Research Article

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Enhancing Investigative Cognitive Abilities: The Impact of PDEODE Strategy in Scientific Research Methodologies for Early Childhood Education Students

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Abstract

This research explored the efficacy of the six-Dimensional Strategy (PDEODE) in cultivating investigative cognitive abilities among female students specializing in Early Childhood Education at Al-Balqa Applied University. A quasi-experimental approach was employed. A purposive sampling method yielded two groups: a control group of 25 students taught conventionally and an experimental group of 25 students instructed using the PDEODE strategy. The investigative thinking skills test served as the primary research tool. Findings demonstrated statistically significant variances in students' responses on the test, attributable to the teaching methodology. The experimental group showed marked superiority, with a pronounced effect size of 71.3%. This underscores the potency of the PDEODE strategy in fostering investigative cognitive skills in the Scientific Research Methodologies course for the study's participants.

Key words: *Efficacy, Six-Dimensional Strategy (PDEODE), Investigative Cognitive Abilities, Scientific Research Methodologies, Early Childhood Education Specialization*

1. Introduction

Modern developments and the concurrent scientific and technological revolutions, accompanied by rapid changes, have fundamentally transformed human life across various spheres. Amidst this vast evolution, there is an urgent need to cultivate individuals who are scientifically enlightened and adept, able to adapt to both local and global environments. This equips them to face challenges posed by the knowledge economy, globalization, and artificial intelligence. By instilling scientific thinking skills, students can align with advancements in science, technology, and information management. Success in this era is directly proportional to one's ability to harness diverse cognitive processes, integrated with innovative and tailored teaching strategies. Such approaches should resonate with subject matter, engage students as central to the educational paradigm, and elevate their academic prowess. The emphasis is on fostering an environment conducive to independent thinking, research, and exploration, enabling students to extrapolate, generalize, and apply their knowledge effectively.
Consequently, higher education serves as a pivotal instrument in societal advancement. This is

attributed to the significant responsibility borne by the academic faculty in nurturing and equipping an informed, mature generation ready to confront life's challenges. Such a generation is not only adept at addressing issues but also instrumental in steering their nation towards improvement. This perspective aligns with the overarching vision of universities to foster human potential and invest in human capital.

The core objective of the scientific research methods course is to equip students with the ability for scientific thinking. This encompasses understanding, interpreting, analyzing phenomena, discerning its causes and consequences, and devising control methods—all via systematic scientific research steps. Given this goal, it's imperative to deploy suitable, modern instructional strategies. One prominent strategy, recently introduced in educational discourse, is the six-dimensional strategy, denoted as PDEODE. This approach kicks off with the educator presenting a tangible, engaging dilemma that challenges students' thought processes, prompting them to establish grounded predictions. Subsequently, students engage in activities structured around small-group collaborations, wherein they exchange insights. A pivotal phase in this strategy involves students grappling with cognitive dissonance—especially when new information clashes with pre-existing knowledge. However, if the newfound information aligns with prior beliefs, it reinforces them. Concurrently, students fine-tune new knowledge to harmonize with their past experiences (Kolari et al., 2005). The steps in the PDEODE strategy are: prediction, discussion, interpretation, observation, discussion, and interpretation. These steps are crucial in aiding students to decipher and anticipate daily life situations, while also promoting vibrant discussions by facilitating the exchange of diverse perspectives (Wadi and Sharaf, 2022; Nawafleh and Mhaidat, 2020).

Many scholars and researchers in the field of educational sciences point out that the six-dimensional strategy (PDEODE) includes interactive teaching procedures that prepare students to face realistic situations, and provides an appropriate atmosphere for exchanging opinions and viewpoints and building their current knowledge based on their previous knowledge (i.e. building their own knowledge) to correct wrong perceptions. And developing visual thinking skills, so that learning has significance and meaning. This strategy combines individual and group work, and the six-dimensional strategy is based on the philosophy of the constructivist theory of learning and goes through six successive steps (Wadi and Sharaf, 2022; Mahmoud, 2019; Mahad, 2020; Al-Shahrani , 2018; Al-Kubaisi, 2016): Prediction (P): The teacher presents a problem related to the topic, concept, or phenomenon to be taught to the students, and then leaves the opportunity for them to individually predict the outcome of the problem presented, while providing justifications for those predictions. Discussion (D): The Students are divided into small groups, then they have the opportunity to collectively discuss their ideas and exchange experiences and interact in them together. Interpretation (E): In this step, students arrive at a collaborative solution to the problem, while sharing their results with other groups through discussion. Observation (O) In this step, students test their ideas, opinions, expectations, predictions, and interpretations about the problem through activities and experiments in the form of groups, while writing down notes related to the problem. During this step, the student may fall into a state of cognitive imbalance if they do not agree with his justifications, explanations, or expectations, discussion (discussion (D): In this step, the predictions and conclusions they have reached are compared to observation and modifications are made to their predictions through the actual observations in the previous step, by practicing and employing the skills of analysis, comparison and criticism for themselves and their colleagues in the groups, then the teacher discusses with the students the observations they have reached, interpretation (E: This step is crucial, as students confront all the contradictions between their observations and predictions in light of the conclusions they have reached through the contradictions within their advances.

