

Research Article

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Teaching Practices of Middle School Science Teachers in Light of the PISA 2025 Test Competencies

Seham Sayer Almutairi , Tahani Salman Alangari

Abstract

Background/purpose. The study aimed to identify the teaching practices of middle school science teachers in light of the PISA 2025 test competencies.

Materials/methods. A descriptive-analytical approach was employed, and an observation card was used to collect information. It was applied to a sample of middle school science teachers in public schools in Jubail City (n = 25).

Results. The study reached several results, the most important of which were: The level of the reality of teaching practices of middle school science teachers in light of the PISA 2025 test competencies in Jubail Governorate schools is generally weak, as the arithmetic mean of the total practices in the observation was 2.15. The level was (medium) in the practices of competency (explaining phenomena scientifically), and at a weak level in the practices of competency (building and evaluating designs for scientific research, and interpreting data and scientific evidence critically), and came at an absent level in the practices of competency (research, evaluation, and using scientific information to make decisions and procedures).

Conclusion. The researchers recommended activating the role of training and professional development centers for teachers to develop their teaching skills in general, and those related to developing students' abilities in the PISA test in particular.

1. Introduction

Education is one of the most important achievements that all countries strive to reform and improve in terms of their development at both the global and local levels. Countries face many challenges, which vary according to the security and economic conditions, but developing education systems and raising the country's status among the ranks of the advanced countries of the world remains the most significant challenge they must overcome.

One of the most significant challenges facing education, especially in developing countries, is its low level compared to other education systems characterized by progress; consequently, the weakness of students' abilities and skills is a fundamental outcome of the education system. This was clarified by several field studies conducted in many Arab countries, including the study by Al-Momani (2023), which indicated that the momentum of curricula increases the burden on teachers, leading to their inability to provide information effectively to their students. In this regard, discussing the connection between teachers' practices and global testing, such as PISA, is important. Teachers are the most important school-level factor in student achievement, and their classroom practice should be aligned with the PISA competencies to prepare students to achieve in real-life problem-solving situations. The present study, therefore, targets the teaching process and how it may explain how students develop the competencies being evaluated in the PISA 2025 framework.

Recently, international tests have emerged as a modern trend, requiring specific qualifications for students to improve their ability to pass these tests. These tests measure their abilities in knowledge, thinking skills, and attitudes at a certain level (Al-Shammari & Al-Zamil, 2024). On the other hand, international tests enable participating countries to improve and develop their educational capabilities by making comparisons in the educational systems of those participating countries. Developed countries also prioritize teaching science and mathematics as curricula that will contribute to forming future scientists and innovators to enhance their countries' global position at the industrial, technological, and economic levels.

Although many countries seek to participate in the "PISA" test (Program for International Student Assessment), Saudi Arabia's experience in this field reflects many countries' challenges. The Kingdom participated for the first time in 2018 among 79 countries worldwide, and the results were below expectations, as it ranked 65th globally with 399 points in reading, 373 in mathematics, and 386 in science (OECD, 2019). Comparing students' results in the international test "PISA" for the year 2021 with those of 2018 reveals that the results remained largely unchanged (OECD, 2022).

The approach adopted by the "PISA" test to assess scientific knowledge differs from most other assessments that examine the extent of mastery of scientific content, as it focuses on students' ability to apply the knowledge and skills they have acquired in their studies. The "PISA" test is held every three years. It extends to (120) minutes, in addition to (15) minutes for questionnaires designated for students, teachers, and leaders of participating schools, to measure the performance of the educational systems of the participating country through the performance of a sample of students aged (15) years from multiple schools. This test assesses students' ability to apply the information and skills acquired during their previous learning period in reading, science, and mathematics to solve real-life and professional problems they encounter (OECD, 2019).

The Education and Training Evaluation Commission (2024) in the Kingdom of Saudi Arabia has explained that the test aims to evaluate knowledge, skills, and attitudes that reflect current changes in educational curricula and measure students' ability to apply knowledge in daily life situations they are exposed to. In support of this trend, the Education and Training Evaluation Commission has developed the Teacher's Guide (2020) for science to clarify the difference between the concepts, knowledge, and skills that a student acquires in the curricula prescribed for science in the Kingdom,

and what is included in the "PISA" test. The intended skills are problem-solving, thinking, and adapting to life's developments.

Many studies have confirmed the relationship between teachers' teaching practices and students' performance on the science test in the "PISA" test, such as the study (Oreskes, 2019), which proved that students' competence in searching for, evaluating, and using scientific information cannot be developed except by the teacher following teaching practices based on direct teaching of cognitive traits and social practices that support science practice. This is also consistent with the study, whose results indicated that the level of teaching practices of science teachers plays a significant role in students' performance on the "PISA" test and that this was evident in the relationship between the levels of teaching practices of science teachers in Canada and the United States of America and the performance of students in these two countries. Also, the study (Kalkan et al., 2020), which aimed to determine the relationship between teacher roles and students' performance on the international student assessment tests "PISA" in the data of the year (2015) in Turkey, Singapore, the United States, Korea, Italy, and Brazil. The results indicated the presence of a significant association between science teachers' teaching practices and student test performance.

