Journal of Higher Education and Academic Advancement
Homepage : https://journal.antispublisher.id/index.php/EJHEAA
Email : admin@antispublisher.com

e-ISSN : 3032-1123
JHEAA, Vol. 3, No. 11, November 2026
Page 1-19
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Journal of Higher Education and Academic Advancement

An Analysis of the Level of Acquisition of Scientific and Experimental Thinking Skills and Their Link to Theoretical Concepts Among Students in the Department of Biology, College of Education for Pure Sciences, Tikrit University

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DOI : https://doi.org/10.61796/jheaa.v3i11.1950

Sections Info

Article history:
Submitted: August 13, 2026
Final Revised: September 07, 2026
Accepted: Oktober 16, 2026
Published: November 03, 2026

Keywords:
Biology
Scientific thinking skills
Experimental thinking skills
Theoretical concepts
University students

ABSTRACT

Objective: *The present study aimed to analyze the level of acquisition of scientific and experimental thinking skills among students of the Department of Biology, college of education for pure sciences, tikrit university, and to identify the relationship between these skills and their ability to link theoretical concepts.* ***Method:*** *The descriptive-analytical method was adopted. The study population consisted of students of the Department of Biology, and the study sample included (157) students, from whom (5) questionnaires were excluded due to incomplete responses, resulting in a final sample of (152) students. A questionnaire was used as the main data collection instrument, consisting of three main dimensions: scientific thinking skills, experimental thinking skills, and theoretical concepts, with (15) items for each dimension.* ***Results:*** *The result showed that there was moderate to high scientific thinking skill and moderate to high experimental thinking skill of the students. In addition, students demonstrated a good knowledge of theoretical concepts. The results also showed that the scientific thinking skill and the ability to link theoretical concepts were found to have positive correlation with a significant relationship at the (0.05) level, as well as the experimental thinking skill and the ability to link theoretical concepts.* ***Novelty:*** *This study provides an integrated analysis of scientific thinking skills, experimental thinking skills, and theoretical concepts among Biology students and demonstrates how these dimensions are related within the context of university science education.*

INTRODUCTION

The concept and role of university education is in the process of undergoing qualitative transformation in the contemporary era. It is no longer restricted to the transmission of theoretical knowledge but now it emphasizes thinking skills at different levels, especially scientific and experimental thinking, as a fundamental way to understand knowledge and use it to describe phenomena and solve problems. Thinking skills are fundamental for the development of learners who can analyse, inquire and make decisions. They are the basis of the learning process in scientific fields, particularly in Biology, which is a field in which observation, experimentation, analysis and reasoning are an intrinsic part of the learning process. Jarwan argues that teaching thinking skills is no longer an option in the education process but a necessity imposed by the needs of the knowledge age in which knowledge and skills are combined to form an active learner [1].

The scientific and experimental thinking skills are very significant in the biology college because the method of science is directly related to the biology as a subject, which

involves the formulation of hypotheses, design of experiments, analysis of results and linking them to explanatory theoretical models. For Abdel Salam, good teaching of science helps students to engage in science as a mental and methodological enterprise rather than simply a collection of abstract facts. He stresses the lack of scientific thinking which causes a gap between theoretical knowledge and practical use [2]. In the same manner, Alian presents that up-to-date science education programmes should be oriented towards developing the research and inquiry skills of students and relate theoretical conceptions with experimental experiences inside and outside the laboratory [3].

In this context, Abu Jadu and Nawfal highlight that scientific thinking is not an automatic process, but needs to be planned, as well as teaching strategies that help to develop the skills of careful observation, interpretation, analysis, experimentation and deduction. They also explain that the gap between possessing theoretical concepts and the skills to apply them represents one of the most prominent challenges of university education, especially in scientific disciplines, where some students succeed in memorization without the ability to apply or provide scientific explanation [4]. This argument is reinforced by Perkins's view that knowledge not linked to thinking is fragile knowledge that quickly fades or fails to explain reality [5].

Educational literature indicates that acquiring scientific and experimental thinking skills is closely linked to the learner's cognitive structure and their ability to organize knowledge and connect it to their prior experiences. Al-Titi emphasizes that skills are not learned in isolation from concepts, but rather through a profound cognitive interaction between theoretical understanding and practical application. The cognitive structure, he argues, provides the framework for acquiring and effectively utilizing skills [6]. Likewise, La'toum et al. explain that educational models that incorporate cognitive and skill-based components are necessary to develop thinking in learners, because this shift takes the student from a passive reception stage to the comprehension, application and analysis stage [7].

From this, it is quite apparent that the level of scientific and experimental thinking skills acquired by students in the biology departments should be analyzed, along with the nature of the relationship between these skills and the theoretical concepts learned, especially in Arab universities.