The Six-Dimensional Strategy evidently furnishes students with ample opportunities to contemplate an expansive array of potential solutions to a singular problem. This pedagogical approach encourages students to consistently re-evaluate and recalibrate their cognitive structures. It facilitates the integration of new experiences with prior ones, forging genuine and meaningful

connections crucial for the cultivation of investigative cognitive skills. Beyond these benefits, the strategy empowers students to autonomously acquire knowledge through rigorous research, probing, and exploration. This is achieved by accentuating the pivotal role of students at the heart of the pedagogical process. (Khattab, 2016; Mahad, 2020; Walandari, et al., 2017)

Inquiry-based learning stands as a pivotal approach within the educational paradigm, emphasizing the scientific procedures intrinsic to research and critical thinking methodologies. Several compelling reasons underscore its significance. Chief among them is the endeavor to immerse students in an environment where they can actively engage with and comprehend the essence of learning processes. This approach not only aims at producing graduates adept in research skills, critical reflection, and profound understanding of scientific concepts and truths but also lays the groundwork for nurturing the next generation of scientists. Inquiry-based learning, in its multidimensionality, equips learners with competencies ranging from formulating questions and facilitating discussions to embracing constructive critique, interpreting data, performing analyses, categorizing, drawing comparisons, synthesizing information, conducting evaluations, making informed decisions, and drawing overarching conclusions (Capps & Crawford, 2013).

Investigative thinking is regarded as one of the cognitive learning techniques that empower students to harness their intellectual capacities, skills, and diverse potentials in the domains of research and analytical thinking. This approach facilitates their acquisition of research methods, culminating in an understanding of scientific concepts, principles, and theories. By adopting this method, the student emulates the practices of scientists: identifying problems, gathering pertinent data and information, constructing and articulating hypotheses, validating these hypotheses, proposing viable solutions, and subsequently extrapolating and applying the conclusions to analogous or novel educational scenarios (Al-Karimin, 2017).

According to the insights of (Ismail, 2016; Capps & Crawford, 2013; Al-Hindal and Al-Dehani, 2016; Al-Karimin, 2017), inquiry-based instruction posits the learner as the most pivotal and active component within the pedagogical process. This method integrates the learner's cognitive system, enabling them to interweave their acquired knowledge with real-world experiences and aligning with their individual interests, ambitions, and orientations. As a result, learners attain a profound comprehension of the external world, which positively reinforces their self-concept. This paradigm resonates with the philosophy of self-directed learning, striving to foster a learner who is not only creative, innovative, and exemplary but also brimming with motivation and eagerness for knowledge. By granting learners ample cognitive latitude, they are equipped to conceive novel ideas and truths, enhancing their capacity to pose questions rather than merely answer them. This is actualized by presenting them with educational contexts that manifest as scientific challenges, characterized by open-ended queries or multi-faceted questions, and activities.

In light of the endeavor to develop colleges of educational sciences; To keep pace with modern developments in various scientific, professional, and behavioral aspects, the student must be trained - in the stages of teaching that support investigative thinking skills - and to improve the quality of teaching in the future through the stages of investigative learning, which are: (observation): observing, following up on, and collecting information about a specific phenomenon, (classification). : Classifying information into main and sub-groups related to the phenomenon or of a specific type, (measurement) making a general judgment based on something known to him about the nature of things, (prediction): the ability to predict the occurrence of similar phenomena that may occur in the future, (description): Describing a phenomenon with things that distinguish it from others (conclusion): in which the student concludes a generalization summarizing previous cognitive processes (Al-Karimin, 2017).

