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Conceptual Misconceptions About Fungi in Tenth-Grade Students and Their Relationship to Scientific Curiosity

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Research Article

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Abstract

Aim. This study aimed to investigate conceptual errors related to fungi and their relationship with the level of scientific curiosity among tenth-grade students in public schools in Jordan.

Method. A descriptive-correlational design was employed to identify students' misconceptions and examine their association with scientific curiosity.

Results. Findings revealed that the highest percentage of conceptual errors occurred in the domain of fungal reproduction, followed by fungal structure and functions, fungi in medicine and industry, and fungi in the environment and their ecological role, while the lowest errors were observed in symbiotic interactions and pathogenic fungi. The results also indicated a high level of scientific curiosity across all domains and on the overall scale. Moreover, a significant negative correlation was found between students' conceptual errors about fungi and their level of scientific curiosity.

Conclusion. The study recommends utilizing students' high scientific curiosity through remedial instructional strategies to address misconceptions about fungi. Additionally, it emphasizes the need for teacher training programs aimed at enhancing educators' ability to identify and correct conceptual errors effectively.

1. Introduction

Fungi are among the core biological concepts that hold particular importance in educational curricula. However, students' understanding of fungi remains marred by numerous conceptual errors, revealing a knowledge gap that requires study and analysis. A positive attitude toward the subject is not a sufficient indicator of a high level of conceptual understanding or achievement among students.

Educational literature, such as Al-Farsi (2022), indicates that basic education students, particularly in the tenth grade, exhibit prominent misconceptions, such as believing fungi belong to the plant kingdom, confusing them with bacteria, or considering them solely harmful organisms. These errors stem from multiple factors, including the presentation of scientific content in a fragmented or inaccurate manner and the lack of effective instructional tools, which lead to entrenched misunderstandings that are difficult to correct later (Hamdiati et al., 2022). These conceptual errors are deeply rooted in students' minds due to their connection to prior experiences or prevalent cultural beliefs. Additionally, the visual similarity between fungi and other organisms, such as plants or bacteria, contributes to confusion. Traditional teaching methods based on memorization and rote learning further limit opportunities for observation and practical experimentation, making scientific concepts susceptible to superficial understanding (Abu Laila, 2018).

The impact of these errors extends beyond the cognitive domain to motivational aspects, particularly scientific curiosity, which is a key internal driver of learning (Zmuda & Jackson, 2015). Students who build their understanding on misconceptions are less inclined to question or explore, whereas accurate understanding fosters inquiry and active investigation (Al-Farsi, 2022). Zaytoun (2017) noted that fostering scientific curiosity enhances positive interaction with biological concepts and encourages students to pose scientifically grounded questions. Thus, conceptual errors about fungi, a prominent biological topic, may significantly weaken scientific curiosity and reduce students' engagement in research and inquiry activities.

This issue gains particular significance in the tenth grade, where scientific concepts begin to solidify and shape future cognitive and professional orientations. Utari et al. (2017) highlighted a high prevalence of misconceptions related to fungal characteristics, reproduction, growth factors, classification, and environmental roles. Persistent conceptual errors at this stage hinder the development of accurate scientific understanding and negatively impact scientific curiosity, which forms a foundational basis for continuous learning and academic success (Wardat et al., 2025; Mansour & Wardat, 2025; Alkouri & Wardat, 2025).

Although mastering biological concepts is a primary goal in biology education, fostering scientific curiosity among students remains an equally critical objective. Zaytoun (2017) emphasized that scientific curiosity enhances knowledge acquisition and contributes to achieving educational goals. However, prevailing educational practices in biology teaching often focus on delivering ready-made information, neglecting the development of curiosity and methods for self-directed knowledge discovery (Demirel & Coşkun, 2009; Weible & Zimmerman, 2016; AlAli & Wardat, 2024; AlAli, Wardat, & Helali, 2024; Wardat & AlAli, 2025).

Based on the above, the need to study conceptual errors about fungi among tenth-grade students and their relationship with scientific curiosity becomes evident. This contributes to developing educational strategies capable of correcting these misconceptions and enhancing curiosity as an effective approach to deeper and more sustainable biology learning (Aldalalah et al., 2025; Jarrah et al., 2025; Saleh et al., 2023; Tashtoush et al., 2023; Winaryati et al., 2025; Garcia et al., 2025; Al-Shraifin et al., 2025).Hence came the idea of the study, which is Conceptual Misconceptions About Fungi in Tenth-Grade Students and Their Relationship to Scientific Curiosity.

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1.1. Problem Statement

Direct educational practice and systematic observation of students' engagement with biology concepts reveal that the topic of fungi frequently elicits inaccurate alternative conceptions and persistent misunderstandings among students. Despite the clear presentation and organization of the educational material, a significant proportion of students exhibit deficiencies in their conceptual understanding of fungi, particularly regarding classification, characteristics, reproduction mechanisms, and ecological roles.

These conceptual errors manifest in several forms, including confusion between fungi and plants due to visual similarities, the misconception that fungi are exclusively harmful, or a lack of awareness of their critical roles in biological systems (Batke et al., 2020). This situation prompts an inquiry into the relationship between these conceptual errors and students' scientific curiosity, as it is posited that misconceptions about scientific concepts may diminish students' inclination to question, explore, and comprehend scientific phenomena (Zaytoun, 1987).