Many studies have shown increasing interest in evaluating the quality of education and student outcomes in light of the requirements of the international student assessment tests, "PISA," which aim to measure their reading, mathematics, and science skills. In this context, Al-Khalifa (2019) sought to evaluate the content of science books in the middle school in the Kingdom of Saudi Arabia according to the scientific competencies included in the scientific knowledge field of the "PISA" program. The study found differences in the content of science books addressing these competencies based on grade level, which affected teachers' performance and how they presented information.

Al-Shammari and Al-Zamil (2024) also aimed to measure the performance level of science teachers in the Kingdom based on proposed standards related to the international test "PISA." The results showed a low level of performance by teachers, with an average score of 1.257, indicating a low degree. The ranking of the standards varied: the cognitive field and the development of scientific attitudes were at a medium level, while the ability to interpret scientific phenomena, scientific research, and scientific issues was at a very low level.

On the other hand, Zhang et al. (2023) investigated the impact of science teachers' additional roles in teaching science courses in accordance with PISA standards on their job satisfaction. The results showed that professional collaboration among teachers had a positive impact on their science teaching and self-efficacy, as their commitment to the PISA principles improved their job satisfaction by helping them achieve their educational goals of enhancing students' science performance.

However, the 2022 PISA test results in Saudi Arabia revealed a general weakness in student performance, as no high-performing students were observed in science, indicating their inability to apply their scientific knowledge creatively and independently in diverse situations, including unfamiliar ones (OECD, 2022).

As the teacher is a crucial element in the educational process, Al-Shammari & Al-Zamil (2024) focused on the impact of teacher qualifications in Korea and China on teaching skills across the curriculum based on the results of PISA 2015. The results showed a positive impact of teachers' qualifications on students' acquisition of the necessary skills, as reflected in the positive results of the "PISA" 2018 tests, where China ranked first, and Korea ranked eighth (OECD, 2019).

Finally, Torrijos-Muelas et al. (2023) investigated the capabilities of science teachers to teach their courses in accordance with the "PISA" test. The results indicated that teaching methods based on inquiry, problem-solving, and modeling enhance science learning by improving the depth of knowledge teachers convey to their students.

Since the gaps in Saudi Arabia's PISA performance are evident, it is urgent to focus on how existing middle school science teaching practices align with the PISA 2025 competencies. Through this, the research aims to provide policymakers, teacher training institutions, and curriculum developers with practical suggestions on improving educational levels to meet global standards (Wu, 2025).

While international studies have shown that teachers' instructional practices play a significant role in student achievement in PISA, little is known about how these practices align with the Saudi context. Saudi Arabia's performance in PISA 2018 and PISA 2021 demonstrates continued weaknesses, but there are no comprehensive studies examining the practices of middle school science teachers in relation to PISA competencies. Such absence of evidence is a clear research gap preventing policymakers and curriculum developers from developing targeted interventions. Thus, this study intends to analyze the instructional practices of Saudi middle school science teachers within the context of PISA 2025 competencies and to suggest actionable recommendations for improving educational outcomes and aligning with international standards.

One key aspect of the study's significance is that it may help provide empirical evidence that directly addresses Saudi Arabia's challenges with international assessments. Once details of teachers' classroom practices have been analyzed, the research might offer insight into the extent to which present teaching practices align with the problem-solving, critical thinking, and application learning areas distinguished in PISA. The fact that Saudi students have demonstrated mastery of content is one part of the issue; understanding the difficulties these students face in applying their knowledge in non-traditional banking contexts is another part of the problem. Another consideration supporting the rationale of the study is that the international literature confirms that the impact of teacher practices on student success outweighs the collective impact of reforms led by policymakers. For instance, Singapore and Finland are examples of higher-performing countries that invest significantly in teacher development through professional development or training, recognizing that large-scale educational reforms are necessary and not stopping at teacher development alone. The considerations presented here may assist Saudi Arabia in its recent reform based on what it learned from its examples and other reforms, as they emphasize teaching practices, not simply curriculum (Al-Shammari & Al-Zamil, 2024).

In the end, this research completes an important cycle of dissection by connecting the realities of the classroom to global standards. The outcomes are expected to provide policymakers, curriculum developers, and training organizations with the evidence needed to develop policy, curriculum, and practice monitoring systems that can lead to improved student performance in international assessment activities and educational and occupational outcomes.

The study problem is represented in the following questions:

1. What is the level of teaching practices related to scientifically explaining phenomena for science teachers in middle school in light of the competencies of the "PISA 2025" test?
2. What is the level of teaching practices related to (building and evaluating designs for scientific research, and interpreting data and scientific evidence critically) for science teachers in the middle school?
3. What is the level of teaching practices related to (research, evaluation, and using scientific information to make decisions and actions) for science teachers in the middle school?

2. Literature Review

2.1. *The International Student Assessment Test "PISA"*

The Program for International Student Assessment (PISA) is an international program that measures students' abilities in mathematics, science, and reading. It was conducted for the first time in 2000 to obtain reliable data on the performance of educational systems in participating countries (Al-Shammari & Al-Zamil, 2024).

The International Student Assessment Test "PISA" is directed at students aged 15 years approaching the end of their compulsory education (OECD, 2022). It is based on the equality of students' ages without considering their grades. This is done to avoid discrepancies, as each country has its own educational system that affects grade and age levels. Also, students aged 15 are about to finish compulsory education in most OECD countries, which allows for examining cumulative educational performance and basic competencies.