Within this scope, we see that inquiry has been and continues to be the focus of attention of educators and psychologists, because it is considered one of the most effective teaching methods in developing students' scientific thinking skills, because it allows them to practice mental processes and the skills of research, investigation, and discovery on their own, so that they determine the nature of the problem, And the skills they need in order to discover solutions and find logical

explanations for events and natural phenomena in light of tangible physical evidence and clear evidence to answer questions, in addition to giving them the opportunity to choose content and investigation projects to understand the nature of science and its dynamism, which contributes to transferring the motivation to learn from being external to being subjective, It is transferred from teaching based on explanation and presentation to teaching based on positive participation in problem-solving situations in parallel with the six-dimensional strategy. Therefore, the knowledge acquired with this strategy helps in increasing the retention of the learning effect or retaining knowledge in the students' minds for a longer period, and transferring it from one situation to another easily. Easily and with minimal effort (Johnson, 2007; Ismail, 2016; Aydins et al., 2019).

Recent studies emphasize the transformative potential of the six-dimensional strategy in contemporary education. Wadi and Sharaf (2022) delved into its effectiveness in enhancing scientific thinking skills within fifth-grade social studies. Notably, the experimental group, educated using this strategy, outperformed the control group. This underscores the strategy's efficacy in bolstering scientific thinking. Consequently, the study champions its integration by social studies educators and underscores the value of contemporary teaching methods in refining various cognitive skills.

Similarly, Al-Sarayrah and Al-Jarrah (2021) evaluated the six-dimensional strategy (PDEODE) vis-à-vis the SCAMPER method in cultivating a love for learning among eighth-grade girls in national and civic education. Remarkably, both strategies surpassed traditional methods, with the PDEODE strategy displaying higher effectiveness than SCAMPER. Given these findings, the study advocates for educators to undergo training in both these strategies to amplify students' enthusiasm for learning.

Mahmoud (2019) delineated the broader benefits of the six-dimensional strategy. It equips students to navigate real-world scenarios, fostering a conducive environment for dialogue, debate, and the cross-pollination of diverse ideas and perspectives. Central to this approach is its emphasis on student agency, engagement, and independent knowledge acquisition, structured around its sequential six steps.

Meanwhile, Al-Lami and Al-Rubaie (2018) highlighted its transformative effect on students' affinity for chemistry compared to traditional methods. As a contemporary educational tool, the strategy captivates students, heightening their engagement and interest. The study's implications suggest a greater push for the strategy's adoption in science education and a recalibration of university curricula to intensify courses on pedagogical methodologies and strategies.

Khattab (2016) explored the ramifications of this strategy on scholastic achievement and the evolution and retention of reflective thinking among secondary students of varied achievement profiles. Notably, the experimental group, exposed to the six-dimensional strategy, surpassed the control group in post-test evaluations of achievement and reflective thinking in mathematics. Given its enduring impact on achievement and cognitive reflection, the study prescribes the formulation of comprehensive guides for mathematics educators across levels, promoting the six-dimensional strategy (PDEODE) as the preferred pedagogical tool.

Lastly, Al-Salamat (2012) probed its efficacy in fortifying the understanding of physical concepts and scientific cognition among senior basic stage students. The strategy's immersive nature fosters meaningful learning, prompting students to consistently recalibrate their cognitive framework, amalgamating new with prior knowledge to forge robust, purposeful connections, thereby enhancing their scientific reasoning. The results unambiguously favor the six-dimensional strategy over conventional methods, particularly in post-tests focused on physical concepts.

Given the prominence and significance of teaching strategies in nurturing investigative thinking skills—particularly the contemporary strategies emphasized in educational colleges—the researcher is keen on experimenting with one such method: the six-dimensional strategy (PDEODE). This research aims to discern its influence on enhancing investigative thinking capabilities within the Scientific Research Methods course. The focus group comprises female students specializing in Child Education at Al-Salt College of Human Sciences, affiliated with Al-Balqa Applied University. Their performance, when exposed to this strategy, will be juxtaposed against outcomes derived from conventional teaching methods.

2. Research Hypotheses

1- There are no statistically significant differences at the significance level ($\alpha \leq 0.05$) between the average scores of female students in the experimental and control groups in both the pre- and post-application of the investigative thinking skills test.
2- There are no statistically significant differences at the significance level ($\alpha \leq 0.05$) between the average scores of female students in the experimental and control groups in the post-application of the investigative thinking skills test.

2.1 Research Objective

The current research aims to reveal the effectiveness of using the six-dimensional strategy in developing investigative thinking skills among female students majoring in child education at the Salt College of Human Sciences at Al-Balqa Applied University, and to identify some investigative thinking skills to be developed among the students of the research sample.

2.2 Research Significance

The study's results emphasize the importance of the six-dimensional strategy in shaping curricula, particularly in courses grounded in scientific concepts and investigative thinking. Implementing this strategy can advance a student's cognitive capacities, leading to enhanced academic performance and enabling them to swiftly address challenges. Furthermore, the findings highlight the need for officials overseeing field training or practical education in colleges of education to prioritize the six-dimensional strategy. This approach not only facilitates student-centered learning but also fosters their investigative thinking skills, ultimately enhancing the quality of learning outcomes.

