

The Impact of Differentiated Instruction on Tenth-Grade Students' Academic Achievement in Biology: A Quasi-Experimental Study in Jordan

Abdulnour Karim Haddad^{1,*}

¹The Department of Requirement Courses Unit, Faculty of Science, Zarqa University, Zarqa, Jordan

*Correspondence: The Department of Requirement Courses Unit, Faculty of Science, Zarqa University, Zarqa, Jordan.
E-mail: ahaddad@zu.edu.jo. ORCID: 0009-0007-8633-2901

Received: September 20, 2025

Accepted: October 15, 2025

Online Published: August 18, 2026

doi:10.5430/jct.v15n3p281

URL: <https://doi.org/10.5430/jct.v15n3p281>

Abstract

This quasi-experimental study investigated the impact of Differentiated Instruction (DI) on the academic achievement of tenth-grade biology students in Jordan. A total of 84 students participated: 42 in an experimental group that received DI strategies tailored to diverse learning needs and 42 in a control group that followed traditional lecture-based methods. The biology teacher completed 20 hours of DI training before an 8-week intervention. Data were collected using a 40-item biology achievement test (Cronbach's $\alpha = 0.87$). Pre- and post-test results revealed a statistically significant improvement in the academic achievement of the experimental group compared to the control group ($p < .001$), with substantial effect sizes (Cohen's $d > 2.4$). An independent samples t-test confirmed no significant gender-based differences in achievement within the experimental group ($t(82) = 0.295$, $p = 0.769$). The findings suggest that DI is an effective and equitable pedagogical approach for enhancing learning outcomes in biology education. The study recommends integrating DI into science teacher training programs and curricula to cater to student diversity.

Keywords: differentiated instruction, academic achievement, biology education, secondary education, quasi-experimental study, Jordan

1. Introduction

Education serves as a fundamental pillar for cognitive and social development, with its effectiveness dependent on continuous pedagogical innovation. Traditional, one-size-fits-all teaching methodologies have faced extensive criticism for their failure to address the diverse learning needs, readiness levels, and interests of students (Tomlinson, 2014). In response, Differentiated Instruction (DI) has emerged as a proactive, student-centered framework that enables educators to modify content, process, product, and the learning environment to maximize individual student growth and engagement (Bondie & Zusho, 2018).

The challenge of addressing learner diversity is particularly pronounced in science education within the Arab world. In Jordan, large class sizes and a standardized national curriculum often hinder the implementation of personalized learning approaches. Biology, a subject characterized by abstract concepts and complex systems, presents significant learning obstacles for many students. Passive learning models prevalent in Jordanian science classrooms have been associated with low achievement scores and declining interest in STEM fields, highlighting the urgent need for innovative, responsive teaching strategies.

Although DI offers a promising solution, its empirical validation within specific Jordanian contexts, particularly in tenth-grade biology classrooms, remains limited. This study aims to address this critical research gap by providing robust, experimental evidence on the efficacy of DI in enhancing academic achievement and promoting equity in Jordanian science education.

1.1 Research Objectives

This study aims to:

1. Assess the effect of differentiated instruction on the academic achievement of tenth-grade biology students.

2. Examine potential gender-based differences in academic achievement resulting from DI implementation.
3. Identify the most effective DI strategies for enhancing student learning in biology.

1.2 Research Hypotheses

- H1: Students taught using differentiated instruction strategies will demonstrate significantly higher academic achievement in biology than those taught through traditional methods.
- H2: There will be no significant difference in academic achievement between male and female students within the experimental group taught using DI.

1.3 Research Questions

This study sought to answer the following questions:

1. To what extent does differentiated instruction impact tenth-grade students' academic achievement in biology?
2. Are there significant gender differences in academic achievement among students taught using differentiated instruction?
3. What are the most effective DI strategies for enhancing biology learning outcomes?

2. Theoretical Framework

This study is grounded in an integrated theoretical framework combining Vygotsky's (1978) Sociocultural Theory, particularly the Zone of Proximal Development (ZPD), and Gardner's (1983) Theory of Multiple Intelligences.

