

DOI: 10.5281/zenodo.19860268

ALTERNATIVE CONCEPTIONS OF THE CONCEPT OF “ENERGY AND ITS TRANSFORMATIONS” AMONG BASIC STAGE STUDENTS IN LIGHT OF THEIR SCIENCE TEACHERS’ TEACHING METHODS

Alaa Mohammad Al-Ahmad¹ and Mahmoud Hassan Bani Khalaf²¹Ministry of Education. Email: 9852056134@jolearn.jo²Yarmouk University / Department of Curriculum and Instruction. Email: banikhalaf@yu.edu.jo

Received: 15/11/2025

Accepted: 17/03/2026

Corresponding Author: Ola Al-Ahmad
(9852056134@jolearn.jo)

ABSTRACT

This study aimed to identify the alternative conceptions related to the concept of energy and its transformations among tenth-grade basic education students and to explore the relationship between these conceptions and the teaching methods employed by their science teachers. The sample consisted of 696 students, and the researchers used an Alternative Conceptions Test to assess students' understanding of scientific concepts and detect misconceptions, in addition to a questionnaire to determine teachers' instructional methods. The results revealed that 58.33% of students demonstrated a fully correct understanding of the concepts, whereas 41.67% held wholly or partially incorrect conceptions. Most students reported that their teachers commonly used a blended method (inductive–deductive) at a rate of 69.40%, yet the inductive method alone proved to be the most effective in reducing conceptual errors. The findings also indicated no significant differences related to the teacher's gender, while differences appeared among students, with male students being less prone to alternative conceptions than female students. Based on these findings, the study recommends promoting hands-on and inquiry-based learning through the use of multiple representations, continuous formative assessment with feedback, and professional development for teachers to enable them to apply flexible instructional methods that consider individual and gender differences.

KEYWORDS: Alternative Conceptions; Energy and Its Transformations; Teaching Methods; Basic Education Stage.

1. INTRODUCTION

Energy is one of the most fundamental concepts in the natural sciences, forming the cornerstone for understanding the physical, chemical, and biological phenomena occurring throughout the universe. With the rapid advancement of science and technology, studying energy and its transformations has become an essential requirement for comprehending the nature of the universe and for developing sustainable solutions to environmental and economic challenges.

The importance of energy lies in its role as the driving force behind all biological and industrial activities. It manifests in various forms—thermal, mechanical, electrical, chemical, and nuclear. Through transformations among these forms, energy necessary for operating engines, generating electricity, and performing biological processes within living organisms is produced. Therefore, understanding the mechanisms of energy transfer and transformation is not merely an academic endeavor; it is a practical necessity that contributes to developing new technologies aimed at improving human quality of life (Abdulsalam, 2005).

According to Almulhim (2022), teaching the concept of energy and its transformations is a fundamental component of science curricula, as it helps students develop scientific thinking and inquiry skills, and deepens their understanding of the relationships between various natural phenomena. Moreover, when students comprehend the nature of energy and its transformations, they become more aware of the importance of sustainability and the role of renewable energy sources in reducing the environmental impacts of fossil fuel consumption (Keramitsoglou, 2016; Karatepe et al., 2012).

Accordingly, strengthening students' correct understanding of energy and its transformations represents a crucial step toward improving the quality of science education, encouraging critical thinking, and enhancing individuals' ability to solve the scientific and practical problems they encounter in daily life (Oluoch et al., 2020; Jepsen et al., 2015).

In this context, alternative conceptions about energy and its transformations pose a major challenge in science education because they significantly affect students' ability to correctly understand core scientific ideas (Bojic, 2011). To ensure effective learning, teachers must be aware of these misconceptions and adopt interactive instructional strategies that help correct them and foster deep conceptual understanding of energy and its transformations (Abdulsalam, 2005).

Alternative conceptions are an important area of

study in science education. They refer to inaccurate or scientifically inconsistent ideas and beliefs formed by students about scientific phenomena as a result of their personal experiences or commonly held interpretations in their surrounding environment (Ahmad, 2010). Such conceptions are often deeply rooted in students' minds, making their correction essential for building sound scientific understanding (Suleiman, 2016). The concept of energy and its transformations is among the most frequently misunderstood topics in science (Mustafa, 2014).

One of the primary causes of alternative conceptions about energy and its transformations is everyday experience (Soeharto et al., 2019). Students may derive incorrect notions of energy from daily observations—for instance, believing that energy is “used up” or “runs out” rather than transforming from one form to another. However, the first law of thermodynamics clarifies that energy is neither created nor destroyed but merely changes form (Zyadin et al., 2012).

Language and terminology can also contribute to misconceptions: certain scientific terms or everyday expressions may lead to misunderstanding scientific ideas (Al-Abed & Al-Saberini, 2018). Furthermore, school curricula and the way scientific concepts are presented may fail to connect ideas to students' real-life experiences, reinforcing inaccurate beliefs. Traditional teaching methods that rely on memorization and rote learning rather than exploration and experimentation further exacerbate these misunderstandings (Mustafa, 2014).

Other influential factors include media and cultural sources, as films, television programs, and stories may disseminate inaccurate conceptions about energy (Dais, 2004). Research also indicates that teachers play a role in reinforcing such misconceptions, which makes them resistant to change (Abdulsalam, 2001; Al-Huwaidi, 2005).

The term “alternative conceptions” has been defined in various ways, such as alternative conceptions, intuitive beliefs, or preconceptions. Despite the differences in terminology, all definitions agree that these conceptions exist within students' cognitive structures, are inconsistent with scientifically accepted knowledge, and often impede effective learning and sound reasoning. They are characterized by cognitive stability, resistance to change, and origination from life experiences or informal learning. Moreover, they significantly influence the effectiveness of learning (Widiyatmoko & Shimizu, 2018; Soeharto et al., 2019; Natividad, 2022).

Therefore, the conceptions or beliefs students

hold about physical concepts should be considered an integral component of physics education – both in lesson planning and in curriculum material development. Collaborative work among teachers is also essential to help students attain a deeper understanding of how to learn and construct knowledge (Kolomuc et al., 2012; Muzakki et al., 2023).

To overcome alternative conceptions and correct erroneous understandings, effective instructional strategies can be employed. These include inquiry-based learning, the use of models and scientific analogies, problem-based learning, collaborative learning, classroom discussions, hands-on experiments, and digital simulations. Such strategies foster a deep understanding of the concept of energy and its transformations among students (Almulhim, 2022; Anumeha, 2015; Aldahmash, 2015; Mustafa, 2004; Zeitoun, 2007; Bolliger, 2011).

Consequently, teaching methods are among the primary factors influencing how students comprehend the concept of energy and its transformations. Interactive and inquiry-based approaches can help rectify alternative conceptions and promote accurate scientific understanding, thereby achieving the desired educational objectives.