Tikrit University, as one of the oldest and most prestigious Arab universities, provides an important field for this type of study, aiming to diagnose the educational reality and identify strengths and weaknesses in learning outcomes. Al-Qatami stresses that knowing students' thinking is an essential requirement in the process of creating curricula and teaching methods and knowing how to integrate theoretical knowledge with practical application [8]. This is what this research seeks to achieve through a systematic scientific analysis based on sound educational research principles [9].

Research problem

Although scientific and experimental thinking skills are emphasized many times in educational literature as necessary skills for science students, the scene in many Arab universities still emphasizes theoretical knowledge without putting it into practice. The dominant approach in the university is to impart knowledge and to teach concepts in packaged form without giving students enough space to train in using scientific thinking methods, which include hypotheses, experiments, analysis, and theory building. This form of education, Jarwan notes, results in superficial learning where students are good at learning and recalling, but could not systematically think nor scientifically interpret [1].

This is especially true in Biology departments where the subject of Biology itself requires disparate theoretical and experimental knowledge. But, numerous researches on education show that the gap between the theory of what students learn and their practical application comes up, leaving them with low scientific and experimental thinking skills. Abdel Salam notes that if this integration does not happen, students will be unable to apply scientific concepts in the explanation of biological phenomena and to translate science knowledge into a conscious science practice [2]. In the same way, Alayan (2010: 133) asserts that the lack of emphasis on inquiry and experimentation skills is one of the main causes of the deficiency of scientific thinking among students of universities in natural science courses.

Some educational literature indicates that students' possession of theoretical concepts does not necessarily mean their ability to apply them in new situations. Many students succeed in achievement tests but are unable to interpret experimental results or link them to relevant scientific theories. Abu Jadu and Nawfal assert that this problem stems from the weak development of thinking skills during teaching, where thinking is treated as an automatic outcome of learning, not a planned educational goal [4]. Perkins reinforces this argument by stating that knowledge not built on deep thinking remains "fragile" and quickly unravels at the first practical application [5].

On the other hand, cognitive structure theory asserts that acquiring scientific and experimental skills requires a cognitive organization that connects concepts and experiences, something that cannot be achieved with teaching methods that focus on the verbal presentation of information. Al-Titi argues that a weak cognitive structure in learners leads to fragmented learning, hindering the transfer of learning from the theoretical to the practical realm [6]. Similarly, La'toum et al. indicate that the absence of educational practices that foster thinking leads to a clear deficiency in students' analytical, deductive, and scientific interpretation skills [7].

In light of the foregoing, and given the scarcity of studies directly addressing the level of scientific and experimental thinking skills acquired by Biology students, particularly within the Iraqi university environment, the need arises for a systematic and scientific study of this problem at Tikrit University. Knowing the level of these skills and uncovering the relationship between these skills and the theoretical concepts learned by students is a basic requirement for designing their scientific preparation programs. Al-

Qatami emphasizes that assessing the reality of students' thinking is a necessary starting point for any educational reform that seeks to improve the quality of educational outcomes [8]. Similarly, Ubaidat et al. stress that accurately defining the problem contributes to guiding scientific research towards applicable and developable results [9]. Therefore, the research question is defined as follows

What is the level of acquisition of scientific and experimental thinking skills by students of the College of Education for Pure Sciences - Department of Biology at Tikrit University, and to what extent are they able to link these skills to the theoretical concepts they study?

The main question branches into the following sub-questions

a. What is the level of scientific thinking skills among students of the College of Education for Pure Sciences - Department of Biology at Tikrit University?
b. What is the level of experimental thinking skills among students of the College of Education for Pure Sciences - Department of Biology at Tikrit University?
c. What is the level of theoretical concepts among students of the College of Education for Pure Sciences - Department of Biology at Tikrit University?
d. What is the relationship between the acquisition of scientific thinking skills by students of the College of Education for Pure Sciences - Department of Biology at Tikrit University and the ability to link theoretical concepts?
e. What is the relationship between the acquisition of experimental thinking skills by students of the College of Education for Pure Sciences - Department of Biology at Tikrit University and the ability to link theoretical concepts?

Research hypotheses:

The research verified the following hypotheses:

a. There is a statistically significant relationship at the significance level of 0.05 between the acquisition of scientific thinking skills and the ability to link theoretical concepts by students of the College of Education for Pure Sciences - Department of Biology at Tikrit University.
b. There is a statistically significant relationship at the significance level of 0.05 between the acquisition of experimental thinking skills and the ability to link theoretical concepts by students of the College of Education for Pure Sciences - Department of Biology at Tikrit University.

