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Chapter 1

SCIENCE TEACHER CANDIDATES' TEMPORAL PERSPECTIVES ON ENVIRONMENTAL CRISES FROM TODAY TO 2050

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Introduction

Contemporary environmental problems are approached not merely as degradations occurring in the physical environment, but as multilayered crises that necessitate rethinking the temporal, ethical, and systemic dimensions of humanity's relationship with nature (Güven, 2011; Rockström et al., 2009; Steffen et al., 2015). The planetary boundaries framework highlights the holistic impact of human activities on Earth systems, demonstrating that environmental issues exhibit an interconnected and systemic structure (Rockström et al., 2009; Steffen et al., 2015). Consequently, the first quarter of the 21st century has been characterized as a period during which human activities exert geologically significant impacts on Earth systems, environmental crises are felt on a global scale, and which some researchers conceptualize as the Anthropocene (Crutzen, Stoermer & Steffen, 2008; IPCC, 2023). Within this context, interrelated problem areas such as climate change, biodiversity loss, depletion of water resources, air pollution, and environmental contamination increasingly render the pressures of human activities on planetary systems visible and measurable (IPBES, 2019). Air pollution causes millions of premature deaths annually (WHO, 2022), and plastic pollution inflicts largely irreversible damage on marine ecosystems (UNEP, 2023). The synthesis

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Chapter 2

SMALL-SCALE AND MICROSCALE CHEMISTRY EXPERIMENTS: A CRITICAL REVIEW OF EVIDENCE-BASED, INCLUSIVE, AND SUSTAINABLE LABORATORY DESIGN

Yüksel ALTUN[1]
Dilay DİNÇDEMİR[2]

Introduction and Purpose

One of the distinctive characteristics of chemistry education is that students are expected not only to learn chemical phenomena at the verbal or symbolic level, but also to make sense of them through observation, measurement, data generation, evidence evaluation, modeling, and explanation construction. For this reason, laboratory activities are considered a central component of chemistry teaching. However, being present in the laboratory, completing a procedure, or observing an expected color change, precipitate formation, or gas evolution does not necessarily indicate that learning has occurred. An effective laboratory experience should make explicit what students observe and why they observe it, which measurements or data support their observations, how they relate their findings to an appropriate chemical model, and what evidence they use to justify their conclusions (Abrahams & Millar, 2008; Hofstein & Lunetta, 2004; Reid & Shah, 2007; Seery, 2020).

The difficulty of learning chemistry is closely associated with the discipline's multiple representational nature. Students are expected to establish connections between macroscopic observations, particulate-level explanations, and symbolic representations; however, these connections rarely emerge spontaneously (Gilbert & Treagust, 2009; Johnstone, 1991; Talanquer, 2011). For example, observing

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forms of evidence, enable small-scale designs to produce learning, safety, and sustainability outcomes.

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Chapter 3

DETERMINING PRE-SERVICE TEACHERS' VIEWS ON A DNA REPLICATION MODEL

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Buse KARATAŞ[2]
Çiğdem Alev ÖZEL[3]

Introduction

One of the fundamental aims of contemporary science education is to enable students to achieve durable and meaningful learning by making abstract concepts concrete. In this respect, biology education, by its very nature, encompasses a great many abstract and microscopic concepts. The topic of DNA—situated within the fields of cell biology, genetics, and molecular biology—consists of content such as nucleotide structure, base pairs, and the double-helix model that students find difficult to grasp through mental models (Bahar, Johnstone, & Hansell, 1999; Prokop, Prokop, & Tunnicliffe, 2007).

There are several reasons why the topic of DNA is difficult to understand in biology education. Among these are that the subject takes place at an invisible, abstract level; that teachers rely largely on lecturing and on textbooks; and that concepts such as nucleotides, base pairs, and replication are remote from students' everyday lives (Aşçı, Özkan, & Tekkaya, 2001; Tekkaya, Çapa, & Yılmaz, 2000). A review of the literature shows that students hold many misconceptions concerning the structure and function of DNA (Karakaya et al., 2020; Sebitosi, 2007). Conducting instruction with the support of materials is therefore of great importance for remedying misconceptions and for making concrete the events that occur at an abstract level.

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of DNA together. In addition, it allowed data to be collected in depth through six open-ended questions.