Research suggests that the accumulation of conceptual errors in the study of fungi not only results in superficial knowledge but also impacts students' motivation for scientific inquiry. Students with misconceptions may be less inclined to exhibit scientific curiosity, thereby limiting their capacity to engage deeply with biological concepts (Küçükyılmaz et al., 2019). Consequently, examining these errors and their influence on scientific curiosity is essential for developing educational strategies that foster accurate understanding and enhance students' intrinsic motivation for learning and scientific exploration (Sudhakar, 2023).

Based on this, the study's problem is defined as the recurring conceptual errors about fungi observed across various academic tracks among tenth-grade students, indicating a systematic educational challenge. This necessitates identifying the causes, analyzing their origins, and proposing evidence-based pedagogical solutions to address conceptual gaps and enhance learning outcomes. So This study addresses the following research questions:

1. What is the prevalence of conceptual errors about fungi among tenth-grade students in public schools in the Ramtha District?

2. What is the level of scientific curiosity among tenth-grade students in public schools in the Ramtha District?

3. Is there a statistically significant correlation (at $\alpha = 0.05$) between conceptual errors about fungi and the level of scientific curiosity among tenth-grade students in public schools in the Ramtha District?

1.2. Research Objectives

The study aims to achieve the following objectives:

- Analyze the nature of conceptual errors related to fungi among tenth-grade students.
- Measure the level of scientific curiosity among tenth-grade students concerning the study of fungi.
- Investigate the relationship between conceptual errors about fungi and students' scientific curiosity.

2. Literature Review

In this context, numerous correlational educational studies have been conducted. For instance, Polons et al. (2008) conducted a study in Turkey to explore children's concepts and ideas about the fungal kingdom before and after educational intervention. The sample consisted of four fifth-grade

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students, and the study adopted a qualitative descriptive approach. The results showed that before instruction, students held misconceptions such as “mold and yeast are not living organisms,” “fungi mean mushrooms,” and “fungi are plants.” Although most misconceptions were corrected post-instruction, students still held ideas inconsistent with scientific perspectives and provided incomplete explanations or overgeneralizations.

Similarly, Utari and Maridi (2017) conducted a study in Indonesia to analyze secondary school students’ conceptual understanding of fungi. The sample included 30 students, and a four-tier diagnostic test was used to measure knowledge, scientific reasoning, confidence in responses, and the level of conceptual errors. The study, which followed a quantitative descriptive approach, revealed weak conceptual understanding, with a high percentage of misconceptions, particularly regarding fungal characteristics, classification, life cycle, growth factors, and reproduction methods.

Küçükyılmaz et al. (2019) conducted a study in Turkey to analyze research trends related to misconceptions in biology education and identify prominent practices and research gaps. The sample included 78 published studies addressing misconceptions in biology education over a specific period, using a descriptive-analytical approach. The results highlighted variability in study objectives, research methods, and data collection tools, as well as a lack of attention to certain misconceptions, indicating a need for further study and analysis.

Issa (2020) conducted a study in Iraq to explore the level of cognitive (scientific) curiosity among preparatory stage female students based on their academic specialization (scientific vs. humanities). The descriptive study included 200 students and found high levels of cognitive curiosity, with no statistically significant differences between scientific and humanities tracks. The results also showed elevated levels across the four aspects of cognitive curiosity measured by the tool.

Gul (2021) conducted a qualitative descriptive study in Turkey with 22 fifth-grade students to identify misconceptions and misunderstandings about the fungal kingdom. The results revealed inaccurate understanding, including confusion between fungi and plants, the belief that fungi are not living organisms, and misconceptions about their structure (e.g., yeast and mold), reproduction, nutrition, and classification.

Hamdiati et al. (2022) conducted a study in Indonesia to analyze tenth-grade students’ mental models about fungi and their alignment with accurate scientific concepts. The descriptive qualitative study, supported by quantitative analysis, used drawings, written tests, concept maps, interviews, and questionnaires with a sample of 30 students. The results showed low-level mental models regarding fungal structure, with 46.43% of responses being incorrect or irrelevant, while responses about fungal reproduction were partially correct at 17.85%.

Al-Farsi (2022) conducted a study in Oman to investigate the nature of conceptual errors in biology among twelfth-grade students and their relationship with certain variables. The descriptive-analytical study included 200 students, using a 30-item multiple-choice diagnostic test on “cell division and respiration” and a questionnaire measuring attitudes toward biology. The results showed the presence of conceptual errors, though not highly prevalent, with males outperforming females (47% errors for females vs. 43% for males). The relationship between attitudes toward biology and conceptual errors was very weak, suggesting that students’ affinity for the subject does not significantly correlate with their errors.

Karakaya and Yilmaz (2023) conducted a study in Turkey to examine secondary school students’ understanding of the life sciences curriculum, specifically the fungal kingdom. The descriptive-analytical study used tests and questionnaires with 52 students, revealing misconceptions such as believing fungi belong to the plant kingdom and unclear distinctions between fungi and other organisms.

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Waller (2024) conducted a study in the United States to develop a spiral educational program to enhance fungal awareness and address Fungal Awareness Disparity Syndrome (FADS) among school students. The descriptive-analytical study involved 150 students from various educational stages, using questionnaires and semi-structured interviews with teachers and biology specialists. The results highlighted a clear gap in knowledge and interest in fungi.

