

Research Article

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Author for correspondence:

Bayan Al-Kasasbeh

✉ baranmohammad12345@gmail.com

✉ Yarmouk University, Jordan



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The Effectiveness of Teaching Based on Multiple Intelligences in Acquiring Chemical Concepts and the Ability to Interpret Household Chemical Phenomena Among Primary 9th Grade Students

Bayan Al-Kasasbeh , Waleed Nawafleh

Abstract

Background/purpose. The study aimed to investigate the effectiveness of teaching based on multiple intelligences in acquiring chemical concepts and the ability to explain household chemical phenomena among basic-stage students.

Materials/methods. The study employed an experimental method with a quasi-experimental design for two non-equivalent groups to achieve its aims. The sample consisted of two ninth-grade classes of female students from a school in the Al-Koura District, selected by convenience sampling, with a total of 64 students (32 in each class). One class was randomly assigned as the experimental group and was taught using the multiple intelligences approach, while the other class served as the control group and was taught using the traditional method. Two multiple-choice tests were prepared: the first to measure the acquisition of chemical concepts, and the second to assess the ability to explain household chemical phenomena. The validity and reliability of both tests were verified.

Results. The study's results revealed a statistically significant difference in the acquisition of chemical concepts by the study subjects, both individually and collectively, and their ability to interpret household chemical phenomena between the two study groups, favoring the experimental group.

Conclusion. The study concluded that teaching based on multiple intelligences is effective in acquiring chemical concepts and enhancing the ability to interpret household chemical phenomena among basic stage students.

1. Introduction

Science teaching is one of the most important processes in any educational system globally. The importance of science and its teaching stems from its significant contribution to the progress and development of nations. Scientific concepts, in their various fields, are the foundational building blocks for learning science, constructing other, more complex forms of knowledge, and understanding and interpreting the scientific phenomena and events that surround us. This requires the search for diverse and modern teaching methods and approaches that place the learner at the center of the educational process and develop their intellectual skills. This enables the nation to advance in all areas of life, develop, and progress at all levels, in light of the tremendous scientific revolution the world is witnessing across all fields.

Because individuals are the basis of development in all fields, it is necessary to pay attention to education in order to achieve sustainable development and scientific education for all students, which is what Project 2061, Science for All, the landmarks of scientific culture, and the National Standards for Science Education (NSES) emphasized in order to enable individuals to improve their lives and deal with developments and enable them to face various challenges, and to prepare them for the future (Zaytoun, 2010), and enable them to keep pace with scientific, cognitive, and technical developments by preparing them cognitively and skillfully, which makes them responsible individuals (Bataineh & Al-Omari, 2024).

By developing its educational system at various levels, Jordan aims to prepare qualified and responsible individuals, providing them with a solid foundation in science and technology. This achieves the goals of science education and science teaching (Zaytoun, 2005). Hence, the effective role of science teaching in science education emerges through the development of individuals' knowledge, thinking, and scientific attitudes. This responsibility falls on everyone, not just specialists in scientific fields (Al-Khazraji, 2011). Students' acquisition of basic scientific information, including concepts, facts, and functional knowledge of living and non-living components, as well as the interpretation of various environmental phenomena, and the development of scientific thinking skills, are among the most important goals of science education (Al-Khalili et al., 1996).

Among the most important characteristics of a scientifically literate individual, as noted by Hurd (1998), are their ability to produce scientific knowledge and their understanding of the relationship between science, technology, and society. They master and practice higher cognitive abilities, employing them to construct and understand fundamental ideas that serve as a basis for solving life and social problems. Khader (2022) also emphasized that understanding the nature of science and scientific endeavor is one of the most prominent characteristics of a scientifically literate individual, helping them to comprehend what is happening around them and facilitating their interaction with scientific and technological products.

Chemistry is considered one of the branches of science that focuses on studying the nature of matter and its properties. Chemistry and its products are linked to all areas of life, including the home sphere. The American Chemical Society has classified it as the scientific subject most closely related to students' lives (Corwin, 2018). Chemistry is a conceptual science, and acquiring concepts is the basis for learning chemistry. Students learn concepts at all educational levels, and this is where the importance of teaching them emerges (Taber, 2019).

Ausubel believes that concepts constitute an individual's mental cognitive structures, and that each person has their unique conceptual structure. Meaningful learning cannot be achieved without understanding the relationships between concepts, both horizontally and vertically (Zaytoun, 2000). Teaching scientific concepts is also consistent with modern teaching methods that focus on higher-order thinking skills and understanding the connections between different phenomena (Al-Masry, 2020).

The acquisition of scientific concepts by learners reduces environmental complexity by identifying points of agreement and difference between different stimuli, facilitates the continuation of learning through generalization, and enhances the learning process, thereby facilitating the integration of acquired cognitive structures with the student's cognitive structure, making it easier to acquire new meanings. It also helps unify the view of events with others and exchange meanings with them, facilitates the organization of students' experiences, and aids in the construction and planning of curricula (Alwan et al., 2014). It also reduces verbalism among students, increases their interest in science and their motivation to teach it, enhances their ability to use the functions of science (explanation, prediction, and control), and their ability to employ information in solving problems and highlighting the connection between the different branches of science (Salama, 2004).

A scientific concept involves generalization and consists of two parts: the noun and the meaning (verbal connotation). It includes characteristics shared by all examples of the concept, called basic characteristics. Students' concept formation expands at each academic stage as they mature and gain experience. Concept formation involves processes such as differentiation, classification (organization), and generalization (Al-Khataybah & Al-Faqihi, 2022).

Concepts are classified into several categories, as noted by Al-Khalili et al. (1996), who categorized concepts based on their degree of comprehension into concrete and abstract concepts, their derivability into primary and derived concepts, their complexity into simple and complex concepts, and their ability to learn into easy and complex concepts.

Students can form scientific concepts in two ways: the first is the inductive approach, which is the natural approach to learning concepts. Concepts are formed by beginning with learning the details and understanding the relationships between them, leading to the development of general concepts. The second approach is the deductive approach, which consolidates the learning of concepts by employing them in new situations, based on the general concept of its details (Zaytoun, 2007). Bruner also identified three stages of concept formation: the material, the sensory, the pictorial, and the symbolic (Saada & Al-Youssef, 1988).

Despite the importance of learning scientific concepts, students face many obstacles to acquiring them, including those related to the nature of the concepts learned in terms of complexity and abstraction, the presence of a defect in their previous learning, their confusion between the meanings and connotations of different concepts, their poor cultural and cognitive background, their weak readiness and motivation to learn, their negative attitudes towards science and its learning, in addition to the application of inappropriate curricula in their teaching, the poor preparation of their teachers, their use of inappropriate teaching methods, in addition to learning science in a language other than their mother tongue (Al-Khataybah & Al-Faqihi, 2022).

One of the most effective ways for teachers to address these obstacles during instruction is to diversify teaching methods and techniques tailored to each age group, ensuring a logical sequence in presenting concepts to students, and supporting them in applying these concepts to real-life situations. This includes engaging students in active learning through various practical, sensory-based educational activities, ensuring their mastery of previously learned concepts, and utilizing modern technologies in the educational process. This includes providing students with sufficient examples to develop accurate images of the concepts, clarify them, and explain the relationships between them, while also applying them to all branches of knowledge. Furthermore, this includes engaging students in realistic assessment activities to ensure their acquisition of the concepts learned and their ability to use them in new situations (Zaytoun, 1991).