The Program for International Student Assessment (PISA) assesses three main school subjects: Subject 1: Science literacy, which is defined as the ability to engage in issues related to science and its ideas; Subject 2: Reading literacy, which is defined as the ability to understand, think, and deal with written texts; to achieve goals, develop knowledge, and participate in society; Subject 3: Mathematics literacy: which is defined as the ability to formulate, use, and interpret mathematics in a variety of contexts, in addition to the ability to use mathematical concepts and procedures to describe, explain, and predict phenomena. More than 80 countries cooperate to build the "PISA" test. The test takes two hours and is in two languages: English and the language of the country in which the test is applied (Polat et al., 2022).

2.2. *Organizing the International Student Assessment Test "PISA"*

The Organization for Economic Co-operation and Development relied on several experts from the ministries of education of the participating countries to meet the needs of the test, successfully implement a test of this size, and define the PISA testing policy (Navarro-Martinez & Peña-Acuña, 2022). These experts are divided into two groups: the first group determines the targeted topics in the "PISA" test in mathematics, science, reading, and problem-solving, and the second group administers the test as a whole and provides guidance on creating the test. Thus, it becomes clear that the international student assessment test, "PISA," is a collaborative effort, not monopolized by a single country or a group of countries. However, a union that includes experts from all countries participating in the test, and each of these experts has specific tasks according to the "PISA" mechanism of work.

2.3. *Implementing the international student assessment test "PISA"*

The test is presented as an electronic assessment, which includes three types of question formats: multiple-choice, short-answer, and long-answer. Regarding sampling, the "PISA" program implements a two-stage stratified sampling design to select schools and students randomly (Jerrim, 2023). In the first stage, random samples are taken from several schools in each participating country using probability samples proportional to size. In the second stage, samples are taken from eligible students randomly selected from each of the randomly selected schools.

PISA assesses three core subjects: reading literacy, mathematics literacy, and science literacy. The test is administered over a three-year cycle (Jerrim, 2023). In addition to the three academic domains, PISA provides a core questionnaire to students to collect information about family background, socioeconomic and cultural aspects, student attitudes toward education, student perceptions of the school environment, habits, life outside school, motivation, and other personal variables. The test is administered to randomly selected students for two hours (Jerrim, 2023).

Local project managers from each country review the tests, and each participating country has designated PISA test correctors who assign marks and scores to the tests according to a protocol established by the PISA consortium and relevant experts. After the correction team has finished, the results are sent to the PISA consortium and the OECD (Ping & Jen, 2023).

2.4. PISA and science literacy

Science literacy is “the ability to deal with science-related issues” (OECD, 2016). Science literacy in PISA is based on the assumption that a student’s specific response to science requires skill and knowledge of science topics, and depends on the student’s readiness to engage with the topics (OECD, 2016).

Although many variables affect students’ levels of scientific performance in science, examining the literature shows that one of the most important factors that determine a student’s level in science is his or her ability to apply it in real life, in addition to the student’s emotional characteristics, such as motivation, self-efficacy, readiness, self-control, and cognitive beliefs, as well as school-related factors including the quality of educational materials, teacher qualifications, and physical characteristics.

Thus, it is clear that the PISA test did not rely on factors related to the school curriculum only to measure students’ ability to know science, but instead relied mainly on measuring students’ ability to apply science knowledge in real life, in addition to assessing the affective (non-cognitive) variables related to students’ performance in science.

The main goal of the PISA program in science is to teach science in a way that enables students to play an informed role in making choices that affect their environment, and to understand the social implications resulting from discussions among experts (OECD, 2022). Therefore, according to the PISA program, science education aims to develop the competence to search for, evaluate, and use scientific information in decision-making and action.

The PISA program also aims to assess knowledge and skills that reflect current changes in the science curriculum and to assess what students can do compared to what they have learned (Al-Baltan, 2022).

The Program for International Student Assessment (PISA) pays great attention to science education, due to the economic necessity facing all countries of economic cooperation and development to ensure the education of the next generation of scientists, as science has a great place in the curriculum schedule alongside mathematics and reading (OECD, 2023).

The representatives of the scientific community, Loureiro et al. (2023) and Wang & Hsieh (2022), draw attention to the role of inquiry-based and interdisciplinary activity in cultivating science skills at the level predicted by PISA. In addition, cross-country comparisons show that the highest-achieving countries have engaged in regular investment in teacher professional development, i.e., Finland and Singapore, which currently have the strongest results in scientific literacy (Martinez-Abad et al., 2023).

2.5. Teaching practices and science teaching competencies according to the PISA test

Teachers' teaching practices are linked to effective learning in the classroom. Teaching practices are defined as practical procedures or actual behavior performed by teachers, according to the different stages of the lesson, to achieve the objectives set in the plan. Competencies are also viewed synonymously with practices as the main reason for successful or unsuccessful performance in science (Putri et al., 2025). Since competence affects performance, many areas of science education are linked to competence, and the aim of developing competencies in the Program for International Student Assessment (PISA) is to link intelligence, problem-solving, and knowledge together.

The three core competencies are the direct sources of the study's observation indicators. For example, practices associated with such conceptual questions as asking, data interpretation activities, and judgment on scientific evidence are all linked to Competencies 1, 2, and 3, respectively (Al-Qawaqza, 2019). This will ascertain that the instrument employed gauges the true instructional behaviors needed to carry out PISA-aligned learning.

