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The Impact of Teaching Using the CASE Model on the Acquisition of Biological Concepts and the Development of Visual Thinking by Second Grade Intermediate Students of Distinguished Schools

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Abstract:
The objective of this research is to examine the effectiveness of the CASE model in enabling second grade intermediate students at distinguished schools to acquire biological concepts and develop their visual thinking. The sample consisted of 57 students enrolled in the second grade at Ghanem Hamoudat Mixed High School for Returnee Displaced Students in the Department of Education of Duhok for the academic year 2024/2025. The sample was intentionally selected and divided into two groups: the experimental group, which was taught using the CASE model, and the control group, which was taught using the conventional method.
The two groups were matched on various variables (age in months, first grade biology score, overall grade point average of the previous year, IQ, pre-test visual thinking level, and parents' educational level). To achieve the research objectives and test its hypotheses, the researcher prepared two instruments. The first was a conceptual test consisting of 30 objective items in two formats: the first in matching format to assess the definition of biological concepts, and the second in a multiple-choice format with three alternatives to assess the elements of example and application. The second instrument was a visual thinking test consisting of 20 objective items with four alternatives each, evenly distributed across the five skills of visual thinking (visual discrimination, information analysis, information interpretation, ambiguity perception and interpretation, and meaning extraction). The researcher verified the validity and psychometric properties of both instruments and their reliability, which amounted to 0.81 for the conceptual test and 0.77 for the visual thinking test, using both the Kuder-Richardson-20 and Cronbach's alpha formulas.
Following the implementation of the experiment, data were collected and statistically analysed, yielding the following results:

- There was no statistically significant difference at the 0.05 level between the mean scores of the experimental and control groups on the test for acquiring biological concepts, although the experimental group's mean was slightly higher.
- There was no statistically significant difference at the 0.05 level between the mean scores of the experimental and control groups on the test for developing visual thinking, even though the experimental group's mean was in its favour.

In light of these results, the researcher drew several conclusions, including the feasibility of applying the CASE model in teaching biology to help second grade intermediate students acquire biological concepts and develop their visual thinking skills. Several recommendations were also made to relevant authorities for educational

development, including the provision of training courses for biology teachers on modern teaching models and approaches.

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1. Research Problem

In view of the rapid development of knowledge and its technologies, educational systems have found themselves in a critical situation that necessitates revising their curricula and teaching methods to keep pace with this sudden and rapid change. This has led developed countries to rush towards modifying and developing their curricular content based on the latest learning theories and e-learning technologies. Among the subjects, the science curricula have been at the forefront, having modified their teaching methods through the adoption of educational models and strategies that focus on the learner, thereby placing the learner at the centre of the educational process and striving to develop his/her scientific personality in its cognitive, skillful, emotional, and social dimensions.

Upon examining the current state of teaching biology, it was found that most biology teachers use conventional methods, focusing primarily on the cognitive aspect at its lower levels of Bloom's taxonomy (i.e. recall and sometimes understanding). Although this approach may achieve high success rates and advanced grades in the subject, it does not fulfil the true objectives of teaching biology. Hence, this research represents an attempt to adopt one of the educational models—namely, the CASE model—which aids students in thinking and quickly resolving biological problems, facilitates the applied acquisition of biological concepts, and enhances their visual thinking skills.

Thus, the research problem can be formulated as the following question:

Q: What is the impact of using the CASE model on the acquisition of biological concepts and the development of visual thinking in second grade intermediate students of distinguished schools?

2. Importance of the Research

Biology is a subject of great importance as it contributes significantly to the progress and development of societies. Developed countries recognised this importance early on and have striven to update and improve their science curricula accordingly. Our Arab educational context similarly requires modernisation through the training and qualification of teachers to employ diverse and contemporary teaching methods centred on the learner (Ambu Saidi & Suleiman, 2009, p. 75). In addition, the rapid advancements in the biological sciences at the beginning of the current century have led to further discoveries, prompting educational institutions to enhance biology teaching methods by adopting strategies and models that create a more supportive learning environment across all educational stages. This enhances the connection between what learners study and their daily lives, thus preparing them to cope with new developments and life changes (Jan, 2010, p. 208).