Importance of the research

First: Scientific importance

a. This research contributes to enriching Iraqi and Arab educational literature in the field of teaching thinking, by addressing scientific and experimental thinking skills among university students, a field that still suffers from limited studies, especially in the field of Biology.
b. It provides an analytical framework that links scientific and experimental thinking skills with theoretical concepts, thereby enhancing the theoretical

understanding of the relationship between abstract scientific knowledge and mental and experimental practice within university education.

c. This opens the door for subsequent studies that address other educational variables related to scientific thinking, such as teaching methods, assessment methods, and the cognitive structure of students in scientific disciplines.
d. It supports modern trends in education that emphasize that thinking is not a byproduct of learning, but rather a fundamental educational goal that must be measured and analyzed scientifically, especially in the fields of natural sciences. [13], [14]

Second: Practical importance

a. Those responsible for developing the biology curricula at Tikrit University are provided with realistic data on the level of students' scientific and experimental thinking skills, which contributes to improving the content of the courses and the methods of presenting them.
b. It helps faculty members diagnose the strengths and weaknesses in their teaching practices, particularly with regard to linking theoretical concepts to practical experimentation within the laboratory.
c. It contributes to directing training programs for faculty members towards focusing on strategies for teaching scientific and experimental thinking instead of being limited to cognitive instruction.
d. It provides results that can be used to improve students' academic and practical performance, by enhancing their ability to analyze, deduce, and interpret scientifically, which positively impacts the quality of university education outcomes.

Research objectives

The current research aims to:

a. To identify the level of acquisition of scientific thinking skills by students of the College of Education for Pure Sciences - Department of Biology at Tikrit University.
b. Revealing the level of acquisition of experimental thinking skills by students of the College of Education for Pure Sciences - Department of Biology.
c. Determining the extent to which students are able to link scientific and experimental thinking skills to the theoretical concepts they study.
d. Providing scientific indicators that can be used to develop methods of teaching biology in university education.

Research boundaries

The scope of the research is as follows:

a. Human limitations: The research is limited to students of the College of Education for Pure Sciences - Department of Biology at Tikrit University.
b. Spatial boundaries: Tikrit University – College of Education for Pure Sciences – Department of Biology.

c. Time limits: The research will be implemented during the 2025-2026 academic year.
d. Subject matter limitations: The research is limited to studying scientific and experimental thinking skills, and their relationship to linking theoretical concepts, without addressing other types of thinking skills.
e. Defining the terms and procedural definitions:

First: Biology Biology are defined as a branch of natural sciences concerned with the study of living organisms in terms of their structure, functions and interaction with the environment, based on the scientific method based on observation, experimentation, analysis and scientific interpretation [3].

Procedurally operationally, biology are defined in this research as the set of courses studied by students of the College of Education for Pure Sciences - Department of Biology at Tikrit University, which deal with biology topics at their various levels, and their impact is measured through the extent to which students acquire scientific and experimental thinking skills and link them to the theoretical concepts contained in these courses.

Second: Scientific thinking skills scientific thinking is defined as a pattern of organized thinking that relies on the use of higher-order mental processes, such as observation, hypothesis formulation, verification, analysis, interpretation, and deduction, with the aim of understanding phenomena and solving problems according to the steps of the scientific method [1]. Abu Jadu and Nawfal also define it as the learner's ability to use systematic, evidence-based thinking methods to arrive at accurate scientific conclusions [4].

Procedurally operationally, scientific thinking skills are defined as the score obtained by a Biology student on the instrument prepared by the researcher to measure scientific thinking skills, which include the skills of: scientific observation, formulating hypotheses, interpreting phenomena, analyzing results, and scientific inference, as shown in the students' responses to the items on the instrument.

Third: Experimental thinking skillsExperimental thinking is defined as the learner's ability to design, conduct, and control scientific experiments, analyze their results, and link them to scientific hypotheses, relying on practical experience and systematic experimentation (Abd al-Salam, 2006: 68). Perkins indicates that experimental thinking represents the practical application of scientific thinking, where ideas and theories are tested through direct experience and experimentation [5].

Procedurally experimental thinking skills are operationally defined as the level of performance of students of the College of Education for Pure Sciences - Department of Biology in tasks and items that measure their ability to: design the experiment, identify the variables, implement experimental procedures, analyze experimental data, and interpret the results, through the approved research tool.

Fourth: Theoretical concepts: Theoretical concepts are defined as abstract mental constructs that represent the fundamental meanings of scientific phenomena and are

used to explain relationships between variables and to understand scientific laws and theories [6]. Hamadat also defines them as organized cognitive units that form the basis upon which scientific knowledge is built, and their depth is measured by the learner's ability to apply them in new situations [10].

