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Assessing Students' Ability to Understand Complex Biological Concepts and Connect Them to Real-World Practical Contexts to Enhance Applied Learning: A Study of Biology Students at Tikrit University

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ABSTRACT

Objective: *The present study was designed to assess the ability of Biology students in Tikrit University to grasp complex biological concepts and to link it with real life applications, and to determine the level of applied learning in the context of such a link.* ***Method:*** *A descriptive-analytical design was adopted. The sample comprised 292 students from the Department of Biology, College of Science, during the 2025–2026 academic year, selected by stratified random sampling. Data were gathered through a 30 item questionnaire that covered three areas: knowledge of complex biological concepts, related learning to applications and real-life situations, and applied learning.* ***Results:*** *The results showed that the students' self-reported knowledge about biological concepts and the students' applied learning was relatively high, while the students' ability in making connections between biological concepts and practical and real situations was in the moderate level. The hypothesis testing revealed no significant differences due to gender, academic year or study mode (morning/evening).* ***Novelty:*** *The study suggests the teachers should apply the practice-oriented teaching model, enhance the laboratory work of students interpreting the experimental results, and develop the assessment system with performance to help students transfer theoretical knowledge into practice, and stimulate their effective applied learning.*

INTRODUCTION

The nature of scientific knowledge is transforming the ways that biology is taught in the university setting. Biological knowledge is no longer just descriptive – memorization of terms and structures – but is now interpretive and practical – complex interacting living systems. This involves the understanding of causality and the relation between the molecular, cellular and ecological levels and the surrounding practical reality [1]. It reflects the fact that the goal of Biology education is no longer to impart knowledge but to build understanding that can be transferred to real world and professional settings.

The general teaching research literature in biology suggests that many university students are able to pass the traditional examinations and yet struggle to grasp the meaning of complex biological concepts, not to mention apply them to realistic problems as in environmental or health problems and biotechnology [2]. This is because there is a heavy reliance on the teaching and assessment methods that focus on superficial recall of information rather than on the skills to connect, interpret and apply knowledge.

In this context the concept of applied learning has been a successful method of education in Biology education because it aims to develop and combine theory and practice with the real environment, so that conceptual learning is more effective and

easier to retain [3]. Various studies have shown that when students experience learning in contexts where the biology concepts are related to real-life situations, they have higher levels of deep understanding and better problem-solving skills and evidence-based decision-making skills [4].

Recent studies have also demonstrated that the quality of assessment tools to gauge learning in biology should move beyond simple recall questions to testing students' capacity to explain intricate biology phenomena, to link concepts together, and to apply concepts in novel and new contexts [5]. This orientation is crucial in Biology colleges where the training of students is geared towards equipping them to face environmental, health and laboratory problems in real life situations.

In the Arab level, several educational studies show that there is a gap between the theoretical part of biology lessons and the practical part of the local environment which has an impact on students' knowledge level and their ability to apply their knowledge in the reality of the environment [6,7]. This chasm is more apparent in higher education, where students are expected to transition from the school-based learning to an applied scientific way of thinking.

Given the above, it is significant that one important aspect to gauge is the understanding of complex concepts of Biology and their link with the immediate practical environment and the real world; to mark the quality of applied learning and to see how effective the programs of the university are in terms of educational and societal objectives.

Research Problem

Although there has been a proliferation of biology education programs in the universities and in the presentation of scientific information to students, the literature on the subject suggests that this does not necessarily correlate with a qualitative improvement in student's deep knowledge of biological concepts or their application in real situations [1]. Students continue to see biological concepts as disjointed bits of information that are challenging to relate to other bits of information or to the world around them.

In higher education, research has also revealed that students face difficulties explaining complex biological phenomena such as the processes in living systems, ecological interactions, and more, particularly when they are presented in the form of an applied situation or open-ended problem [8]. This weakness in conceptual linking and learning transfer indicates the problems with the teaching and assessment practices being followed.

In the Arab context, several studies showed that science and biology learning are assessed mainly based on the lower order cognitive dimensions (memorize, understand) with minimal consideration to the higher order dimensions (analyze, interpret, apply) related to environmental conditions and societal conditions [16]. Thus, students emerge from school with theoretical knowledge, but they are unable to apply it to real-life or workplace.

The importance of this problem is heightened in Biology colleges, given the direct relevance of this specialization to the environmental, health, and nutritional issues facing society. A weak connection between biological concepts and practical reality thus becomes an obstacle to achieving sustainable development goals and serving the community [2].