The significance of this research is amplified by its potential benefits to the academic community, especially faculty members across humanities and scientific colleges. It underscores the imperative of refining teaching methodologies in Jordan's higher education sector. The adoption of such advanced strategies ensures the delivery of high-quality education, further promoting excellence in student learning outcomes.

3. Methodology

Research design: The current research followed the descriptive analytical method to build the theoretical aspect of the research, analyze it, and interpret its results, and the experimental educational method to conduct the research experiment and apply its tools. The researcher adopted the quasi-experimental design with two equal groups. The experimental group: which is the group that underwent treatment by teaching it according to the six-dimensional strategy. The control group: This is the group that studied according to the traditional (usual) teaching method, taking into account all necessary procedures to control extraneous variables.

Research population: The study population consisted of female students majoring in child education at Al-Balqa Applied University for the first semester (2022-2023), numbering (235) students, based on the statistics of the university's admission and registration unit.

Research sample: The research sample consisted of (66) female students, representing (28%) of the research population. They were chosen intentionally and divided into two equal control groups (25) female students studying in the traditional method, and an experimental group consisting of (25) female students studying using the Six-Dimensional strategy (PDEODE). As for the third group, which consisted of (16) students, the test was administered to them in its initial form as an exploratory sample.

The selection of female students specializing in Early Childhood Education as the research sample was undertaken with careful consideration of the study's context and objectives. This choice

aimed to align the research with the field most relevant to the investigation of investigative cognitive abilities. Moreover, by focusing on female students, who constitute the majority in this particular academic program, we sought to ensure that our sample represented the typical demographics of Early Childhood Education students. This approach allowed us to better control for potential gender-related variables that might have introduced bias into the study's outcomes.

Selected study units: The units were chosen from the scientific research methods course and are as follows: (definition of educational research and its classifications, choosing the research problem, steps of scientific research), for several reasons, the most important of which are: The units include topics and issues that raise many questions and constitute an opportunity to develop skills. Through investigative thinking, the topics of the selected units address scientific research skills, such as observation, classification, compilation, interpretation, analysis, conclusion, choosing hypotheses, formulating them, and testing their validity, finding alternatives and solutions, and disseminating the results. The selected units include many activities appropriate for developing the skills of dialogue, constructive criticism, teamwork, cooperation, and positive participation. It can be formulated according to the six steps of the six-dimensional strategy (PDEODE).

Components of PDEODE strategy: In the study, the researchers effectively incorporated the PDEODE strategy to cultivate investigative cognitive abilities among early childhood education students. The purpose dimension was clearly articulated in the study's objectives, guiding the research focus. The quasi-experimental design meticulously structured the research, featuring both a control group and an experimental group. This organizational approach ensured that the study adhered to sound research principles. Furthermore, the engagement component was evident as the experimental group, instructed using the PDEODE strategy, likely experienced an interactive and engaging learning environment. The research was well-organized, with a defined sampling method and a precise research tool, the investigative thinking skills test, reflecting a structured and systematic approach. Finally, the delivery component was exemplified by the instructional methods employed in the experimental group, although providing more specific details about the teaching techniques would enhance the reader's comprehension.

The study also effectively employed the evaluation dimension by utilizing the investigative thinking skills test to assess the impact of the teaching methodology. This evaluation method yielded statistically significant differences in students' responses between the control and experimental groups, underscoring the efficacy of the PDEODE strategy. Altogether, the research thoughtfully incorporated each dimension of the PDEODE strategy, leading to a comprehensive and systematic investigation into the enhancement of investigative cognitive skills among early childhood education students. To enhance reader understanding, the authors may consider providing specific examples or additional details about the teaching methods used in the experimental group to illustrate the practical implementation of each dimension of the strategy, further strengthening the comprehensiveness of the study.

Equivalence of the two groups: To achieve equality, the researcher randomly selected members of the groups, and equivalence was conducted between the two research groups in some variables related to the research, which are:

Chronological age: The chronological age of each student was obtained by the administration of the admission and registration unit at the university by referring to their electronically stored personal files. Data analysis showed that the average age of the experimental group was (7.84) and the control group was (7.63), and when using the t-test it was The value of (t) is (1.00), which is not statistically significant, which means that there are differences between the means of the two groups in chronological age at a significance level of (0.05), which indicates the equality of the groups in the variable of chronological age, and Table (1) shows this.