Moreover, to improve science teaching, foster thinking, and promote knowledge acquisition, numerous educational models have emerged that can be utilised to enhance learners' thinking skills. Among these are models based on the constructivist theory of cognitive development, which aim to equip learners with experiences and skills that transition them from concrete operational stages to formal operational stages, where logical thinking begins to develop (Kamal, 2006, p. 24).

The CASE model of accelerated thinking through science teaching is one such model that aims to raise the level of thinking and cognitive growth, focusing on abstract thinking and its gradual development from observation to inference and deduction. It is one of the modern models applied in certain developed countries such as the USA and the UK in science teaching (Hassan, 2005, p. 214).

Furthermore, the acquisition of scientific concepts necessitates the use of teaching strategies and educational models that ensure the proper formation and retention of such concepts. Learning concepts is one of the major challenges faced by educators; hence, there must be an emphasis on learner-active teaching strategies that encourage practical engagement with the subject matter, moving away from traditional methods. Modern teaching employs a wide range of strategies that empower students to acquire knowledge independently—a process often referred to as strategic instruction.

Globally, there is also a growing emphasis on reorienting school education toward the acquisition and development of thinking skills, as studies have indicated that students achieve higher academic success due to these skills, which have become an integral component of the curriculum. It appears that a student's success in their studies requires mastery of basic learning skills in addition to cognitive skills (Al-Sarour, 2003, p. 18).

Visual stimulation, as a fundamental tool, plays a vital role in forming and processing mental images through the representation of ideas. This aids learners in obtaining, representing, interpreting, perceiving, and retaining information, which is then expressed both visually and verbally in a clear and precise manner (Razouqi & Suha, 2013, p. 305).

Thus, the significance of this research is summarised by the question:

What is the impact of teaching using the CASE model on the acquisition of biological concepts and the development of visual thinking in second grade intermediate students of distinguished schools?

3. Research Aims

The research aims to examine the effectiveness of the CASE model in enabling second grade intermediate students to acquire biological concepts and develop their visual thinking skills.

4. Research Hypotheses

To achieve the research objectives, the following two hypotheses were formulated:

- **H1:** There is no statistically significant difference at the 0.05 level between the mean scores of the experimental and control groups on the biological concepts test.
- **H2:** There is no statistically significant difference at the 0.05 level between the mean scores of the experimental and control groups on the visual thinking test.

5. Research Limitations

This research is bounded by the following limitations:

- **Population:** Second grade intermediate students in distinguished schools in the Nineveh Governorate.
- **Location:** Distinguished schools under the Directorate of Education in Nineveh.
- **Time:** The academic year 2024/2025.
- **Content:** The chapters on Plant Anatomy, Invertebrate Animals, and Vertebrates from the Biology textbook for distinguished schools (Seventh Edition, 2023).

6. Definition of Terms

- **Model:**

Al-Haila (2003) defined it as "a set of important, interrelated, interconnected, and interactive steps that lead to the development of educational materials to achieve specific objectives for a particular type of learner, in light of certain theoretical concepts and principles" (Al-Haila, 2003, p. 101).
Zaitoun (2005) described it as "a schematic representation on which events or occurrences and their interrelationships are precisely depicted to facilitate the explanation of those unclear or misunderstood phenomena" (Zaitoun, 2005, p. 2).

- **CASE Model:**

Al-Najdi et al. (2005) defined it as "an educational model based on Piaget's constructivist theory of cognition and Vygotsky's social constructivism, whereby knowledge is constructed through both personal and social dimensions" (Al-Najdi et al., 2005, p. 293).
Afanna and Al-Jaysh (2009) defined it as "an organised method with specific steps that employs a set of activities designed to help learners deal with conflicting events, encouraging them to reflect on their thought processes

and clarifying how such thinking occurs in the context of the educational situation" (Afanna & Al-Jaysh, 2009, p. 88).