Accordingly, the current research problem lies in the need to assess the ability of students in the Department of Biology, College of Science, Tikrit University, to understand complex biological concepts and connect them to their surrounding practical and real-world environment, and to examine its role in enhancing their applied learning, using a scientifically grounded assessment tool based on contemporary theoretical and educational foundations. The research problem can therefore be stated in the following question:

What is the level of ability of students in the Department of Biology, College of Science, Tikrit University, to understand complex biological concepts and connect them to their surrounding practical and real-world environment, and what role does this play in enhancing their applied learning?

Research Questions

The main research question gives rise to the following sub-questions:

- What is the level of ability of students in the Department of Biology, College of Science, Tikrit University, to understand complex biological concepts?
- What is the level of students' ability to connect theoretical biological concepts to their surrounding practical and real-world environment?
- What is the level of applied learning among students in the Department of Biology, College of Science, in light of linking biological concepts with real-world applications?

Research Hypotheses

In light of the nature of the research and the adopted descriptive-analytical approach, the following null hypotheses were formulated:

- There are no statistically significant differences at the 0.05 level in the ability of students in the Department of Biology, College of Science, to understand complex biological concepts and connect them to the practical and real-world environment attributable to gender (male/female).
- There are no statistically significant differences at the 0.05 level in students' ability to understand complex biological concepts and connect them to the real-world environment attributable to academic year (first, second, third, fourth).
- There are no statistically significant differences at the 0.05 level in students' ability to understand complex biological concepts and connect them to the real-world environment attributable to study mode (morning/evening).

Significance of the Research

Theoretical significance:

- The research contributes to enriching the educational literature on university biology education by focusing on the assessment of deep understanding and the linking of

concepts to practical reality, an area that remains under-researched in the Arab literature.

- It offers a conceptual framework that can inform future studies concerned with applied learning and its assessment in the biology.
- It provides a measurement tool built on scientific foundations that can be developed further or used in future research on assessing the learning of complex biological concepts.

Practical significance:

- The findings can help those who teach Biology courses to identify weaknesses in students' understanding of concepts and in their ability to connect them to reality.
- They provide academic decision-makers with evidence-based indicators that can inform the development of curricula and of teaching and assessment methods in Biology colleges.
- They contribute to improving the preparation of graduates by strengthening their ability to apply biological knowledge in real environmental, health, and laboratory situations.

Research Objectives

The present research aims to:

- Determine the level of ability of students in the Department of Biology, College of Science, Tikrit University, to understand complex biological concepts.
- Determine the level of students' ability to connect theoretical biological concepts to their surrounding practical and real-world environment.
- Determine the level of applied learning among students in the Department of Biology, College of Science, in light of linking biological concepts with real-world applications.
- Identify differences in students' ability to understand and connect biological concepts according to gender, academic year, and study mode.
- Present findings that can be used to develop Biology teaching and assessment methods in ways that enhance applied learning.

Research Delimitations

- **Human delimitation**: The research was limited to students of the Department of Biology, College of Science, Tikrit University, enrolled in morning and evening study, of both genders, across the four academic years included in the sample, as the target group for assessing the ability to understand complex biological concepts and connect them to real-world applications.
- **Temporal delimitation**: The research was conducted during the 2025–2026 academic year; the instrument was administered and the data were collected during the semester in which the fieldwork was carried out.
- **Spatial delimitation**: The research was limited to the Department of Biology, College of Science, Tikrit University; its findings cannot be generalized to other colleges or universities except where educational and environmental conditions are similar.

- **Subject delimitation**: The research was limited to assessing students' ability to understand complex biological concepts, their ability to connect these concepts to the surrounding practical and real-world environment, and their applied learning, according to the domains and dimensions of the questionnaire.

Definition of Terms

1. Complex biological concepts

Complex biological concepts are those that involve multi-level relationships among the components of living systems, including dynamic interactions between structure and function, and that require learners to integrate knowledge across different levels of organization, such as molecules, cells, organisms, and ecosystems [1,2].

Operational definition: The score a student obtains on the questionnaire items that measure his or her ability to understand the structural and explanatory aspects of biological concepts, reflecting the student's level of comprehension and analysis.

2. Linking biological concepts to the practical and real-world environment

The learner's ability to use biological knowledge to explain natural and environmental phenomena, to understand environmental health problems, and to relate scientific content to meaningful real-life contexts [3, 4].

Operational definition: The score a student obtains on the questionnaire items that measure his or her ability to apply theoretical biological concepts to practical and real-world situations, as defined within the domain of linking biological knowledge to the surrounding environment.