Procedurally theoretical concepts are operationally defined as the set of scientific concepts studied by students of the College of Education for Pure Sciences - Department of Biology within their coursework, and the level of their understanding is measured through the students' ability to interpret them and link them to the results of scientific experiments, as shown in their responses to the items of the research instrument.

Theoretical framework and previous studies:

First: Theoretical Framework:

First requirement: Scientific thinking skills in the subject of biology

Scientific thinking skills are fundamental to teaching Biology, as this subject is inherently based on understanding biological phenomena through careful observation, systematic analysis, and the construction of evidence-based scientific explanations. Scientific thinking is a mental pattern that is structured and scientific thinking is a pattern of thinking in which learners solve scientific problems systematically without relying on randomness or intuition, but by using structured mental processes, Jarwan [1] states.

Abu Jadu and Nawfal state that it is not enough to just give the scientific content of the course, especially in biology to teach scientific thinking skills. Instead, it is a matter of conscious planning of learning situations that stimulate the learner's mind, provoke questions, analysis, deduction. They also observe that the lack of development of these skills results in a clear gap between the theoretical knowledge that the student has and his/her capacity to apply it to explain the scientific phenomena [4].

Educational literature is found to substantiate that the study of Biology is a good field for scientific thinking skills because it involves topics which can be interpreted, analysed and related to cause and effect. By emphasizing the skills of scientific thinking in science education, science educators can help students develop the ability to apply scientific laws in novel situations instead of memorizing facts without developing scientific awareness [2].

The second requirement: Experimental thinking skills in the subject of Biology

Experimental thinking is also related to the nature of Biology, which is a subject in which the laboratory is a basic tool for testing scientific hypotheses and for the understanding of biological phenomena. Experimental thinking means to plan, to carry out, to control and to analyze the result of an experiment in a systematic and scientific way [2].

Perkins believes that experimental thinking is the way in which scientific thinking is applied to practice; that the learner is able to go from the theoretic to the experimental and so enrich the depth of learning and its stability of the scientific concepts. He also notes that superficial learning, which lacks true understanding of the nature of science, occurs when there is a lack of experimental experience [5].

Biology education, in this regard, should be centred on teaching students the experimental thinking skills, including identifying variables, gathering data, analysing result and relating to theory. He thinks that if these practices are not present in the laboratory, there is a lack of a connection between theory and practice that affects the students' science thinking ability [3].

Third requirement: Theoretical concepts in the subject of Biology

Theoretical concepts constitute the epistemological basis on which sciences, such as the biology, are based. These ideas are the explanation of phenomena and the relationships that regulate them in the biological world. Al-Titi (2004: 29) describes theoretical concepts as abstractions of mental constructs which form the organization of scientific knowledge and facilitate the learner to understand and interpret the relationship between phenomena in an integrated cognitive system.

Hamadat believes that learning scientific concepts is not limited to memorizing their definitions, but requires understanding them deeply and linking them to practical experiments and experiences, stressing that a weak grasp of theoretical concepts leads to a deficiency in interpreting experimental results and understanding scientific laws [10].

Latoum et al. also point out that linking theoretical concepts with practical application is a fundamental condition for meaningful learning, as this link contributes to the transfer of learning and enhances the learner's ability to apply knowledge in new situations. This perspective underscores the importance of integrating theoretical concepts with scientific and experimental thinking skills in Biology education [7].

Second: Previous Studies

1) Al-Mahdawi's study (2013)

I aimedthe studyTo identify the role of Islamic education teachers in developing scientific thinking skills among secondary school students. To achieve the study's objectives, the researcher used the descriptive method and designed a questionnaire to collect data. The study population consisted of (5069) male and female students, while the study sample comprised (492) male and female students selected using cluster random sampling. The researcher relied on percentages, arithmetic means, standard deviation, and the (T) For independent samples.

The study reached several important conclusions, most notably that the overall arithmetic mean for the level of Islamic education teachers' practice of developing scientific thinking skills was (3.28), which is considered an average level. The results also showed variations in the degree of practice of scientific thinking skills, with interpretation ranking first, followed by observation, evaluation, comparison, application, classification, and finally, summarization. Furthermore, the study revealed no statistically significant differences at the (0.05) level in the participants' assessments based on gender, grade, or department.

This study clearly demonstrates that the development of scientific thinking skills is not achieved to the desired level, even in the educational stages where these skills are supposed to be instilled. It also confirms that a teacher's possession of knowledge does

not necessarily translate into the effective application of thinking skills in the classroom [11].