Zaytoun (2005) suggested six dimensions to measure students' acquisition of scientific concepts, namely: determining the verbal meaning of the scientific concept, discovering the scientific concept, interpreting observations using the scientific concept, using the scientific concept in solving

problems, using the scientific concept in reasoning, deduction and generalization, and applying the scientific concept. The researcher adopted these dimensions to measure students' acquisition of chemical scientific concepts.

Acquiring general scientific concepts helps students study and interpret scientific phenomena, including chemistry, and integrate theoretical and practical aspects, thereby providing them with a deeper understanding. It also helps teachers identify students' thinking patterns and thus develop them (Ma'badah & Bani Khalaf, 2018). Explaining and understanding natural and life phenomena is the primary goal of science, whether viewed as a body of knowledge, as a method of research or thinking, or as a combination of both aspects (Zaytoun, 2005). Understanding knowledge and applying it to interpret cosmic phenomena and make informed decisions related to them is one of the primary goals of education in Jordan at all educational levels, as stated by the National Center for Curriculum Development (2024).

Chemistry, its phenomena, and applications are all around us and in our homes, and we cannot continue our lives without them. It is present in kitchens, bathrooms, and even in basic home building materials, as well as in body care products, cosmetics, perfumes, medicines, and home appliances (Jackson, 1996/2007). Therefore, understanding and interpreting household chemical phenomena is essential and a daily necessity for everyone.

Describing and explaining the phenomena around us is one of the primary goals science seeks to achieve for learners. Describing phenomena alone is not sufficient to understand and comprehend them. They must be explained by understanding what is meant by the phenomena, the causes leading to their occurrence, and the factors that influence and are influenced by them. Therefore, description and explanation are the foundation upon which we proceed to the two subsequent goals of science: the ability to predict phenomena and the ability to control and manipulate them (Kazem & Zaki, 1973).

Learning about phenomena extends beyond the classroom to students' environments and homes, which attracts students' attention and increases their curiosity and motivation to learn. Furthermore, the sequencing of teaching phenomena organizes the presentation of educational material in a logical and meaningful manner for students, facilitating its understanding (Huncosky, 2019). Interpreting phenomena is understanding the relationships between events and between them. The interpretation process consists of three elements: limiting the phenomenon to be interpreted, limiting the factors that influence its occurrence, and understanding the functional relationships between the phenomenon and the factors that influence its occurrence (Ismail, 1989).

The role of teachers in teaching scientific phenomena is to identify the scientific phenomena they will teach students, so that they are linked to their personal experiences. They also determine the appropriate period for teaching each phenomenon based on its importance. They also diversify the teaching methods and activities used in teaching phenomena. They also encourage students to find practical explanations and solve problems related to the phenomena by immersing them in activities that help them discover ideas related to scientific phenomena. They also support students' questions and their pursuit of understanding various scientific phenomena by forming strong partnerships with parents and the community (Huncosky, 2019).

In educational literature, various methods and approaches contribute to the acquisition of general scientific concepts among students, enabling them to interpret scientific and chemical phenomena. The best of these methods and means is that which contributes to the development of thinking in its various forms, and takes into account individual differences, including the development and growth of intelligence in the learner, which is considered a trait that can be acquired and developed. Therefore, this study aimed to develop and teach an educational unit based on multiple

intelligences to investigate its effect on students' acquisition of chemical concepts and their ability to interpret chemical phenomena.

In this context, Howard Gardner pointed out in 1983 the existence of paths to intelligence that he called multiple intelligences, which differ from Binet's conception of it and from measuring intelligence through the mental quotient (IQ), through individuals developing abilities that match their requirements and help them adapt to their lifestyles (Amer & Mohammed, 2008). Gardner expanded the definition of intelligence in his book, *Frames of Mind*, and suggested the existence of seven intelligences, then added an eighth intelligence, and proposed the possibility of a ninth intelligence (Shawaheen, 2014).

Gardner's theory of multiple intelligences aims to expand on the most relevant sciences, namely cognitive psychology and developmental psychology, and outline the broad lines for employing mental competencies in different cultural frameworks, and the interest of those responsible for improving individuals' capabilities, in addition to ensuring the effectiveness and efficiency of educational techniques. The theory of multiple intelligences suggests that individuals should utilize their preferred learning style to develop their capabilities, as their strengths and weaknesses vary. This is based on two pillars: that individuals learn in different ways, and their inability to learn everything that can be learned (Al-Khafaf, 2017).

Gardner's multiple intelligences consist of: verbal-linguistic intelligence, which is represented by the skill of using language and using words orally and in writing; logical-mathematical intelligence, which is represented by possessing critical logical thinking skills and skill in dealing with numbers; visual-spatial intelligence, which is represented by the ability to imagine and visually perceive, know relative locations, places and directions, and build mental images; auditory-musical intelligence, which is represented by individuals practicing various vocal and auditory activities and their sense of sounds; bodily-kinesthetic intelligence, which is represented by individuals' ability to employ their bodies in a diverse way in their daily lives; interpersonal-social intelligence, which is represented by individuals' ability to deal with others and understand their behaviors, feelings, motives, moods and intentions; and personal-intrapersonal intelligence, which is represented by individuals' ability to understand and respect themselves and realize Their moods, motives and aspirations, and natural intelligence, which is represented in individuals' discrimination and sensitivity to the elements and components of nature and their awareness of the changes that occur to it and their impact on the human being, and existential intelligence, which is represented in unifying the view of life and its comprehensiveness to include morals, religion, philosophy, and the individual's knowledge of his position on this life and his awareness of values (Shawaheen, 2014; Armstrong, 2009).

Regarding the importance and applications of the theory of multiple intelligences in the educational field, it takes into account the needs of students, which increases their activity, efficiency, and ability to acquire various knowledge and skills, leading to increased self-respect, enhanced experiences, and improved problem-solving abilities. Multiple intelligences also highlight the role of parents and society in learning (Hussein, 2005), in addition to their role in raising students' achievement and motivation to learn, and improving teachers' deep performance and understanding of their tasks and their students. This will be positively reflected in the quality of the educational process. It also helps learners understand themselves, which is reflected in their interactions with their teachers and the curricula and learning methods used. It also takes into account the educational content, educational objectives, and teaching methods that consider the intelligences of learners, as the diversity of teaching methods based on intelligences requires us to diversify the methods of measurement and evaluation used (Afaneh & Al-Khazindar, 2007).

To achieve effective learning with multiple intelligences, the teacher must help students discover their intelligences and how to activate them, and guide them in employing their intelligences to

achieve educational goals. He must build his curriculum, through which he diversifies teaching and assessment strategies that take into account students' characteristics and support their use of their intelligences in performing various tasks (Al-Khafaf, 2017). He also designs and implements diverse educational activities that attract students and manages learning time intelligently to achieve educational goals. He is an example to be emulated by his students in adopting a qualitative approach to thinking, transferring the impact of learning to their environments, and achieving continuous lifelong learning (Abu Al-Hajj & Al-Musalha, 2016). He also takes into account, in his assessment, the integration of intelligences into assessment activities, thereby understanding students' thinking and real achievements, and assessing them with an honest evaluation (Hoerr, 2000).

The importance of the theory of multiple intelligences in developing the educational process is highlighted by fostering students' personalities and building their knowledge, as well as their scientific, life, research, and technical skills. It also enhances their ability to learn complex subjects, their capacity to apply the impact of learning to their lives, their ability to evaluate themselves effectively, and their leadership abilities and potential for collective learning (Nasr & Al-Saht, 2016).