3. Applied learning

A pattern of learning that focuses on integrating theoretical knowledge with practical experience by engaging learners in real activities that allow them to use what they have learned to solve problems and make decisions, thereby enhancing deep understanding and the transfer of learning [9,5].

Operational definition: The total score a student obtains on the applied learning domain of the questionnaire, reflecting the extent to which he or she uses biological concepts in applied situations related to practical and environmental reality.

4. Assessment

An organized, systematic process of collecting and analyzing data on students' learning in order to make judgments, based on scientific criteria, about their level of understanding and performance, and to use these judgments to improve teaching and learning [10].

Operational definition: In this research, assessment refers to administering the questionnaire designed for this purpose and statistically analyzing students' responses to determine their level of ability to understand complex biological concepts and connect them to the real-world environment [11].

5. Biology students

Students enrolled in academic programs specializing in the biological sciences and their various branches, who are expected to acquire theoretical knowledge and applied skills that qualify them to deal with environmental, health, and scientific issues [3].

Operational definition: The students of the Department of Biology, College of Science, Tikrit University, who comprised the research sample and responded to the research instrument during the administration period.

Biology education at the university level and the nature of biological knowledge

The Biology are among the most complex scientific disciplines, due to the intricacy of biological knowledge, and the overlap between several levels of biological organization, from molecules to large scale ecosystems. The educational literature indicates that this complexity requires university education to move beyond traditional methods focused on transmitting information toward building deep conceptual understanding based on interpretation, linking, and analysis [2,12].

The concepts that comprise biology must be taught in relation to the relationships among them and with the world of living systems; understanding life phenomena demands understanding of dynamic interactions in living systems, not just the sum of their parts, Nehm [1] emphasizes. Therefore, the concept of scientific thinking, understanding of complex systems, and relating theory to real contexts are fundamental areas of concern for university Biology education.

Dolan [3] also mentions that one of the biggest problems in university biology education is that students learn the content of science, yet cannot apply it to real-world, practical settings, resulting in "shallow learning" that is easily forgotten.

Complex biological concepts and the challenges of learning them

Complex biological concepts are characterized by multiple levels of explanations, non-linear relationships, and reciprocal causal interactions between the components of a biological system [1,13]. These are cells, regulation, homeostasis, ecological interactions, heredity and evolution.

The difficulty in grasping these concepts has been observed in several studies, which tell us that it is not lack of information, but inability to relate parts of information to a whole that causes trouble for university students [8,14]. This lack of strength is frequently revealed when students are required to describe new phenomena or make use of concepts in new situations.

Singer et al. [2] claims that overemphasis on memorization and lecturing in biology education causes the students to have alternative or incomplete conceptions, thereby making it difficult for deep learning to take place and for learning to transfer to other situations.

Deep understanding in biology education

Deep understanding is a key term in current science education and is defined as the ability of the learner to explain knowledge, relate knowledge to other concepts, and apply knowledge to new situations rather than simply remember and reproduce it [5, 15]. Deep understanding has been linked to the students' interpretative ability in biology education, along with understanding of causal relationships, the connections between levels of biological organization, and application of concepts in real-world contexts in the environment and human health [4,16].

Research shows that students who master the big ideas in biology are more likely to be able to solve science problems and make decisions based on the evidence than students who learn the big ideas by rote [3].

The importance of linking biological concepts to the real-world environment

The real-world context is one of the fundamental concepts that help students understand the importance of what they are learning about and gain appreciation for science and its applications. As highlighted by Gilissen et al. [4], context-based learning will benefit concept building, students' learning motivation and conceptual understanding. In the same way, Kolb [9] believes that effective learning is achieved when the learner experiences the learning first, reflects on the experience, and then reorganizes his or her knowledge in terms of the experience, thereby reinforcing what has been learned and making it easier for the learner to transfer the knowledge to other contexts.

This connection with the real-world environment is manifested in Biology education through explaining phenomena of the environment and health problems, and introducing the applications in the laboratory, which makes Biology knowledge more relevant to students' lives, and their community [2,17].

Applied learning in Biology education

Applied learning is an educational strategy in which the theoretical learning contents are combined with practical contents through the creation of learning situations which are similar to or derived from reality situations. Based on the literature, this kind of learning is stated to be able to strengthen deep understanding, develop higher order thinking skills and the transfer of learning [9].

Applied learning has many roles in biology education, such as enhancing students' understanding of complex concepts, developing problem-solving skills, and empowering students to face the problems in the environment and health [3].

According to Laverty et al. [5] assessment procedures must reflect learning in practice, and the methods used to assess learning must directly measure the ability to practice and interpret the knowledge, rather than just recall it.

