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Analysis of Educational Challenges for Science Teachers and Solutions with Emphasis on the Role of the Teacher

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A B S T R A C T

Purpose: This study aims to identify the educational challenges faced by science teachers in the secondary education system of Iraq.

Methods and Materials: This study employs a qualitative research approach and using content analysis with an inductive methodology. The research environment included science teachers, science subject group leaders, and curriculum developers who were selected through purposive sampling based on specific criteria. The primary data collection tool was semi-structured in-depth interviews. The interviews continued until theoretical saturation was reached, with a total of 23 participants.

Findings: The initial coding led to the identification of five subcategories of challenges faced by teachers: skills, knowledge, ethical characteristics, attitudes, and abilities. Based on these challenges, corresponding solutions emerged.

Conclusion: In light of the findings, it is recommended that to overcome the identified educational problems in science education, all aspects highlighted in this study should be reviewed, and necessary reforms should be implemented to enhance the effectiveness of science education, with a particular emphasis on the role of the teacher.

Keywords: *Educational challenges, science teachers, teacher's role, education*

1. Introduction

Improving educational systems is a critical goal in all countries due to the significant role of education in individual and professional growth (Sotoudeh Moghadam et al., 2024). Students, as the future builders of society, hold great importance in education, and neglecting them could lead to irreparable harm to society (Russell & Qiu, 2024; Salman Al-Oda et al., 2024; Shariati et al., 2024). The current era is seen as one in which the goal of education is not merely to transfer cultural heritage and human experiences to the new generation, but to bring about positive changes in knowledge, attitudes, and ultimately human behavior (Kudusheva & Amanova, 2022). The rapidly growing field of scientific knowledge and continuous technological advancements have connected social issues and sciences in an unprecedented way. This transformation has increased the need to reform science curricula in schools (Arbid & Tairab, 2020). In fact, from the moment individuals begin their lives, they start acquiring knowledge, skills, and behaviors that form the foundation of their learning through their life experiences. These characteristics grow further through the education they receive in later years, which contributes to their overall quality. Therefore, the quality of educational services provided to individuals is of great importance. Teachers bear significant responsibility in enhancing the quality of educational services. This is because teachers are the individuals who guide and facilitate learning (Yildiz, 2021). The primary task of a teacher is to find and apply the most effective teaching methods using their skills and to bring about desired behavioral changes in students. In other words, for teachers, the goal is to use a method to teach a subject (Majoni, 2017). Some studies suggest that the learning process begins with student engagement in academic activities. Student engagement includes two components: first, the time students dedicate to their studies and other activities that shape their success, and the effort they put into these areas; second, the ways in which educational institutions allocate resources and organize learning opportunities that encourage students to participate in learning activities and benefit from them. A review of recent research shows that academic engagement in various subjects, including science, is a multidimensional construct consisting of cognitive, emotional, behavioral, and contextual components (Reeve & Lee, 2014).

At the same time, with the advancement of science and technology and the emergence of new learning theories, new approaches to science and methods of teaching science have been introduced. Concurrently, new approaches have emerged in determining educational goals and the teaching process. Today, human perspectives on teaching extend beyond traditional classroom instruction to include new approaches and trends, derived from educational sciences, psychology, sociology, and management, in the field of teaching and the role of teachers. These approaches encourage teachers to view their teaching and role from a broader perspective, and by applying them, improve the quality of student learning and holistic development (Mehrvarz et al., 2012). Among the subjects that require a re-evaluation of teaching methods is the subject of science (Ahmadi et al., 2012), as science is one of the most debated branches of knowledge that every country needs for increasing power, security, and overall development. Science is the most important discipline in today's world, and due to its connection with the discovery of the secrets of nature, it plays a vital role in solving global problems (Samadi, 2018). This is why strategic research centers worldwide are planning to lead in this science (Li et al., 2022).