Science education according to the PISA test involves three competencies: Competency 1: Competency in providing explanations for natural phenomena, artefacts, and technologies; Competency 2: Competency in constructing and evaluating designs for scientific inquiry and critically interpreting scientific data and evidence, which is the ability to consider whether the study design is fit for purpose, how it can be improved, and whether appropriate procedures have been used; and Competency 3: Competency in finding and critically evaluating scientific information and then using this knowledge to make decisions that guide action (PISA, 2023).

These competencies require knowledge. Competency 1 requires explaining scientific phenomena and knowing the content of science, in addition to the nature of scientific explanations and supporting evidence, while Competencies 2 and 3 require more than knowledge, as they depend on understanding how scientific knowledge is created, and the degree of confidence in teaching it, which is generally called scientific practices.

These three previous competencies for teaching science require the teacher to follow teaching procedures and practices that are consistent with them and achieve their main objectives in a way that contributes to qualifying students for the international assessment test (PISA) - especially - about providing explanations for phenomena, and constructing and evaluating designs for scientific investigation and searching for information, collecting it and evaluating it objectively.

2.6. Core Science Competencies in the PISA 2025 Framework

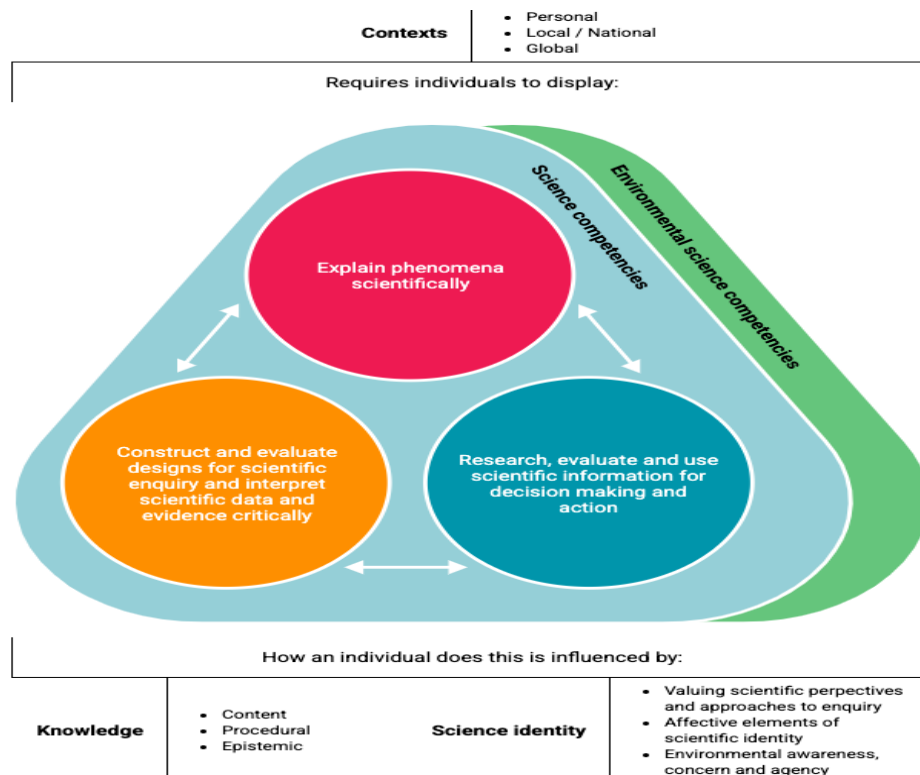


Figure 1. Core Science Competencies in the PISA 2025 Framework

3. Methodology

3.1. General Background

The study used the descriptive analytical method. "The descriptive method deals with the study of existing and available research events, phenomena and practices without the researcher having any intentional intervention in their course, and the researcher must interact with them through description and analysis" (Buntha, Yasri, & Duangpummet, 2024), by trying to identify the teaching practices of science teachers in the middle school in light of the "PISA" test competencies in the Jubail Industrial City.

The study community consisted of all science teachers in the middle stage in public education schools in the Jubail Industrial City in 2024 (n=30) according to the statistics of the Jubail Education Office, and the middle education was tested. This is because it is the stage that precedes the application of the International Program for Student Assessment (PISA), which provides greater opportunities to improve student results in the stage at which the PISA program is applied to them.

This descriptive-analytical research design allows for consideration of patterns and relationships relevant to policy and practice. It serves to analyze contextual influences on teaching, allows comparisons of how groups of schools perform, and establishes a basis for developing recommendations that simultaneously address practices at the classroom level and policies at the system level. The analysis used descriptive statistics to condense teaching methods. The analysis also included comparisons of the differences in context across teacher levels of experience and their specialties. The analysis showed the rigor and replicability of the study. Enhanced statistical tests like reliability testing and validity assessments were used to enhance interpretations, ensuring findings could not only be generalized but also direct the evidence-based educational reforms (Buntha, Yasri, & Duangpummet, 2024).

The study sample included all members of the original community of teachers, except that several teachers refused to answer, i.e., they apologized for participating, and some of them did not respond in a way that achieved the goal of applying the observation tool; therefore, the final number of the study sample was (n=25) in the middle school, and the representation rate was (83.3%) of the study community.