Sudhakar (2025) conducted a study in India to explore the relationship between curiosity and scientific attitudes among primary school students. The descriptive-analytical study, with a sample of 120 randomly selected students, found a statistically significant relationship between curiosity and scientific attitudes.

Al-Razzaz (2025) conducted a study in Jordan to investigate scientific curiosity among children and methods to foster it in educational and real-world settings, focusing on the relationship between curiosity, intelligence, and academic performance. The descriptive-analytical study showed that curiosity is a key factor in improving academic performance, comparable to intelligence. It emphasized that curiosity fosters critical thinking and self-efficacy through strategies like open-ended questions and experiential learning, while reducing reliance on modern technology and encouraging interaction with the natural environment. The results also highlighted the role of families and teachers in supporting free exploration, noting that curious children exhibit greater resilience in facing anxiety and challenges.

The review of prior studies indicates that most focused on identifying misconceptions about fungi, analyzing students' mental models, or describing their conceptual understanding, while others examined cognitive or scientific curiosity independently, without directly linking these dimensions. The targeted educational stages varied between primary and secondary levels, with most studies adopting descriptive-analytical or qualitative approaches without deeply exploring the interplay between conceptual errors and motivational factors. Herein lies the originality of the current study, which seeks to link conceptual errors about fungi with the level of scientific curiosity among tenth-grade students, offering deeper insight into how unscientific conceptions impact learning motivation and inquiry-based thinking. This study addresses a research gap in the local and Arab context by integrating cognitive and motivational dimensions, providing results that can be educationally applied to develop strategies for correcting misconceptions and fostering scientific curiosity simultaneously.

2.1. Theoretical Significance

This study contributes to the literature on school biology education by addressing a gap concerning conceptual errors about fungi and their relationship with scientific curiosity among tenth-grade students. It provides a comprehensive framework for understanding how misconceptions hinder students' ability to explore scientific knowledge and cultivate an interest in inquiry. The study elucidates the interplay between conceptual errors and scientific curiosity, demonstrating how inaccurate understanding undermines students' motivation to question and explore, thereby reducing engagement with biological concepts. Furthermore, it offers validated instruments for assessing these errors and measuring scientific curiosity, facilitating the development of effective educational strategies to enhance students' understanding of critical scientific concepts.

2.2. Practical Significance

The findings enable curriculum developers and educators to identify prevalent misconceptions and design interactive activities and strategies to correct them while fostering scientific curiosity. The study equips teachers to accurately diagnose students' misconceptions and create remedial, inquiry-based lessons that promote accurate understanding and encourage active engagement with scientific knowledge. Additionally, it provides a foundation for evidence-based interventions, enabling the design of measurable educational or enrichment programs to enhance science learning and stimulate

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students' curiosity. The approach can be extended to other scientific topics to promote cognitive engagement and advance science education broadly.

2.3. Study Terms and Operational Definitions

The study includes the following terminological and operational definitions:

- Conceptual Errors: Terminologically, these are incorrect conceptions or misunderstandings held by learners about a specific topic, resulting from inaccurate interpretations or misperceptions of information, leading to knowledge that contradicts established scientific concepts. They pose significant challenges in education by hindering learners' ability to assimilate and apply new concepts (Novak, 1987, p. 5). Operationally, conceptual errors are the incorrect conceptions about fungi held by tenth-grade students in public schools in the Ramtha District, including misconceptions such as confusing fungi with plants or misunderstanding their ecological roles (e.g., decomposition and nutrient recycling), measured through a specifically designed test.

- Fungi: Terminologically, fungi are eukaryotic organisms characterized by cell walls containing chitin, relying on the decomposition of organic matter for nutrition, and classified into types such as yeasts, molds, and macroscopic fungi (Cavalier-Smith, 1998, pp. 203–266). Operationally, fungi refer to the biological concepts covered in the "classification of living organisms" unit in the biology textbook prescribed for tenth-grade students in Jordan.

- Scientific Curiosity: Terminologically, curiosity is a positive emotional orientation toward exploring new, challenging information and experiences, pursuing and self-regulating them, and is critical in education for driving student success (Kashdan & Roberts, 2004, p. 792). Scientific curiosity is the desire to understand content related to natural phenomena (Spektor-Levy et al., 2013). Operationally, it is defined as the intrinsic motivation of tenth-grade students in public schools in the Ramtha District to engage in scientific activities and explore environmental topics, measured through responses to a scientific curiosity scale developed for this study.

2.4. Study Limitations

The study is subject to the following limitations:

- Subject Limitation: The study focuses exclusively on conceptual errors about fungi and their relationship with scientific curiosity among tenth-grade students.

- Spatial Limitation: The study was conducted in public schools in the Ramtha District.

- Human Limitation: The study sample consists of tenth-grade students in public schools in the Ramtha District.

- Temporal Limitation: The study was conducted during the second semester of the 2024–2025 academic year.

2.5. Study Constraints

The generalizability of the findings depends on the psychometric properties of the data collection instruments and the validity of the sample's responses. The results are applicable to populations with similar characteristics.