In science curricula, life skills and scientific process skills are incorporated to achieve these goals. These skills are the foundation of real learning, knowledge production, and literacy (Zorlu & Sezek, 2019). The goal in science education programs is to help students acquire scientific process skills, as well as fundamental knowledge concepts (Zorlu et al., 2014). Helping students develop scientific process skills is crucial for fostering a generation that learns and teaches in a meaningful way and is scientifically literate (Zorlu et al., 2014). To achieve the goals of science education through empowering students to learn the capabilities and habits of managing information from a scientific perspective, new methods and techniques are used in science classrooms (Dasdemir & Doymus, 2012). Modern teaching approaches emphasize student-centered learning, cognition, problem-solving, and critical thinking. Science curricula provide the greatest opportunities for students to acquire these concepts (Karakuyu & Can, 2020), as learning abstract and difficult concepts is easier for students through creative teaching methods (Danckwardt-Lilliestrom et al., 2018). Therefore, educational systems strive to implement written resources in various content areas, especially science curricula, using more effective methods in the classroom. Experience has shown that curriculum implementation can be improved through various strategies, and comparative studies, as one of these operational methods, provide more

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comprehensive information about educational system policies regarding curriculum implementation and the nature of decisions made by individuals involved in various positions regarding the execution of program contents, thus offering the most valuable data for the role of program implementers. There are various reasons for curriculum revisions, including improving the quality of education (Tay & Bas, 2015) and advancements in science and technology (Sonmez & Kılıcoglu, 2016). Therefore, information gathered from studying global educational systems in this context can serve as a source of inspiration. What is currently observed in the implementation of science curricula are methods that echo activities and actions from past traditions. Despite curriculum documents emphasizing the use of new approaches based on modern learning theories, many schools and educational institutions remain entrenched in their habitual teaching methods. Moreover, science learning in schools is often described as difficult and boring compared to other subjects. Thus, teachers are concerned about students' engagement, as it is essential for supporting student progress (Lashari et al., 2018). On the other hand, examining the practical components of teaching methods through studying the implementation strategies of other countries provides more appropriate indicators for adapting them to the culture and educational contexts of different countries, as these strategies demonstrate their value for optimal student learning through actual practice. Gaining understanding about the nature, philosophy, and implementation of these teaching methods can lead educators and teachers to adopt a positive mindset toward new methods, motivating and encouraging them to implement these methods more effectively in their classrooms (Kashanian et al., 2021). Based on the above, this study seeks to answer the question: What are the educational challenges faced by science teachers, and what are the solutions for overcoming these challenges with an emphasis on the role of the teacher?

2. Methods and Materials

In the present study, a qualitative research approach was adopted, utilizing inductive content analysis. One of the common and initial definitions of content analysis comes from Berelson. According to Berelson, in content analysis, the observable characteristics of a message (text, conversation, etc.) are described objectively (independent of the researcher's personal interpretation) and systematically. From this perspective, content analysis is a method that discovers specific characteristics of a message in an objective manner and according to certain rules. In qualitative content analysis, more focus is given to the latent meanings in the text and interviews, with the aim of inferring and extracting meaning from it. Moreover, when a researcher aims to gain a new understanding in a particular domain and to develop a model or theory in that area, qualitative content analysis is employed. Content analysis has various approaches, one of which is inductive content analysis. The use of an inductive approach, sometimes referred to as conventional content analysis, is especially necessary when there is insufficient information about a phenomenon and the researcher seeks to build the required background knowledge. This method of content analysis primarily aims to reduce information and provide a precise description of a topic. In this context, the purpose of inductive research is to derive findings by focusing on the dominant themes within the data. This means that the researcher gradually summarizes the data under study in order to identify the core concepts and themes related to the research topic. In fact, in qualitative content analysis with an inductive approach, the following objectives are pursued:

- Transforming extensive textual information into summaries and abstracts, and extracting the main themes present within it.
- Establishing a clear and precise connection between research questions and the obtained findings.
- Developing a model or theory around the structure of the studied text, or uncovering processes embedded within the text.

From this viewpoint, qualitative content analysis starts with scattered textual data and gradually moves to higher levels of abstraction by extracting embedded concepts. In the inductive content analysis process, initial coding and grouping similar codes into a single category lead to the creation of several primary categories. In later stages of the research, these categories are compared with each other, and those that are closely related are placed under broader categories. Each of these intermediate categories represents a specific section or class of the research topic. These categories can be interconnected and, at a higher level of abstraction, grouped under a main category. In the present study, the researcher avoided using pre-determined categories and allowed categories and labeling to emerge from the data itself, thus adopting an inductive approach. In this process, after conducting interviews and performing initial coding, similar codes were grouped under primary

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categories, and each subcategory was placed around the main category. Additionally, the unit of analysis in this study was the paragraph.