Adey & Shayer (2010) defined it as a model derived from Piaget's constructivism and Vygotsky's social theory, comprising five stages—concrete preparation, cognitive conflict, concept construction, metacognitive perception, and bridging—along with teacher-prepared activities that need not be presented in a fixed sequence (Adey & Shayer, 2010, p. 897).

- **Acquisition:**

Qutami (1998) defined it as "the amount of stimuli that a learner can acquire by observing it at one instance and recall in the same form" (Qutami, 1998, p. 106).
Abu Jaddo (2003) described it as "the initial stage of learning during which a new behaviour is incorporated into the learner's behavioural repertoire" (Abu Jaddo, 2003,p.424).
Samara and Al-Adili (2008) defined it as "an initial association between stimulus and response, whereby a neutral stimulus becomes conditioned and elicits a conditioned response" (Samara & Al-Adili, 2008, p. 43).

- **Scientific Concept:**

Nebhan (2008) described it as "mental constructs formed by the mind to create a general mental image of objects, events, and phenomena" (Nebhan, 2008, p. 209).
Attia (2009) defined it as "a mental representation that encompasses common characteristics or the image formed from sensory perceptions" (Attia, 2009, p. 44).
Alyan (2010) defined it as "a collection of objects, symbols, or events grouped together based on shared features, which can be referred to by a specific name or symbol" (Alyan, 2010, p. 21).

- **Visual Thinking:**

Razouqi and Abd al-Karim (2015) defined it as "a series of processes that reflect the learner's ability to read a visual form and convert its visual language into written language, extracting information from it" (Razouqi & Abd al-Karim, 2015, p. 270).
Kousa (2019) described it as "a cognitive ability that enables the learner to utilise the sense of sight to perceive meanings, symbols, and extract and analyse information from images, converting it into written or spoken language, and retaining it in their cognitive environment" (Kousa, 2019, p. 401).
Aslih and Al-Shuwaiki (2020) defined it as "a cognitive process related to visual sensory inputs that reflects the ability to read, interpret, and analyse a visual image and then express it in written or spoken language conveying its intended meaning" (Aslih & Al-Shuwaiki, 2020, p. 81).

7. Theoretical Framework

First Axis: The CASE Model

This model is an application of constructivism that emphasises two educational objectives: the cognitive dimension—pertaining to the functional acquisition of knowledge and scientific concepts—and the skill dimension—concerning formal thought processes and the practice of these skills at early educational stages (beyond the twelfth grade). Its importance has been confirmed by several local and international studies on science education. The model is based on several assumptions:

Assumptions of Accelerated Cognitive Learning:

- The learner constructs knowledge through interaction with the environment and by practising specific mental processes.
- Education serves to enhance the learning environment by equipping learners with skills essential for performing cognitive tasks.
- The cognitive structures acquired by learners are flexible and transferable, potentially forming new associations among individuals.
- Learners can achieve equilibrium between their cognitive structures and the surrounding environment through adaptation, thereby reaching true learning.

- Knowledge is constructed in three forms (cognitive, intellectual, and performance), guiding the learner's understanding and idea comprehension (Afanna & Youssef, 2009, p. 245).
- It increases learners' motivation and their active engagement in scientific learning (Sadeq, 2002, p. 61).