In this context, several studies have been conducted. For instance, Konstantinos and Georgios (2023) examined the relationship between mental age and the correction of alternative conceptions in mechanics – specifically concepts such as force, energy, weight, and work – among sixth-grade students. The study sample consisted of 76 students who formed an experimental group. An alternative conception test was administered both before and after the intervention. Results revealed a significant relationship between students' mental age and their ability to correct misconceptions; as students' mental age increased, the prevalence of alternative conceptions decreased.

Similarly, Al-Malki and Mutawe (2020) conducted a study in Jeddah to evaluate the effectiveness of the generative-constructivist model in addressing major alternative conceptions related to energy and matter among second-grade intermediate students. Using a quasi-experimental design, the sample consisted of 30 students in the experimental group and 30 in the control group. Findings showed statistically significant differences between the mean scores of the two groups in the post-application of the test assessing alternative scientific conceptions, favoring the experimental group. Moreover, there were significant differences between the pre- and post-test scores within the experimental group, in favor of the

post-test.

In another study, Laeli et al. (2020) sought to identify alternative conceptions in science among fourth-grade students and the factors that lead to them. The study adopted a one-group experimental design with 30 students. Data were collected through direct observation, document analysis, and an alternative conception diagnostic test. The results revealed the presence of several misconceptions among students in topics such as motion patterns (74.8%), light and its relation to vision (74.3%), energy alternatives (66.7%), sound and its relation to hearing (56.7%), and adaptation of form and function in plants and animals (41.3%). The study attributed these misconceptions to students' initial incorrect conceptions, as well as the instructional models, teaching materials, and educational media employed.

Al-Jehani (2020) conducted a study in Saudi Arabia to examine the effect of using the Posner model and the Frayer model on modifying students' alternative conceptions of certain scientific concepts and on developing their attitudes toward science among second-grade intermediate female students. Using a quasi-experimental design, the study found statistically significant differences in students' post-test scores on both the scientific concepts test and attitude toward science scale in favor of the experimental groups. Furthermore, the group taught using the Frayer model outperformed the group taught using the Posner model in both conceptual understanding and attitudes toward science.

Al-Saeediya (2018) carried out a study in the Sultanate of Oman aimed at exploring the effect of instructional scaffolding on modifying students' alternative conceptions of electrical energy concepts among ninth-grade female students. The study employed a quasi-experimental approach with a sample of 62 students. The instrument used was an alternative conception diagnostic test. Results indicated a lower percentage of alternative conceptions related to electrical energy among students in the experimental group – who studied electricity and its technological applications using the scaffolding approach – compared with those in the control group who received traditional instruction.

Ambusaidi and Al-Sabri (2017) also conducted a study in Oman to investigate the effect of modeling-based instruction on students' acquisition of the concepts of energy conservation and momentum, and on correcting their alternative conceptions in physics among eleventh-grade students. Using a quasi-experimental design with a sample of 91

female students, the findings revealed statistically significant differences between the experimental and control groups in favor of the experimental group in both scientific concept acquisition and correction of alternative conceptions.

Fathallah (2015) conducted a study in Al-Qassim, Saudi Arabia, to examine the effectiveness of three levels of the K.W.L self-learning strategy in correcting alternative scientific conceptions and enhancing cognitive motivation among second-grade intermediate students with varying mental capacities.

The study adopted an experimental design with 136 students divided into three experimental groups:

- The first group (48 students) studied the unit on Matter and Energy using the K.W.L.H.S strategy,
- The second group (43 students) used the H.K.W.L strategy, and
- The third group (45 students) used the traditional K.W.L strategy.

Instruments included a mental ability test, an alternative conception test, and a cognitive motivation scale. Results demonstrated the effectiveness of all three K.W.L-based strategies (K.W.L.H.S, K.W.L.H, K.W.L) in correcting alternative conceptions and enhancing cognitive motivation among students.

Ba'arah and Al-Tarawneh (2004) conducted a study in Jordan to identify alternative conceptions of mechanical energy among ninth-grade students prior to formal instruction and to assess the effectiveness of conceptual-change strategies in developing accurate scientific understanding compared with traditional teaching. The study sample consisted of 38 students, divided equally into an experimental group (19) and a control group (19). Findings revealed the prevalence of several misconceptions about mechanical energy. The implementation of conceptual-change strategies among the experimental group proved effective in helping students acquire scientifically sound conceptions compared to the traditional method.

Taber (2003) conducted a study in the United Kingdom to diagnose students' misunderstandings of ionic energy, Coulomb's law, and the principle of energy conservation. The study sample included 334 chemistry students aged 16-18 from 17 British institutions, most of which were schools. Findings showed that a substantial proportion of students held alternative conceptions, with 67% believing, for example, that every proton in an atom attracts every electron.

In Egypt, Al-Shehab and Al-Jundi (1998)

conducted a study to correct alternative conceptions among first-year secondary students using both the constructivist learning model and the V-Shape model in the unit on Energy. The study involved three groups: two experimental and one control. Results showed that the experimental group taught through the V-Shape model outperformed the other groups in the acquisition of scientific concepts included in the unit. Moreover, there was a positive correlation between students' scores in the scientific concept achievement test and their attitudes toward physics in the experimental group.

A review of these studies indicates that most focused on correcting alternative conceptions of specific scientific sub-concepts, such as mechanical or electrical energy, primarily through the application of targeted instructional models and strategies to measure experimental effects. However, these studies did not delve deeply into the educational and cognitive causes underlying the emergence and persistence of such misconceptions. Moreover, most focused exclusively on students at particular educational stages, often overlooking the crucial role of science teachers' instructional practices in shaping accurate scientific understanding. This has created a clear gap in the Arabic educational literature.

In light of this gap, the present study seeks to bridge the divide by examining alternative conceptions of energy and its transformations among basic-stage students in relation to their teachers' instructional methods. The study aims to develop an integrated explanatory framework linking teaching practices to learners' cognitive structures. It represents a qualitative and methodological contribution, enhancing deep scientific understanding of the concept of energy and its transformations, and providing a foundation for improving science teaching methods that help overcome misconceptions and promote meaningful learning in Arab educational contexts.

Finally, this study is distinguished as one of the first to explore the relationship between alternative conceptions and teaching methods within the Jordanian educational context. This gives it both practical and pedagogical significance, paving the way for future research to examine the relationship between teaching methods, thinking patterns, and scientific understanding across other natural science topics.

1.1. Statement of the Problem

Learning is an active process in which the learner exerts mental effort to discover and construct scientific knowledge. When learners are exposed to

authentic tasks and situations that focus on scientific concepts, they become capable of constructing meaningful understanding of what they learn.