The participants in this research included science teachers, head teachers of science departments, and curriculum developers of science textbooks. These participants were asked to identify the educational problems in science lessons. The sampling method used in this study was purposive sampling based on specific criteria (familiarity with the content of the science subject, the educational problems of this subject with an emphasis on the teacher's role, and possible solutions). Furthermore, since in qualitative approaches theoretical saturation determines the sample size, the researcher did not initially set a fixed number for the interviews. Accordingly, the researcher conducted interviews with science teachers, head teachers of science departments, and curriculum developers who had sufficient and relevant knowledge about the educational problems in science lessons, and continued this process until theoretical saturation was reached. Theoretical saturation is the point during coding when no new codes can emerge from the data. The number of participants in this study reached 15 based on the principle of theoretical saturation.

The primary technique used for data collection in this research was in-depth semi-structured interviews. The participants were asked to identify the educational problems in science lessons. During the interviews, any ambiguities regarding the description of each indicator were addressed, and an initial summary was generated. Additionally, the interview guide for this study was structured around two main sections: demographic questions related to the research environment and main questions regarding the educational problems in science lessons. To ensure the validity and reliability of the findings, two methods were used. In the first method, after conducting and transcribing the interviews, the interview transcripts were returned to the participants for them to confirm the accuracy of their statements. Furthermore, any ambiguities in the content were discussed with the participants and clarified. The second method was related to verifying the accuracy of the results. After completing the final coding and identifying the model, this model was presented to a number of teachers to confirm the validity of the final findings of the research.

3. Findings and Results

In Amos 23 software, five indices (NFI, RFI, IFI, GFI, CFI) are reported based on the comparison of the chi-square value of the model with the chi-square value of the baseline model. All these indices range between 0 and 1, and the closer the value is to 1, the more acceptable the model is.

Table 1

Model Fit Indices of Confirmatory Factor Analysis for the Main Category of Teacher-Oriented Solutions

Index Name	Standard Index Value	Index Value in the Proposed Model	Conclusion
x^2/df	Less than 5	2.001	Model fit is acceptable
IFI	Greater than or close to 0.90	0.974	Model fit is acceptable
NFI	Greater than or close to 0.90	0.963	Model fit is acceptable
TLI	Greater than or close to 0.90	0.971	Model fit is acceptable
CFI	Greater than or close to 0.90	0.968	Model fit is acceptable
RMSEA	Less than 0.10	0.083	Model fit is acceptable

One of the general indices used to account for free parameters in the calculation of the fit index is the normalized or relative chi-square, which is computed by dividing the chi-square value by the model's degrees of freedom. Generally, values between 2 and 3 are considered acceptable for this index. However, views on this matter differ. Schumacher and Lomax (2008) consider values between 1 and 5, Carmines and McIver (1981) consider values between 2 and 3, Ullman (2001) considers values between 1 and 2, and Kline (2005) considers values between 1 and 3 as acceptable.

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Table 2

Subcategories and Concepts Related to the Main Category of Teacher-Oriented Solutions