Linking and assessing biological concepts

Assessment is the crucial component of the teaching and learning process; it is intended to gather correct data about what the students have learnt in relation to the teaching and learning process, so as to improve the process. Effective assessment should assess real understanding rather than an ability to answer stereotyped questions, as noted by Black and Wiliam [10].

A review of the literature in biology education shows that the literature is dominated by the demand for assessment instruments that are able to measure the understanding of complex concepts, connect concepts with one another and apply knowledge in real situations [5,18].The questionnaire is a appropriate instrument to reveal students’ perception about their understanding to link and apply knowledge especially in descriptive analytical study when it is designed based on clear scientific foundations.

Studies on understanding complex biological concepts

A study by Klymkowsky, Underwood, and Garvin-Doxas [8] showed that, although university students are successful in passing their biology courses, they have incomplete or alternative conceptions of the basic concepts of biology, especially those related to complex living systems. The results indicated that these challenges are not the result of inadequate content knowledge, but rather the lack of relationships between concepts and the students' dependence on memorization instead of understanding. The findings are similar to those of Singer et al. [2] who found that university biology education still emphasizes transmission of knowledge rather than the development of explanatory understanding and therefore, students lack of skills to deal with complex concepts in new contexts.

Studies on linking biological concepts to practical reality

Dolan [3] discussed the significance of context in the context of learning in biology education, claiming that students who learned in contexts related to environmental and health realities have more deep understanding and transfer of learning than those who have learned in abstract contexts. Similarly, Gilissen et al. [4] found that a systems approach together with connecting biology to real-life situations leads to better explanation of complex biological phenomena and meaningful learning by students.

Studies on applied learning in science education

Kolb [9] demonstrated that experiential learning is an effective way to bridge the gap between theory and practice and can reinforce learning and transfer it to new contexts. Laverty et al. [5] also showed that the true test of applied learning is when it is supported by assessment methods that measure recall, as well as ability to apply and analyse. It is clear that a comparison of the two indicates that Kolb has given the theoretical bases of applied learning whereas Laverty et al. have described the assessment aspect of applied learning, highlighting the need to connect the assessment methods used with the design of the learning. In the study of applied learning in biology this is important for it to be connected with the design of the learning.

Related Arab studies

At the Arab level, Al-Osaimi [6] has found that the teaching method based on interaction and practical work in the teaching of biology has contributed to the development of biological concepts and scientific sense among the secondary school students compared to the traditional teaching method. Jad [7] also identified that the use of assessment for learning in biology education had an impact on deep understanding attainment of secondary school students and highlighted the inadequacies in traditional assessment methods that are focused on memorization.

Similarities and differences among previous studies

Most previous Arab and international studies agree that students show weakness in understanding complex biological concepts and linking them to practical reality, as a result of reliance on traditional teaching and assessment methods. However, these studies differ in how they approach the problem: some focus on diagnosing conceptual

understanding, others address teaching strategies, and still others concentrate on assessment tools.

Position of the present research relative to previous studies

Despite the richness of previous studies, they have mostly focused on the effectiveness of specific teaching strategies, the diagnosis of conceptual understanding, or the development of alternative assessment tools; they have not directly assessed students' ability to understand complex biological concepts and connect them to the practical and real-world environment in the Iraqi university context, particularly in Biology departments. The present study is unique in its emphasis on the assessment as a tool to uncover the reality of applied learning, in considering the relationship between the biological concepts and the real world as a strong core domain, and in its use of a sample of students belonging to the Department of Biology, College of Science, Tikrit University, where there was a gap in the Arab literature.

RESEARCH METHOD

Research methodology

To achieve the objectives of the present research and answer its questions, the descriptive-analytical approach was adopted, as it is among the most suitable approaches for studying students' perceptions and abilities and for revealing statistically significant differences in relation to demographic variables. This approach relies on collecting data from the field, analyzing them statistically, and interpreting the relationships among variables without intervening in or controlling them.

This approach suits the nature of the present research, which seeks to identify the ability of Biology students to apply biological concepts in analyzing practical problems in laboratories and research projects, and to reveal differences according to gender, academic year, and study mode.

Research population

The research population consisted of all students of the Department of Biology, College of Science, Tikrit University, enrolled in the 2025–2026 academic year in both morning and evening study.

According to official statistics issued by Tikrit University for that year, the population comprised 843 male and female students, distributed as follows: morning study, 448 students; evening study, 395 students.

This population is suitable for the present research because the Biology specialization is closely tied to the practical application of theoretical concepts in laboratories and research projects.