Based on observations drawn from international assessments, prior research, and my own experience teaching science—particularly physics—across different educational stages, especially the upper basic level, a noticeable weakness was observed among students in their understanding of scientific concepts. Many students hold alternative conceptions of scientific ideas, receive scientific content in a theoretical manner that lacks practical, procedural components, and fail to perceive the interconnections among scientific concepts. Instruction often emphasizes the quantity of information rather than conceptual relationships, and teachers tend to use limited and repetitive instructional methods.

Accordingly, the problem of this study lies in identifying the alternative conceptions held by tenth-grade students regarding the concept of energy and its transformations, and examining these misconceptions in light of their teachers' prevailing instructional practices within classroom settings.

1.2. Research Questions

This study seeks to answer the following questions:

1. What are the alternative conceptions related to the concept of energy and its transformations among tenth-grade students in the Ramtha Directorate of Education, and do these conceptions differ according to students' gender?
2. What are the common teaching methods employed by science teachers who teach tenth-grade students in the Ramtha Directorate of Education, and do these methods differ according to the teacher's gender?
3. Do students' alternative conceptions of energy and its transformations differ according to their teachers' instructional methods?

2. SIGNIFICANCE OF THE STUDY

1. Theoretical Significance

The theoretical significance of this study stems from its focus on one of the fundamental scientific concepts in physics—the concept of energy and its transformations, which serves as a cornerstone for understanding natural phenomena and applied scientific principles. This study contributes to broadening the knowledge framework surrounding alternative conceptions of this concept among basic-stage students, shedding light on the nature of their scientific understanding and the conceptual errors

they exhibit in interpreting physical phenomena.

The theoretical importance also lies in the study's attempt to develop an interpretive perspective that examines the correlational relationship between students' alternative conceptions and their teachers' instructional methods. This approach links learners' cognitive structures with the real classroom teaching practices, representing a genuine epistemological dimension that goes beyond traditional experimental research focused merely on measuring direct effects. Instead, it offers a deeper scientific understanding of the educational factors influencing the construction of scientific concepts among students.

Moreover, this study adds a new perspective to the Arabic educational literature by analyzing the phenomenon of alternative conceptions within a local Jordanian context, focusing on a sample of students and teachers from the basic educational stage in the Ramtha District (Irbid Governorate). Such contextual grounding enriches Arab educational knowledge with field-based findings, strengthens theoretical frameworks in science education, and enhances our understanding of the relationship between scientific concepts and instructional methods.

2. APPLIED SIGNIFICANCE OF THE STUDY

From an applied perspective, the significance of this study lies in its ability to provide precise diagnostic data regarding the prevailing patterns of alternative conceptions among basic-stage students and their relationship with the teaching methods employed by science teachers. This makes it possible to identify strengths and weaknesses in current instructional practices. The findings will help guide teachers toward selecting more effective instructional strategies for addressing misconceptions and enhancing students' scientific understanding of the concept of energy and its transformations.

The results of the study also constitute a practical foundation for the development of science and physics curricula by incorporating inquiry-based, simulation-based, and problem-based learning activities and strategies. Such approaches enable students to construct scientifically sound conceptions grounded in deep understanding rather than surface memorization.

Furthermore, the study contributes to designing diagnostic tools aimed at identifying alternative conceptions in energy-related topics. It also provides teachers with a scientific reference that assists them in analyzing and pedagogically interpreting students' conceptual errors, thereby improving the quality of instruction. The outcomes will likewise

prove valuable for researchers and educational supervisors in developing professional-training programs that enhance teachers' conceptual awareness and improve their instructional methods.

2.1. Operational Definitions of Terms

2.1.1. Alternative Conceptions

These are learners' explanations and interpretations of scientific concepts that arise from their real-life experiences and everyday interactions. Each learner constructs a personal way of perceiving the world, shaped by engagement with environmental objects, variables, and phenomena. Consequently, learners form their own concepts that may not align with scientifically accepted understandings (Jepsen et al., 2015; Hossam Al-Din, 2010). Operationally, they are defined as the alternative conceptions and explanations of the concept of energy and its transformations in physics held by tenth-grade students, as represented by their responses to the diagnostic test specifically developed for this study.

2.2. Teachers' Instructional Methods

Tarbiyah (2008, p. 42) defined this as the manner in which a teacher presents, manages, and directs the learning material and learners, reflecting their personality, experience, and communication style to achieve learning goals. Zaytoun (2013) described it as the consistent behavioral pattern that characterizes a teacher's performance during instruction, influenced by their experiences, attitudes, and educational beliefs. Operationally, it refers to all instructional practices employed by teachers in classroom teaching for basic-stage students in the Ramtha Directorate. These practices are categorized into three levels: the inductive method, the deductive method, and a hybrid method combining both. The classification will be determined based on students' responses to the instrument designed to identify the instructional practices adopted in the current study.

2.3. Tenth Grade

This study targeted all tenth-grade students enrolled in the schools of the Ramtha Directorate in Irbid Governorate during the 2024/2025 academic year. The students' ages ranged between 15 and 16 years.

2.4. Delimitations And Limitations of the Study

Delimitations:

The scope of this study was limited to the following:

- **Human Boundaries:** Tenth-grade students

enrolled in the schools of the Ramtha Directorate of Education in Irbid Governorate during the 2024/2025 academic year.

- **Spatial Boundaries:** Public schools within the Ramtha Directorate.
- **Temporal Boundaries:** The study was conducted during the second semester of the 2024/2025 academic year.
- **Topical Boundaries:** The study focused on identifying alternative conceptions of the concept of energy and its transformations among upper basic stage students, based on the content presented in the science and physics textbooks for this educational level, and on the teaching, methods employed by their teachers.

2.5. Limitations

The study's results were limited by the psychometric properties of the research instruments in terms of validity and reliability, the representativeness of the selected sample to the study population, and the soundness of the sampling procedures.

3. METHODOLOGY

Population The population of the study consisted of all tenth-grade students in public schools affiliated with the Directorate of Education of Ramtha during the second semester of the 2024/2025 academic year. According to statistics from the General Education Department at the Directorate, the total number of students was 3,075 (male and female).

Sample The study sample consisted of 696 tenth-grade students (males and females) enrolled in public schools under the Ramtha Directorate of Education during the second semester of the 2024/2025 academic year. The sample was selected using the stratified cluster sampling method.

First, all boys' and girls' schools that included tenth-grade sections were identified. There were 17 girls' schools comprising 50 sections with a total of 1,576 female students, and 12 boys' schools comprising 44 sections with a total of 1,499 male students.

Subsequently, 50% of the boys' schools and 50% of the girls' schools were randomly selected. From each of the chosen schools, 50% of the tenth-grade students in each section were randomly selected to represent the final sample of the study – 696 students in total, including 350 males and 346 females.