Primary Concepts	Questions	Conceptual Phrase
Skills	Question 1	Skill in using laboratory equipment
	Question 2	Skill in using computers and digital literacy
	Question 3	Simulation skills
	Question 4	Familiarity with active teaching methods
	Question 5	Familiarity with problem-solving skills
	Question 6	Classroom management skills
	Question 7	Advising students on how to work
	Question 8	Team-building skills (forming homogeneous teams)
	Question 9	Familiarity with project-based approaches
	Question 10	Researcher traits
	Question 11	Skill in working with models
	Question 12	Skill in integrating art with teaching methods
	Question 13	Skill in storytelling
Knowledge	Question 14	Familiarity with curriculum planning in science lessons
	Question 15	Familiarity with proper evaluation methods in science lessons
	Question 16	Familiarity with international standards in science education
	Question 17	Familiarity with psychology of individual differences in learning practical skills
	Question 18	Familiarity with research centers related to science education
	Question 19	Possessing interdisciplinary knowledge
Ethical Traits	Question 20	Patience in teaching practical skills
	Question 21	Facilitating the learning process instead of obstructing it
	Question 22	Responsibility for student learning
	Question 23	Providing timely reactions and feedback
	Question 24	Tolerating visible and committed mistakes
Attitudes	Question 25	Belief in sharing knowledge with teachers of other subjects
	Question 26	Belief in networking among science teachers
	Question 27	Belief in the necessity of professional development for teachers
	Question 28	Teacher's distancing from stereotypes in science education
	Question 29	Teacher's belief in changing their approach to learning
Abilities	Question 30	Creative thinking skills
	Question 31	Problem-solving ability, concern for issues
	Question 32	Ability to stimulate curiosity in students
	Question 33	Ability to simplify abstract issues in science lessons
	Question 34	Ability to create simple educational models
	Question 35	Ability to use educational kits
	Question 36	Ability to assist students in overcoming academic failures
	Question 37	Ability to manage peer-to-peer teaching

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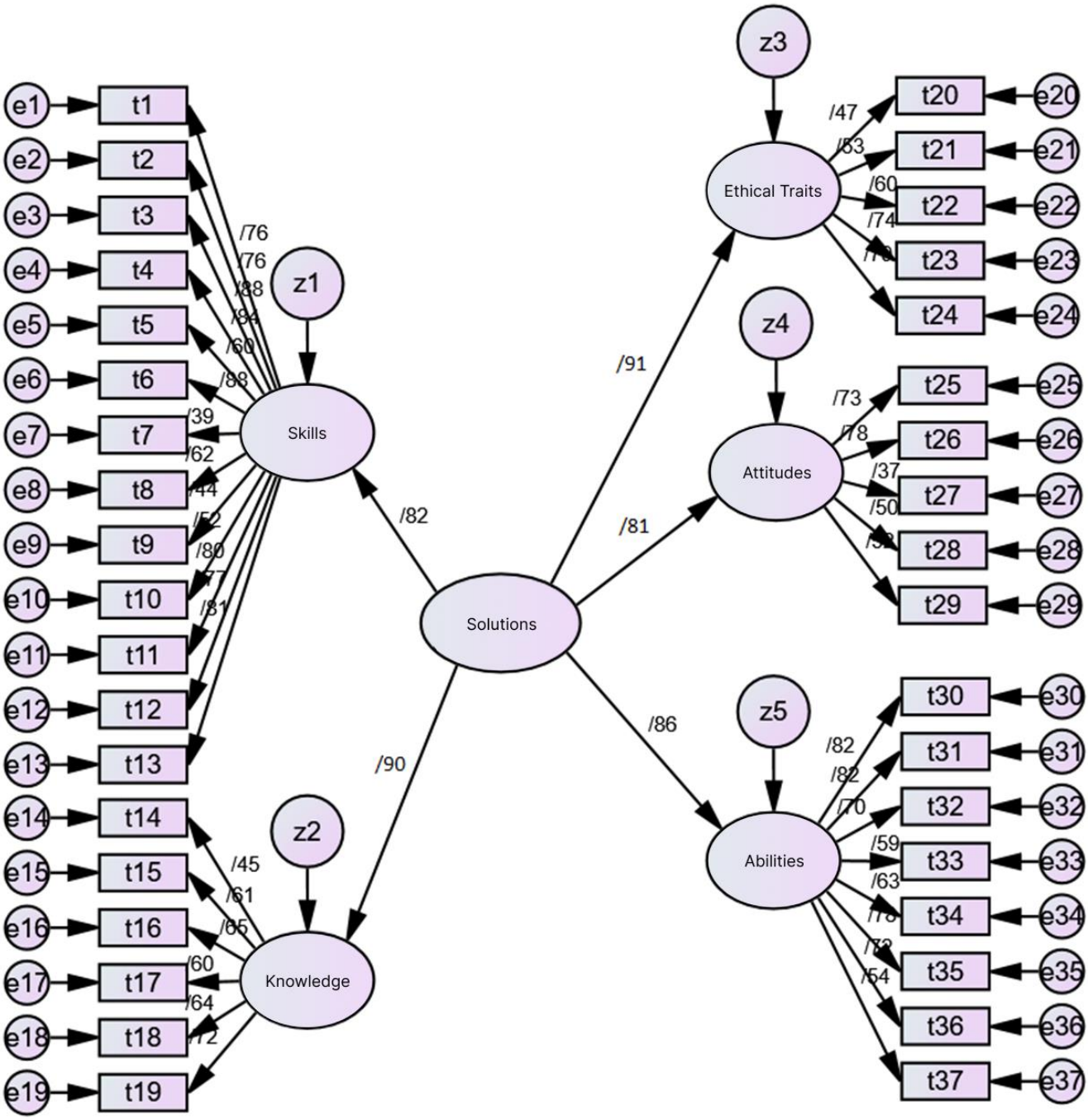
Figure 1