Research sample

The sample was selected using stratified random sampling to ensure fair representation of all population categories according to gender, academic year, and study mode (morning/evening).

The sample size for this study was determined to be about 35% of the research population which amounted to 292 of 843 students in the descriptive-analytical studies;

a statistically acceptable sample size. Demographic Distribution of the sample is presented in Table 1.

Table 1. Distribution of the research sample by demographic variables

Variable	Category	Number of students	Percentage
Gender	Male	126	43.2%
	Female	166	56.8%
Academic year	First	76	26.0%
	Second	68	23.3%
	Third	78	26.7%
	Fourth	70	24.0%
Study mode	Morning	171	58.6%
	Evening	121	41.4%

Research instrument

To achieve the research objectives, a scale was constructed to assess students' theoretical understanding of biological concepts and their ability to link these concepts to the practical and real-world environment. It was based on the educational literature and relevant previous studies, taking into account the nature of the Iraqi university environment and the specificity of the biology specialization.

The scale consisted of three main domains: the first, understanding complex biological concepts; the second, linking theoretical biological concepts to the surrounding practical and real-world environment; and the third, applied learning in light of linking biological concepts with real-world applications. The scale comprised 30 items in total (10 items per domain), answered on a three-point Likert-type scale (always, sometimes, never).

Psychometric properties of the scale

Content validity (expert validity): To verify content validity, the initial version of the scale was presented to seven experts specializing in the biology, educational psychology, and measurement and evaluation, who were asked to judge:

- The suitability of the items for the research purposes.
- The clarity and linguistic accuracy of the wording.
- The extent to which each item belongs to its domain.
- The order of the domains and their logical sequence.

Based on the experts' comments, the following modifications were made:

- Six items were reworded for greater clarity.
- Two items with similar meanings were merged.
- The sequence of some of the research projects related items was changed to reflect the sequence of practical work in the lab. The final scale was then made up of 30 items spread over 3 domains.

Internal consistency reliability: To assess the internal consistency of the scale, Cronbach's alpha coefficient was calculated for each domain and for the scale as a whole; the results are shown in Table 2.

Table 2. Cronbach's alpha coefficients for the scale domains

Domain	Number of items	Cronbach's alpha
Understanding complex biological concepts	10	0.87
Linking theoretical biological concepts to the surrounding practical and real-world environment	10	0.85
Applied learning in light of linking biological concepts with real-world applications	10	0.88

The values obtained show a high internal consistency of the scale.

Split-half reliability: The split-half method was also used: the items were divided into two halves, the correlation coefficient between the haves was calculated, and the values were corrected using the Spearman–Brown formula, as shown in Table 3.

Table 3. Split-half reliability of the scale domains

Domain	Number of items	Correlation coefficient (r)	Spearman–Brown corrected coefficient
Understanding complex biological concepts	10	0.82	0.90
Linking theoretical biological concepts to the surrounding practical and real-world environment	10	0.80	0.88
Applied learning in light of linking biological concepts with real-world applications	10	0.84	0.91

These results indicate that the scale has a high degree of reliability.

Overall reliability of the scale

All of the domains have high degrees of reliability, as shown by the Spearman–Brown corrected coefficients, of which all are ≥ 0.88. This shows that the instrument has good internal consistency, thus making the instrument can measure the ability of students in the Department of Biology to understand and apply biological concepts, so as to strengthen the reliability of the data obtained from the research sample.

Questionnaire instructions

Detailed and precise instructions were given at the beginning of the questionnaire to help the participants understand what to answer and to ensure that the answers were given in the same way throughout the questionnaire. Instructions described the general purpose of the research and the way to select the proper answer for every item and a sample item with a solution was provided to demonstrate the proper way to respond.

The instructions also contained the full statement of confidentiality, that is, they were not asked to put their own name or any information which might allow them to be identified, and they were assured that all their answers would be treated as scientific data only and not for any other purpose. The instructions also highlighted the importance of selecting only one of the three responses for each item (see Appendix), as this is a fundamental requirement for the scientific development of psychological and educational measures, with the aim of ensuring the validity and reliability of the measure.

Scoring of the questionnaire

The scale used three response options for each item (always, sometimes, never), and the questionnaire was scored according to the following weighting system:

- Positive items: always = 3 points, sometimes = 2 points, never = 1 point.
- Negative items: always = 1 point, sometimes = 2 points, never = 3 points.

Accordingly, each student's total score was calculated by summing the weights of his or her responses to all items of the scale. The maximum possible score was 63 and the minimum possible score was 21.