2.1 Vygotsky's Zone of Proximal Development (ZPD)

Vygotsky's ZPD conceptualizes the gap between what a learner can accomplish independently and what they can achieve with expert guidance. This theory posits that optimal learning occurs through targeted instruction and scaffolding within this zone. In this study, the ZPD provides the theoretical foundation for DI strategies such as tiered assignments and flexible grouping. Diagnostic pre-assessments were employed to determine individual readiness levels, enabling the design of activities with varying complexity and the provision of strategic scaffolding, which was gradually withdrawn as student competence increased.

2.2 Gardner's Theory of Multiple Intelligences

Gardner's theory challenges the unitary view of intelligence by proposing multiple distinct intelligences (e.g., linguistic, logical-mathematical, spatial, kinesthetic). This paradigm acknowledges diverse cognitive strengths and learning preferences. In this study, the Multiple Intelligences theory informed DI through varied content delivery methods (multimedia, hands-on activities, texts), multiple assessment formats, flexible grouping based on learning preferences, and choice boards that allowed students to demonstrate understanding through their dominant intelligences.

The integration of these theories creates a comprehensive framework. Vygotsky's ZPD addresses the "readiness" component, ensuring an appropriate challenge level, while Gardner's Multiple Intelligences inform the "interest" and "learning profile" dimensions, providing multiple pathways for engaging with and mastering biological concepts.

2.3 Additional Theoretical Foundations

Beyond Vygotsky's sociocultural theory and Gardner's multiple intelligences, this study draws upon Bandura's (1997) social cognitive theory, particularly the concept of self-efficacy, which aligns with DI's goal of building student confidence through appropriately challenging tasks. Furthermore, Bruner's (1996) constructivist approach emphasizes that learning is an active process where learners construct new ideas—a principle that underpins DI's student-centered methodology.

The theoretical underpinnings of DI are further supported by contemporary research. Subban (2006) established the research basis for differentiated instruction, demonstrating its philosophical and psychological foundations. Tieso (2005) examined how grouping practices and curricular adjustments—core components of DI—significantly impact student achievement. These theoretical perspectives collectively support DI as a comprehensive approach addressing readiness, interest, and learning profiles (Tomlinson, 2014; Bondie & Zusho, 2018).

3. Literature Review

3.1 Empirical Evidence on DI in Science Education

International research provides evidence supporting the use of Differentiated Instruction. Santangelo and Tomlinson (2012) examined teacher educators' perceptions and use of differentiated instruction practices, while a systematic review and meta-analysis by Deunk et al. (2018) reported positive cognitive effects of differentiation practices in primary education. In science-specific contexts, Al-Shehri (2020) reported that DI significantly improved achievement and critical thinking skills among sixth-grade science students. Similarly, Salar and Turgut (2021) found that DI combined with the 5E learning cycle enhanced physics understanding. Beyond these studies, Valiandes (2015) demonstrated that DI significantly promoted literacy and reading in mixed-ability classrooms, highlighting its role in fostering educational equity. Furthermore, Bertso (2005) specifically investigated biology education and found that differentiated homework assignments effectively enhanced academic achievement.

3.2 DI in Arab Educational Contexts

Research on DI in the Arab world is gradually expanding but remains relatively scarce compared to international literature. The existing studies, however, predominantly report positive outcomes. Al-Zahrani (2021) in Saudi Arabia documented significant improvements in chemistry achievement following a DI intervention. In Jordan, Obeidat (2022) found that DI strategies enhanced critical thinking skills among students. A recent study by Selden and Sakulwongs (2024) also demonstrated the effectiveness of DI on science learning achievement for elementary students in a similar international context. While these findings are promising, a gap remains in the Jordanian context regarding experimental, subject-specific studies at the secondary level, particularly in biology. This study addresses this gap by providing quasi-experimental evidence on the effect of DI in tenth-grade biology classrooms.

4. Methodology

4.1 Research Design

This study employed a quasi-experimental pretest-posttest control group design.

4.2 Participants and Sampling Technique

The study involved 84 tenth-grade students (42 males, 42 females) from the Latin Patriarchate Mixed Schools in Jordan. A multistage sampling approach was employed: the school was purposively selected due to its representative demographics, and four tenth-grade classes were then randomly selected and assigned to experimental and control groups. The selected classes were assigned to either the experimental group ($n=42$) or the control group ($n=42$). An independent samples t-test confirmed no significant difference in pre-test scores between the groups ($t(82) = 1.21$, $p = .231$), establishing initial equivalence.