3. Methodology

3.1. Research Design

This study employed a descriptive-correlational design to examine conceptual errors about fungi and their relationship with scientific curiosity among tenth-grade students. This approach was deemed appropriate for achieving the study's objectives and answering its research questions.

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3.2. Study Population

The population consisted of all tenth-grade students in public schools under the Ramtha District Directorate of Education during the second semester of the 2024–2025 academic year, totaling 3,493 students (male and female), as reported by the Directorate's General Education Department.

3.3. Study Sample

The sample comprised 635 tenth-grade students (279 males, 356 females) from public schools in the Ramtha District during the second semester of the 2024–2025 academic year. Participants were selected using stratified cluster sampling. Schools with tenth-grade classes were identified: 23 female schools with 56 classes (1,720 female students) and 17 male schools with 53 classes (1,773 male students). Fifty percent of male and female schools were randomly selected, followed by a random selection of 50% of tenth-grade students from each class, resulting in a final sample of 635 students.

3.4. Instruments

Two instruments were developed to achieve the study's objectives:

Instrument 1: Conceptual Errors Test on Fungi

The test was designed to identify conceptual errors about fungi among tenth-grade students in the Ramtha District. It was developed through the following steps:

- Purpose: To detect conceptual errors about fungi.

- Development: The test was based on the fungi content in the third unit of the tenth-grade biology textbook, a review of educational literature, and prior scales, such as Karakaya and Yilmaz (2023). This study, a qualitative case study with 52 secondary school students in Central Anatolia, Turkey, during 2022–2023, used qualitative tools to identify misconceptions about fungi's biological characteristics, classification, ecological roles, and human impacts.

Face Validity: The initial test was reviewed by 11 experts in curriculum development, science teaching methods, educational psychology, and assessment. They evaluated content accuracy, item suitability, linguistic clarity, and suggested modifications. Based on feedback focusing on wording and presentation, the final test comprised 30 items across five domains (6 items each): fungal reproduction, fungal structure and functions, fungi in the environment and ecological roles, fungi in medicine and industry, and symbiotic interactions and pathogenic fungi.

Difficulty and Discrimination Coefficients: The test was piloted with 30 students from Zainab Bint Al-Rasool Secondary School for Girls and Abi Tammam Comprehensive Secondary School for Boys in the Ramtha District. Difficulty coefficients ranged from 0.29 to 0.80, and discrimination coefficients ranged from 0.40 to 0.78, meeting Odeh's (2010) criteria for retaining items (difficulty: 0.20–0.80; discrimination: >0.39). All 30 items were retained. The coefficients are presented in Table 1:

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Table 1. Difficulty and Discrimination Coefficients for Items of the Conceptual Errors Test on Fungi

Item	Difficulty	Discrimination	Item	Difficulty	Discrimination	Item	Difficulty	Discrimination
1	0.65	0.67	11	0.79	0.70	21	0.48	0.53
2	0.29	0.41	12	0.32	0.44	22	0.39	0.52
3	0.49	0.45	13	0.49	0.46	23	0.46	0.56
4	0.78	0.78	14	0.38	0.41	24	0.49	0.59
5	0.47	0.42	15	0.67	0.54	25	0.80	0.78
6	0.37	0.40	16	0.42	0.53	26	0.36	0.44
7	0.65	0.62	17	0.73	0.62	27	0.40	0.59
8	0.71	0.72	18	0.50	0.48	28	0.68	0.64
9	0.41	0.53	19	0.35	0.44	29	0.75	0.68
10	0.45	0.50	20	0.80	0.73	30	0.43	0.50

Table 1 shows that difficulty coefficients ranged from 0.29 to 0.80, and discrimination coefficients ranged from 0.40 to 0.78, which are acceptable per Odeh (2010), who recommends retaining items with difficulty coefficients between 0.20 and 0.80 and discrimination coefficients above 0.39. No items were deleted, and the final test consisted of 30 items across 5 domains.

Reliability: Internal consistency was assessed using Cronbach's alpha on the pilot sample. The overall test reliability was 0.88, with subscale reliabilities presented in Table 2:

Table 2. Internal Consistency Reliability Coefficients for the Conceptual Errors Test on Fungi and Its Domains

Domain	Reliability	Items
Fungal reproduction	0.85	6
Fungal structure and functions	0.79	6
Fungi in the environment and ecological roles	0.81	6
Fungi in medicine and industry	0.83	6
Symbiotic interactions and pathogenic fungi	0.77	6
Total test	0.88	30

Table 2 indicates that the overall test reliability was 0.88, with subscale reliabilities ranging from 0.77 to 0.85.

Test Duration: The average completion time for the pilot sample was 45 minutes.

Administration and Scoring: The paper-based test assigned 3 points for a correct answer with a correct explanation, 2 points for a correct answer with an incorrect explanation or vice versa, and 1 point for both incorrect. Domain scores ranged from 6 to 18, and total scores ranged from 30 to 90.