Table 4. Response weights for positive and negative items

Response option	Positive items	Negative items
Always	3	1
Sometimes	2	2
Never	1	3

Administration of the research instrument

After the scale had been constructed and its psychometric properties verified, the questionnaire was administered to the main research sample of 292 students from the Department of Biology, College of Science, Tikrit University, on Sunday, 22 January 2026.

The researcher met with the participants in person in most cases, explained the research objectives and the importance of participating, and clarified how to respond to the questionnaire items, in order to ensure accurate responses and the highest possible degree of objectivity and honesty in data collection.

Statistical methods

To analyze the data obtained from the scale, a set of statistical methods suited to the nature of the data and the research hypotheses was used, as follows:

- Descriptive statistics: frequencies, percentages, means, and standard deviations were calculated for each domain of the scale in order to describe students' responses and the degree of variation among them.
- Inferential tests: the one-sample t-test was used to compare the sample mean on each domain with the hypothetical (theoretical) mean of the scale; the independent-samples t-test was used to examine differences by gender and by study mode

(morning/evening); and one-way analysis of variance (ANOVA) was used to examine differences among the academic years.

- Correlation tests: Pearson's correlation coefficient was used to examine the relationships among the domains of the scale.
- Reliability tests: Cronbach's alpha and the split-half method were used to verify the reliability of the scale and the dependability of its results for scientific interpretation.

These statistical methods were selected to suit the nature of the variables in the research and the aims of the study in revealing differences and relationships among demographic variables and students' responses, so as to arrive at accurate results.

RESULTS AND DISCUSSION

This chapter presents the research results and provides a comprehensive discussion in light of the research objectives and questions, utilizing the statistical methods described previously. The purpose is to analyze the level of understanding of complex biological concepts, the integration of these concepts into the practical environment, and the level of applied learning among students of the Department of Biology, College of Science, Tikrit University.

1. Discussion on Understanding Complex Biological Concepts

The results indicated a statistically significant difference at the 0.05 level between the sample mean (18.74) and the hypothetical mean (14), with a calculated t-value of 24.16, which exceeds the critical t-value (1.968). This demonstrates that students possess a relatively high level of theoretical comprehension regarding complex biological structures and functions.

- Interpretation: This outcome aligns with the structured progression of Biology curricula across academic years, building a solid foundational knowledge base. However, as noted in prior literature, conceptual comprehension often remains abstract, relying heavily on cognitive recall rather than deep practical mastery.

2. Discussion on Linking Concepts to the Real-World Environment

The analysis revealed a statistically significant difference with a sample mean of 16.02 and a calculated t-value of 8.92 ($p < 0.05$). Although statistically significant above the hypothetical mean, this score reflects a moderate level of practical linkage, trailing behind pure theoretical understanding.

- Interpretation: This gap is consistent with findings by Dolan and Gilissen et al., who emphasized that conventional laboratory sessions often function as rigid, procedural routines rather than dynamic investigations of real-world environmental or health problems. Bridging this gap requires shifting laboratory pedagogy toward inquiry-based and context-driven learning.

3. Discussion on Applied Learning Outcomes

Students demonstrated a robust level of applied learning, with a mean score of 19.47 and a calculated t-value of 27.83 ($p < 0.05$).

- Interpretation: This indicates that when given proper academic and practical frameworks, students show strong readiness to integrate theory with practice.

Supporting active engagement in research projects enhances meaningful learning transfer.

4. Evaluation of Research Hypotheses

- Gender: Independent-samples t-test showed no significant differences between male and female students ($t = 0.94$, $p > 0.05$). This supports the notion that both genders experience identical institutional conditions, instructional strategies, and curriculum demands.
- Academic Year: One-way ANOVA revealed no significant variance across the four academic years ($F = 2.11$, $p > 0.05$). This suggests that traditional instructional models may not inherently foster progressive improvements in practical application skills over time without deliberate pedagogical interventions.
- Study Mode: Morning and evening students showed comparable performance ($t = 1.12$, $p > 0.05$), reflecting uniform course requirements and assessment guidelines across both tracks.

Presentation and Interpretation of Results

This chapter presents the research results and their interpretation in light of the research objectives and questions, using the statistical methods described in Chapter Three, in order to answer the research questions concerning the level of understanding of complex biological concepts, the linking of these concepts to the practical environment, and the level of applied learning among students of the Department of Biology, College of Science, Tikrit University.

Objective 1: The level of ability of students in the Department of Biology, College of Science, Tikrit University, to understand complex biological concepts. To achieve this objective, the mean and standard deviation of the scores of the 292 participating students on the domain of understanding complex biological concepts were calculated, and the significance of the difference between the sample mean and the hypothetical mean of the scale was tested using the one-sample t-test.