2) Al-Qadri's study [12]

I aimed the this study aimed to determine the extent to which science teachers utilize metacognitive thinking skills in teaching scientific concepts, and to identify differences in this practice based on the variables of teaching experience and gender. To achieve this, the researcher developed a questionnaire consisting of 26 items distributed across three domains: planning, control, and evaluation, after verifying its validity and reliability. The instrument was administered to a sample of 142 male and female science teachers in Amman Governorate during the first semester of the 2010/2011 academic year.

The study results showed that science teachers' overall level of practice in metacognitive thinking skills when teaching scientific concepts was moderate, with 14 skills found to be at a moderate level and 12 at a high level. The results also showed no statistically significant differences with regard to teaching experience and gender. However, the study revealed several obstacles that hinder the application of these skills during teaching.

Commenting on previous studies and ways to benefit from them

The reviewed previous studies contributed to the researcher's clear scientific understanding of the nature of scientific and experimental thinking skills, and the most prominent educational methods used to develop them, particularly those addressing the teacher's role and classroom practices in fostering students' thinking. This exposure enabled the researcher to grasp the general theoretical framework of scientific thinking and understand its dimensions and sub-skills, which directly influenced the precise and clear definition of the current research variables and the formulation of its fundamental concepts.

The researcher also benefited from previous studies in guiding her methodological choices, as they helped her determine the appropriate methodology for the nature of the research and select the study population and sample in accordance with the research objectives and procedures. By analyzing the tools used in those studies, she was able to utilize their experience in creating the measurement tool she is currently using, including item construction and the determination of measurement domains related to scientific and experimental thinking skills and the connection to theoretical constructs.

In contrast, the results of previous studies assisted the researcher interpret the research problem and deepen its dimensions. Most of these studies revealed average levels of thinking skills practice or development among both teachers and learners, which reinforced the researcher's conviction that there is an educational gap between teaching scientific concepts and acquiring the associated thinking skills. This formed a scientific starting point for defining the current research problem and formulating its questions realistically, based on documented previous findings.

Finally, the researcher benefited from previous studies in selecting appropriate statistical methods for data processing and results analysis, and in comparing the findings of the current research with those of previous studies when discussing the results. This analytical commentary also helped to highlight the points of agreement and disagreement between the current research and those studies, and to identify the scientific contribution that the research seeks to make in the field of science education and the development of scientific and experimental thinking among students sections biology.

RESEARCH METHOD

Research Methodology

The current research adopted the descriptive-analytical approach, as it is suitable for the nature of the research objectives, which seek to analyze the level of acquisition. Students of Biology departments. This approach focuses on developing scientific and experimental thinking skills in Biology and exploring how these skills relate to theoretical concepts. It involves describing the phenomenon as it exists in reality, then analyzing and interpreting the data scientifically within the framework of theoretical studies and previous research, without the researcher interfering with or controlling the variables.

Research community

The research community consists of studentsThe first and second stages inCollege of Education for Pure Sciences - Department of BiologyAt Tikrit UniversityDuring the school year2025–2026The area where the research was conducted. This area was selected. The two academic stages Because of its importance in establishing basic scientific concepts and developing scientific and experimental thinking skills, which represent a basis for moving to higher educational levels.

Research sample

The research sample consisted of (157) studentsFrom the first and second phases of the studyStudents of the College of Education for Pure Sciences - Department of Biology at Tikrit University They were selected using the available method that suited the field application conditions of the research. After collecting the questionnaires, (5) questionnaires were excluded due to incomplete answers to their items, and thus the final number of research sample members whose responses were subjected to statistical analysis was (152) students.

Search tool

The research tool was designed as a questionnaire directed at students with the aim of measuring the level of mastery of the College of Education for Pure Sciences - Department of Biology. At Tikrit University For scientific thinking skills, experimental thinking skills, and theoretical concepts in the biology, the statements are designed in a direct and clear manner to facilitate student understanding and objective response. Each statement is formulated to reflect a specific aspect of the skill or concept, comprehensively covering all dimensions of each topic without repetition or ambiguity.

The questionnaire aims to measuring the level of ownership students for scientific and experimental thinking skills and revealing the extent of student understanding B Theoretical concepts and their connection to practical application in the subject of Biology and providing quantitative data that can be statistically analyzed to draw conclusions related to the level of thinking and the connection to theoretical concepts. The questionnaire consists of three main sections:"Axis Student ownership level B Scientific thinking skills (15 statements) and axis Student ownership level Experimental thinking skills (15 statements) and axis Student ownership level Theoretical concepts (15 statements)". Thus, the total number of questionnaire items was 45, all of which were designed on a five-point Likert scale (strongly agree – agree – neutral – disagree – strongly disagree).