In line with the results obtained, recommendations were developed for researchers and practitioners. First, it is recommended that the effect of the developed model on student achievement and on the durability of learning be tested with experimental and quasi-experimental designs, so that the positive expectations described by pre-service teachers are tested directly against learning outcomes. Second, in order to remedy the durability limitation that participants commonly pointed to, the model should be reproduced with more robust and sustainable materials, and improvements such as fixing the moving parts and adding protective housing should be made. Third, in future studies, obtaining the views of students and in-service teachers as well as of pre-service teachers will allow the model to be evaluated from the perspective of different stakeholders. Finally, it is recommended that teacher-education programmes include hands-on activities that strengthen pre-service teachers' competencies in model development and model-based instruction.

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Chapter 4

THE IMPACT OF EDUCATIONAL GAME DESIGN ON SCIENCE TEACHER CANDIDATES' ATTITUDES TOWARDS GAMES, GAME EVALUATIONS, AND PROCESS VIEWS

Emre YILDIZ[1]

Introduction

To appeal to today's Gen Z students, curricula need to support active learning, leverage technology, and present multiple stimuli simultaneously. While traditional methods may not fully meet the expectations of this new generation, student-centered approaches, in which students construct knowledge through their own experiences, play a significant role in lasting learning (Yıldız et al., 2018). Current studies indicate that for learning to be permanent, students must actively participate in hands-on learning experiences. In this context, educational games, which structure and transform play—a natural learning tool—into a goal-oriented framework, make the learning process more engaging and motivating (Laamarti et al., 2014). Educational games stand out as an effective pedagogical tool for developing 21st-century skills such as critical thinking, creative thinking, problem-solving, and collaboration (Cai et al., 2025; Huang & Chen, 2025). Game-based applications, especially in science education, significantly increase students' problem-solving skills and their understanding of fundamental concepts (Yıldız et al., 2016; Yıldız et al., 2017).

The realization of these benefits depends on how effectively educational games are used in the classroom; teachers' attitudes toward this method are among the primary factors influencing this. A positive attitude toward the method enables teachers to apply these innovative approaches more readily, whereas a negative attitude hinders the integration of game-based learning into the classroom (Ertuğrul & Karamustafaoğlu, 2021). Some studies in the literature indicate that

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Instead of having teacher candidates design games independently, the affective and cognitive gains of the models they create through collaborative workshops with middle school students can be evaluated.

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Bölüm 5

AN EXAMINATION OF PRE-SERVICE SCIENCE TEACHERS' WRITTEN ARGUMENTS AND ATTITUDES TOWARDS SOCIO-SCIENTIFIC ISSUES IN THE JIGSAW-SUPPORTED ARGUMENTATION PROCESS

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Introduction

The rapid advancements in science and technology necessitate that individuals not only have access to information but also be able to critically evaluate, question, and adapt that information to different situations (Chernyshenko et al., 2018; Lederman et al., 2025). These developments have rendered traditional knowledge-transmission-based approaches in science education insufficient, necessitating that teaching processes focus on developing students' higher-order thinking skills. In this context, critical thinking, scientific reasoning, and problem-solving skills hold a significant place among 21st-century skills (Care et al., 2018; National Research Council [NRC], 2012). Various methods and techniques have been employed to develop these skills, and their effects have been examined.

Cooperative learning is one of these methods. Because cooperative learning requires group work, it particularly improves social skills such as communication and cooperation, and increases students' academic success by helping them take responsibility for their learning (Doymuş, 2008; Johnson & Johnson, 2014; Jones & Jones, 2008; Özdilek et al., 2018). In this respect, cooperative learning is effective in acquiring 21st-century skills, including cognitive skills such as achievement,

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Accordingly, it is recommended that more emphasis be placed on practices that support students' active participation in discussion processes in educational settings.

The study showed that jigsaw-assisted activities supported the evaluation of different perspectives and collaborative thinking processes of PSTs. Therefore, integrating argumentation-based applications supported by cooperative learning techniques into teaching can enhance students' scientific reasoning and critical thinking skills.

It has been observed that PSTs develop more structured and reasoned explanations in their written arguments as the process progresses. Accordingly, it is suggested that regular writing activities and discussion-based practices be incorporated into teaching processes to improve written argumentation skills.