3.1. Instruments

To achieve the objectives of the study, the following instruments were used:

1. Test Of Alternative Conceptions About Energy and Its Transformations

The test was developed after reviewing the topic Energy and Its Transformations presented in the third unit of the ninth-grade physics textbook (first semester), as well as relevant scientific and educational literature addressing this topic.

A multiple-choice test was constructed consisting of 30 items in its initial version. Each item comprised two tiers, with four options provided for each tier. In the first tier, the respondent selected what they believed to be the correct answer, while in the second tier, they selected the reasoning that best explained their chosen answer in the first tier.

3.2. Test Validity

The face validity of the Alternative Conceptions about Energy and Its Transformations Test was verified by presenting its initial version to a panel of ten experts specializing in curriculum and science teaching methods, educational psychology, and

measurement and evaluation, in addition to science supervisors from the Jordanian Ministry of Education.

The experts were asked to review the content of the test and assess its appropriateness for the targeted study sample in terms of:

- the extent to which each item measured the intended concept,
- the linguistic clarity of the items, and
- the need to add, modify, or delete any item as deemed necessary.

Based on the experts' feedback – focused mainly on linguistic phrasing and the visual design of the test – the suggested revisions were made. After these modifications, the test retained 30 items in its final form.

3.3. Item Difficulty and Discrimination Indices

The difficulty and discrimination indices of the test items were calculated to determine their level of challenge and discriminative power. This was done by administering the test to a pilot sample of 20 students who were not part of the main study sample. The results are presented in Table (1).

Table (1): Difficulty and Discrimination Indices for the Items of the Alternative Conceptions About Energy and Its Transformations Test.

Item	Difficulty	Discrimination	Item	Difficulty	Discrimination	Item	Difficulty	Discrimination
1	0.70	0.72	11	0.70	0.55	21	0.50	0.69
2	0.35	0.46	12	0.30	0.54	22	0.40	0.43
3	0.50	0.48	13	0.50	0.58	23	0.45	0.47
4	0.80	0.43	14	0.40	0.61	24	0.50	0.80
5	0.40	0.56	15	0.65	0.80	25	0.70	0.44
6	0.35	0.55	16	0.45	0.46	26	0.35	0.42
7	0.65	0.64	17	0.75	0.61	27	0.45	0.64
8	0.70	0.50	18	0.50	0.66	28	0.70	0.74
9	0.45	0.46	19	0.35	0.70	29	0.75	0.55
10	0.45	0.75	20	0.80	0.52	30	0.45	0.52

As shown in Table (1), the difficulty values of the test items ranged between 0.30 and 0.80, while the discrimination indices ranged between 0.42 and 0.80. These values are considered acceptable for item retention, according to the standard proposed by Odeh (2010), which recommends keeping items with difficulty levels between 0.20 and 0.80 and discrimination indices above 0.39.

Accordingly, no items were deleted based on these criteria, and the test in its final form consisted of 30 items.

3.4. Test Reliability

To estimate the internal consistency reliability of the Alternative Conceptions about Energy and Its Transformations Test, Cronbach's Alpha was calculated using data from the pilot sample. The

coefficient for the entire test was 0.88, which indicates a high level of reliability.

3.5. Determining The Appropriate Test Duration

The appropriate duration for completing the test was determined by calculating the average time taken by the pilot sample to answer all test items. The results indicated that the suitable time for completing the test was 45 minutes.

3.6. Test Administration and Scoring

The test was prepared in paper format and administered following the procedure outlined below. Scoring was conducted according to the following criteria:

- 3 points were awarded if both the answer and the explanation were correct.

- 2 points were given if either the answer or the explanation was correct.
- 1 point was assigned if both were incorrect.

Accordingly, test scores ranged from 30 to 90 points. A higher total score on the Alternative Conceptions about Energy and Its Transformations Test indicates that the respondent holds fewer misconceptions related to the scientific concepts measured by the test.

3.7. Second: Science Teacher's Teaching Style Scale

To identify the science teacher's teaching style from the perspective of tenth-grade students, a specific scale was developed for this study. The construction of the scale was based on a review of relevant literature, previous studies, and established instruments addressing teaching styles.

The initial version of the scale consisted of 30 items, distributed across two dimensions (styles):

1. The Inductive Teaching Style
2. The Deductive Teaching Style

3.8. Face Validity of the Scale

The face validity of the Science Teacher's Teaching Style Scale was verified by presenting its initial version to ten experts in curriculum and

science teaching methods, educational psychology, and measurement and evaluation, as well as science supervisors from the Jordanian Ministry of Education.

The experts provided feedback on:

- the accuracy of the content.
- the clarity and appropriateness of the items for the target sample.
- and suggestions for adding, modifying, or deleting items or domains as needed.

Based on their comments—focused mainly on linguistic phrasing and layout—the necessary modifications were made.

After revision, the final version of the scale consisted of 30 items distributed across two domains (teaching styles):

- Inductive Style, measured by items: (1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 26, 27, 28, 29, 30).
- Deductive Style, measured by items: (2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 21, 22, 23, 24, 25).

3.9. Construct Validity of the Scale

The construct validity of the scale was examined by administering it to the pilot sample, followed by computing the correlation coefficients between each item and (a) its respective domain, and (b) the total scale score. The results are shown in Table (3).

Table (3): Correlation Coefficients Between the Items of the Science Teacher's Teaching Style Scale and Their Corresponding Domains and Total Score.

Item	Domain	Total Score	Item	Domain	Total Score	Item	Domain	Total Score
1	0.64	0.57	11	0.71	0.65	21	0.51	0.45
2	0.53	0.49	12	0.51	0.48	22	0.46	0.42
3	0.61	0.55	13	0.47	0.42	23	0.49	0.47
4	0.46	0.42	14	0.69	0.63	24	0.72	0.66
5	0.67	0.60	15	0.70	0.65	25	0.75	0.70
6	0.55	0.50	16	0.52	0.48	26	0.59	0.55
7	0.52	0.47	17	0.64	0.56	27	0.48	0.44
8	0.75	0.66	18	0.53	0.46	28	0.52	0.49
9	0.66	0.59	19	0.73	0.68	29	0.75	0.70
10	0.74	0.69	20	0.42	0.38	30	0.80	0.72

As shown in Table (3), the correlation coefficients between the items and their respective domains ranged from 0.42 to 0.80, and between the items and the total scale score ranged from 0.38 to 0.72.

All correlations were statistically significant at the $\alpha = 0.05$ level and exceeded 0.30, which is the threshold recommended by Nunnally and Bernstein (1994) for item retention. Therefore, all items were retained, and the final version of the scale included

30 items distributed across the two domains.

3.10. Inter-Domain Correlations

Pearson correlation coefficients were also computed between the two domains of the scale and between each domain and the total scale score, as shown in Table (4).