Steps of the CASE Model:

1. **Concrete Preparation:**
   - Teachers divide learners into small groups for enhanced benefits.
   - A scientific problem or question related to the lesson is presented to the students.
   - The teacher assumes a facilitator role rather than being merely a source of information.
   - Learners are given the opportunity to express the relationships they have identified, the strategies they used, and the procedures they carried out.
   - Teachers bridge the gap between the lesson's experiences and everyday life.
2. **Cognitive Conflict:**
   - Teachers present a situation that is unusual or perplexing, contradicting learners' expectations.
   - Such a situation generates a state of cognitive imbalance that prompts learners to reevaluate their current knowledge and thinking patterns, enabling them to adapt to the new scenario.
   - This sudden discrepancy often induces surprise and stimulates learners to engage enthusiastically in resolving the conflict through challenging activities.
3. **Metacognition (Thinking about Thinking):**
   - Learners become aware of their own thinking processes, thus enabling them to take control of and manage their own learning.
   - They learn to identify the type of thinking used in solving a problem, which in turn helps them to organise their thought processes independently, thereby accelerating cognitive growth (Al-Jundi, 2002, p. 277).
4. **Bridging:**
   - This phase involves connecting the experiences gained during the activity to real-life applications and to other academic subjects.
   - It constructs intellectual bridges between classroom activities and practical applications by transforming theoretical knowledge into practical, everyday contexts.

Role of the Teacher in the CASE Model:

According to Afanna and Ibrahim (2009), the teacher's role is to:

- Pose classroom problems that generate cognitive conflict.
- Manage and facilitate classroom discussions that guide learners toward recognising and resolving cognitive discrepancies.
- Observe learners' thought processes and problem-solving strategies.
- Encourage learners to reconsider their thinking to accelerate cognitive growth.
- Guide learners by drawing on their prior learning experiences to build connections between academic content and real-life contexts.

Second Axis: Scientific Concepts

Importance of Concepts:

- Concepts are essential in guiding the selection of curricular content, serving as a fundamental criterion in forming and acquiring knowledge.
- They facilitate the construction of coherent, sequential curricula across various educational levels, ensuring continuity.
- Concepts act as an effective bridge linking diverse academic subjects, contributing to integrated knowledge—a contemporary trend in education.
- They assist curriculum planners and educators in developing clear, purposeful, and well-defined instructional material.
- They enable the transfer of learning effects to new educational contexts (Abu Diya, 2011).

Learning Scientific Concepts:

A learner is deemed to have acquired a concept when they can:

- Present the essential attributes of the concept with illustrative examples that distinguish it from others.
- Differentiate between examples that belong to the concept and those that do not.
- Formulate an acceptable verbal or symbolic definition that elucidates its core features.
- Apply the learnt concept in novel situations.
- Understand the relationship between the concept and other subordinate related concepts (Khadar, 2006, p. 333).

Third Axis: Visual Thinking

Visual perception is the primary gateway through which individuals acquire knowledge of their surroundings. Consequently, many of the most significant cognitive processes stem directly from our ability to see. Visual thinking reduces reliance on verbal language in effective processing and is a cognitive skill that assists learners in obtaining, representing, interpreting, and retaining information, which they then express both visually and verbally (Amer & Al-Masri, 2016, p. 67).

Visual Thinking Skills:

These skills vary according to the educational context and include:

- **Visual Reading:** The ability to discern details in shapes or images.
- **Visual Discrimination:** The capacity to recognise and differentiate between various images and forms.
- **Spatial Relationship Perception:** The ability to understand and relate the positions of different elements.
- **Visual Closure:** The ability to focus on finer details while recognising incomplete images.

Tools for Visual Thinking:

Visual information can be represented using three main tools:

- **Images:** The most precise means of communication, though often costly.
- **Verbal Symbols:** Utilised in the form of words; these are more common despite being abstract.
- **Schematic Drawings:** Employed by visual artists to conceptualise ideas and propose ideal solutions, which include:
    - **Image-based Drawings:** Easily recognisable depictions of an object or idea, often annotated with concise details using printed cutouts or computer-generated images.
    - **Concept-based Drawings:** These often offer a similar level of detail and innovation in representing a readily identifiable object (Al-Afoun & Al-Sahib, 2012; Mahdi, 2006).