4.3 Instruments

The primary instrument was a 40-item multiple-choice biology achievement test, developed based on the curriculum units covered during the intervention. The test was validated by a panel of three experts in science education (face and content validity). A pilot study with 30 students from a non-participating school established high reliability (Cronbach's $\alpha = 0.87$).

4.4 Intervention and Procedures

The study was conducted in three phases over 11 weeks:

Phase 1: Preparation (2 weeks)

The biology teacher received 20 hours of training on DI principles and strategies. Differentiated lesson plans and materials were developed.

Phase 2: Intervention (8 weeks)

The experimental group received DI for four 45-minute sessions per week, while the control group received traditional, lecture-based instruction covering identical content.

Implementation of Differentiated Instruction:

The DI intervention was implemented across three biology units:

- Unit 1: Cellular Structure and Function (2 weeks)
- Unit 2: Genetics and Heredity (3 weeks)
- Unit 3: Human Physiology (3 weeks)

Teacher Training and Preparation:

The biology teacher completed 20 hours of specialized DI training focusing on:

- Designing tiered assignments for mixed-ability classrooms
- Creating flexible grouping strategies
- Developing multiple assessment formats

Specific DI Strategies Employed:

1. Tiered Assignments (Genetics Unit Example):
 - Level 1: Basic Punnett square problems (remedial)
 - Level 2: Complex inheritance patterns (grade-level)
 - Level 3: Real-world genetic counseling scenarios (advanced)
2. Flexible Grouping Approaches:
 - Readiness-based groups for skill-building sessions
 - Interest-based groups for project work
 - Mixed-ability groups for peer tutoring
3. Varied Content Delivery:
 - Multimedia simulations, hands-on models, and modified texts
4. Choice Boards:
 - Students selected activities to demonstrate mastery (e.g., create a diagram, write a report, build a model)

Phase 3: Data Collection (1 week)

The post-test was administered to both groups.

4.5 Data Analysis

Data were analyzed using SPSS version 26. The analytical procedure included:

1. Descriptive statistics (means, standard deviations, gain scores)
2. Assumption testing (normality via Shapiro-Wilk, homogeneity of variance via Levene's test)
3. Inferential statistics (independent t-tests, ANCOVA with pre-test as covariate)
4. Effect size calculations using Cohen's d

A significance level of $\alpha = 0.05$ was established for all statistical tests.

4.6 Ethical Considerations

The study adhered to ethical principles in educational research:

- Informed consent was obtained from school administration and parents
- Student participation was voluntary
- Confidentiality of data was maintained throughout the study
- The control group received the DI intervention after the study concluded

5. Results

5.1 Preliminary Analysis and Descriptive Statistics

Preliminary analyses confirmed the validity of statistical assumptions. The Shapiro-Wilk test verified normal data distribution ($p > .05$), and Levene's test established homogeneity of variances between groups ($p > .05$). Baseline equivalence between experimental and control groups was confirmed through an independent samples t-test on pre-test scores ($t(82) = 1.21, p = .231$).

5.2 Academic Achievement Outcomes

The consolidated results presented in Table 1 provide an overview of the intervention's impact. The experimental group demonstrated substantial and statistically significant gains compared to the control group.

Table 1. Academic Achievement Results by Group and Gender

Group	Gender	N	Pre-test Mean	Post-test Mean	Mean Gain	p-value	Effect Size (Cohen's d)
Experimental	Male	42	42.15	79.70	37.55	<.001	2.45
Experimental	Female	42	41.85	80.62	38.77	<.001	2.58
Control	Male	42	39.20	46.30	7.10	.065	0.30
Control	Female	42	38.45	47.14	8.69	.024	0.37

An analysis of covariance (ANCOVA) revealed a statistically significant main effect of teaching method on post-test scores, $F(1, 81) = 385.74$, $p < .001$, with a very large effect size (partial = 0.83). This indicates a strong association between the teaching method and post-test achievement, providing robust support for Hypothesis 1 (H1).