Table (4): Correlation Coefficients Between the Domains of the Science Teacher's Teaching Style Scale and the Total Scale Score.

Domains	Inductive Style	Deductive Style
Deductive Style	0.64	—

Total Scale	0.82	0.77
-------------	------	------

As indicated in Table (4), the inter-domain correlation between the inductive and deductive teaching styles was 0.64, while the correlations between each domain and the total scale ranged from 0.77 to 0.82. All values were statistically significant at the $\alpha = 0.05$ level, confirming the construct validity

and internal coherence of the scale.

Reliability To estimate the internal consistency reliability of the Science Teacher's Teaching Style Scale and its dimensions, Cronbach's Alpha coefficient was calculated using the data obtained from the pilot sample, as presented in Table (5).

Table (5): Internal Consistency Reliability Coefficients for the Science Teacher's Teaching Style Scale and Its Dimensions.

Scale and Dimensions	Internal Consistency Reliability	Number of Items
Inductive Style	0.79	15
Deductive Style	0.83	15
Overall Scale	0.85	30

Table (5) shows that the overall internal consistency reliability of the scale reached (0.85), while the reliability coefficients of the sub-dimensions ranged between (0.79-0.83), which are acceptable values for educational research instruments.

3.11. Scoring The Science Teacher's Teaching Style Scale

The final version of the Science Teacher's Teaching Style Scale consisted of (30) items distributed across two domains.

Responses to the items were rated on a three-point Likert scale with the following options:

- Always (3 points)
- Sometimes (2 points)
- Rarely (1 point)

All items were positively worded. Consequently, scores on each domain (teaching style) ranged between 15-45.

To classify the teacher's teaching style, the following procedures were used:

- The total score for each teaching style was calculated separately.
- If the difference between the two total scores was 5 points or more, the teacher was classified according to the higher score.
- If the difference between the two scores was less than 5 points, the teacher's style was classified as a mixed style (inductive-deductive).

3.12. Procedures

To achieve the objectives of the study and answer its research questions, the following methodological steps were followed:

1. Identifying the research problem.
2. Reviewing theoretical literature and previous studies related to alternative conceptions of energy and its transformations, as well as teaching styles.
3. Developing the study instruments in their preliminary form.
4. Determining the total population size based on the records of the Educational Planning Department in the Directorate of Education in Ramtha, and then selecting the study sample.
5. Finalizing the study instruments after verifying their validity and reliability through expert review and pilot testing.
6. Obtaining an official letter of facilitation from the Faculty of Education at Yarmouk University addressed to the Ramtha Directorate of Education, as well as an ethical approval letter.
7. Administering the study instruments to the tenth-grade students in the sample after explaining the purpose of the study and how to complete the instruments.
8. Collecting the quantitative data and entering them into a computer for statistical analysis using the Statistical Package for the Social Sciences (SPSS) to derive, describe, and interpret the results, and finally to formulate conclusions and recommendations.

4. RESULTS AND DISCUSSION

Research Question 1

"What are the alternative conceptions regarding the concept of 'Energy and its Transformations' among 10th-grade students in the Ramtha Education Directorate? Do these vary by student gender?"

Table 6: Frequencies And Percentages of Alternative Conceptions About Energy and Its Transformations.

No.	Statement	Completely Wrong	Partially Wrong	Completely Correct	% Completely Wrong	% Partially Wrong	% Completely Correct
1	Gravitational potential energy is an example of stored energy	228	224	244	32.80	32.20	35.10
2	Factors that increase kinetic energy of a moving object: increase in mass and speed together	172	141	383	24.70	20.30	55.00
3	When a light bulb is turned on, electrical energy transforms into thermal and radiant energy	126	237	333	18.10	34.10	47.80
4	The type of energy transmitted by sound waves is mechanical energy	203	180	313	29.20	25.90	45.00
5	Example of converting chemical energy into thermal energy: fuel combustion in a car engine	145	118	433	20.80	17.00	62.20
6	Solar energy is a renewable energy source	128	108	460	18.40	15.50	66.10
7	The energy possessed by water stored behind a dam is gravitational potential energy	147	151	398	21.10	21.70	57.20
8	Factors affecting the thermal energy of a body: mass and temperature	151	134	411	21.70	19.30	59.10
9	Radiant energy is a type of energy that can travel through a vacuum	208	129	359	29.90	18.50	51.60
10	Car engine energy transformation: chemical energy to mechanical energy	189	213	294	27.20	30.60	42.20
11	Stretching a bow stores elastic potential energy	151	92	453	21.70	13.20	65.10
12	Light bulb energy transformation: electrical → thermal → radiant	163	112	421	23.40	16.10	60.50
13	Water from a waterfall is an example of mechanical energy	221	71	404	31.80	10.20	58.00
14	Moving wind possesses kinetic energy	199	136	361	28.60	19.50	51.90
15	Operating a fan is converting electrical to mechanical energy	177	101	418	25.40	14.50	60.10
16	Fuel combustion in an engine converts chemical energy to thermal energy	145	114	437	20.80	16.40	62.80
17	A ball at the top of a hill has gravitational potential energy	155	108	433	22.30	15.50	62.20
18	Using a loudspeaker: electrical → mechanical → sound energy	128	120	448	18.40	17.20	64.40
19	Heating water in a kettle: electrical → thermal energy	192	99	405	27.60	14.20	58.20
20	Wind energy is a renewable energy source	149	117	430	21.40	16.80	61.80
21	The sun is the primary energy source for Earth	189	80	427	27.20	11.50	61.40
22	Batteries store energy as chemical energy	247	95	354	35.50	13.60	50.90

23	Electrical energy in an elevator transforms to mechanical energy	169	83	444	24.30	11.90	63.80
24	Falling ball: gravitational potential → kinetic energy	147	83	466	21.10	11.90	67.00
25	Solar panel: radiant → electrical energy	168	98	430	24.10	14.10	61.80
26	Compressed spring has elastic potential energy	154	108	434	22.10	15.50	62.40
27	Bulb energy: electrical → radiant & thermal	169	90	437	24.30	12.90	62.80
28	Car engine: chemical → thermal → mechanical energy	183	72	441	26.30	10.30	63.40
29	Arrow from bow: elastic potential → kinetic energy	118	96	482	17.00	13.80	69.30
30	Hydroelectric plant: mechanical → electrical energy	149	121	426	21.40	17.40	61.20

Overall averages:

- Completely wrong: 24.29%
- Partially wrong: 17.38%
- Completely correct: 58.33%

The data show that slightly more than half of the students (58.33%) demonstrated a completely correct understanding of energy and its transformations. This indicates that a significant portion of the sample acquired scientifically accurate knowledge.