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Instrument 2: Scientific Curiosity Scale on Fungi

To measure scientific curiosity about fungi among tenth-grade students, a scale was developed based on studies such as Al-Khalidi (2020) and Issa (2020). The initial scale comprised 40 items across five domains (8 items each):

- Desire for exploration: Interest in understanding fungi's roles and environmental relationships.
- Question posing: Readiness to ask scientific questions about fungi and their functions.
- Critical thinking: Ability to analyze fungi-related information and connect it to real-world contexts.
- Desire for practical research: Inclination to seek answers through experiments and scientific sources.
- Interest in practical applications: Awareness of fungi's benefits and applications in life

Face Validity of the Scientific Curiosity Scale on Fungi

The face validity of the Scientific Curiosity Scale on Fungi was verified by presenting its initial version to 11 experts in curriculum development, science teaching methods, educational psychology, assessment, and science education supervisors from Jordan's Ministry of Education. They evaluated the scale's content accuracy, item suitability for the target sample, linguistic clarity of items, and suggested additions, modifications, or deletions of items or domains. Based on their feedback, which focused on linguistic phrasing and technical presentation, revisions were made. The final scale consisted of 40 items across five domains: desire for exploration (items 1–8), question posing (items 9–16), critical thinking (items 17–24), desire for practical research (items 25–32), and interest in practical applications (items 33–40).

Construct Validity of the Scientific Curiosity Scale on Fungi

Construct validity was assessed by administering the scale to a pilot sample and calculating Pearson correlation coefficients between each item's score, its respective domain, and the total scale score, as shown in Table 3.

Table 3. Correlation Coefficients Between Items of the Scientific Curiosity Scale on Fungi, Their Respective Domains, and the Total Scale Score

Item	Domain Correlation	Total Correlation	Item	Domain Correlation	Total Correlation	Item	Domain Correlation	Total Correlation	Item	Domain Correlation	Total Correlation
1	0.74	0.69	11	0.47	0.36	21	0.49	0.34	31	0.41	0.39
2	0.77	0.71	12	0.57	0.48	22	0.54	0.47	32	0.73	0.71
3	0.74	0.65	13	0.70	0.64	23	0.56	0.51	33	0.74	0.68
4	0.63	0.48	14	0.45	0.40	24	0.65	0.57	34	0.64	0.58
5	0.67	0.63	15	0.62	0.51	25	0.60	0.46	35	0.72	0.67
6	0.71	0.66	16	0.41	0.51	26	0.46	0.42	36	0.64	0.58
7	0.47	0.40	17	0.60	0.55	27	0.55	0.46	37	0.68	0.56
8	0.69	0.65	18	0.52	0.48	28	0.61	0.50	38	0.44	0.34
9	0.52	0.40	19	0.68	0.57	29	0.55	0.50	39	0.63	0.57
10	0.51	0.43	20	0.61	0.55	30	0.60	0.52	40	0.47	0.39

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Table 3 shows that item-domain correlations ranged from 0.41 to 0.77, and item-total correlations ranged from 0.34 to 0.71, all exceeding 0.30 and statistically significant at $\alpha = 0.05$. These values are acceptable per Nunnally and Bernstein (1994), who recommend retaining items with correlations above 0.30 with their domain and total score. Thus, the final scale retained all 40 items across 5 domains.

Pearson correlation coefficients were also calculated between the scale's domains and between each domain and the total scale score, as shown in Table 4.

Table 4. Correlation Coefficients Between Domains of the Scientific Curiosity Scale on Fungi, the Total Scale, and Inter-Domain Correlations

Domain	Desire for Exploration	Question Posing	Critical Thinking	Desire for Practical Research	Interest in Practical Applications
Question Posing	0.67				
Critical Thinking	0.58	0.53			
Desire for Practical Research	0.63	0.68	0.62		
Interest in Practical Applications	0.55	0.54	0.55	0.68	
Total Scale	0.83	0.80	0.85	0.79	0.87

Table 4 indicates that inter-domain correlations ranged from 0.53 to 0.68, and domain-total correlations ranged from 0.79 to 0.87, all statistically significant at $\alpha = 0.05$.

Reliability of the Scientific Curiosity Scale on Fungi

Internal consistency was assessed using Cronbach's alpha on the pilot sample data, as shown in Table 5.

Table 5. Internal Consistency Reliability Coefficients for the Scientific Curiosity Scale on Fungi and Its Domains

Domain	Reliability	Items
Desire for Exploration	0.80	8
Question Posing	0.75	8
Critical Thinking	0.82	8
Desire for Practical Research	0.84	8
Interest in Practical Applications	0.78	8
Total Scale	0.86	40

Table 5 shows that the overall scale reliability was 0.86, with subscale reliabilities ranging from 0.75 to 0.84.

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Scoring of the Scientific Curiosity Scale on Fungi

The final scale consisted of 40 items across 5 domains, using a 5-point Likert scale (always = 5, often = 4, sometimes = 3, rarely = 2, never = 1), with all items positively worded. Total scores ranged from 40 to 200, with higher scores indicating greater scientific curiosity about fungi. To objectively interpret mean responses, the range (5 – 1 = 4) was divided by 5 (4 ÷ 5 = 0.80), yielding the following categories: very high (4.21–5.00), high (3.41–4.20), moderate (2.61–3.40), low (1.81–2.60), and very low (1.00–1.80).