Second-Order Confirmatory Factor Analysis Model for the Main Category of Teacher-Oriented Solutions



4. Discussion and Conclusion

In explaining these findings, and under the category of teacher skills as one of the strategies for addressing educational challenges in science lessons, it can be said that in the ever-evolving landscape of education, individuals who appear in the classroom as teachers play a crucial role in ensuring the success of schools and students. Modern teachers face unique challenges and opportunities every day. For successful performance in this dynamic environment, continuous skill development is not only beneficial but also essential. This is because skills enhance the learning environment, significantly influencing student learning outcomes. One of the most significant challenges faced by teachers teaching subjects like science is the integration of the subject with other lessons and the diversity of students

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with different abilities, interests, characteristics, learning styles, and specific behavioral dynamics. Skill development offers valuable strategies for effective interaction and management of student populations. Professional and skill development creates a conducive learning environment, turning learning into an enjoyable and exciting experience for students. Teacher development programs focus not only on teaching techniques but also on building confidence and resilience in educators (Hosseini et al., 2022; Shariati et al., 2024). Teachers of science subjects often face uncertainty and unpredictable situations due to the nature of the subject. Through targeted training of teacher skills, they gain the necessary confidence to manage unexpected situations, adapt quickly to new environments, and deliver effective lessons. This confidence transforms the classroom into a positive space, stimulating students' enthusiasm for learning. It seems that developing skills for science teachers is not only an investment in teachers' professional growth but also an investment in the future of education. By equipping teachers with the necessary skills, knowledge, and confidence, they can create rich learning experiences for their students. This means that continuous skill development is the foundation for creating a vibrant, engaging, and inclusive educational environment. An environment that nurtures the potential of every learner and paves the way for a brighter future.

Laboratory skills are among the necessary skills for science teachers. Successful science learning requires student engagement, working with equipment, and developing skills in observation and exploration. The use of educational equipment allows students to incorporate their auditory, visual, and tactile senses into the learning process (Maddukelleng et al., 2023). Therefore, learning through such methods is deep and lasting. Achieving this kind of learning requires the teacher's competency in handling laboratory equipment and mastery in its use, knowing how to use it correctly, understanding potential hazards, and maintaining it properly. Computer skills and digital literacy are also essential for science teachers. The technological world today has made cyberspace and the digital realm inevitable. The ability to use information and communication tools and digital technologies to find, evaluate, create, and transfer information is called digital literacy. This literacy requires both technical and cognitive skills. Digital literacy is the ability to easily identify and creatively use available technologies for learning, problem-solving, and overcoming learning challenges in the vast digital world. Skills such as technology use, information search and evaluation, data management, media management, and content creation are essential for science teachers to ensure the accuracy, depth, and level of information they provide. The ability to search for new material on the web, evaluate information provided by students, use online learning resources for science, and create multimedia content are also necessary skills for science teachers. Simulation skills are another required skill for teachers. One of the significant challenges in education is that students rarely experience practical, hands-on activities that allow them to directly apply what they have learned. Many educational researchers believe that theoretical lessons do not offer much value to students and fail to establish an interactive relationship between teacher and student. The use of virtual simulations is considered one of the solutions to address educational challenges in science. This environment can provide conditions where teachers can experiment with new teaching methods without harming real students. Multilayered virtual environments allow multiple users to interact simultaneously. Besides virtual simulation, physical simulation is another essential skill for science teachers. In this method, the teacher can use physical objects, such as stones or metals, to simulate lesson content, making learning more tangible and less abstract. Familiarity with active teaching methods is another necessary skill for teachers. Active teaching methods, or student-centered teaching, put responsibility for learning on the students. In active teaching, the teacher assumes the role of a facilitator, guiding students in the learning process. Instead of providing one-way information, methods are employed that encourage students to participate and collaborate more in the learning process. Role-playing, group discussion, problem-solving, peer teaching, and project-based teaching are some of the active teaching methods that can reduce educational challenges in science.