Through the researcher's work as a chemistry teacher, she observed a weakness among students in grasping scientific concepts and in understanding everyday chemical phenomena. Through searching for a way to address this weakness, the researcher found that taking into account multiple intelligences in the educational process may help learners overcome these weaknesses. The researcher also found that some studies have proven the effectiveness of taking into account multiple intelligences in teaching, as noted by Al-Badour and Al-Khataybah (2004) and Al-Aqayleh et al. (2021). Many studies also recommend paying attention to research in the field of science learning, particularly in areas such as students' thinking and their care for their learning environment, as seen in the study by Al-Omari and Al-Nawafleh (2011). In addition, no study directly investigates the effectiveness of teaching chemistry according to the theory of multiple intelligences in helping primary school students, specifically ninth-grade students, acquire chemical concepts and interpret household chemical phenomena in the context of science. The researcher, therefore, the study problem crystallized in the following questions:

Question 1: How effective is teaching based on multiple intelligences in acquiring chemical concepts among primary 9th-grade students?

Question 2: How effective is teaching based on multiple intelligences in explaining household chemical phenomena among primary 9th-grade students?

The study aims to explore the effectiveness of teaching a chemistry unit based on multiple intelligences in developing basic chemical concepts and the ability to interpret household chemical phenomena in elementary school students.

This study provided relevant researchers and educators with a theoretical background on the study variables, namely multiple intelligences, the acquisition of scientific chemical concepts, and the ability to interpret household chemical phenomena. The importance of this aspect lies in its addressing a dependent variable, the interpretation of household chemical phenomena, which previous studies have not addressed.

The study also provided researchers with instruments that can be used in similar studies (a test for the acquisition of scientific chemical concepts, a test for interpreting household chemical phenomena, and a guide for teaching the unit on metal activity according to multiple intelligences). It will also guide decision-makers toward adopting a new approach to curriculum planning and development. It will also open the way for researchers to conduct studies and research on multiple intelligences. Science teachers will also benefit from the results of this study to improve their teaching performance and classroom practices.

The study was conducted at Jdita Secondary School for Girls, a government school affiliated with the Directorate of Education for the Al-Kura District in Irbid Governorate, Jordan, during the second semester of the 2024/2025 academic year. The study was administered to a group of ninth-grade female students, which limits the generalizability of the findings to the study population or similar groups. The study was limited to the teaching of a unit, the third unit (Metal Activity) of the chemistry course. The study's results are determined by the design of the measurement instruments used and their validity and reliability, the nature of the study procedures, their accuracy, and the integrity of their implementation, as well as the seriousness and accuracy of the study sample in responding to the questionnaire.

2. Literature Review

When reviewing the educational literature related to the study variables, several studies were identified, including Al-Aqayleh et al. (2021) conducted a study aimed at designing an educational unit based on multiple intelligences in the subject of physics and assessing its impact on developing motivation towards learning among ninth-grade students in Jordan. The study followed the quasi-experimental approach. The study sample consisted of 42 female students from a school selected using the convenience sampling method, divided into two groups: an experimental group and a control group. A scale of motivation towards learning physics was prepared, and its validity and reliability were confirmed. The study revealed statistically significant differences in motivation towards learning physics among ninth-grade female students, attributed to the teaching method favoring the experimental group.

Al-Aqayleh et al. (2021) conducted a study in Jordan to design a physics instructional unit based on multiple intelligences and to examine its impact on ninth-grade students' motivation to learn. The study employed a quasi-experimental design, with a sample of 42 female students selected through convenience sampling and divided into an experimental and a control group. A motivation scale for learning physics was developed, with confirmed validity and reliability. The results indicated statistically significant improvements in motivation for the experimental group, highlighting the positive effect of the multiple intelligences-based teaching method.

Al-Rabi (2019) investigated the relationship between emotional intelligence and mindfulness among students at Yarmouk University in Jordan. The study sample consisted of 165 male students and 255 female students who were selected using the available method. The study followed the descriptive correlational approach. The Mindfulness Scale and the Emotional Intelligence Scale were used. The study concluded that there is a correlation between mindfulness and emotional intelligence among students at Yarmouk University.

Aydin's study (2019) aimed to reveal the impact of applying the theory of multiple intelligences on students' academic success in Turkey. The study followed a descriptive-analytical methodology. The researcher reviewed several previous studies that addressed this topic and analyzed them according to specific factors. The results concluded that the use of educational activities based on multiple intelligences contributes to improving students' academic achievement, with the effect varying depending on some factors such as the subject matter and geographical area.

Al-Zoubi's (2017) study aimed to investigate the effect of multiple intelligences on the acquisition of scientific concepts and the development of attitudes among seventh-grade students in Jordan. The study was conducted with 60 students in Balqa Governorate, who were intentionally selected. A quasi-experimental approach was employed, and a concept test was developed to assess the level of acquisition of scientific concepts. A questionnaire was prepared to measure the level of attitudes towards the science subject. The study concluded that there is a statistically significant effect of the multiple intelligences strategy on the acquisition of scientific concepts and the development of attitudes towards science attributed to the teaching method.

Al-Qawasmeh and Al-Qadri (2017) conducted a study aimed at revealing the effect of using electronically supported and non-electronically supported multiple intelligence strategies on interpreting scientific phenomena among third-grade students in Jordan. The study followed the qualitative and quasi-experimental approach. The study sample consisted of 75 male and female students, who were intentionally selected and randomly assigned into three groups: two experimental groups and one control group. The researchers prepared a test instrument for interpreting scientific phenomena and verified its validity and reliability. The results showed statistically significant differences in the ability to interpret scientific phenomena attributed to teaching strategies, favoring the two experimental groups.

Bas (2016) conducted a study in Turkey to examine the effect of instruction based on Multiple Intelligences Theory (MIT) on students' academic achievement. Using a meta-analytic approach, the study collected and analyzed previous research, comparing effect sizes across variables such as educational level, subject matter, type of thesis/dissertation, geographical region, sample size, and duration of the experimental intervention. The sample included 75 experimental postgraduate theses. The results indicated that MIT-based instruction had a large effect on students' academic achievement. No statistically significant differences were found among the effect sizes for the examined variables, except for educational level.

Al-Badour and Al-Khataybah (2004) conducted a study in Jordan to examine the effect of using the multiple intelligences strategy on seventh-grade students' achievement in science and their acquisition of science process skills. The sample consisted of 97 male and female students selected purposively. The study employed a descriptive-analytical approach, using a science achievement test, a translated and modified science process skills test, and the Multiple Intelligences Test (McKenzie) to assess students' multiple intelligences after translation and adaptation. The results revealed statistically significant improvements in both achievement and acquisition of science process skills in favor of the multiple intelligences strategy.

Davis (2004) conducted a descriptive applied study aimed at investigating the effect of a program based on multiple intelligences on the academic achievement of fourth-grade students in science in the United States. The study sample consisted of 20 fourth-grade students, who were selected using a convenience sampling method. The researcher employed the theory of multiple intelligences and brain-based learning to develop a program, utilizing an achievement instrument both before and after exposing participants to the program. The study's results showed a significant improvement in students' achievement, behavior, and self-esteem.

Tuysüz and Geban (2000) conducted a study aimed at investigating the effect of applying a model based on the five-cycle learning model and the theory of multiple intelligences on the achievement of ninth-grade students in a Turkish school, in terms of concept retention, attitudes towards chemistry, and the level of self-motivation. The study employed a quasi-experimental approach, with a sample comprising 151 male and female students, divided into two groups: experimental and control. The results showed statistically significant differences in academic achievement, positive attitudes towards chemistry, and specific dimensions of motivation, attributed to the teaching method that favors the five-cycle learning model and multiple intelligences. However, no significant differences were observed in anxiety and self-efficacy.