8. Previous Studies

The researcher reviewed several previous studies relevant to the independent and dependent variables of this research, including:

- **Imran (2015):** Conducted at the Islamic University in Gaza, Palestine, this study examined the impact of the Adey & Shayer model on modifying alternative conceptions of scientific concepts among ninth grade students. A sample of 64 students was divided into an experimental group taught using the model and a control group taught using traditional methods, with results showing statistically significant differences favouring the experimental group.
- **Al-Sumaydi (2017):** Conducted in Iraq, this study investigated the effect of the Adey & Shayer model on the acquisition of biological concepts and the development of reflective thinking among fifth grade science students. The sample (69 students) was divided into experimental and control groups, with results indicating statistically significant differences favouring the experimental group in both tests.

- **Al-Shamari (2011):** Conducted in Iraq, this study examined the effect of the scientific station strategy and circular concept maps on physics achievement and learning processes among teacher-training students in Tikrit, showing statistically significant differences favouring one of the experimental groups.
- **Ali (2023):** Conducted in Iraq at the University of Zakho, this research investigated the effect of the circular house strategy on biology achievement and the development of reflective thinking among tenth grade science students. Statistically significant differences were found favouring the experimental group.
- **Al-Musamiya (2020):** Conducted in Jordan, this study assessed the impact of augmented reality on science achievement and visual thinking among third grade science students at Al-Quwaysima, finding statistically significant differences in favour of the experimental group.
- **Bro (2023):** Conducted in Iraq, this study examined the effectiveness of an integrated systemic and visual approach in teaching physics, finding statistically significant differences favouring the experimental groups in both the acquisition of physical concepts and the development of visual thinking.

9. Research Methodology and Procedures

Selection of the Experimental Design:

The researcher employed a 2×2 experimental design, given that the research involves one independent variable (the CASE model versus the conventional method) and two dependent variables (acquisition of biological concepts and visual thinking). In this design:

Group	Pre-test	Independent variable	Post-test
Experimental group	Visual Thinking	Model **Case**	Acquisition of biological concepts
Control group		Conventional method	Visual Thinking

- The experimental group is taught using the CASE (receiving both the biological concepts test and the visual thinking test).
- The control group is taught using the conventional method.

Ensuring equivalence in several variables deemed influential (e.g. age, previous academic performance, pre-test scores, IQ) was a prerequisite for this design.

Determination of the Research Population:

The research population consisted of all second grade intermediate students in distinguished schools in the Nineveh Governorate for the academic year 2024–2025.

Selection of the Research Sample:

A representative subset was intentionally selected from the second grade intermediate students. The researcher chose Ghanem Hamoudat Secondary School for Distinguished Students, ensuring two sections:

- Section (A): 29 students randomly selected as the control group (taught via conventional methods).
- Section (B): 28 students as the experimental group (taught using the CASE model).

Equivalence of the Research Groups:

Despite a random distribution of the groups, the researcher further ensured equivalence in variables that might affect the dependent variables (chronological age in months, previous year's overall average, first grade biology score, pre-test visual thinking scores, intelligence levels).

Research Requirements:

In order to implement the experiment, several lesson plans were prepared in accordance with both the CASE model and the conventional method, following these steps:

1. **Analysis of the Scientific Material:**

The researcher identified the chapters on Plant Anatomy, Invertebrate Animals, and Vertebrates from the Biology textbook for distinguished schools (Seventh Edition, 2023), taught in the second semester of the academic year 2024–2025.

A content analysis was carried out to extract both the main and subsidiary biological concepts, along with the associated pages, activities, and illustrative biological images.

2. Formulation of Behavioural Objectives:

Based on the content analysis and events associated with teaching, the researcher adopted the first four levels of Bloom's taxonomy (recall, understanding, application, analysis) for the cognitive domain. A total of 153 behavioural objectives were formulated corresponding to the lesson content (distributed as 45, 52, and 56 objectives respectively), and then presented as Appendix 3 to a panel of experts. An agreement rate of 80% was required for acceptance, which all objectives achieved or exceeded, with minor modifications where necessary.