The following is a description of the study sample according to the initial data:

3.2. According to the specialization variable

Table 1. Distribution of the number of members of the questionnaire sample according to the specialization variable and its percentage

Coding	Specialization	Sample	Percentage %
1	Biology	9	36.0
2	Chemistry	11	44.0
3	Physics	5	20.0
Total		25	100.0

It is noted from Table 1 that the sample members were distributed into (9) teachers specializing in biology, (11) specializing in chemistry, and (5) specializing in physics.

3.3. According to experience

Table 2. Distribution of the number of questionnaire sample members according to experience

Coding	Experience	Sample	Percentage %
1	1 – 5 years	10	40.0
2	6 – 10 years	3	12.0
3	11 – 15 years	8	32.0
4	More than 15 years	4	16.0
Total		25	100.0

It is noted from Table (2) that (40%) of the sample members have (1-5 years) experience, that (12%) of them have (6-10 years of experience), that (32%) of them have (11-15 years of experience), and that (16%) of them have (more than 15 years of experience).

3.4. Instrument and Procedures

The study instrument was an observation card to evaluate the teaching practices of science teachers in the middle school, in line with the competencies of the "PISA 2025" test. The card aims to identify the reality of these practices and determine their level. The card was formulated based on several reliable sources, including the teaching processes included in the Program for International Student Assessment (PISA), and the reference framework document for the science curriculum "PISA 2025" (OECD, 2023), in addition to previous studies that focused on preparing observation cards for teaching practices according to this program. The observation process entailed three classroom visits for each teacher on various science lessons (biology, chemistry, physics). Observers were trained science education researchers skilled in using the observation rubric, and inter-rater reliability was guaranteed through calibration meetings. The four weeks were taken in the Spring 2024 term.

The instrument included a list of teaching practices related to the three main competencies in the "PISA" program, which are: explaining phenomena scientifically, building and evaluating designs for scientific research, interpreting data and evidence critically, and researching, evaluating, and using information to make decisions and actions. The card included 15 indicators for the first competency, 17 indicators for the second competency, and seven indicators for the third competency. A four-point rating scale (high, medium, weak, absent) was established for each indicator, with numerical scores ranging from 3 to 0 assigned to determine the level of implementation. In addition, the instrument collected demographic characteristics, teaching background and professional development history to provide enhanced context for making meaning of how instructional strategies align with international performance indicators.

3.5. Controlling for Subjectivity

In order to guarantee objectivity, the dual-observer system was applied as each lesson was graded by two observers independently (Putri et al., 2025). Misunderstandings in ranking were brought up and solved. The observers were trained in practice observations and consensus-building sessions to minimize bias.

3.6. Validity

The card was adjusted, and its validity and reliability were verified to ensure accuracy. Regarding the validity of the content, the card was presented to a group of specialists who evaluated the validity of the indicators and their suitability for measuring scientific competencies, as well as their linguistic formulation. The percentage of agreement between the referees was taken as an indicator of the validity of the content, as the indicators that obtained an agreement rate of more than 80% were retained, resulting in the final card consisting of 37 indicators. The validity of internal consistency was also verified using Pearson's correlation coefficient, as the correlation coefficients were calculated

between the scores of the indicators and the total score for each scientific competency, in addition to the total score of the card, which showed strong internal consistency that enhances its credibility and suitability for assessing teaching practices objectively and accurately (OECD, 2023).

3.7. Reliability

The reliability of the card was also verified across individuals, as the researchers agreed with a colleague on the purpose of the study and the mechanism for applying for the observation card. (3) Lessons were observed for three teachers outside the final sample, as each researcher independently filled out an observation card for each lesson. After a week, the researchers re-observed the same teachers using the card. After recording the observations and dumping the data, the average percentage of agreement between the observers was calculated using the equation:

Agreement percentage = number of agreements / (number of agreements + number of disagreements) × 100.

The value of the agreement coefficient reached 85%, indicating high reliability of the card, as determined by Cooper (1973, p. 27).

In addition, reliability was measured using the Cronbach's alpha method, where the reliability of each dimension of the card was calculated separately, in addition to calculating the reliability of the card as a whole. The results indicated that the card has a high degree of reliability, as the Cronbach's alpha value for the card as a whole reached 0.87, which reflects its reliability and accuracy in measuring teaching practices.

The response mechanism for the observation card statements was designed to ask the observer to choose one of four alternatives that express the level of teaching practices. The available alternatives were: high (4), medium (3), weak (2), and absent (1). This system was used to measure the degree of teaching practices for each statement of the card according to the Likert scale, which provides a quantitative interpretation of the observers' responses. The levels of practices were determined based on the weighted average of each statement, which was classified according to Table 3.

Table 3. Weighted average significance scale

Weighted average		Level of practices
from	to	
1	75.1	Absent
1.76	2.50	Weak
2.51	3.25	Medium
3.26	4	High

4. Results

4.1. The level of teaching practices related to explaining phenomena scientifically in light of the PISA 2025 test competencies

The frequencies, percentages, and arithmetic means were analyzed to determine the level of teaching practices of middle school science teachers in light of the PISA 2025 test competencies in the dimension of explaining phenomena scientifically. Standard deviations of the study sample observation results were calculated based on the statements indicating the reality of teaching practices of middle school science teachers in light of the PISA 2025 test competencies in this dimension and their arrangement. The results are shown in Table 4.