It is noted from the previous studies that they were conducted in different settings and followed various methodologies. Most of them employed a quasi-experimental design, while a few used a descriptive approach or combined experimental and descriptive methods. In this regard, the present study is similar to the majority of studies that adopted a quasi-experimental methodology.

However, the current study differs from previous research in its variables, the grade level on which it was applied, the knowledge domain it addressed—chemistry—and the tools used and how

they were developed. To the best of the researchers' knowledge, no studies have specifically examined the effectiveness of teaching based on multiple intelligences in acquiring chemical concepts or explaining household chemical phenomena at any grade level. Only one study (Al-Zoubi, 2017) investigated scientific concepts, and one study (Al-Qawasmeh & Al-Qadri, 2017) addressed the explanation of scientific (but not chemical) phenomena.

This distinction sets the current study apart, as chemical concepts are characterized by their abstract nature and require students to understand them in order to explain chemical phenomena present in their homes. Moreover, the study sample was selected from ninth-grade students, who are in a stage of developing abstract thinking and have studied various chemical concepts that enable them to interpret the chemical phenomena around them.

Based on the above, and in light of the educational interest in developing the educational system by implementing constructivist teaching approaches that place the student at the center of the learning process—and given the importance of Multiple Intelligences Theory—the need for this study emerged. The study aims to teach an instructional unit based on multiple intelligences and to examine its effect on acquiring one of the most essential foundations of the educational process, namely the acquisition of chemical concepts, as well as the ability to explain household chemical phenomena.

3. Methodology

3.1. Research Method

The current study employed an experimental approach in its procedures, utilizing a quasi-experimental design. This design involved selecting two groups of primary school students: a control group that studied according to the traditional method and an experimental group that studied using the multiple intelligences method. A pre- and post-test of chemical concepts and the interpretation of household chemical phenomena was administered to members of both study groups.

3.2. Participants

The study sample consisted of 64 ninth-grade female students from Jadita Secondary School for Girls, affiliated with the Directorate of Education of the Al-Koura District, during the second semester of the 2024/2025 academic year. The school was selected using a convenience sampling method due to the researcher's employment there and the availability of the necessary facilities and resources for conducting the study.

Two ninth-grade classes were then randomly chosen from a total of four classes at the school, with each class comprising 32 students. One class was randomly assigned as the control group, which was taught using the traditional method, while the other was designated as the experimental group, which was taught using the multiple intelligences approach. Ninth-grade students were specifically selected because they are in the stage of developing abstract thinking, which is essential for understanding abstract chemical concepts and, consequently, for the ability to explain chemical phenomena.

3.3. Study Tools

3.3.1 Chemical Concepts Attainment Test

To achieve the study objectives, a test was developed to measure the chemical concepts of the study participants in the educational unit, represented by Unit 3, Metals Activity, from the ninth-grade chemistry textbook for the second semester. This test was based on several studies, including Al-Zoubi's study (2017). The test consisted of 30 multiple-choice items, each with four alternatives. The items were distributed across six dimensions: identifying the verbal meaning, discovering the

scientific concept, interpreting observations, using the concept to solve problems, using the scientific concept in reasoning, deduction, and generalization, and applying the concept. Each dimension had five items.

Validity of the Test

To verify the validity of the test, it was presented in its preliminary form, along with a list of the main dimensions and their corresponding behavioral indicators, to a group of judges, including faculty members from Jordanian universities, educational supervisors, and experienced teachers specializing in science curricula and teaching methods, measurement, and evaluation. They were asked to provide their opinions on the test, including the wording and clarity of the items, as well as the correlation between the behavioral indicators and the dimensions of chemical concepts. In light of the judges' opinions, the test was modified to reflect changes in the linguistic wording of certain items, resulting in the final version.

Difficulty and discrimination coefficients were also calculated for the test items, with difficulty coefficient values ranging between 0.23 and 0.64. These values are appropriate for the test items, as the difficulty coefficient values should range between 0.20 and 0.80 (Awda, 2010, p. 287). While the values of the discrimination coefficients of the test items ranged between (0.27) and (0.82), Awda (2010, p. 285) indicated that the values of the discrimination coefficients should not be less than (0.40), and the items whose discrimination coefficient is greater than or equal to (0.20) and less than (0.40) are preferable to be improved and modified; therefore, the researcher improved and modified them in terms of linguistic formulation, or changed the alternatives.

Reliability of the Test

To verify the test's reliability, it was administered to a pilot sample of 23 female students, including both those from the study population and those outside the sample. It was re-administered to them two weeks after the first application. The test-retest reliability coefficient (Pearson) was estimated between the results of the two applications. The internal consistency reliability coefficient (Cronbach's alpha) was also estimated from the results of the first application. The test-retest reliability coefficients for the dimensions of the Chemical Concepts Test ranged from 0.74 to 0.84, with an overall value of 0.81; all of which are acceptable for the current study. The internal consistency reliability coefficients (Cronbach's alpha) for the dimensions of the Chemical Concepts Test ranged between 0.80 and 0.89, while the value for the test as a whole was 0.90; all of which are acceptable for the current study.

3.3.2. Interpretation of Household Chemical Phenomena Test

To achieve the objectives of the current study, a test was developed to measure the interpretation of household chemical phenomena among the study subjects. This was based on several studies, including the study by Al-Qawasmeh and Al-Qadri (2017). The test consisted of 20 multiple-choice items, each with four alternatives. These items were distributed across some of the household chemical phenomena encountered by the students and related to Unit Three, Metals Activity, for the ninth-grade second-semester students.

Validity of the Test

To verify the validity of the test, it was presented in its preliminary form to a group of judges to express their opinions on the test, in terms of: the clarity of its instructions, the suitability of the proposed phenomena for the level of primary school students, and the appropriateness and accuracy of the correction criteria. In light of the judges' opinions, the test was modified to include the following changes: modifying the linguistic wording of some paragraphs, deleting and replacing five paragraphs with others, resulting in the final form of the test and answer sheet.

Difficulty and discrimination coefficients were also calculated for the test items, and the values of the item difficulty coefficients ranged between 0.41 and 0.68. These values are appropriate for the test items, as it is preferable for the values of the item difficulty coefficients to range between 0.20 and 0.80 (Awda, 2010, p. 287). Meanwhile, the values of the discrimination coefficients for the test items ranged between 0.27 and 0.82, with Awda (2010, p. 285) indicating that the values of the discrimination coefficients should be no less than 0.40. Items with a discrimination coefficient greater than or equal to 0.20 and less than 0.40 should be improved and modified. Therefore, the researcher improved and modified it in terms of linguistic formulation, or changed the alternatives.

Reliability of the Test

To verify the reliability of the test, it was administered to the aforementioned pilot sample and then re-administered to them two weeks later. The Pearson correlation coefficient was estimated between the results of the two applications, reaching a value of 0.90 for the test items as a whole. The internal consistency reliability coefficient (Cronbach's alpha) was also estimated from the first application, reaching a value of 0.94 for the test items as a whole. These are both acceptable values for the current study.

3.4. Teaching Guide for the Instructional Unit Based on Multiple Intelligences

The guide was prepared through a series of steps:

1. Reviewing models of evidence from studies based on multiple intelligences.

2. Developing the guide, which consists of an introduction and theoretical framework on multiple intelligences, teaching instruments used, the target group, the duration of implementation, and the overall outcomes of the unit. It also includes guidelines for teaching the unit, a timetable for teaching the unit, and daily plans that clarify the lesson title, lesson topic, and objectives, as well as the materials and instruments used, the teaching strategies employed, and the assessment strategies and instruments utilized. It also outlines the procedures for implementing the lesson and the required homework. The intelligences used in each lesson are also clarified, with the researcher providing activities for each lesson and corresponding grading scales.