Study Procedures

To achieve the study's objectives and answer its research questions, the following steps were followed:

- Defined the research problem.
- Reviewed theoretical literature and prior studies on conceptual errors about fungi and students' scientific curiosity.
- Developed initial versions of the study instruments.
- Determined the total population size using records from the Ramtha Directorate of Education's Planning Department and selected the sample.
- Finalized the instruments after verifying their validity and reliability through expert review and pilot testing.
- Obtained a facilitation letter from the Ramtha Directorate for public schools.
- Administered the instruments to the sample of tenth-grade students, explaining the response method and purpose.
- Collected quantitative data, entered it into a computer, and analyzed it using the Statistical Package for the Social Sciences (SPSS) to derive, describe, and interpret results, leading to recommendations and suggestions.

Ethical Considerations

The study was approved by the Ethics Committee of the Jordanian Ministry of Education, and informed consent was obtained from all participants.

4. Results

The first research question was: "What is the percentage of conceptual errors about fungi among tenth-grade students in public schools in the Ramtha District?" To address this question, frequencies and percentages of conceptual errors about fungi were calculated for the study sample of tenth-grade students, as shown in Tables 6, 7, 8, and 9.

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Table 6. Frequencies and Percentages of Conceptual Errors in the Domain of "Fungal Reproduction" Among the Study Sample

Domain	Statistic	Completely Wrong (%)	Partially Wrong (%)	Completely Correct (%)
Fungal Reproduction	Percentage (%)	37.28	45.72	16.97
Fungal Structure and Functions	Percentage (%)	33.93	41.57	24.50
Fungi in the Environment and Ecological Roles	Percentage (%)	31.17	42.57	26.28
Fungi in Medicine and Industry	Percentage (%)	31.65	38.70	29.68
Symbiotic Interactions and Pathogenic Fungi	Percentage (%)	28.67	48.60	22.70

These results indicate a high prevalence of conceptual errors among students regarding fungi across all domains, suggesting deficiencies in their cognitive structure and difficulties in understanding related scientific concepts. The highest percentage of completely wrong responses was in the domain of "Fungal Reproduction" (37.28%), an educationally significant proportion, indicating that students face challenges in comprehending sexual and asexual reproduction mechanisms and fungal life cycles, often presented in an abstract theoretical manner without visual aids or modeling. These findings may be attributed to the limited use of interactive illustrative tools, such as animations or representative models, and some teachers' reliance on rote memorization rather than fostering inquiry and exploratory understanding.

In the domain of "Fungal Structure and Functions," the percentage of completely wrong responses was 33.93%, reinforcing the notion that concepts related to the microscopic structure of living organisms, such as hyphae, cell walls, and fruiting bodies, pose significant challenges for students, particularly in the absence of necessary illustrative tools like three-dimensional models or microscopic images. These results may be attributed to students' difficulty in visualizing the internal structure and functions of fungi due to the lack of practical laboratory experimentation and inadequate use of appropriate visual resources to support accurate conceptual understanding.

Conversely, a relative improvement in understanding was observed in the domain of "Fungi in Medicine and Industry," where 29.68% of students demonstrated completely correct responses, the highest among the five domains. This can be explained by the domain's direct relevance to students' lives and familiar applications, such as the use of fungi in producing antibiotics like penicillin or in fermented food production like bread and cheese. These results may be attributed to the proximity of these concepts to students' daily lives, facilitating connections between scientific content and real-world experiences, thereby enhancing understanding through tangible prior knowledge.

In the domain of "Fungi in the Environment and Ecological Roles," the percentage of completely wrong responses was 31.17%, while completely correct responses reached 26.28%, reflecting a relatively moderate level of understanding. This improvement may be due to the proximity of environmental concepts to students' lived experiences, such as organic decomposition or nutrient recycling in nature. These results may be attributed to the occasional teaching of this domain through general explanations without delving into precise ecological relationships, coupled with the absence of inquiry-based activities that allow students to directly observe fungi's impact in their local environment.

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In the domain of "Symbiotic Interactions and Pathogenic Fungi," despite the lowest percentage of completely wrong responses (28.67%), the percentage of partially wrong responses was the highest (48.60%), indicating that most students possess incomplete or superficial knowledge in this domain. These results may be attributed to the complexity of the concepts involved, which combine beneficial and harmful roles of fungi, potentially leading to conceptual confusion, especially when distinctions between symbiotic and pathogenic interactions are unclear, and due to the lack of effective use of diverse illustrative examples. Overall, these results highlight the urgent need to review teaching methods and strategies for fungi at the school level. The data clearly suggest that traditional methods relying on rote memorization and lecturing are insufficient for correcting conceptual errors or building deep scientific understanding, necessitating the adoption of inquiry-based, active learning strategies, the use of models and digital simulations, and linking concepts to direct real-world applications. The general gap in understanding may also be attributed to the lack of prior diagnosis of students' conceptual errors and failure to account for their diverse learning styles, leading to the presentation of educational content in a way that does not align with their needs or prior conceptions.

Additionally, frequencies and percentages of conceptual errors for the items of the Conceptual Errors Test on Fungi were calculated for the study sample, as shown in Table 7.