Table 4. Frequencies, percentages, arithmetic means, and standard deviations of the results of observing sample individuals at the level of practices of the first dimension of the card

Practices	absent		Weak		Medium		High		Weighted average	ST	Practice level
	Freq.	%	Freq.	%	Freq.	%	Freq.	%			
Students are asked questions that require thinking skills to explain scientific phenomena	2	8	3	12	8	32	12	48	3.20	0.96	Medium
Link the academic content of the science subject to scientific issues	4	16	3	12	5	20	13	52	3.08	1.15	Medium
Assigns students tasks that require creative solutions to scientific problems	15	60	4	16	2	8	4	16	1.80	1.15	Weak
Train students to deduce the potential impacts of scientific issues on the local and global community	9	36	1	4	4	16	11	44	2.68	1.38	Medium
Train students on methods of linking conceptual knowledge with procedural knowledge	4	16	2	8	5	20	14	56	3.16	1.14	Medium
Practice cooperative learning with students	5	20	6	24	2	8	12	48	2.84	1.25	Medium
Discuss with students the role of science in explaining phenomena and developing solutions to scientific issues	8	32	5	20	4	16	8	32	2.48	1.26	Weak
Enhance students' engagement in discussions based on arguments from scientific evidence	4	16	3	12	4	16	14	56	3.12	1.17	Medium
Design training situations for students that require them to apply the information they have learned in a way that is relevant to reality	10	40	1	4	3	12	11	44	2.60	1.41	Medium

Practices	absent		Weak		Medium		High		Weighted average	ST	Practice level
	Freq.	%	Freq.	%	Freq.	%	Freq.	%			
Ask his students to provide scientific justifications for their predictions about issues related to science	8	32	4	16	3	12	10	40	2.60	1.32	Medium
Show scientific models to the students to help them explain scientific phenomena	8	32	5	20	3	12	10	40	2.60	1.32	Medium
Provide activities that require the implementation of scientific phenomena	12	48	2	8	6	24	5	20	2.16	1.25	weak
Help students employ previous information and knowledge in realistic contexts	7	28	3	12	2	8	13	52	2.88	1.27	Medium
Train students to deduce scientific relationships that link different scientific concepts	5	20	6	24	1	4	13	52	2.88	1.27	Medium
Shed light on the employment value of scientific knowledge in life	10	40	6	24	1	4	8	32	2.28	1.31	Weak
Explaining phenomena scientifically									2.68	0.68	Medium

It is clear from Table 4 that the level of practice of explaining phenomena scientifically was "medium" among science teachers in the middle school. The level of practices is average for 11) practices, and weak for 4).

In the first ranks, the statement "Ask students questions that require thinking skills to explain scientific phenomena" came first, with an arithmetic mean of 3.20 and a standard deviation of 0.96. The statement "Train students on methods of linking conceptual knowledge and procedural knowledge" ranked second, with an arithmetic mean of 3.16 and a standard deviation of 1.14. The statement "Enhance students' engagement in discussions based on arguments from scientific evidence" came in third place, with an arithmetic mean of 3.12 and a standard deviation of 1.17.

These results agreed with the study of Al-Shammari and Al-Zamil (2024), which showed that the rate of performance of science teachers in explaining phenomena scientifically was low. Also, these results are consistent with the University of Nottingham report, which investigated the reasons for the low performance of students in the PISA test in science. One of the most important reasons that the report focused on was the low levels of teaching practices for science teachers, as the report confirmed the low level of teaching practices in most countries that ranked low in the PISA test.

The researchers attribute the low teaching practices among science teachers to the teachers not receiving sufficient training in the scientific competencies included in the Program for International Student Assessment (PISA) and other international tests during the university stage. This is consistent with the study's results (Susanti & Eijkelhof, 2019), which indicated low student teacher abilities in the competencies specific to the Program for International Student Assessment (PISA).

The low level of teaching practices among science teachers can also be attributed to the lack of participation by middle school science teachers in educational courses that incorporate guidelines provided by the Organization for Economic Co-operation and Development to ministries of education in various countries. This is consistent with the study, which indicated that the teacher's lack of participation in continuous learning courses leads to low teaching practices.

- The level of teaching practices related to building and evaluating designs for scientific research, and interpreting data and scientific evidence critically in light of the PISA 2025 test competencies

To determine the level of teaching practices of middle school science teachers in light of the PISA 2025 test competencies in the dimension (building and evaluating designs for scientific research and interpreting data and scientific evidence critically), the frequencies, percentages, arithmetic means, and standard deviations of the results of observing the study sample were calculated on the statements indicating the level of the reality of teaching practices of middle school science teachers in light of the PISA 2025 test competencies in this dimension. The results were shown in Table 5.