5.3 Analysis of Gender Differences

To address the second hypothesis concerning gender-based differences, an independent samples t-test was conducted on the post-test scores of the experimental group. The results showed no statistically significant difference in achievement between male ($M = 79.70$, $SD = 19.30$) and female ($M = 80.62$, $SD = 17.85$) students who experienced the DI intervention ($t(82) = 0.295$, $p = 0.769$), with a negligible effect size (Cohen's $d = 0.065$). This non-significant result supports Hypothesis 2 (H2), indicating similar outcomes for male and female students within the experimental group.

6. Discussion

6.1 Interpretation of Key Findings

This study provides evidence supporting the efficacy of Differentiated Instruction in enhancing academic achievement among tenth-grade biology students in Jordan. The experimental group's substantial mean gain of approximately 38 points, compared to a mean gain of approximately 8 points in the control group, represents a nearly five-fold difference in learning gains. This difference is further supported by the ANCOVA results and the large effect sizes ($d > 2.4$). These findings align with the theoretical frameworks of Vygotsky (1978) and Gardner (1983), suggesting that instruction systematically tailored to students' readiness levels and diverse intelligences can create favorable conditions for learning. The results are consistent with previous international research on differentiation practices (Deunk et al., 2018) and extend their applicability to the Jordanian educational context. The effect sizes ($d > 2.4$) observed in this study exceed those reported in similar regional studies (Al-Shehri, 2020; Al-Zahrani, 2021), suggesting that the comprehensive DI approach implemented here may be particularly effective in biology education.

6.2 DI as a Strategy for Educational Equity

A significant finding of this study is the absence of statistically significant gender-based differences in achievement within the experimental group. This outcome indicates that the DI framework created an inclusive learning environment in which male and female students achieved similar outcomes. By offering multiple pathways to access content, process information, and demonstrate understanding, DI catered to varied strengths and learning preferences. This positions DI as an approach that may support both achievement and educational equity in STEM education within the Jordanian context and similar educational environments. This finding is consistent with Valiandes (2015), who demonstrated that DI promotes educational equity in mixed-ability classrooms, and extends this evidence to gender equity in science education.

6.3 Theoretical and Practical Implications

Theoretically, these findings strongly support the integrated framework of Vygotsky's Zone of Proximal Development and Gardner's Theory of Multiple Intelligences. The success of tiered assignments and strategic scaffolding confirms the importance of targeting instruction within a student's ZPD, while the positive response to varied content delivery and choice boards validates the relevance of addressing multiple intelligences. These practical outcomes align with the recommendations of Bondie and Zusho (2018) for making differentiation practical through classroom routines, and demonstrate the feasibility of implementing these strategies in Jordanian schools as shown in Obeidat's (2022) work on critical thinking.

6.4 Limitations and Avenues for Future Research

Despite the strong results, this study has certain limitations. The 8-week intervention period, while sufficient to demonstrate significant effects, does not provide data on long-term knowledge retention. Future research should employ longitudinal designs to assess the sustainability of these gains. Furthermore, the reliance on quantitative

measures, while useful for assessing achievement outcomes, limits understanding of qualitative shifts in student engagement, motivation, and classroom dynamics. A mixed-methods approach in future studies could yield richer insights into the mechanisms behind DI's effectiveness, exploring the lived experiences of both students and teachers. This recommendation echoes the approach taken by Salar and Turgut (2021), who combined DI with the 5E learning cycle to examine both achievement and self-efficacy outcomes.

7. Conclusion and Recommendations

This study provides quasi-experimental evidence that implementing Differentiated Instruction can be an effective approach to improving biology education in Jordan. Building on the foundational work of Tomlinson (2014) and recent regional studies (Al-Zahrani, 2021; Obeidat, 2022), this research demonstrates that DI significantly improves academic achievement and showed comparable benefits for male and female students.

Based on these findings, the following recommendations are made:

1. For Policymakers and Curriculum Developers: Integrate DI principles into the national science curriculum and teacher guidebooks to support differentiated practices.
2. For Teacher Training Institutions: Incorporate mandatory, practical training on DI strategies into pre-service and in-service teacher education programs.
3. For Practicing Teachers: Actively adopt and adapt DI strategies, beginning with tiered assignments and choice boards, to address the diverse needs of their students.
4. For Researchers: Conduct longitudinal studies to assess the long-term impact of DI and investigate its effectiveness across different subjects and grade levels within the Arab region.