Table 5. One-sample t-test for difference between sample mean and hypothetical mean on understanding more complex concepts in biology.

Sample size	Mean	SD	Hypothetical mean	df	Calculated t	Critical t (0.05)	Significance
292	18.74	3.21	14	291	24.16	1.968	Significant

The results obtained in Table 5 show that the calculated t-value (24.16) is greater than the critical t-value (1.968) at the 0.05 level of significance indicating that the mean score of the sample is different from the hypothetical mean score of the scale. This means that students in Biology are relatively able to grasp complex biological concepts when compared to the assumed level. This finding can be attributed to the basic theoretical curriculum in Biology, in which students are taught step by step in the academic year, building up their content knowledge and thus developing a solid understanding of the concept. This understanding is usually only theoretical, and is based on cognitive

comprehension rather than practical understanding, which is explored in subsequent objectives.

Objective 2: The level of ability of students in the Department of Biology, College of Science, to connect theoretical biological concepts to the surrounding practical and real-world environment. Averaging scores across the participants and calculating the standard deviation of their scores in the domain of linking biological concepts to the practical and real-world environment was performed, and the one-sample t-test was used to compare the mean score of the participants and the hypothetical mean of the scale.

Table 6. One-sample t-test for the difference between the sample mean and the hypothetical mean on linking biological concepts to practical reality

Sample size	Mean	SD	Hypothetical mean	df	Calculated t	Critical t (0.05)	Significance
292	16.02	3.68	14	291	8.92	1.968	Significant

The results in Table 6 show a statistically significant difference at the 0.05 level between the sample mean and the hypothetical mean, with a calculated t-value (8.92) higher than the critical value. This indicates that students' ability to connect theoretical biological concepts to the practical and real-world environment was at a moderate level, tending toward high, but lower than their level of understanding of abstract theoretical concepts.

This may be attributed to the university learning environment, which, despite having laboratories and practical experiments, still often tends to carry out experiments as a routine procedure without sufficient focus on interpreting the results and linking them to real-life or environmental problems. This leads to a relative gap between theoretical knowledge and practical application among students.

Objective 3: The level of applied learning among students of the Department of Biology, College of Science, in light of linking biological concepts with real-world applications. To achieve this objective, the mean and standard deviation of the participants' scores on the applied learning domain were calculated and compared with the hypothetical mean of the scale using the one-sample t-test.

Table 7. One-sample t-test for the difference between the sample mean and the hypothetical mean on applied learning

Sample size	Mean	SD	Hypothetical mean	df	Calculated t	Critical t (0.05)	Significance
292	19.47	3.54	14	291	27.83	1.968	Significant

The results in Table 7 indicate a statistically significant difference at the 0.05 level between the sample mean and the hypothetical mean, with a calculated t-value of 27.83, reflecting a good level of applied learning among students of the Department of Biology. This result suggests that students are positively disposed toward applied learning when

they are given the opportunity to connect theoretical concepts with real-world applications, whether through laboratories or research projects. It could also indicate students' interest in the application of biological knowledge in real-life situations, even with the constraints of limited resources and theoretical courses.

Testing the research hypotheses

The ability of the students of the Department of Biology, College of Science to grasp complex concepts in the field of biology and relate to practical and real-life environment, based on the gender of the student (Male/female) is not significantly different at the 0.05 level. To test this hypothesis, the independent-samples t-test was used to examine the significance of the difference between the mean total-scale scores of male and female students.

Table 8. Independent-samples t-test for differences by gender

Gender	Sample size	Mean	SD	df	Calculated t	Critical t (0.05)	Significance
Male	126	53.81	6.34	290	0.94	1.968	Not significant
Female	166	54.56	6.01				

The results in Table 8 indicate that the calculated t-value (0.94) was lower than the critical t-value (1.968) at the 0.05 significance level, indicating no statistically significant differences between male and female students in their ability to understand complex biological concepts and connect them to the practical and real-world environment. The null hypothesis is therefore retained, and it can be concluded that gender has no significant effect in this respect.

This result may be explained by the fact that students of both genders are exposed to similar educational conditions in terms of curricula, teaching methods, and practical laboratory training, which leads to convergent levels of understanding and application; it also reflects the nature of the biology specialization, which depends on scientific competence more than on demographic characteristics.

The difference in students' understanding of complex concepts in biology and its relevance to the real world is not statistically different at the 0.05 level due to academic year. To test this hypothesis, one-way analysis of variance (ANOVA) was conducted to determine differences in the mean scores across academic year (first, second, third, fourth) for students.