3. To ensure the validity of the guide, it was presented to a group of science teachers for evaluation in terms of content, objectives, clarity of instructions, applicability of strategies, target audience, and implementation procedures. Their comments were taken into account to develop the final version of the guide.

3.5. Study Variables

The independent variable is the teaching method, which has two categories (conventional and multiple intelligences).

Dependent variables: These included:

- Chemical concepts attainment.
- Explaining household chemical phenomena

3.6. Study Procedures

The researchers followed a set of steps to implement the study, as follows:

1. Defining the study problem and formulating its questions.

2. Reviewing educational literature and previous studies related to multiple intelligences and the acquisition of scientific and chemical concepts, and interpreting scientific and chemical phenomena by surveying periodicals and magazines relevant to the study topic.

3. Developing study instruments by consulting relevant references and educational studies, and then verifying their psychometric properties.
4. Obtaining official approvals from the relevant authorities to conduct the study, represented by a letter facilitating the task from the Deanship of the College of Education at Yarmouk University to the Directorate of Education in Koura District, followed by obtaining a letter facilitating the task from the Directorate of Education in Koura District to the affiliated public schools.
5. The study instruments were applied to a survey sample selected from the same school, facilitating the researcher's use of the instruments and ensuring their validity and reliability.
6. The official study sample was selected by choosing Jdita Secondary School for Girls, as the researcher was a teacher there. Two classes of ninth-grade students were selected using the available method, with one class randomly assigned as a control group and the other as an experimental group.
7. The study instruments were applied to the study sample before teaching (pre-test).
8. The Metals Activity Unit was taught to the two study groups (experimental and control). The unit took nine weeks, from February 12, 2025, to April 17, 2025, for both groups. The unit consisted of 9 class periods, distributed over 9 weeks, with one period per week. The experimental group was taught using the multiple intelligences approach, while the control group was taught using the traditional method.
9. The study instruments, consisting of two tests, were applied to the two study groups after the unit was completed (post-test).
10. Correcting students' responses to the study instruments and entering pre- and post-test scores into the computer.
11. Analyzing data, drawing conclusions, discussing them, and issuing several recommendations.

3.7. Data Analysis

To answer the first research question, the observed means, standard deviations, and adjusted means of both study groups' performance on the combined items of the Chemical Concepts Test were calculated. Analysis of Covariance (ANCOVA) was used to determine the statistical significance of differences between post-test means according to the teaching method. Additionally, the means, standard deviations, and adjusted means for each dimension of the Chemical Concepts Test were computed, and Multivariate Analysis of Covariance (MANCOVA) was employed to examine differences across dimensions. Eta squared (η^2) was calculated to determine the effect size of the teaching method (Cohen, 1988).

To answer the second research question, the observed means, standard deviations, and adjusted means of both study groups' performance on the combined items of the Household Chemical Phenomena Interpretation Test were calculated. ANCOVA was used to examine the statistical significance of differences between post-test means, and Eta squared (η^2) was computed to assess the effect size of the teaching method (Cohen, 1988).

4. Results

4.1. Result Related to the First Question

This question stated, "What is the effectiveness of teaching according to multiple intelligences in acquiring chemical concepts among primary 9th-grade students?" This question resulted in the null hypothesis, which states: "There is no statistically significant difference at ($\alpha = 0.05$) between the means score of the study subjects' performance on the overall chemical concepts test and its

dimensions (identifying verbal significance, discovering the scientific concept, interpreting observations, using the scientific concept in reasoning, deduction, and generalization, using the concept in problem-solving, and applying the concept) attributable to the teaching method (conventional or multiple intelligences)."

The following is a presentation of the hypothesis test on the test as a whole and its dimensions: On the chemical concepts test as a whole: To answer the question and verify its hypothesis on the level of the test as a whole, the means and standard deviations were calculated for the pre-, post-, and adjusted post-performance of the study individuals on the total chemical concepts test, according to the teaching method (conventional, multiple intelligences), and Table (1) shows this.

Table 1. Means and Standard Deviations of the Participants' Performance in the Pre-test, Post-test, and Adjusted Post-test on the Overall Chemistry Concepts Test, According to the Teaching Method

Teaching Method	Pre-test		Post-test		Adjusted	
	Mean	Std. Deviation	Mean	Std. Deviation	Adjusted Mean	Standard Error
Conventional	10.13	2.70	19.94	4.20	20.07	0.61
Multiple Intelligences	10.48	2.84	25.57	3.86	25.43	0.61

It is evident from Table 1 that there is a significant difference between the pre-test and post-test means for the experimental group's performance, as well as a significant difference between the post-test means of the control and experimental groups. To determine the statistical significance of these apparent post-test differences based on the teaching method, Analysis of Covariance (ANCOVA) was used, as shown in Table 2.

Table 2. Results of the Analysis of Covariance (ANCOVA) for the Post-test Means of the Participants' Performance on the Overall Chemistry Concepts Test According to the Teaching Method

Source	Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
Pre-test (Covariate)	273.805	1	273.805	22.695		
Teaching Method	458.561	1	458.561	*38.009	0.000	0.384
Error	735.945	61	12.065			
Corrected Total	1516.000	63				

Statistically significant at ($\alpha = 0.05$)

Considering the results of the analysis of variance shown in Table (2), it is noted that the value of statistical significance for the teaching method reached (0.000), which is less than ($\alpha=0.05$); which indicates the rejection of the null hypothesis at the level of the overall test and the acceptance of the alternative, which states: "There is a statistically significant difference at ($\alpha=0.05$) between the mean score of the study individuals' performance on the overall chemical concepts test, attributed to the teaching method (the usual, and multiple intelligences)." From the adjusted mean scores shown in Table (1), it is clear that the statistically significant difference was in favor of the performance of the individuals in the experimental group who were taught using the multiple intelligences method, and

the effect size was calculated, which reached a value of (0.384), which is a high effect size (Cohen, 1988); It indicates that (38.4%) of the variance (improvement) in the study individuals' post-test performance on the total chemical concepts test is due to the multiple intelligences method.

On the dimensions of chemical concepts individually: the mean scores and standard deviations of the study individuals' performance before, after, and after the adjusted for each dimension of the chemical concepts test (determining the verbal meaning, discovering the scientific concept, interpreting observations, using the concept in solving problems, using the scientific concept in reasoning, deduction, and generalization, and applying the concept) were calculated according to the teaching method, and Table (3) shows that.

Table 3. Means and Standard Deviations of the Pre-, Post-, and Adjusted Post-Test Performance of the Study Participants on Each Dimension of the Chemical Concepts Test According to the Teaching Method

Dimension	Teaching Method	Pre-test		Post-test		Adjusted	
		Mean	Std. Deviation	Mean	Std. Deviation	Adjusted Mean	Standard Error
Determine verbal meaning	Conventional	2.31	0.86	3.75	1.05	1.98	0.22
	Multiple Intelligences	1.94	0.95	4.66	0.70	2.72	0.22
Discovering the scientific concept	Conventional	1.91	0.73	3.53	0.95	1.97	0.14
	Multiple Intelligences	1.53	1.29	4.56	0.88	2.58	0.14
Interpretation of notes	Conventional	1.66	0.87	3.22	1.01	1.70	0.14
	Multiple Intelligences	1.88	1.07	4.44	0.76	2.85	0.14
Using the concept in problem-solving	Conventional	1.28	0.96	2.50	1.05	1.85	0.11
	Multiple Intelligences	1.38	0.83	3.22	1.10	2.55	0.11
Using the scientific concept in reasoning, deduction, and generalization	Conventional	1.38	0.91	3.31	1.26	1.83	0.13
	Multiple Intelligences	1.97	1.26	4.06	0.91	2.72	0.13
Application of the concept	Conventional	1.59	1.29	3.63	1.60	1.83	0.13
	Multiple Intelligences	1.78	0.97	4.63	1.16	2.72	0.13

Table 3 shows apparent differences between the pre- and post-test means of the experimental group's performance, as well as apparent differences between the post-test means of the control

and experimental groups. To determine the statistical significance of these observed post-test differences according to the teaching method, a Multivariate Analysis of Covariance (MANCOVA) was conducted, as presented in Table 4.