Table 5. Frequencies, percentages, arithmetic means, and standard deviations of the results of observing sample members at the level of practices of the second dimension of the card

Practices	Absent		Weak		Medium		High		Weighted average	ST	Level
	Freq.	%	Freq.	%	Freq.	%	Freq.	%			
Train students to know the independent and dependent variables related to scientific phenomena	16	64	1	4	1	4	7	28	1,96	1,37	Weak
Alert students to extraneous variables that may change the results of interpreting scientific phenomena	18	72	0	0	1	4	6	24	1,80	1,32	Weak
Direct students to clarify, explain, and correct misconceptions related to the phenomenon	14	56	1	4	5	20	5	20	2,04	1,27	Weak
Train students to use data, illustrative figures, and charts related to scientific phenomena	12	48	2	8	0	0	11	44	2,40	1,47	Weak
Train students to use the steps of scientific research to reach results	24	96	0	0	0	0	1	4	1,12	0,60	Absent
Train students on how to interpret scientific results accurately and scientifically	19	76	1	4	1	4	4	16	1,60	1,15	Absent
Train students to interpret and analyze data and draw appropriate conclusions	19	76	1	4	2	8	3	12	1,56	1,08	Absent
Direct students to formulate scientific hypotheses that can be researched	19	76	1	4	1	4	4	16	1,60	1,15	Absent

Train them to follow scientific methods to answer research questions	24	96	1	4	0	0	0	0	1,04	0,20	Absent
Direct students to scientific issues that are subject to scientific research and investigation	8	32	3	12	1	4	13	52	2,76	1,39	Absent
Train students to formulate hypotheses based on evidence in scientific texts related to the topic	21	84	1	4	0	0	3	12	1,40	1,00	Absent
Train students on how to identify keywords used in researching a specific scientific issue	4	16	3	12	1	4	17	68	3,24	1,20	Medium
Train students on mechanisms for formulating scientific questions	19	76	1	4	1	4	4	16	1,60	1,15	Absent
Train students on building correct scientific models	17	68	2	8	0	0	6	24	1,80	1,29	Absent
Pose precise scientific questions to students that help them search for an explanation of scientific issues	10	40	4	16	2	8	9	36	2,40	1,35	Weak
Construct and evaluate designs for scientific research, and interpret scientific data and evidence critically									1,89	0,71	Weak

Table (5) shows that the level of practices of the competency of "building and evaluating designs for scientific research and interpreting scientific data and evidence critically" was "weak" among science teachers in the middle school in Jubail Governorate; as the level of practices was "medium" for (2) practices, a weak level for (6) practices, and an absent level for (7) practices.

In the first ranks, the statement "Train students on how to identify the keywords used in searching for a specific scientific issue" ranked first, with an arithmetic mean of 3.24 and a standard deviation of 1.20. The statement "He directs students to scientific issues that are subject to scientific research and investigation" ranked second, with an arithmetic mean of 2.76 and a standard deviation of 1.39. The statement "Ask precise scientific questions to students to help them search for an explanation for scientific issues" ranked third, with an arithmetic mean of 2.40 and a standard deviation of 1.35. The statement "Train middle school students to use data, illustrative figures, and graphs related to scientific phenomena" had an arithmetic mean of 2.40, with a standard deviation of 1.47.

These results were consistent with the study of Al-Shammari and Al-Zamil (2024), which indicated that the rate of performance of science teachers in scientific research was low. These results also align with the study by Doil & Pietzner (2023), which found a lower level of teaching practices among science teachers in Germany compared to those in Canada, Finland, and Singapore. This resulted in a low level of student performance in the "PISA" test compared to those three countries, whose teachers had higher teaching practices than those in Germany.

The previous results can be explained by the lack of interest among educational administrations in identifying the factors affecting students' performance in science on the "PISA" test, addressing

them individually, and finding ways to improve students' performance in the "PISA" test. This is consistent with what Azigwe (2022) indicated, where he indicated the need to provide questionnaires to students, teachers, and school administration; to identify the reasons for the poor performance of students, and then follow methods and practices that help improve the performance of students in the "PISA" test.

4.2. The level of teaching practices related to research, evaluation, and the use of scientific information to make decisions and actions in light of the competencies of the PISA 2025 test

To determine the level of teaching practices of middle school science teachers in light of the competencies of the PISA 2025 test in the dimension (research, evaluation, and the use of scientific information to make decisions and actions). The frequencies, percentages, arithmetic means, and standard deviations were calculated for the results of the observation of the study sample on the statements indicating the level of the reality of teaching practices of middle school science teachers in light of the competencies of the PISA 2025 test in this dimension. The results are shown in Table 6.

Table 6. Frequencies, percentages, arithmetic means, and standard deviations of the results of observing sample individuals at the level of practices of the third dimension of the card

Practices	Absent		Weak		Medium		High		Weighted average	ST	Level
	Freq.	%	Freq.	%	Freq.	%	Freq.	%			
Train students to criticize the credibility of scientific data and information in various research areas	18	72	2	8	3	12	2	8	1,56	1,00	Absent
Train students on methods of evaluating scientific evidence	18	72	2	8	1	4	4	16	1,64	1,15	Absent
Train students to make decisions related to scientific issues according to the scientific information available on these issues	16	64	2	8	0	0	7	28	1,92	1,35	Weak
Train students to evaluate explanations related to scientific issues	17	68	0	0	1	4	7	28	1,92	1,38	Weak
Train students to evaluate scientific arguments and evidence by looking at different sources, such as the Internet and newspapers, in terms of their degree of trustworthiness	23	92	1	4	1	4	0	0	1,12	0,44	Absent
Help students verify the validity of scientific hypotheses	22	88	0	0	0	0	3	12	1,36	0,99	Absent
Allow students to know how to distinguish between arguments based on scientific evidence and theories	22	88	0	0	0	0	3	12	1,36	0,99	Absent

Practices	Absent		Weak		Medium		High		Weighted average	ST	Level
	Freq.	%	Freq.	%	Freq.	%	Freq.	%			
Research, evaluate, and use scientific information to make decisions and take actions									1,55	0,70	Absent

Table (6) shows that the level of teaching practices for the competency of "research, evaluation, and use of scientific information to make decisions and procedures" was "absent" among science teachers in middle school in Jubail Governorate, as the level of practices was "weak" for 2 two practices. The level was "absent" for (5) practices.