Psychometric properties

First: Honesty

1. Content credibility (reviewer credibility): The questionnaire was reviewed by seven experienced professors of education and Biology with expertise in teaching, measurement, and evaluation methods. They were asked to assess the statements in terms of clarity, relevance, comprehensiveness, and the precision with which the questions were formulated to reflect thinking skills and scientific concepts. Based on their recommendations, some statements were revised to be clearer and to ensure they accurately measured what they were intended to measure.

Table 1. Results of the judges' evaluation of the content's authenticityResearch questionnaire.

Key notes	Overall assessment	Arbitrator
Clear language is essential; more practical examples would be beneficial.	Very acceptable	Arbitrator 1
Perfectly suited for all axes	excellent	Arbitrator 2
Some phrases need minor rewording.	Very acceptable	Arbitrator 3
All statements are clear and straightforward.	excellent	Judge 4
Focus on linking concepts to experiences	Very acceptable	Judge 5
No substantive observations	excellent	Judge 6
Suitable for the target age group	excellent	Judge 7

The table shows that most of the judges gave a high rating (excellent or very acceptable), which indicates that the questionnaire has a high degree of content validity, and that the statements cover the three axes accurately and clearly.

2. The validity of internal consistency: The internal consistency of the instrument was measured using the correlation coefficient of the statements with the overall axis total, and the results showed that all statements were positively correlated with the overall total of their scale.

Table 2. Correlation coefficients of statements to the overall total of axes research questionnaire

Average	Highest correlation value	Lowest correlation value	Axis
0.59	0.72	0.45	Scientific thinking
0.57	0.70	0.42	Experimental thinking
0.61	0.74	0.48	Theoretical concepts

The values indicate that all statements are meaningfully related to the overall axis total, confirming the validity of the instrument's internal consistency and that it accurately measures what it is supposed to measure.

Second: Stability

1. Cronbach's alpha stability: Cronbach's alpha reliability was calculated for the entire instrument and for each axis separately, with the aim of measuring the consistency of responses among the sample members.

Table 3. Cronbach's Alpha values for to Axes the questionnaire college

Cronbach's alpha value	Number of phrases	Axis
0.87	15	Scientific thinking
0.85	15	Experimental thinking
0.88	15	Theoretical concepts
0.90	45	Total tool

Cronbach's alpha values are high (above 0.80) for each axis and for the overall instrument, indicating that the questionnaire has high reliability and that the responses are internally consistent among the students B.

2. The stability of the half-division: The split-half method was applied, where the questionnaire was divided into two halves (odd and even statements), and then Spearman-Brown's correlation coefficient was calculated to estimate reliability.

Table 4. Half-segment stability of axesResearch questionnaire

Brown laboratories	The correlation coefficient between the two halves spearman	Axis
0.90	0.82	Scientific thinking
0.88	0.80	Experimental thinking
0.91	0.84	Theoretical concepts
0.92	0.85	Total tool

The results showed high reliability across all axes, with the Spearman-Brown coefficient exceeding 0.88, confirming that the tool is reliable and dependable in accurately measuring research variables.

Procedures for implementing field research:

The researcher began the field application procedures after completing the collection of theoretical information from its Arabic and foreign sources, which helped in building the theoretical framework and defining the research concepts and its main variables. The literature relevant to the level of student mastery was also reviewed.BFor scientific and experimental thinking skills, as well as theoretical concepts in the subject of biology, to guide the design of the research tool accurately and in accordance with the study objectives.

Subsequently, the research instrument (questionnaire) was designed according to its three axes: scientific thinking skills, experimental thinking skills, and theoretical concepts. Forty-five statements were formulated, distributed across the axes, to accurately cover aspects of the skills and concepts. The instrument was reviewed by seven experienced professors of education and biology, who provided feedback on the clarity, accuracy, and comprehensiveness of the statements. The questionnaire was then revised based on their recommendations to ensure content validity.

The researcher obtained the necessary approvals from the official authorities to administer the questionnaire to sample the study participants, with an explanation of the research objective and how to answer the questions to ensure the highest level of honesty in the responses.

The questionnaire was administered in the field on [date]28/9/2026The research sample consisted of (157) male and female students, with 5 questionnaires excluded due to incomplete responses, resulting in a final sample size of 152 students. Data confidentiality was stressed, and it was stated that the data would only be used for scientific purposes.

The researcher, after gathering the questionnaire, started the phase of data analysis with suitable statistical methods such as means, standard deviation, correlation coefficient and analysis of variances based on the variables of the research. These procedures enabled the researcher to draw accurate conclusions about the students' level of scientific and experimental thinking skills and their connection to theoretical concepts, thus achieving the research objectives.