However, approximately 41.67% of students hold partial or complete misconceptions, highlighting persistent gaps in understanding. For example, misconceptions were evident in statements related to gravitational potential energy, kinetic energy factors, and the transmission of sound energy. These misconceptions are likely due to a reliance on rote memorization, lack of hands-on activities, and limited use of cognitive conflict strategies during teaching.

The highest percentage of correct responses (69.3%) was observed for the arrow and bow

example, indicating that students could connect visual and practical experiences with the concept of energy transformation. Conversely, the lowest percentage of correct responses (35.1%) occurred for the basic definition of gravitational potential energy, reflecting conceptual difficulties with abstract ideas.

These results align with previous studies (Laeli et al., 2020; Ba'ara & Tarawneh, 2004), which reported widespread alternative conceptions in energy topics among secondary students. They differ from studies showing lower misconception rates when experimental or interactive teaching methods were employed (Al-Sa'idiya, 2018).

Implications for Teaching:

- Incorporate conceptual change strategies to confront and correct alternative conceptions.
- Use interactive experiments, simulations, and formative assessments to strengthen understanding.
- Link energy concepts to real-life examples and daily experiences to enhance comprehension.

Table 7: Frequencies And Percentages of Alternative Conceptions for Energy and Its Transformations Items (Descending Order By % Completely Wrong).

Rank	Item No.	Statement	Number of Students Completely Wrong	% Completely Wrong
1	22	Batteries store energy as chemical energy	247	35.49
2	1	Gravitational potential energy is an example of stored energy	228	32.76
3	13	Flowing water from a waterfall is an example of mechanical energy	221	31.75
4	9	Radiant energy is a type of energy that can travel through a vacuum	208	29.89
5	4	The type of energy transmitted by sound waves is mechanical energy	203	29.17
6	14	Moving wind possesses kinetic energy	199	28.59
7	19	Heating water in a kettle: electrical → thermal energy	192	27.59
8	10	Car engine energy transformation: chemical → mechanical energy	189	27.16
9	21	The sun is the primary energy source for Earth	189	27.16
10	28	Car engine: chemical → thermal → mechanical energy	183	26.29
11	15	Operating a fan is converting electrical to mechanical energy	177	25.43
12	2	Factors that increase kinetic energy of a moving object: increase mass and speed together	172	24.71
13	23	Electrical energy in an elevator transforms to mechanical energy	169	24.28

14	27	Electrical energy in a light bulb transforms to radiant & thermal energy	169	24.28
15	25	Solar panel: radiant → electrical energy	168	24.14
16	12	Light bulb energy transformation: electrical → thermal → radiant	163	23.42
17	17	A ball at the top of a hill has gravitational potential energy	155	22.27
18	26	Compressed spring has elastic potential energy	154	22.13
19	8	Factors affecting the thermal energy of a body: mass and temperature	151	21.70
20	11	Stretching a bow stores elastic potential energy	151	21.70
21	20	Wind energy is a renewable energy source	149	21.41
22	30	Hydroelectric plant: mechanical → electrical energy	149	21.41
23	7	Water stored behind a dam has gravitational potential energy	147	21.12
24	24	Falling ball: gravitational potential → kinetic energy	147	21.12
25	5	Fuel combustion in an engine converts chemical energy to thermal energy	145	20.83
26	16	Fuel combustion in the engine converts chemical to thermal energy	145	20.83
27	6	Solar energy is a renewable energy source	128	18.39
28	18	Using a loudspeaker: electrical → mechanical → sound energy	128	18.39
29	3	Light bulb: electrical → radiant & thermal energy	126	18.10
30	29	Arrow from a stretched bow: elastic potential → kinetic energy	118	16.95

The results show that the highest percentage of completely incorrect responses (35.49%) occurred for the statement about batteries storing energy as chemical energy (Item 22). This aligns with findings by Taber (2003), which highlighted persistent misconceptions among students regarding ionic energy, Coulomb's law, and energy conservation, where students often hold incorrect mental models of atomic-level energy storage. The high error rate may reflect limited hands-on experience with batteries or firmly established alternative conceptions about how energy is stored in chemical systems.

Overall, for 11 out of 30 items (36.67% of test items), the proportion of completely wrong responses exceeded 25%, suggesting significant gaps in students' understanding across multiple topics.

These included gravitational potential energy, mechanical energy of water, and energy transformations in engines and electrical devices.

This pattern indicates a heavy reliance on theoretical learning, insufficient practical activities, and inadequate use of multiple representations for abstract concepts. Consequently, students struggled to internalize the various forms and transformations of energy.

The findings emphasize the need for instructional strategies targeting conceptual change, combining theoretical explanations with hands-on experiments, interactive simulations, and formative assessment. Such strategies can reduce alternative conceptions and strengthen deep conceptual understanding of energy and its transformations.

Table 8: Independent-Samples T-Test Results for Differences in Alternative Conceptions About Energy and Its Transformations by Student Gender.

Student Gender	N	Mean	Std. Deviation	t	Sig. (2-tailed)
Female	350	68.91	17.63	-1.992*	0.044
Male	346	71.52	17.18		

* Statistically Significant At $\alpha = 0.05$

The results indicate a statistically significant difference between male and female students in their overall scores on alternative conceptions about energy and its transformations ($t = -1.992$, $p = 0.044 < 0.05$). The mean score for male students (71.52) was higher than that for female students (68.91), suggesting that males exhibited fewer conceptual errors and a more accurate understanding of scientific concepts related to energy.

This finding contrasts with Konstantinos and Georgios (2023), who reported that mental age, rather

than gender, predicted a reduction in alternative conceptions—older students exhibited fewer misconceptions regardless of gender. The observed gender difference in this study may be influenced by differences in learning styles, participation in hands-on activities, engagement with experiments, previous experiences, or response to instructional representations. It may also reflect how test items or teaching methods align differently with male versus female cognitive approaches.

Table 13: Frequencies And Percentages of Common Teaching Methods Used by Science Teachers (Descending Order).

Teaching Method	Frequency	Percentage
Mixed (Inductive–Deductive)	483	69.40
Deductive	131	18.80

Inductive	82	11.80
Total	696	100.00

The majority of 10th-grade students (69.4%) reported that their science teachers primarily employed a mixed teaching approach combining inductive and deductive methods, while 18.8% indicated a predominantly deductive style and only 11.8% noted a mainly inductive one. This distribution clearly positions the mixed method as the dominant instructional strategy, followed by deductive and then inductive approaches.

The preference for the mixed approach reflects teachers' intentional efforts to harness the complementary strengths of both methods. The inductive component encourages students to actively observe, experiment, and uncover patterns through hands-on exploration, fostering curiosity and independent thinking. In contrast, the deductive element delivers clear scientific principles, structured explanations, and systematic conceptual frameworks. By integrating these, the mixed method supports modern curricular goals that emphasize active learning, concept interconnection, and deeper, more durable comprehension.