Future research is expected to contribute to the field by examining long-term applications across different learning levels and with diverse sample groups. Furthermore, investigating the impact of technology-supported argumentation applications on students' scientific thinking and decision-making processes is an important research area for future studies.

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Chapter 6

CURRICULUM FLEXIBILITY AND CONTEXTUAL ADAPTATION IN SCIENCE EDUCATION

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Introduction

Contemporary science education is shaped by the tension between efforts to create consistent and high expectations for all students through centralised structures like the Next Generation Science Standards (NGSS) in the United States, and the needs of local contexts (Nordine & Fortus, 2026). Within this framework, curriculum flexibility in science education makes it possible to reconceptualise the classroom as a dynamic social system where students construct meaning by using their own ideas (Adah Miller et al., 2025; Nordine & Fortus, 2026).

Project-based learning (PBL) and science, technology, engineering, and mathematics (STEM) practices provide rich learning contexts where students from diverse demographic groups can develop their cognitive flexibility and knowledge-in-use skills (Adah Miller et al., 2025; Kwon & Lee, 2025). Associating science education with flexible and project-based models structured around real-world issues is directly linked to discussions on the use of contexts such as climate change, biotechnology, and the water crisis as effective tools in curriculum design (Adah Miller et al., 2025; Nordine & Fortus, 2026; Zhang & Ma, 2023).

Standardised curricula tend to reduce education to abstract disciplinary subjects and performance expectations that are detached from context. This can create a "curriculum coverage mentality" in teachers that limits opportunities for in-depth learning (Nordine & Fortus, 2026; Touchet et al., 2024). Considering international assessments, the stagnation in science achievement in many developed countries has been discussed in terms of the insufficient alignment between standardised

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Future Research Directions

Future studies should address curriculum flexibility in science education not by reducing it to single variables, but through the ecological interactions among socioeconomic conditions, school culture, and teacher agency. Examining these interactions through longitudinal and comparative studies is essential for understanding how flexible curriculum practices are shaped across different contexts.

In particular, the sustainable effects of CCD processes on teacher identities and classroom practices, as well as how these processes are reflected in student learning outcomes, should be investigated.

The transferability of skills such as creativity and critical thinking, acquired through PBL and STEM-PBL practices, to different disciplines and life situations should be considered as a key evaluation criterion for the success of flexible curricula.

How teacher agency is manifested in different cultural contexts and school typologies (e.g., in the context of differences between public and private schools) should also be investigated.

Finally, OER and digital tools should be evaluated by considering their impact on instructional quality, professional judgement, and contextual adaptation strategies.

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Chapter 7

AN EXAMINATION OF THE READABILITY OF ABSTRACTS FROM READABILITY STUDIES ON BIOLOGY TOPICS PUBLISHED IN TÜRKIYE BETWEEN 2000 AND 2026

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Introduction

Readability, in one of its simplest definitions, refers to a text addressing the reader's level—in other words, being understood by the reader (Ateşman, 1997; Çoban, 2014). A text's comprehensibility and clarity determine its readability and understandability. Although these two concepts are often confused, readability stems primarily from the text's structural characteristics, whereas comprehensibility is addressed within a broader framework that encompasses contextual complexity and individual personality traits (Telles & Salotti, 2024).

Readability is often measured using three approaches: expert judgment, the readability index method, and readability formulas (Board of Education and Discipline [TTKB], 2021). Studies on readability have facilitated the identification of factors influencing reading success and have helped improve readability outcomes through the widespread adoption of appropriate formulas (DuBay, 2004). However, readability levels in different languages may not be measurable using the same formulas due to differences in language structures (Temur, 2003). Consequently, the literature contains numerous readability formulas developed for different languages. The most widely used ones for English and Turkish are the Flesch-Kincaid Grade Level (Kincaid et al., 1975), Flesch Reading Ease Formula (Flesch, 1948), Gunning-Fog Index (Gunning, 1952), Ateşman Formula (Ateşman,

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By expanding the content of academic writing courses offered in graduate programs, future researchers can be taught not only how to produce scientific content but also, through practical exercises, how to test this content using readability metrics, how to establish a balance between words and sentences, and how to optimize it linguistically.

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