Table 4. Results of the Multivariate Analysis of Covariance (MANCOVA) for the Post-Test Mean Scores of the Study Participants on the Dimensions of the Chemical Concepts Test According to the Teaching Method.

Source	Dimension	Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
Covariate (Pre-test Verbal Significance Identification)	Determine verbal meaning	2.024	1	2.024	3.235		
	Discovering the scientific concept	4.815	1	4.815	6.239		
	Interpretation of notes	0.680	1	0.680	0.885		
	Using the concept in problem-solving	6.219	1	6.219	5.925		
	Using the scientific concept in reasoning, deduction, and generalization	3.312	1	3.312	3.308		
Covariate (Pre-test Scientific Concept Identification)	Application of the concept	9.545	1	9.545	5.541		
	Determine verbal meaning	0.213	1	0.213	0.341		
	Discovering the scientific concept	0.477	1	0.477	0.618		
	Interpretation of notes	0.628	1	0.628	0.817		
	Using the concept in problem-solving	0.537	1	0.537	0.511		
Covariate (Pre-test Interpretation of Observations)	Using the scientific concept in reasoning, deduction, and generalization	0.623	1	0.623	0.622		
	Application of the concept	0.881	1	0.881	0.511		
	Determine verbal meaning	0.004	1	0.004	0.006		
	Discovering the scientific concept	1.270	1	1.270	1.646		
	Interpretation of notes	2.783	1	2.783	3.620		
	Using the concept in problem-solving	0.148	1	0.148	0.141		
	Using the scientific concept in reasoning, deduction, and generalization	0.001	1	0.001	0.001		
	Application of the concept	0.724	1	0.724	0.420		
	Determine verbal meaning	3.194	1	3.194	5.103		

Source	Dimension	Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
Covariate (Pre-test Use of the Concept in Problem Solving)	Discovering the scientific concept	0.323	1	0.323	0.418		
	Interpretation of notes	0.181	1	0.181	0.236		
	Using the concept in problem-solving	2.710	1	2.710	2.581		
	Using the scientific concept in reasoning, deduction, and generalization	3.494	1	3.494	3.489		
	Application of the concept	5.695	1	5.695	3.306		
Covariate (Pre-test Use of the Scientific Concept in Reasoning, Inference, and Generalization)	Determine verbal meaning	6.633	1	6.633	10.598		
	Discovering the scientific concept	0.818	1	0.818	1.059		
	Interpretation of notes	0.303	1	0.303	0.394		
	Using the concept in problem-solving	1.398	1	1.398	1.331		
	Using the scientific concept in reasoning, deduction, and generalization	0.368	1	0.368	0.367		
Covariate (Pre-test Concept Application)	Application of the concept	0.004	1	0.004	0.002		
	Determine verbal meaning	0.695	1	0.695	1.111		
	Discovering the scientific concept	0.441	1	0.441	0.571		
	Interpretation of notes	0.541	1	0.541	0.703		
	Using the concept in problem-solving	0.267	1	0.267	0.255		
	Using the scientific concept in reasoning, deduction, and generalization	7.424	1	7.424	7.413		
	Application of the concept	1.413	1	1.413	0.820		
	Determine verbal meaning	8.191	1	8.191	*13.086	0.001	0.189
	Discovering the scientific concept	13.658	1	13.658	*17.696	0.000	0.240
	Interpretation of notes	19.397	1	19.397	*25.236	0.000	0.311
Hotelling's Trace = 0.747, p = 0.000**	Using the concept in problem-solving	6.574	1	6.574	*6.263	0.015	0.101

Source	Dimension	Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
Error	Using the scientific concept in reasoning, deduction, and generalization	7.943	1	7.943	*7.932	0.007	0.124
	Application of the concept	19.304	1	19.304	*11.206	0.001	0.167
	Determine verbal meaning	35.051	56	0.626			
	Discovering the scientific concept	43.222	56	0.772			
	Interpretation of notes	43.044	56	0.769			
	Using the concept in problem-solving	58.781	56	1.050			
	Using the scientific concept in reasoning, deduction, and generalization	56.080	56	1.001			
	Application of the concept	96.469	56	1.723			
Adjusted Total	Determine verbal meaning	62.359	63				
	Discovering the scientific concept	68.859	63				
	Interpretation of notes	73.109	63				
	Using the concept in problem-solving	79.734	63				
	Using the scientific concept in reasoning, deduction, and generalization	83.750	63				
	Application of the concept	137.000	63				

*Statistically significant at ($\alpha=0.05$)

Based on the results of the multivariate analysis of variance shown in Table 4, it is observed that the significance value for Hotelling's Trace test, concerning the variable "teaching method," was (0.000), which is less than ($\alpha=0.05$). This suggests that there is a statistically significant difference in at least one dimension of chemical concepts resulting from the teaching method. To identify which specific dimension was affected by the teaching method, a univariate analysis of covariance (ANCOVA) was conducted for each dimension separately. The results were as follows:

The significance value for the dimension of "identifying verbal meaning" concerning the teaching method was (0.001), which is less than ($\alpha = 0.05$). This indicates the rejection of the null sub-hypothesis related to this dimension and the acceptance of the alternative hypothesis, which states:

"There is a statistically significant difference at the level of ($\alpha=0.05$) between the mean scores of the study participants on the dimension of chemical concepts (identifying verbal meaning) attributed to the teaching method."

Based on the mean scores shown in Table 3, it is evident that the statistically significant difference was in favor of the experimental group participants who were taught using the Multiple Intelligences teaching method. The effect size for the identifying verbal meaning dimension was calculated and found to be 0.189, which is considered a large effect size (Cohen, 1988). This indicates that 18.9% of the variance (improvement) in the post-test performance on this dimension is attributable to the Multiple Intelligences teaching method.

The significance value for the "scientific concept discovery" dimension about the teaching method was (0.000), which is less than ($\alpha = 0.05$). This indicates the rejection of the null hypothesis related to this dimension and the acceptance of the alternative hypothesis, which states:

There is a statistically significant difference at the level of ($\alpha=0.05$) between the mean scores of the study participants on the chemical concepts dimension (scientific concept discovery) attributable to the teaching method."

Based on the mean scores presented in Table 3, it is evident that the experimental group participants, who were taught using the Multiple Intelligences teaching method, showed a statistically significant difference. The effect size for the scientific concept discovery dimension was calculated to be 0.240, which is considered a large effect size (Cohen, 1988). This indicates that 24.0% of the variance (improvement) in the participants' post-test performance on this dimension is attributable to the Multiple Intelligences teaching method.