Table 9. One-way ANOVA results by academic year

Source of variance	Sum of squares	df	Mean square	Calculated F	Critical F (0.05)	Significance
Between groups	214.36	3	71.45	2.11	2.64	Not significant
Within groups	9754.82	288	33.87			
Total	9969.18	291	-			

From the result that is shown in the table 9, it can be seen that the calculated F value (2.11) was less than the critical F value (2.64) at 0.05 level of significance among the student of different academic years in their ability to understand and relate biological concepts to the actual environment hence, there is no statistically significant difference among the students of the different academic years. Thus, the null hypothesis is accepted. The outcome indicates that the quality of the link between theory and practice in the academic years is not directly related, suggesting a possible correlation in teaching and assessment practices across the academic years, and with a higher focus on theoretical content rather than thorough analytical application.

The differences between students' ability to understand the complex contents of biological concepts and the connection to the real-world environment due to the study mode (morning/evening) is not statistically significant at the 0.05 level. This was tested by an independent-samples t-test which compared the mean scores of morning-study and evening-study students.

Table 10. Independent-samples t-test for differences by study mode

Study mode	Sample size	Mean	SD	df	Calculated t	Critical t (0.05)	Significance
Morning	171	54.61	6.08	290	1.12	1.968	Not significant
Evening	121	53.74	6.29				

The results in Table 10 indicate that the calculated t-value (1.12) was lower than the critical t-value (1.968), indicating no statistically significant differences in students' ability to understand and connect biological concepts according to study mode; the null hypothesis is therefore retained. This outcome is related to the fact that the content of the courses, their laboratory requirements and assessment are similar in the morning and evening study, meaning that there are not major differences in understanding or application that would lead to this result.

CONCLUSION

Fundamental Finding: As revealed in the results presented in Chapter Four, students of the Department of Biology, College of Science demonstrate high level of theoretical understanding of complex biological concepts, medium level of connection with real world environment and good level of application in the presence of a suitable context. This trend implies that the issue does not lie with weak knowledge, but rather with how knowledge is transferred to meaningful applied practice; thus, there is a need for teaching and assessment approaches that reinforce the connection between concepts and reality. The hypothesis tests indicated that there were no significant differences in students' understanding of and link with complex biological concepts to the practical and real world setting for gender, academic year and study mode. The findings indicate the problem studied is general and educational–systemic in nature and not limited in terms of demographic characteristics, thus the need for teaching and assessment practices that

can meet the needs of all students, irrespective of their characteristics. **Implication :** Incorporating a framework of teaching that emphasizes real problem analysis and relates biology concepts to real environmental, health, and laboratory contexts, and not just theoretical presentation of content. Creating laboratory activities that will not only involve procedural steps, but also interpretation of results, relating to reality and discussion of their environmental, medical and agricultural applicability. Using assessment methods that require students to show and demonstrate, rather than just achieve—case studies, mini research projects, and performance assessment measures, rather than achievement measures. Inviting students to integrate in the curricula, real life examples and situations that ask students to apply biological concepts for analysis, interpretation and decision making. Conducting training courses for faculty members of the Department of Biology, College of Science, on the use of learning strategies for practical application and on the application of theory to reality. Encouraging student graduation projects to focus on actual environmental and health concerns to enhance the critical thinking to be used in real, applied environments. **Limitation :** There is a number of limitations in this study. First, the data are based on the student's self-reports, meaning that the data represent perceived, not demonstrated, ability and may suffer from the influence of social desirability; future studies should triangulate these data with some tasks that require students to perform and/or some validated concept inventories. Second, the sample consisted of one department from one university so the results may not be representative. Third, since it is a cross-sectional design, causal inferences regarding the effect of academic progression cannot be made. Fourth, the three response options limit the variance of the scores and could affect the group-wise difference. **Future Research :** Evaluation of the impact of educational programmes using applied learning and/or problem-based learning on the ability to relate biological concepts to real life. Comparing the level of understanding as well as use of Biology by the students with other scientific college students such as medicine and agriculture. Exploring other factors (e.g., teaching strategies, assessment strategies, lab experience) and how they relate to students' applied knowledge of biological concepts. Developing assessment instruments reflecting the real situation or practice in order to better assess applied learning. Identifying educational factors, from the perspective of students and teachers that inhibit or facilitate linking educational aspects related to biology concepts to reality using interviews or classroom observation. Researching the congruence between the learning outcomes of Biology students and labour market needs in the areas of environment, health and research.

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