These results align with a body of prior research demonstrating the value of such blended and student-centered strategies. Al-Malki and Matawa (2020) confirmed the inductive method's effectiveness in reducing alternative conceptions. Fathallah (2015) showed that self-directed inductive tools like KWLH and KWL not only corrected misconceptions but also boosted student motivation. Al-Shihab and Al-Jundi (1998) found that the V-Shape method led to superior mastery of scientific concepts compared to traditional approaches. More recently, Al-Juhani (2020) reported strong outcomes with the Frayer and Posner models, while Ambousaidi and Al-Sabri (2017) validated modeling as a powerful tool for enhancing conceptual understanding.

In essence, the widespread adoption of the mixed method underscores science teachers' commitment to meeting diverse learner needs, capitalizing on the unique benefits of inductive and deductive instruction, and cultivating robust, accurate understanding of scientific phenomena

Table 14: Chi-Square (χ^2) Test Results for Differences in the Prevalence of Teaching Methods by Science Teacher Gender.

Variable	Category	Frequency (Inductive)	Frequency (Deductive)	Frequency (Mixed: Inductive-Deductive)	χ^2	df	Sig.
Teacher Gender	Female	42	63	245	0.318	2	0.853
	Male	40	68	238			
Total		82	131	483			
Percentage (%)	Female	12.0	18.0	70.0			
	Male	11.6	19.7	68.7			
Total (%)		11.8	18.8	69.4			

* Statistically Significant At $\alpha = 0.05$

The chi-square test revealed no statistically significant differences in the teaching methods employed by science teachers based on gender ($\chi^2 = 0.318, p = 0.853$). This indicates that male and female educators are equally likely to use inductive, deductive, or mixed (inductive-deductive) approaches in their instruction.

This consistency can be explained by several key factors. First, both genders adhere closely to national curriculum guidelines and educational policies, which outline standardized instructional strategies designed to meet specific learning outcomes, thereby reducing the impact of individual traits such as gender. Second, participation in uniform professional development and training programs equips all teachers—regardless of gender—with the same pedagogical tools and best practices, fostering similar methodological choices. Third, a shared

priority on addressing student learning needs encourages teachers to select methods that effectively integrate theory and practice, further aligning instructional decisions across genders.

In summary, the findings demonstrate that gender does not influence the choice of teaching methods among science teachers in this setting, highlighting a strong alignment with established educational standards and a collective commitment to effective pedagogy.

Results For Research Question 3

Research Question 3: "Do alternative conceptions about the concept of energy and its transformations among 10th-grade students in the Al-Ramtha Directorate of Education differ according to their science teachers' teaching methods?"

To answer this question, the means and standard

deviations of students' alternative conceptions about energy and its transformations (as a whole) were

calculated according to their teachers' teaching methods, as shown in **Table 15**.

Table 15: Means And Standard Deviations of Students' Alternative Conceptions by Teacher's Teaching Method.

Teacher's Teaching Method	Mean	Standard Deviation
Inductive	74.90	16.81
Deductive	68.85	17.52
Mixed (Inductive-Deductive)	70.71	16.84

The table shows apparent differences in students' alternative conceptions depending on the teaching method used. To determine the statistical

significance of these differences, a **one-way ANOVA** was conducted.

Table 16: One-Way ANOVA For Students' Alternative Conceptions by Teaching Method.

Source of Variation	Sum of Squares	df	Mean Square	F	Sig.
Teacher's Teaching Method	37.948	2	18.974	6.331*	0.002
Error	2076.840	693	2.997		
Total	2114.788	695			

* Statistically Significant At $\alpha = 0.05$

The ANOVA results indicate statistically significant differences ($F = 6.331$, $p = 0.002$) between students' mean scores on alternative conceptions, attributed to

the teacher's teaching method. To identify which groups differed, a Scheffe post-hoc test was conducted.

Table 17: Scheffe Post-Hoc Test for Students' Alternative Conceptions by Teaching Method.

Teaching Method	Mean	Difference with Inductive	Difference with Deductive
Inductive	74.901	-	6.050*
Deductive	68.851	-6.050*	-
Mixed (Inductive-Deductive)	70.707	4.194*	-1.856

* Statistically Significant At $\alpha = 0.05$

The results indicate that students whose teachers employed the inductive method exhibited significantly fewer misconceptions compared to those instructed through deductive or mixed approaches. This outcome underscores the value of the inductive strategy, where learners actively observe, experiment, and derive principles on their own, thereby fostering a deeper comprehension of scientific concepts and minimizing the persistence of alternative conceptions.

These observations align closely with established research in the field. For instance, Al-Malki and Mataw (2020) highlighted the inductive method's success in rectifying alternative conceptions among students. Similarly, Fathallah (2015) found that self-guided inductive techniques—such as K.W.L.H.S, K.W.L.H, and K.W.L—proved highly effective in addressing and correcting misconceptions. In addition, Al-Shihab and Al-Jundi (1998) noted that learners exposed to the V-Shape method surpassed peers in other groups when it came to grasping scientific ideas.

The superior performance of the inductive method can be attributed to its emphasis on hands-on exploration and critical thinking, which bridges

theoretical knowledge with real-world applications and helps construct precise mental frameworks for scientific phenomena. In contrast, deductive and mixed methods often depend more on direct explanations or memorization-based instruction, which limits students' chances to identify and resolve their own misconceptions.

Recommendations

- Enhance inductive and experiential learning: Increase experimental activities and self-discovery tasks, using multiple representations to link theory with practical applications.
- Continuous assessment: Implement short quizzes with immediate feedback to correct errors and monitor student understanding regularly.
- Teacher skill development: Train teachers to effectively combine inductive and deductive strategies and design activities that accommodate individual differences and gender, ensuring balanced learning.