References

- Al-Shehri, M. S. (2020). Effect of differentiated instruction on the achievement and development of critical thinking skills among sixth-grade science students. *International Journal of Learning, Teaching and Educational Research*, 19(10), 77-99.
- Al-Zahrani, A. M. (2021). The impact of differentiated instruction on chemistry achievement in Saudi secondary schools. *Journal of Educational Science*, 29(2), 45-67.
- Bandura, A. (1997). *Self-efficacy: The exercise of control*. W. H. Freeman.
- Bertsos, G. F. (2005). *Differentiating biology homework to enhance academic achievement* [Master's thesis, Eastern Michigan University]. EMU Digital Commons.
- Bondie, R. S., & Zusho, A. (2018). *Differentiated instruction made practical: Engaging the extremes through classroom routines*. Routledge.
- Bruner, J. S. (1996). *The culture of education*. Harvard University Press.
- Deunk, M. I., Smale-Jacobse, A. E., de Boer, H., Doolaard, S., & Bosker, R. J. (2018). Effective differentiation practices: A systematic review and meta-analysis of studies on the cognitive effects of differentiation practices in primary education. *Educational Research Review*, 24, 31-54.
- Gardner, H. (1983). *Frames of mind: The theory of multiple intelligences*. Basic Books.
- Heacox, D. (2012). *Differentiating instruction in the regular classroom: How to reach and teach all learners*. Free Spirit Publishing.
- Levy, H. M. (2008). Meeting the needs of all students through differentiated instruction: Helping every child reach and exceed standards. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, 81(4), 161-164.
- Obeidat, R. (2022). Differentiated instruction and critical thinking skills in Jordanian schools. *Jordanian Educational Journal*, 15(3), 112-130.
- Salar, R., & Turgut, U. (2021). Effect of differentiated instruction and 5E learning cycle on academic achievement and self-efficacy of students in physics lesson. *Science Education International*, 32(1), 4-13.
- Santangelo, T., & Tomlinson, C. A. (2012). Teacher educators' perceptions and use of differentiated instruction practices: An exploratory investigation. *Action in Teacher Education*, 34(4), 309-327.
- Selden, C., & Sakulwongs, N. (2024). The effectiveness of using differentiated instruction on science learning

- achievement for grade 5 Bhutanese students. *Journal of Research and Curriculum Development*, 14(2), 32-43.
- Subban, P. (2006). Differentiated instruction: A research basis. *International Education Journal*, 7(7), 935-947.
- Tieso, C. (2005). The effects of grouping practices and curricular adjustments on achievement. *Journal for the Education of the Gifted*, 29(1), 60-89.
- Tomlinson, C. A. (2014). *The differentiated classroom: Responding to the needs of all learners* (2nd ed.). ASCD.
- Valiandes, S. (2015). Evaluating the impact of differentiated instruction on literacy and reading in mixed ability classrooms: Quality and equity dimensions of education effectiveness. *Studies in Educational Evaluation*, 45, 17-26.
- Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Acknowledgments

The author extends sincere gratitude to the administration, teachers, and students of the Latin Patriarchate Mixed Schools for their invaluable participation and cooperation in this study. Their willingness to engage in this research was fundamental to its success.

The author is deeply grateful to Dr. Ghada Al-Asmar for her expert supervision and guidance throughout the practical application of the study. Her insights were instrumental in ensuring the faithful implementation of the differentiated instruction model in the classroom.

The author also expresses deep appreciation to Ms. Hadeel Ibrahim Musleh for her meticulous work in the statistical analysis. Her expertise in data validation and interpretation significantly enhanced the methodological rigor and reliability of the research findings.

The completion of this project was made possible by the dedicated contributions of these individuals.

Authors contributions

The author was responsible for the conceptualization and design of the study, methodology, data collection, interpretation of the results, drafting and revising the manuscript, and approval of the final version for publication.

Funding

Not applicable.

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Disclosure of AI Use

Generative AI tools were used solely for language editing and proofreading. The author reviewed the final text and remains fully responsible for the content.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Sciedu Press.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

Provenance and peer review

Not commissioned; externally double-blind peer reviewed.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

Open access

This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).

Copyrights

Copyright for this article is retained by the author(s), with first publication rights granted to the journal.