Statistical methods:

The arithmetic mean was used to determine the level of students' possession of scientific and experimental thinking skills, as well as their level of understanding of theoretical concepts in the subject of biology.

The standard deviation was calculated to illustrate the variation in student responses within each axis of the questionnaire, reflecting the degree of homogeneity of the sample in possessing skills and understanding concepts.

Percentages were used to provide an overall picture of the distribution of student scores within each level of the scale (high, medium, low).

The test was used (T) For independent samples when comparing student results according to possible demographic variables, such as gender or grade, to ensure that there are statistically significant differences in the level of mastery of skills and concepts.

The correlation coefficient was calculated (Pearson Correlation) to study the relationship between research variables, i.e., the extent to which students' level of scientific and experimental thinking skills is related to their level of understanding of theoretical concepts.

Simple and multiple variance analysis was used when needed to explain the effect of more than one variable on student results.

Cronbach's alpha coefficient was calculated to estimate the reliability of the questionnaire as a whole and for each axis separately, ensuring internal consistency of the responses.

The half-split method was used (Split-Half Reliability) with Spearman-Brown coefficient to confirm the additional stability of the instrument.

The correlation coefficients of the statements were used with the overall total for each axis to ensure the internal consistency of the instrument.

These combined statistical methods enabled the researcher to accurately analyze the data and draw reliable conclusions about the level of students' possession of scientific and experimental thinking skills and their connection to theoretical concepts, thus accurately reflecting the educational reality.

RESULTS AND DISCUSSION

Result

Answer Regarding the research questions:

1. What is the level of scientific thinking skills among students of the College of Education for Pure Sciences - Department of Biology at Tikrit University?

This question is designed to assess the scientific thinking abilities in Biology among the students with the help of 15 statements of the first part of the questionnaire.The arithmetic mean and standard deviation were used to determine skill levels and analyze the variance in responses. The following table shows the results:

Table 5. Arithmetic Means and Standard Deviations of Scientific Thinking Skills

Deviation	Average	Phrase	Deviation	Average	Phrase	Deviation	Average	Phrase
0.80	3.52		0.77	3.53		0.78	3.52	
0.77	3.55		0.76	3.51		0.82	3.48	
0.76	3.53		0.78	3.56		0.75	3.60	
0.78	3.56		0.79	3.54		0.79	3.55	
0.77	3.57		0.75	3.57		0.80	3.50	
						0.78	3.54	Total

The results indicate that the students' level of scientific thinking skills is high to average, with averages ranging between 3.48 and 3.60. This shows that the students are able to use observation, analysis, interpretation, comparison and summarization skills, with an opportunity to enhance some less practiced skills through more practical applications.

2. What is the level of experimental thinking skills among students of the College of Education for Pure Sciences - Department of Biology at Tikrit University?

This question aims to determine the level of students' experimental thinking skills, which is the ability to conduct scientific experiments, analyze results, and relate them to theoretical concepts. Data from 15 statements in the second section of the questionnaire were used. The following table shows the results:

Table 6. Arithmetic Means and Standard Deviations of Experimental Thinking Skills

Deviation	Average	Phrase	Deviation	Average	Phrase	Deviation	Average	Phrase
0.80	3.46		0.78	3.47		0.81	3.46	
0.78	3.47		0.76	3.49		0.79	3.50	
0.79	3.48		0.82	3.45		0.85	3.42	
0.78	3.50		0.77	3.50		0.80	3.48	
0.77	3.57		0.79	3.48		0.83	3.44	
						0.81	3.47	Total

The results indicate that students possess moderate to high levels of experimental thinking skills. They can perform experiments, operate laboratory equipment, record data, and analyse the data. Some statements that received slightly lower average scores suggest a need to enhance skills in controlling variables and accurate documentation.

3. What is the level of theoretical concepts among students of the College of Education for Pure Sciences - Department of Biology at Tikrit University?

This question assesses students' knowledge of scientific concepts and their ability to apply these concepts to real-world situations. The data has been obtained from 15 statements in the third part of the questionnaire. The results are displayed in the table below:

Table 7. Arithmetic Means and Standard Deviations of Theoretical Concepts

Deviation	Average	Phrase	Deviation	Average	Phrase	Deviation	Average	Phrase
0.75	3.60		0.76	3.59		0.76	3.60	
0.78	3.57		0.75	3.61		0.79	3.55	
0.74	3.61		0.77	3.60		0.77	3.58	
0.75	3.62		0.78	3.58		0.74	3.62	
0.76	3.60		0.76	3.59		0.78	3.57	
						0.77	3.59	Total

The results show that students possess a good understanding of theoretical concepts, with the ability to connect these concepts to practical skills. The overall average of 3.59 reflects good performance, but also indicates potential for strengthening some of the more complex concepts.