Along with skills, possessing the necessary knowledge in the subject is another factor that reduces educational challenges. Familiarity with curriculum planning in science is vital for organizing teaching-learning activities to bring about desired changes in learners' behavior and evaluating the extent of these changes (Şahin et al., 2024). Moreover, knowledge of proper evaluation methods is important to avoid traditional, one-dimensional assessments that focus solely on the students' knowledge level and ignore other skills, such as analytical thinking. Science teachers must also be familiar with international standards in science education to prepare students for participation in international olympiads and motivate them. Understanding individual

differences in learning practical skills, changing expectations, and improving academic achievement, as well as being aware of research centers related to science and utilizing interdisciplinary knowledge, are essential for creating synergy and integrating science lessons with other subjects.

The research findings also indicated that possessing unique ethical characteristics in science teachers contributes to reducing educational challenges. Active student engagement in science lessons can eliminate the typical classroom discipline issues. Additionally, teaching practical skills individually to each student, along with repetition and practice, requires patience from the teacher. Furthermore, due to the inherent characteristics of the subject, the teacher's role in science education is to facilitate the learning process. A learning facilitator is responsible for helping students make the most of their visible and hidden potential through encouragement and guidance (Abdollahi et al., 2022; Jabarooti & Bagherimajd, 2023; Popova, 2021). Such educators aim to create an environment conducive to learning and help students develop the necessary skills for success. Additionally, qualities such as responsibility for learning, providing timely feedback, and being tolerant of students' mistakes due to their curiosity and exploration are expected from science teachers.

Beliefs such as sharing knowledge with teachers of other subjects, networking among science teachers, continuous professional development, distancing from teaching stereotypes, and changing teachers' attitudes towards learning are other strategies for overcoming educational challenges. Knowledge sharing involves voluntarily sharing acquired skills and experiences with other teachers. When a teacher shares knowledge, they guide others using their expertise, insights, and ideas to help them better understand their situation. In an educational context, knowledge sharing can be a systematic activity aimed at transferring and exchanging knowledge and experience among teachers with a common goal (Conradty & Bogner, 2020; Erfani & Aminimofrad, 2020; Gholampour et al., 2020). Networking among teachers is crucial for professional development and providing new perspectives and ideas. Moreover, networking offers opportunities for teachers to learn about the latest educational advancements and methods from their peers. Effective networking helps teachers overcome educational challenges by providing access to valuable new information.

Finally, every educational system will only succeed in fulfilling its mission if teachers possess scientific competence, are familiar with teaching methods, and are equipped with professional skills. Therefore, the three essential factors for teachers to succeed in the educational environment are having scientific qualifications, effective educational knowledge, and the integration of scientific knowledge with practical experiences. The rapid advancement of educational science and technology today requires that teachers continuously engage in empowerment processes, knowledge enhancement, and acquisition of necessary teaching skills. Action research, teaching research, and narrative research are among the methods for enhancing teachers' knowledge in the current educational world. Teachers must recognize that to enhance their profession, they must engage in knowledge enhancement and empowerment, even letting go of outdated knowledge as much of the previously acquired knowledge may have become obsolete or further developed.

Authors' Contributions

Authors equally contributed to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethical Considerations

All procedures performed in studies involving human participants were under the ethical standards of the institutional and, or national research committee and with

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the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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