Table 7. Frequencies and Percentages of Conceptual Errors for Items of the Conceptual Errors Test on Fungi Among the Study Sample, Ordered Descendingly by Error Percentages

Rank	Item	Attribute	Number of Completely Wrong Responses	Error Percentage (%)
1	1	Understanding the role of fungi in the environment	295	46.46
2	5	Understanding asexual reproduction in fungi	242	38.11
3	11	Identifying functions of fungi	242	38.11
4	19	Identifying types of fungal reproduction	234	36.85
5	3	Understanding fungal structure	231	36.38
6	7	Understanding the function of hyphae in fungi	231	36.38
7	2	Understanding sexual reproduction in fungi	223	35.12
8	6	Understanding spore formation in fungi	223	35.12
9	10	Distinguishing between fungi and algae	223	35.12
10	24	Understanding the relationship between fungi and other organisms	219	34.49
11	15	Understanding the use of fungi in industries	215	33.86
12	23	Distinguishing between types of fungi	215	33.86
13	30	Understanding the role of fungi in the economy	211	33.23
14	4	Distinguishing between fungi and plants	208	32.76

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15	9	Understanding rapid fungal growth	204	32.13
16	13	Distinguishing between fungi and plants	204	32.13
17	29	Distinguishing between toxic and non-toxic fungi	204	32.13
18	8	Understanding fungal feeding methods	197	31.02
19	12	Understanding the relationship between fungi and plants in the environment	197	31.02
20	14	Understanding the role of fungi in medicine production	193	30.39
21	17	Knowing spore transmission methods	193	30.39
22	18	Knowing fungal classification	193	30.39
23	26	Understanding the use of fungi in environmental applications	193	30.39
24	16	Understanding characteristics of pathogenic fungi	189	29.76
25	22	Knowing fungi used in medicine	189	29.76
26	20	Understanding the impact of fungi on the environment	178	28.03
27	28	Understanding symbiotic relationships between fungi and plants	178	28.03
28	21	Knowing types of pathogenic fungi	170	26.77
29	27	Knowing reproduction in pathogenic fungi	166	26.14
30	25	Understanding fungi as heterotrophic organisms	140	22.05

The results show that the highest percentage of completely wrong responses was for the item "Understanding the role of fungi in the environment," with 46.46% of the 635 students in the sample. Based on the acceptable threshold for conceptual errors set by experts for this study at a maximum of 25%, it was found that 32.546% of students had misconceptions on 29 items (97% of the test's 30 items). This result, highlighting a high percentage of students with completely wrong responses in understanding the role of fungi in the environment (46.46%) and 32.546% with conceptual errors across 97% of test items, reveals a structural weakness not only in scientific understanding but also in ecological biological thinking. These findings suggest that students not only lack information but also have a gap in their overall conceptualization of natural processes and their dynamic relationships, perceiving fungi as marginal or harmful rather than as active living organisms in life cycles, as often implied by non-scientific everyday perceptions.

These results align with studies by Bolones et al. (2008), Otari et al. (2017), Ghoul (2021), Hamidati et al. (2022), and Karakaya and Yilmaz (2023), which demonstrated widespread misconceptions among students, such as confusing fungi with plants or considering fungi non-living, and highlighted weaknesses in understanding fundamental concepts like reproduction and fungal structure. However, these findings differ from Al-Farsi (2022), which suggested such errors are less common. These results may be attributed to the dominance of non-scientific preconceptions from

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popular culture and non-school sources (e.g., media, everyday conversations, or superficial curricula), which form an alternative cognitive framework conflicting with classroom content. Failure to address these preconceptions at the outset makes correct concepts difficult to integrate into students' cognitive structures. Additionally, students may lack the cognitive tools to interpret complex ecological processes like nutrient recycling due to insufficient practice in systemic and relational thinking that links living organisms and their ecological roles holistically.

Furthermore, the accumulation of conceptual errors in approximately one-third of students across 97% of test items may reflect weaknesses in the school assessment system's ability to detect and correct misconceptions early, allowing students to progress with confused and inaccurate understandings of fundamental concepts. Addressing these results requires not only improving information presentation but also restructuring the educational system to include concept analysis, confronting preconceptions, and fostering organized ecological thinking as part of scientific reasoning practices.

4.1. Results for the Second Research Question

The second research question was: "What is the level of scientific curiosity about fungi among tenth-grade students in public schools in the Ramtha District?" To address this question, means and standard deviations for the domains of scientific curiosity about fungi were calculated for the study sample of tenth-grade students in the Ramtha District, as shown in Table 8.

Table 8. Means and Standard Deviations for Scientific Curiosity About Fungi and Its Domains Among the Study Sample, Ordered Descendingly by Means

Rank	Item	Domain	Mean	Standard Deviation	Level
1	2	Question Posing	3.75	0.35	High
2	4	Desire for Practical Research	3.74	0.38	High
3	1	Desire for Exploration	3.68	0.51	High
4	5	Interest in Practical Applications	3.64	0.49	High
5	3	Critical Thinking	3.62	0.43	High
		Scientific Curiosity (Total)	3.62	0.36	High

The results indicate that the overall level of scientific curiosity about fungi among the study sample was high. The domains were ranked as follows: Question Posing ranked first at a high level, followed by Desire for Practical Research in second place at a high level, Desire for Exploration in third place at a high level, Interest in Practical Applications in fourth place at a high level, and Critical Thinking in fifth and final place at a high level.