In the first ranks, the statement "Train students to make decisions related to scientific issues according to the available scientific information about these issues" came in first place, with an arithmetic mean (1.92) and a standard deviation (1.350.96). The statement "Train students to evaluate explanations related to scientific issues" ranked second, with an arithmetic mean of 1.92 and a standard deviation of 1.38. The statement "Train students on methods of evaluating scientific evidence" came in third place, with an arithmetic mean of 1.64 and a standard deviation of 1.15.

These results are consistent with the study of Zhang et al. (2023), which aimed to investigate the impact of additional roles played by science teachers in teaching science courses according to the standards and competencies of the international student assessment tests "PISA", as the results indicated the low teaching practices of science teachers.

The researchers attribute the low teaching practices among science teachers to the fact that the curriculum did not accurately address scientific competencies and their indicators. This is consistent with the study of (Al-Khalifa, 2019) whose results indicated that there are differences in the content of science books in the middle school for the scientific competencies included in the field of scientific knowledge of the International Program for Student Assessment "PISA", which was also confirmed by the results of the study (Abu Ouda, M. F., Al-Nabi, N. H., & Ziyada, 2022). This issue is also mentioned in computer science education in other countries, such as the Slovak Republic and the Czech Republic, where the main weakness appears to be insufficient quality, or rather, the lack of relevant textbooks. The results also indicate a large deficit regarding the attractiveness of teachers' tasks during informatics lessons.

This issue is also mentioned in another subject: computer science education in other countries, such as the Slovak Republic and the Czech Republic, where the main weakness seems to be the insufficient quality of textbooks. The results also indicate a significant deficit in the attractiveness of teachers' tasks during informatics lessons (Záhorec et al., 2023).

The difference in teaching practices under various disciplines was identified subject-wise. Chemistry teachers display a relatively higher match with Competency 1 indicators, which is probably caused by the course's more practical and experiment-based character (Koerfer et al., 2025). In contrast, physics and biology teachers exhibited fewer levels of engagement in the Competency 3 practices, including evidence-based decision-making. This implies that the approach to professional development should be differentiated according to the pedagogical challenges of every subject.

The fact that the highest number of ratings in this domain are labeled as absent and weak means one can only presuppose two options: either the current curriculum does not specifically incorporate the PISA-focused scientific reasoning tasks, or the teachers are not informed about how to realize this indicator (Wu, 2025). To be able to break this gap, there is a need to realign the curriculum further, and there is a need to conduct specific training.

5. Conclusion

In light of the study's results, it was found that the teaching practices of science teachers in the middle school in Jubail Governorate, according to the competencies of the PISA 2025 test, were

generally weak. The results showed that the practices of explaining phenomena scientifically were at a medium level. In contrast, the practices of building and evaluating designs for scientific research and critically interpreting data and scientific evidence were weak. As for the practices related to research, evaluation, and the use of scientific information to make decisions and actions, they were at an absent level. These results reflect the urgent need to improve and develop the teaching practices of science teachers in line with the requirements of international tests.

Based on these findings, the study recommends practical and creative measures that contribute to developing these practices. The assimilation of micro-teaching cycles, which involve the teachers practicing PISA-related teaching strategies and receiving feedback from colleagues, is among the strategies recommended. Also, professional development can be supplied in a flexible and scalable form using lesson study groups and modular web-based courses (such as those on scientific reasoning or interpretation of data). The use of training models should involve the introduction of scenario tasks (based on real PISA items in science).

First, it is necessary to enhance professional training programs for teachers before and during service, so that these programs focus on the scientific competencies required in the PISA test while providing continuous opportunities to develop their teaching skills through interactive activities based on inquiry-based learning and problem-solving methods. These efforts can also be supported by establishing interactive educational laboratories equipped with modern technologies such as virtual reality and artificial intelligence, to allow teachers and students to experience scientific practices that simulate PISA requirements.

Additionally, it is recommended that an electronic educational platform that combines interactive resources and self-assessment tools be developed, allowing teachers to evaluate their progress continuously. Educational fellowship programs can also be designed to allow teachers to exchange experiences with colleagues from countries that excel in the PISA tests, which enhances their professional capabilities.

To enrich the educational experience, it is recommended to integrate creative arts and educational game technologies into science teaching, which makes the learning process more attractive and practical. Moreover, educational supervision should be further activated to monitor and analyze current teaching practices, while providing practical recommendations for development. Material and moral incentives can be allocated to teachers who excel in applying the scientific competencies of PISA, which enhances their motivation to adopt innovative teaching practices.

Future studies aimed at designing and implementing training programs to develop the teaching practices of science teachers should also be conducted while evaluating the impact of these programs on improving educational performance. In addition, factors that affect teaching practices can be studied, such as the challenges teachers face in applying scientific competencies and the practical ways to overcome them.

Declarations

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

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