The significance value for the "interpreting observations" dimension about the teaching method was (0.000), which is less than ($\alpha = 0.05$). This indicates the rejection of the null hypothesis for this dimension and the acceptance of the alternative hypothesis, which states:

"There is a statistically significant difference at the level of ($\alpha = 0.05$) between the mean scores of the study participants on the chemical concept dimension (interpreting observations) attributable to the teaching method."

From the mean scores presented in Table 3, it is evident that the experimental group participants, who were taught using the Multiple Intelligences teaching method, showed a statistically significant difference in their performance. The effect size for the interpreting observations dimension was calculated at 0.311, which is considered a large effect size (Cohen, 1988). This indicates that 31.1% of the variance (improvement) in the participants' post-test performance on this dimension is attributed to the Multiple Intelligences teaching method.

The significance value for the "applying the concept in problem-solving" dimension about the teaching method was (0.015), which is less than ($\alpha = 0.05$). This indicates the rejection of the null hypothesis for this dimension and the acceptance of the alternative hypothesis, which states:

"There is a statistically significant difference at the level of ($\alpha = 0.05$) between the mean scores of the study participants on the chemical concepts dimension (applying the concept in problem-solving) attributable to the teaching method."

Based on the mean scores presented in Table 3, it is evident that the statistically significant difference was in favor of the experimental group participants who were taught using the Multiple Intelligences teaching method. The effect size for applying the concept in the problem-solving dimension was calculated to be 0.101, which is considered a medium effect size (Cohen, 1988). This indicates that 10.1% of the variance (improvement) in the participants' post-test performance on this dimension is attributed to the Multiple Intelligences teaching method.

The significance value for the "applying the scientific concept in reasoning, inference, and generalization" dimension of the teaching method was (0.007), which is less than ($\alpha = 0.05$). This

indicates the rejection of the null hypothesis related to this dimension and the acceptance of the alternative hypothesis, which states:

"There is a statistically significant difference at the level of ($\alpha = 0.05$) between the mean scores of the study participants on the chemical concepts dimension (applying the scientific concept in reasoning, inference, and generalization) attributable to the teaching method."

From the mean scores presented in Table 3, it is evident that the experimental group participants, who were taught using the Multiple Intelligences teaching method, showed a statistically significant difference. The effect size for this dimension was calculated to be (0.124), which is considered a medium effect size (Cohen, 1988). This indicates that 12.4% of the variance (improvement) in the participants' post-test performance on this dimension is attributed to the Multiple Intelligences teaching method.

The significance value for the "application of the concept" dimension according to the teaching method was (0.001), which is less than ($\alpha = 0.05$). This indicates the rejection of the null hypothesis related to this dimension and acceptance of the alternative hypothesis, which states:

"There is a statistically significant difference at the level of ($\alpha = 0.05$) between the mean scores of the study participants on the chemical concepts dimension (application of the concept) attributable to the teaching method."

From the mean scores shown in Table 3, it is evident that the experimental group participants, who were taught using the Multiple Intelligences teaching method, performed significantly better than the control group participants. The effect size for the application of the concept dimension was calculated to be 0.167, which is considered a large effect size (Cohen, 1988). This indicates that 16.7% of the variance (improvement) in the participants' post-test performance on this dimension is attributed to the Multiple Intelligences teaching method.

4.2. Result Related to the Second Question

This question states: "What is the effectiveness of teaching according to Multiple Intelligences in interpreting household chemical phenomena among primary 9th-grade students?"

The following null hypothesis was derived from this question: "There is no statistically significant difference at ($\alpha=0.05$) between the mean scores of the study participants on the overall items of the household chemical phenomena interpretation test attributable to the teaching method (traditional vs. Multiple Intelligences)."

To answer the question and verify its hypothesis, the means and standard deviations of the study participants' pre-test, post-test, and adjusted post-test performances on the overall items of the household chemical phenomena interpretation test were calculated according to the teaching method (traditional vs. Multiple Intelligences). Table 5 illustrates these results.

Table 5. Means and Standard Deviations of the Study Participants' Pre-Test, Post-Test, and Adjusted Post-Test Performance on the Overall Items of the Household Chemical Phenomena Interpretation Test, According to the Teaching Method

Teaching Method	Pre-test		Post-test		Overall post-test performance	
	Mean	Std. Deviation	Mean	Std. Deviation	Adjusted Mean	Standard Error
Conventional	8.47	2.63	13.41	2.03	13.40	0.36
Multiple Intelligences	8.41	2.87	17.91	2.37	17.92	0.36

Table 5 shows an apparent difference between the pre-test and post-test means of the experimental group's performance, as well as an apparent difference between the post-test means of the control and experimental groups. To determine the statistical significance of these observed post-test differences according to the teaching method, a univariate analysis of covariance (ANCOVA) was conducted, as shown in Table 6.

Table 6. Results of the Univariate Analysis of Covariance (ANCOVA) for the Post-Test Mean Scores of the Study Participants on the Overall Items of the Household Chemical Phenomena Interpretation Test According to the Teaching Method

Source	Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
Pre-test (paired)	55.273	1	55.273	13.641		
Teaching Method	327.051	1	327.051	*80.716	0.000	0.570
Error	247.164	61	4.052			
Corrected Total	626.438	63				

*Statistically significant at ($\alpha=0.05$)

Based on the results of the analysis of variance shown in Table 6, it is observed that the significance value for the teaching method was (0.000), which is less than ($\alpha = 0.05$). This indicates the rejection of the null hypothesis and the acceptance of the alternative hypothesis, which states:

"There is a statistically significant difference at the level of ($\alpha = 0.05$) between the mean scores of the study participants on the overall items of the household chemical phenomena interpretation test attributable to the teaching method (traditional vs. Multiple Intelligences)."

From the mean scores presented in Table 5, it is evident that the experimental group participants, who were taught using the Multiple Intelligences method, showed a statistically significant difference in their performance. The effect size was calculated to be 0.570, which is considered a large effect size (Cohen, 1988). This indicates that 57.0% of the variance (improvement) in the participants' post-test performance on the household chemical phenomena interpretation test is attributable to the Multiple Intelligences teaching method.

5. Discussion

5.1. Discussion of the First Question

The study's result demonstrates the effectiveness of teaching according to multiple intelligences in students' acquisition of chemical concepts in all their dimensions and with a large impact size, when compared to teaching in the traditional way, in which the learner is passive in the learning process, receiving information from the teacher and focusing on memorizing and retrieving knowledge.

This result may be attributed to the characteristics that distinguish teaching according to multiple intelligences, which reflect the constructivist approach to learning, in which the teacher's role is to guide and direct the learning process. The student is an active participant in the learning process, implementing, evaluating, researching, investigating, experimenting, and thinking critically. Teaching according to multiple intelligences also requires the teacher to diversify the teaching strategies, activities, and experiences that are employed in learning, including linguistic, logical, mathematical, visual, artistic, manual, skill, social, and natural environmental, as well as individual and group thinking and reflection activities, and employing all available sources. An educational or technical

enhancement to the learning process, making the learning process more enjoyable and engaging for students.

This result may also be attributed to the fact that teaching based on multiple intelligences requires teachers to diversify the methods, strategies, and assessment instruments used to accommodate all types of intelligences in students. This led to the development of students' diverse mental abilities, not limited to their ability to memorize and retrieve. Furthermore, by learning based on multiple intelligences, students transcend the confines of their school to their homes and environment. Learning based on multiple intelligences is both individualized and collaborative, taking into account students' differences and unique strengths. This positively impacts their motivation to learn, as mentioned by Al-Aqayleh et al. (2021), and their engagement with the subject, thereby developing their various scientific, mental, and manual skills and enhancing their capacity for creativity and innovation. Also the use of multiple intelligences in teaching provided students with the opportunity to dialogue and present arguments. In this context, Sekerci & Canpolat (2014) indicate that presenting arguments contributes to the acquisition of chemical concepts, and Kola (2017) indicates that presenting arguments improves science learning.