These findings suggest that tenth-grade students in the Ramtha District exhibit a high level of scientific curiosity about fungi, reflecting a positive orientation toward exploring this vital area of scientific knowledge. The ranking of domains indicates that students' curiosity primarily centers on question posing, suggesting active mental engagement in inquiry and efforts to understand fungi-related phenomena, a key indicator of active scientific thinking. The high rankings of Desire for Practical Research and Desire for Exploration indicate a genuine motivation for experimentation and verification beyond theoretical learning, suggesting a somewhat supportive educational environment for participation and experimentation. Interest in Practical Applications reflects students' awareness of the connection between scientific concepts and their daily lives and environmental realities, enhancing the perceived relevance of their learning. However, Critical Thinking, despite being at a

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high level, ranked last, suggesting that students are more inclined toward exploration and research than deep analysis or critical evaluation of hypotheses and results, an area requiring further reinforcement and training in educational settings.

These results align with studies by Issa (2020), Al-Razzaz (2025), and Sudhakar (2025), which emphasized scientific curiosity as a key factor in enhancing academic learning, particularly through question posing and desire for practical research. However, they differ from Humaidati et al. (2022), which indicated that poor conceptual understanding and misconceptions negatively impact scientific inquiry, limiting students' ability to exercise curiosity. These findings may be attributed to the intriguing and sometimes mysterious nature of fungi, linked to significant environmental and health issues, which stimulates students' curiosity and encourages questioning and exploration. They may also relate to teaching methods emphasizing simulation or practical experimentation, which foster curiosity and engagement but may be less effective in developing critical thinking skills if not designed systematically to target this ability.

4.2. Results for the Third Research Question

The third research question was: "Is there a statistically significant correlation (α = 0.05) between conceptual errors about fungi and the level of scientific curiosity among tenth-grade students in public schools in the Ramtha District?" To address this question, Pearson correlation coefficients were calculated between conceptual errors about fungi and the level of scientific curiosity among the study sample, as shown in Table 9.

Table 9. Pearson Correlation Coefficients Between Conceptual Errors About Fungi and Scientific Curiosity Among the Study Sample

Variable	Scientific Curiosity About Fungi
Conceptual Errors About Fungi	r=-0.470*

**Statistically significant at α = 0.05.*

The results indicate a negative (inverse) correlation between conceptual errors about fungi and scientific curiosity about fungi, with a coefficient of -0.470, statistically significant at α = 0.05. This implies that an increase in conceptual errors is associated with a decrease in scientific curiosity, and vice versa.

These findings align with studies by Zaytoun (2017), Humaidati et al. (2022), and Sudhakar (2025), which confirmed that sound conceptual understanding enhances scientific curiosity and intrinsic motivation for learning, and vice versa. They partially differ from studies by Al-Khalidi (2020), Issa (2020), and Al-Razzaz (2025), which suggested that high scientific curiosity can exist despite alternative conceptions, highlighting the complexity of the relationship between curiosity and conceptual understanding and opening avenues for further research into mediating factors. This can be explained by the notion that conceptual errors act as cognitive barriers, limiting students' ability to engage in inquiry and reducing their intrinsic motivation for discovery, while high scientific curiosity drives students to research, verify, and correct their concepts, reducing conceptual errors. Thus, these results reflect the interplay between accurate scientific understanding and intrinsic learning motivation, where scientific curiosity contributes to building more accurate knowledge, while accumulated conceptual errors hinder the development of scientific curiosity.

7. Suggestion

Leverage students' high scientific curiosity in remedial teaching strategies to address conceptual errors about fungi through inquiry-based and experimental activities. Develop teacher training

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programs to enable early diagnosis and correction of conceptual errors using diverse methods and strategies. Integrate visual representations and real-world applications in teaching fungi to enhance deep scientific understanding and reduce conceptual confusion and Conduct future studies on the relationship between scientific curiosity and conceptual errors in various scientific topics, considering the impact of individual and academic variables and Conducting future studies using advanced analyses such as multiple regression or structural modeling.

7.1. Limitations

Despite its advantages, the research has limitations, which are: The study focuses exclusively on conceptual errors about fungi and their relationship with scientific curiosity among tenth-grade students and The study was conducted in public schools in the Ramtha District.

7.2. Conclusion

The research reveals misconceptions about fungi among tenth-grade students and their relationship to scientific curiosity, by presenting a clear and realistic scientific framework. A test and questionnaire were used, and their validity and reliability were verified. The results indicated the presence of The results revealed that the highest percentage of complete conceptual errors was in the domain of "fungal reproduction," followed by "fungal structure and functions," then "fungi in medicine and industry," followed by "fungi in the environment and their ecological role," with the lowest errors in "symbiotic interactions and pathogenic fungi." Additionally, the results showed a high level of scientific curiosity across all domains and on the scale as a whole. A negative (inverse) correlation was found between conceptual errors about fungi and the level of scientific curiosity regarding fungi. Despite the inverse (negative) correlation between conceptual errors about fungi and the level of scientific curiosity related to them, and the difficulties that researchers faced while applying the test, positive results were revealed, the Arabic library was enriched, and good literature was added regarding conceptual errors and their relationship to scientific curiosity.

Declarations

Author Contributions. Ferdous Hussein Bani Melhem: Data collection, literature review, and initial manuscript drafting. Mahmoud Hassan Bani Khalaf: Conceptualization, methodology design, data analysis, and supervision. Both authors reviewed and approved the final version of the manuscript prior to submission.

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Data Availability Statement. The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

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