REFERENCES

- Abdelsalam, A. (2001). *Modern trends in science teaching*. Mansoura: Ayak Copy Center.
- Abdelsalam, A. (2005). Effectiveness of a proposed constructivist model in correcting fifth-grade students' misconceptions about the concept of energy. 9th Annual Conference for Science and Math Teachers, American University of Beirut, Lebanon.
- Ahmad, R. (2010). Effectiveness of a proposed strategy based on concept maps in correcting alternative conceptions of some scientific concepts among primary school students (Unpublished master's thesis). Faculty of Education, Benha University, Egypt.
- Al-Abed, N., & Al-Sabbari, M. (2018). The effect of using the circular house strategy on achievement and correcting alternative conceptions in life sciences among ninth-grade female students. *Journal of Educational and Psychological Studies*, 26(14), 536–560.
- Al-Dahmash, A. (2015). The effect of using low-cost alternative experiments in correcting misconceptions of matter, its properties, and states among seventh-grade students. *Journal of Educational and Psychological Sciences*, 115, 179–209.
- Al-Huwaidi, Z. (2005). *Modern methods in science teaching*. Al Ain, UAE: University Book House.
- Al-Juhani, A. (2020). Effectiveness of Poster and Qaraier models in correcting alternative conceptions of some scientific concepts and developing attitudes toward science among second-grade middle school female students. *Educational Journal*, 76, 1553–1618. Sohag University, Faculty of Education.
- Al-Malki, S., & Mataw, D. (2020). Effectiveness of the generative constructivist model in correcting alternative conceptions of some matter and energy concepts among second-grade students. *Egyptian Society for Scientific Education*, 23(34), 1–44.
- Almulhim, A. (2022). Understanding public awareness and attitudes toward renewable energy resources in Saudi Arabia. *Renewable Energy*, 192, 572–582.
- Al-Saeedi, W., & Ambusaidi, A. (2018). The effect of using educational supports in correcting alternative conceptions of electrical concepts among ninth-grade female students. *International Journal of Educational and Psychological Studies*, 4(1), 22–41.
- Al-Shihab, M., & Al-Jundi, A. (1998). Correcting alternative conceptions of some scientific concepts using constructivist learning models and V-Shape method for first-year secondary students in physics. *Egyptian Society for Science Education, 3rd Scientific Conference*, 2, Ismailia, Egypt.
- Ambusaidi, A., & Al-Sabri, R. (2017). The effect of modeling-based instruction on correcting alternative conceptions of energy conservation and momentum among eleventh-grade students. *Journal of Educational Studies*, 11(1), 53–70. Sultanate of Oman.
- Anumeha, B. (2015). Students' awareness of learning styles and their perceptions of a mixed-method approach for learning. *International Journal of Applied and Basic Medical Research*, 5(11), 58–65.
- Ba'ara, H., & Al-Tarawneh, M. (2004). The effect of conceptual change strategies on correcting alternative conceptions related to the concept of mechanical energy among ninth-grade students. *Educational Science Studies*, 31(1), University of Jordan.
- Bojic, M. (2011). Energy literacy of secondary students in New York State (USA): A measure of knowledge, affect, and behavior. *Energy Policy*.
- Bolliger, D. (2011). Learning styles and students' perceptions of the use of interactive online tutorials. *British Journal of Educational Technology*, 42, 470–481.
- Dias, R. (2004). Energy education: Breaking up the rational energy use barriers. *Energy Policy*, 32(11), 1339–1347.
- Fathallah, M. (2015). Effectiveness of three levels of the self-table strategy (K.W.L) in correcting alternative conceptions of scientific concepts and developing cognitive motivation among second-grade middle school students with different mental abilities. *Journal of Scientific Education*, 18(2), 183–119.
- Hussam Al-Din, L. (2010). Correcting alternative conceptions in electricity and its relation to scientific reasoning among ninth-grade students. *Curriculum and Teaching Methods Studies*, 159, 94–143.
- Jepsen, D., Varhegyi, M., & Teo, S. (2015). The association between learning styles and perception of teaching quality. *Education + Training*, 57(5), 575–587. <https://doi.org/10.1108/ET-02-2014-0005>
- Karatepe, Y., Varbak, N. S., Keçebaş, A., & Yumurtacı, M. (2012). The levels of awareness about renewable energy sources of university students in Turkey. *Renewable Energy*, 174–179.
- Keramitsoglou, K. (2016). Exploring adolescents' knowledge, perceptions, and attitudes towards renewable energy sources. *Renewable and Sustainable Energy Reviews*, 1159–1169.
- Kolomuc, A., Ozmen, H., Metin, M., & Acisli, S. (2012). The effect of animation-enhanced worksheets prepared

- based on the 5E model for grade 9 students on alternative conceptions of physical and chemical changes. *Procedia - Social and Behavioral Sciences*, 46, 1761–1765.
- Konstantinos, K. T., & Georgios, S. (2023). Correlation of primary school students' misconceptions about concepts of mechanics with their mental age. *European Journal of Education Studies*, 10(1), 77–89.
- Laeli, C. M. H., & Gunarhadi, M. (2020). Misconception of science learning in primary school students. In 3rd International Conference on Learning Innovation and Quality Education (ICLIQE 2019) (pp. 657–671).
- Mustafa, I., Zayat, A., & Abdel-Qader, H. (2004). *Al-Mu'jam Al-Wasit*. Arabic Language Academy, Shorouk International Library, Cairo.
- Mustafa, M. (2014). The importance of diagnosing alternative conceptions in science teaching and strategies for correcting them. *Al-Hikmah Journal*, 31, 188–208.
- Muzakki, N. A., Diana, S., & Priyandoko, D. (2023). Misconception analysis of cell material using four-tier multiple choice diagnostic test. *Quagga: Jurnal Pendidikan dan Biologi*, 15(2), 120–130.
- Natividad, L. R. (2022). Understanding alternative conceptions: Constructivism and nature of science approach. *Lukad: An Online Journal of Pedagogy*, 2(1), 21–30.
- Oluoch, S., Lal, P., Susaeta, A., & Vedwan, N. (2020). Assessment of public awareness, acceptance, and attitudes towards renewable energy in Kenya. *Scientific African*, 9, e00512.
- Salmian, K. (2016). Correcting alternative conceptions based on conceptual laboratory supports for positive health issues and students' attitudes. *Journal of Scientific Education*, 19(4), 113–157.
- Soeharto, S., Csapó, B., Sarimanah, E., Dewi, F. I., & Sabri, T. (2019). A review of students' common misconceptions in science and their diagnostic assessment tools. *Jurnal Pendidikan IPA Indonesia*, 8(2), 247–266.
- Taber, K. (2003). Understanding ionisation energy: Physical, chemical and alternative conceptions. *Chemistry Education Research and Practice*, 4(2).
- Tarbiyah, M. (2008). *Modern teaching methods and strategies*. Amman: Hamourabi Publishing, 1st Edition, p. 42.
- Widiyatmoko, A., & Shimizu, K. (2018). Literature review of factors contributing to students' misconceptions in light and optical instruments. *International Journal of Environmental and Science Education*, 13(10), 853–863.
- Zaitoun, A. (2007). *Constructivist theory and science teaching strategies*. Amman: Dar Al-Shorouk.
- Zaitoun, A. (2013). *Science teaching methods*. Amman: Dar Al-Shorouk.
- Zyadin, A., Puhakka, A., Ahponen, P., Cronberg, T., & Pelkonen, P. (2012). School students' knowledge, perceptions, and attitudes toward renewable energy in Jordan. *Renewable Energy*, 45, 78–85.