Given that teaching according to multiple intelligences focuses on all mental abilities, this has been positively reflected in the students' ability to identify definitions that reflect the meanings of concepts, i.e., identify the verbal meaning of the learned chemical concepts; their ability to classify examples of different chemical concepts and generalize their features to their examples, and determine the extent to which different examples belong to them, i.e., discover chemical concepts using the processes of discrimination, classification, and generalization; their ability to identify the causes of the occurrence of different events based on their understanding of different chemical concepts, i.e., the ability to interpret observations using chemical concepts; their ability to link learned chemical concepts to their real lives; and use their knowledge to interpret the problems they encounter, thus finding appropriate solutions for them by predicting and isolating the factors that lead to their occurrence, i.e., using chemical concepts to solve problems; and their ability to perceive the relationship between general chemical concepts and less general concepts, and to move from general concepts to their examples or to less general concepts, and to build logical inferences and new knowledge based on their understanding of chemical concepts. They can make general judgments and rules based on various observations, i.e., apply chemical concepts in reasoning, deduction, and generalization. They are also able to understand real-life or scientific situations by applying chemical concepts through the use of higher scientific and analytical skills, i.e., applying the chemical concept.

This result is consistent with the study of Al-Zoubi (2017), which indicated the effectiveness of teaching based on multiple intelligences in acquiring scientific concepts among seventh-grade students in Jordan. It also aligns with other studies that have demonstrated the effectiveness of multiple intelligences in academic achievement, as the acquisition of concepts is considered part of academic achievement. For example, Tuysüz and Geban (2000) conducted a study in Turkey and reported that teaching based on multiple intelligences increased the academic achievement of ninth-grade students. Similarly, Al-Badour and Al-Khataybah (2004) found in Jordan that teaching based on multiple intelligences improved the achievement of seventh-grade students in science, while Davis (2004) reported increased achievement among fourth-grade students in science. Bas (2016) conducted a meta-analytic study in Turkey and found that instruction based on Multiple Intelligences Theory had a large effect on students' academic achievement. Likewise, Aydin (2019) in Turkey analyzed several previous studies and concluded that using instructional activities based on multiple intelligences enhances students' academic performance. All of these findings support and validate the results obtained in the present study.

5.2. Discussion of the Second Question

The findings of this question demonstrate the effectiveness of teaching according to Multiple Intelligences in interpreting household chemical phenomena among the experimental group students, compared to traditional teaching methods, where learners play a passive role in the learning process, receiving information from their teacher and focusing mainly on memorization and recall. Consequently, their learning is limited to memorizing phenomena presented by the teacher without linking them to prior concepts within their cognitive structure. In contrast, teaching according to Multiple Intelligences emphasizes all intellectual abilities, which leads the students to acquire the necessary chemical concepts to interpret chemical phenomena.

This result may be attributed to the fact that teaching according to Multiple Intelligences reflects all aspects of constructivist learning, emphasizing student-centeredness and considering individual differences and variations among learners. It involves diversifying teaching strategies, learning experiences, and educational activities, especially those that focus on investigating phenomena and events that students encounter daily or hear about from various sources. This approach highlights the role of the student as an inquisitive researcher or a young scientist. Moreover, it incorporates a variety of activities, assessment methods, and strategies that genuinely reflect the students' abilities, as well as diverse educational resources, whether technological, software-based, or material, used throughout the learning process and in interpreting different phenomena students may encounter or observe.

Additionally, this result may be explained by the fact that teaching based on Multiple Intelligences enhances students' capacities for thinking, reflection, and contemplation about their surroundings. Consequently, it develops their abilities to interpret and explain various events and phenomena they may experience at school or at home. This embodies the core of constructivist learning, which aims to transfer the impact of students' learning in various subjects—including chemistry—into their daily lives, homes, and environments. This has increased the students' ability to interpret chemical phenomena they observe and encounter daily in different parts of their homes, such as kitchens, bathrooms, gardens, and other household areas. This is achieved by encouraging them to investigate the causes of these phenomena out of intrinsic motivation, satisfying their curiosity by identifying household chemical phenomena and the factors leading to their occurrence. They then determine the relationship between the presence of these factors and the phenomenon itself, which is known as their interpretation of the phenomenon.

The result of this question is consistent with the study of Al-Qawasmeh and Al-Qadri (2017), which was conducted in Jordan and found that the use of both electronically supported and unsupported multiple intelligences strategies had an effect on students' ability to interpret scientific phenomena among third-grade students. This finding also aligns with studies that demonstrated the effectiveness of multiple intelligences in teaching other dependent variables that may contribute to developing the ability to interpret scientific phenomena, such as achievement, motivation, attitudes, and scientific processes. For instance, Tuysüz and Geban (2000) examined achievement and attitudes as dependent variables, Al-Badour and Al-Khataybah (2004) investigated achievement and scientific processes, Davis (2004) focused on achievement, Aydin (2019) analyzed achievement across multiple studies, and Al-Aqayleh et al. (2021) examined motivation. Students with positive attitudes toward science are more motivated to learn it, which leads them to engage in various scientific processes—the foundation of knowledge construction—and thereby acquire knowledge and additional concepts that help them interpret scientific phenomena, including chemical phenomena. No studies were found that contradicted the results of the current study.

6. Conclusion

Based on the findings of this study regarding the effectiveness of teaching according to multiple intelligences in enabling students to acquire chemical concepts in all their dimensions, and its effectiveness in enhancing their ability to interpret household chemical phenomena compared to the traditional teaching method, the importance of employing multiple intelligences in teaching chemistry becomes evident. This approach helps to strengthen students' understanding through the acquisition of chemical concepts and improves their ability to explain surrounding household chemical phenomena.

Despite the limitations of the sample size and the study duration, it provides a foundation that can guide decision-makers and teachers in integrating multiple intelligences into teaching. Accordingly, there is a need to train teachers in the use of multiple intelligences in instruction, develop curricula that consider students' diverse intelligences, and provide a supportive learning environment that fosters these intelligences and their development.

7. Suggestion and Recommendations

- Encourage policymakers, supervisors, and curriculum developers to design instructional units in chemistry and other subjects based on multiple intelligences, given their positive impact on the acquisition of chemical concepts and the interpretation of chemical phenomena.
- Encourage science teachers to employ multiple intelligences in teaching science and provide them with the necessary training to do so.
- Conduct similar studies to examine the effectiveness of applying multiple intelligences in addressing other dependent variables, higher grade levels, and different subjects.

Declarations

Author Contributions. Designing two tests used to detect the effect of teaching based on multiple intelligences in acquiring chemical concepts and the ability to interpret household chemical phenomena among primary school students.

Conflicts of Interest. The authors declare no conflict of interest.

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About the Contributor(s)

Bayan Al-Kasasbeh, Chemistry teacher holding a Bachelor's degree in Applied Chemistry, a High Diploma in Pre-service Teacher Preparation and Qualification, and a Master's degree in Science Curricula and Teaching Methods.

Email: byanmohmmad12345@gmail.com

ORCID: <https://orcid.org/0009-0006-8735-0303>

Waleed Nawafleh, Professor of Science Curricula and Teaching Methods – Department of Curricula and Instruction – Yarmouk University.

Email: wnawafleh@yu.edu.jo

ORCID: <https://orcid.org/0009-0001-2164-4054>

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