x} \geq 2.50$ = Agreed; $\bar{x} < 2.50$ = Disagreed, N = 120

The results shown in Table 2 reveals that the mean scores of the respondents for all the items are above the cut off mean of 2.50, indicating an agreement with the items on how science teachers perceive the effectiveness of digital mentoring platforms compared to traditional methods. The standard deviation scores ranged from 0.77 to 1.02, indicating homogeneity amongst responses and a similar consensus of opinion. The cluster mean of 3.06 and SD of 0.91 is greater than the criterion mean which indicates that digital mentoring is effective in science teacher development. This implies that showed

that the perception of science teachers on effectiveness of digital mentoring compared to traditional methods is high.

DISCUSSION OF FINDINGS

The result of this study has shown that digital mentoring is effective for science teacher continuous professional development. The cluster means of 3.19 and SD of 0.85, 3.06 and SD of 0.91 is greater than the criterion mean which indicates that digital mentoring is effective in science teacher development. Akilu and Mujidat, (2024); Nayan, et al. (2024); Serap Erdoğan, et al. (2022). The finding of this study also agrees with

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that of Okolie et al. (2020), Shah et al. (2023), Pena et al. (2022), and Montgomery (2017), whom all affirmed that digital mentoring is effective on science teachers' professional development.

The study is also in line with the findings of Lerman (2020), who compared virtual mentoring compares to face-to-face mentoring on the development of leadership self-efficacy for college students attested that virtual mentoring/online learning was superior to relaying critical leadership skills to the student than face-to-face learning. Tiffany (2020) also attested that virtual mentoring program participation impacted the utilization of Twitter, blogging, and video observation for pre-service agriculture teachers, as well as a relationship between virtual mentoring participation and blogging usage for in-service teachers.

Mayra and Yessenia (2022) studies which revealed that in-service agriculture teachers who had participated in a virtual mentoring program exhibited higher overall digital literacy levels and technology self-efficacy levels than those in-service agriculture teachers who had not participated in a virtual mentoring program and that virtual (digital) mentoring is an effective method to support science teachers' professional development. Serap, et al. (2022) developed an e-Mentoring-Based Education Program (e-MENTE:PT) for preschool teachers and tested its effectiveness on their professional development during the in-service support period; which attested that the virtual (e-MENTE:PT) program supported preschool teachers' professional knowledge, learning environments and classroom applications, and an e-mentoring based teaching management system was effective on professional development. he findings of the present study also supports Mayra and Yessenia (2022) work on virtual mentoring and coaching in education who noted that technology improvements have opened an avenue for online mentoring and coaching for in-service teachers; and their findings showed that virtual mentoring and coaching is an effective method to support teachers. As indicated by Thuthukile and Paul (2022) that mentors experiences and personal characteristics, and abilities to create

opportunities for growth influenced the pre-service teachers' experiences during teaching practice; and the mentees perceptions toward mentor-mentee relationships also influenced their experience. Hence, digital mentoring sessions can be introduced to promote teacher education and teacher capacity for the 21st-century classroom. More so, the findings of this study agrees to that of Andersen and Wellen, (2023) which revealed that virtual (digital) mentoring led to the development of communication and leadership skills, and a cultivation of civic responsibility and a sense of empowerment to make a difference among science teachers. Andersen and Wellen, (2023) attested that being a mentor in the digital era helped in the reduction of biases and development of cultural humility; the development of communication and leadership skills; and a cultivation of civic responsibility and a sense of empowerment to make a difference.

Also, Nayan, et al. (2024) on GuidifyMe, a groundbreaking digital mentorship platform aimed at revolutionizing the mentorship landscape by seamlessly connecting knowledge seekers with experienced mentors across diverse domains; and revealed its impact on user engagement, knowledge acquisition, and overall growth, highlighting its potential to democratize access to transformative mentorship opportunities. However, the findings of the study contradicts with that of Akilu and Mujidat, (2024) who revealed that both virtual and on-site mentoring interventions contributed to improvements in instructional delivery effectiveness of early-career biology teachers.

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 and retention within the profession (Clement, 2018; Ehlers, 2019). Mentors play a critical role in supporting early-career teachers' transition into the profession, providing them with emotional

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support, practical guidance, and opportunities for professional growth (Darling-hammond et al., 2017). Moreover, mentoring has a direct impact on student learning outcomes, including academic achievement (Olu-Ajayi, 2017), socio-emotional development, and school engagement. 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. 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; digital mentoring is vital in transforming the science teacher for the 21st century classroom.

CONCLUSION AND RECOMMENDATIONS

It is evident from the findings of this study to conclude that that digital mentoring is effective in science teacher development. As shown from the findings, mentoring sessions can help new teachers question their ingrained beliefs about teaching and learning, encouraging them to reflect on their experiences and develop new, more effective approaches in the 21st-century classroom. By providing a safe space for exploration and challenge, mentoring can foster transformative learning in new teachers, ultimately leading to a deeper understanding of themselves, their students, and the art of teaching which can be more innovative through technologies.

Hence, it is recommended that; science teachers should be encouraged to use digital mentoring platforms for a continuous professional development. Establishing ongoing digital support systems for teachers to stay updated with emerging technologies and teaching practices through workshops, online courses, and peer collaboration can help in science teachers' continuous development in transforming the 21st century classroom.

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