3. Preparation of Lesson Plans:

Based on the content analysis, the formulated behavioural objectives, and the number of teaching sessions (three per week), two sets of lesson plans were prepared: one for the experimental group (using the CASE model) and one for the control group (using conventional methods). These were reviewed and approved by a panel of experts in science teaching, resulting in the preparation of an additional 16 lesson plans for each method for the remainder of the topics.

- **Research Instruments:**

The research utilised two tests:

1. Conceptual Test:

The researcher developed a conceptual test to measure the level of acquisition of biological concepts among the sample, following these steps:

a. **Content Analysis:** Identification of 42 key and subsidiary biological concepts from the predetermined chapters, to serve as the basis for constructing test items from the Biology textbook content.

b. **Formulation of Behavioural Objectives:** Out of the 153 objectives based on Bloom's taxonomy (recall, understanding, application, analysis), 30 were selected to design test items at the levels of recall, comprehension, and application—corresponding to the elements of definition, discrimination, and application.

c. **Determination of the Number of Test Items:** Based on the concept elements and the objectives, 30 test items were selected that fit the characteristics of the sample.

d. **Preparation of a Test Blueprint:** A blueprint was designed to ensure comprehensive and objective coverage of the lesson and its intended objectives.

e. **Test Item Formats:** The test items were designed as objective items using two formats—matching (to assess definitions) and multiple-choice (three alternatives, to assess examples and applications)—ensuring objectivity and ease of grading.

f. Psychometric Evaluation: The test's validity was confirmed with an 80% expert agreement, and its reliability was calculated using the Kuder-Richardson-20 formula, yielding a coefficient of 0.82 (deemed acceptable; Al-Shayib, 2009, p. 109).

g. **Statistical Analysis:** A pilot study with 32 students outside the main sample was conducted to evaluate item discrimination, difficulty, and the effectiveness of distractors as follows:

- **Discrimination Index**: Its values ranged between (0.33–0.48), which are acceptable for all items (Al-Nabhan, 2004, p. 188).
- **Difficulty Index**: Its values ranged between (0.33–0.48), which are acceptable based on the criterion-referenced range (0.20–0.80) (Samara, 1989, p. 109). Accordingly, the researcher verified the appropriateness of the items' difficulty levels.
- **Effectiveness of Distractors**: The effectiveness of the distractors (incorrect alternatives) in the conceptual test's objective items was calculated. A distractor is considered effective if it has a negative discrimination value and is less than (0.05). All distractors met this criterion and were deemed acceptable.

2. **Visual Thinking Test:**

Developed to measure the visual thinking skills of the sample, this test—based on previous instruments—comprises 20 multiple-choice items with four alternatives each, evenly distributed across the five visual thinking skills. Its psychometric properties were verified (validity of 80% by expert panel and a Cronbach's alpha of 0.78), ensuring its suitability for the study. They were calculated and found to be as follows

- **Discrimination Index**: Its values ranged between (0.33–0.48), which are acceptable for all items (Al-Nabhan, 2004, p. 188).
- **Difficulty Index**: Its values ranged between (0.33–0.48), which are acceptable based on the criterion-referenced range (0.20–0.80) (Samara, 1989, p. 109). Accordingly, the researcher verified the appropriateness of the items' difficulty levels.
- **Effectiveness of Distractors**: The effectiveness of the distractors (incorrect alternatives) in the conceptual test's objective items was calculated. A distractor is considered effective if it has a negative discrimination value and is less than (0.05). All distractors met this criterion and were deemed acceptable.