Verification of Research Hypotheses

First hypothesis: There is a statistically significant relationship between students' acquisition of scientific thinking skills and their ability to connect theoretical concepts. Pearson's correlation coefficient was used between the mean of the scientific thinking axis and the dependent variable (theoretical concepts). The following table shows the results:

Table 8. Pearson's Correlation Coefficient Between Scientific Thinking and Theoretical Concepts

r	Level of significance	Variable 2	Variable 1
0.62	0.000	Theoretical concepts	Scientific thinking

The value indicates ((r = 0.62) indicates a strong and statistically significant positive correlation between possessing scientific thinking skills and linking theoretical concepts, thus confirming the first hypothesis.

Second hypothesis: There is a statistically significant relationship between students' acquisition of experimental thinking skills and their ability to connect theoretical concepts. Pearson's correlation coefficient was calculated between the axis of empirical thinking and the axis of theoretical concepts. The following table shows the results:

Table 9. Pearson's Correlation Coefficient Between Experimental Thinking and Theoretical Concepts

r	Level of significance	Variable 2	Variable 1
0.58	0.000	Theoretical concepts	Thinking Experimental

The value indicates ((r = 0.58) indicates a moderate to strong positive correlation between possessing experimental thinking skills and students' ability to connect theoretical concepts, with statistical significance at the 0.05 level, which confirms the fulfillment of the second hypothesis.

Discussion

From an instructional perspective, the results justify strengthening inquiry-oriented laboratory tasks, project-based learning, and structured reflection. Such approaches can create repeated opportunities for students to explain why a procedure is used, evaluate the quality of evidence, identify possible sources of error, and revise interpretations. The high reliability of the instrument (overall Cronbach's alpha = 0.90)

supports confidence in the internal consistency of the measured dimensions, although the descriptive and correlational design does not establish causal effects. Future research should therefore test instructional interventions experimentally and examine whether improvements in scientific and experimental thinking produce measurable gains in achievement, problem solving, and transfer of biological concepts.

The relationship between experimental thinking and theoretical concepts was also positive and statistically significant ($r = 0.58$, $p < 0.001$). Although slightly weaker than the scientific-thinking relationship, the result confirms that laboratory reasoning is an important bridge between abstract biological knowledge and practical application. Al-Qadri similarly emphasized the importance of metacognitive practices in teaching scientific concepts, particularly planning, monitoring, and evaluation [12]. Accordingly, biology instruction at the university level should not treat laboratory work as a procedural supplement; rather, experiments should require students to formulate hypotheses, identify variables, justify procedures, analyze data, and explicitly connect outcomes to theoretical explanations.

The positive correlation between scientific thinking and theoretical concepts ($r = 0.62$, $p < 0.001$) shows that students who report stronger scientific reasoning also tend to demonstrate a stronger capacity to connect and interpret biological concepts. This result is consistent with the theoretical position that knowledge becomes more durable when learners actively organize concepts, test explanations, and apply evidence-based reasoning rather than relying primarily on memorization [4], [5], [6], [7], [8], [9], [10]. It also aligns with Al-Mahdawi's finding that scientific-thinking practices may remain at a moderate level when instructional practice does not systematically cultivate the relevant subskills [11].

The findings indicate that students demonstrated moderate-to-high scientific thinking skills (overall mean = 3.54) and experimental thinking skills (overall mean = 3.47), while their understanding of theoretical concepts was comparatively stronger (overall mean = 3.59). This pattern supports the view that scientific learning becomes more meaningful when conceptual knowledge is integrated with observation, analysis, hypothesis formulation, experimentation, and inference [1], [2], [3], [4], [5], [6], [7]. The relatively lower experimental-thinking mean suggests that practical competence may develop less consistently than conceptual understanding when laboratory activities do not provide sufficient opportunities for variable control, repeated trials, systematic documentation, and interpretation of evidence.

CONCLUSION

Fundamental Finding: The results indicated that the research hypotheses have been supported with a strong positive correlation between scientific thinking skills and theoretical concepts ($r = 0.62$), while the experimental thinking skills were found to be in the moderate to strong positive correlation ($r = 0.58$) between them and theoretical concepts. **Implication:** This highlights the need of scientific and experimental skills in

teaching science to improve their theoretical knowledge. **Limitation:** The study was limited to students of the College of Education for Pure Sciences - Department of Biology at Tikrit University during the 2025-2026 academic year and focused specifically on scientific thinking skills, experimental thinking skills, and theoretical concepts. **Future Research:** Suggesting further studies in the relationship between scientific and experimental thinking and other concepts like academic achievement, motivation and problem solving.

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