10. Implementation of the Experiment

After selecting the sample and ensuring group equivalence, and following the preparation of lesson plans and instruments, the experiment was implemented on Tuesday, 14 February 2024, beginning with the pre-test on biological concepts. The experiment lasted for two months until 20 April 2025. At the conclusion of the experiment, the following assessments were administered:

- **Biological Concepts Test:** Scored by awarding 1 point for a correct answer and 0 for an incorrect, omitted, or multiple-marked answer (total score ranging from 0 to 30).
- **Visual Thinking Test:** Similarly scored with a total possible score ranging from 0 to 20.Data were recorded accordingly.

11. Statistical Methods

Appropriate statistical tools were employed for data processing and analysis using the SPSS software.

12. Presentation and Discussion of Research Results

Upon analysis of the data, the following results were obtained:

○ **First Main Hypothesis:**

It was hypothesised that there is no statistically significant difference at the 0.05 level between the mean scores of the experimental and control groups on the biological concepts test.
To test this hypothesis, the researcher calculated the mean and standard deviation for both groups as follows:

Group	Number	Mean	Standard Deviation	t-value (Calculated)	t-value (Tabulated)	Significance
Experimental	28	21.13	3.982	0.437	2.004	**Not statistically significant**
Control	29	20.73	2.809			

The table indicates that the calculated t-value is (0.437), which is lower than the tabulated value of (2.004) at the significance level of (0.05) and a degree of freedom (55). This means that the null hypothesis is accepted, indicating that there is no statistically significant difference between the experimental group, which was taught using the proposed method, and the control group, which was taught using the traditional method, in the test measuring the acquisition of biological concepts.
This result contradicts the findings of previous studies by Omran (2015), Al-Sumaida'i (2017), and Al-Shammari (2011). The researcher attributes this outcome, related to the first null hypothesis and its inconsistency with

earlier studies, to several possible factors. One explanation is the similarity in academic levels among students; as students in distinguished schools generally demonstrate high academic achievement, the individual differences in the acquisition of concepts between the experimental and control groups may have been minimal, rendering them statistically undetectable due to the convergence of their cognitive and basic skill levels.
Moreover, the non-significant difference might be attributed to the possibility that the instructional program used for the experimental group (CASE) was not as effective as the conventional teaching method applied in the control group, especially when dealing with gifted students. Additionally, accompanying factors such as the relatively short duration of the intervention or the students' reliance on their personal abilities rather than the experimental approach might have influenced the results of the experimental group.

- **Second Main Hypothesis:**

It was hypothesised that there is no statistically significant difference at the 0.05 level between the mean differences (post-test minus pre-test) of the experimental and control groups on the visual thinking test. The calculations yielded the following:

Group	Number	Mean	Standard Deviation	t-value (Calculated)	t-value (Tabulated)	Significance
Experimental	28	3.42	3.0	1.03	2.0	**Not statistically significant**
Control	29	2.63	2.8			

The table shows that the calculated *t*-value for the differences in development scores in the visual thinking test is (1.03), which is lower than the tabulated *t*-value of (2.00) at a significance level of (0.05) and with (55) degrees of freedom. This indicates acceptance of the null hypothesis: "There are no statistically significant differences at the 0.05 level between the mean difference scores of the experimental and control groups in the visual thinking test."
In other words, the use of the CASE model was not effective in producing significant development in the visual thinking skills of the experimental group. Although there was a numerical difference in the mean scores between the pre-test and post-test in favour of the experimental group, this difference did not reach statistical significance.
These findings contradict the results of previous studies by Ali (2023), Masamiya (2020), and Perot (2023). The researcher attributes this outcome to the characteristics of gifted students, particularly their diligence and tendency to rely on their personal skills, which may have reduced the observable impact of the CASE model when applied to this category of learners

13. Recommendations and Suggestions

Based on the research findings, the researcher makes the following recommendations:

- Biology teachers in intermediate schools should adopt modern educational models in their teaching.
- The curriculum committee for Biology at the Ministry of Education should consider incorporating visual thinking skills into the curriculum.

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