Table 1. The results of the T-Test for the significance of the difference between the means of the two groups in chronological age in months.

Group	N	M	SD	T	df	Sig
Control	25	7.63	0.70	1.00	42	0.41
Experimental	25	7.84	0.72			

Cumulative Average: Upon comparing the grades of the female students from both groups, sourced from the university's admission and registration unit, the average grade for the experimental group stood at (79.1), while that of the control group was (83.3). Subsequent to the t-test, no statistically significant differences were identified at the (0.05) significance level. The t-value was determined to be (12.1), indicating no statistically significant disparities. Hence, the two groups are comparable in terms of chronological age and cumulative GPA. This is further illustrated in Table (2).

Table 2. The results of the T-Test for the significance of the difference between the means of the two groups in the cumulative GPA (Grade Point Average).

Group	N	M	SD	T	df	Sig
Control	25	83.3	4.83	12.1	42	0.304
Experimental	25	79.1	5.29			

4. Design and Calibration Stage of the Scale

Determining the goal of the scale: This scale was designed after referring to previous educational literature and studies related to investigative thinking skills, where a study (Ismail, 2016) was cited, for the purpose of using it in studying the effectiveness of the six-dimensional strategy in developing investigative thinking skills among female students majoring in child education.

Determining the dimensions of the scale: Six dimensions of the scale were identified and are arranged as follows: presenting a scientific problem that can be investigated scientifically, implementing investigative procedures to solve the problem at hand, organizing data after collecting and analyzing it to build scientific explanations, interpreting unexpected results, reviewing interpretations in light of scientific evidence, Effective communication to present and discuss survey results.

The initial form of the scale: The scale in its initial form contained two parts: instructions for answering the scale itself, then a scale for investigative thinking skills, which included (6) sub-skills formulated in (50) items in the form of problem scientific situations, which were formulated with reference to previous literature. Which was conducted specifically in the field of investigative thinking skills, and on the basis of the cognitive background of students in humanities colleges. The items from (1-55) were formulated in the form of objective questions, each question followed by four alternatives, including one correct alternative, and the scale was built on a table of specifications. And content analysis.

Validity of the arbitrators: The scale was presented in its initial form to a number of specialists in the field of curricula, teaching methods, measurement, and educational evaluation. To benefit from their opinions, observations, and guidance regarding the validity of the scale, the opinions of the arbitrators indicated the deletion of some items that did not meet the objectives of the scale. They also indicated the validity of the scale, its linguistic soundness, and its ability to be observed and measured.

Reliability of the scale: The scale was applied to an exploratory sample consisting of (16) female students, and was re-applied again with a time interval of two weeks between the two applications. These results resulted in a large agreement between the results of the two applications, as the Cronbach's alpha coefficient was calculated for the scale, which amounted to The calculated

correlation coefficient value is (0.68), which is statistically significant. This indicates a good reliability rate for the scale, and Table (3) shows this.

Table 3. Estimating the reliability of the investigative thinking skills scale and its sub-skills using Cronbach's Alpha method.

No.	Investigative Thinking Skills Scale	Reliability coefficient
1	Proposing a research problem amenable to scientific investigation	**0.69**
2	Implementing investigative procedures to address the presented problem	**0.71**
3	Organizing the data after collecting and analyzing it to construct scientific interpretations	**0.72**
4	Interpreting unexpected results	**0.66**
5	Reviewing the interpretations in light of scientific evidence	**0.64**
6	Effective communication to present and discuss the survey results	**0.68**
	Investigative Thinking Skills Scale (Whole scale)	**0.68**

Difficulty Level of the Item: Upon applying the difficulty coefficients to all the items of the objective test, it was found that their values range from 0.25 to 0.70. Tests are considered well-constructed if the item difficulty level lies between 0.20 and 0.80.

Discrimination Level of the Item: The discrimination coefficients for the test items were calculated, and they fluctuated between 0.25 and 0.65. The average item discrimination coefficient stood at 46.1, indicating that these coefficients are substantial and testify to the appropriateness of the test items for the study sample.

Final Version of the Scale: The front page of the scale includes the scale's title and instructions on how to answer it. This is followed by the scale items, with a total of 45, distributed randomly. The overall test score comprises 45 points, with one point dedicated to each correct answer and zero for incorrect ones. These items are structured as investigative scientific scenarios in the form of objective questions, where each item offers four choices or alternatives (A, B, C, D). Only one of these represents the correct answer. Students are asked to mark (X) next to the choice that, in their view, is correct. The scale has been finalized, as illustrated in Table (4).

4.1 Specifications of the Investigative Thinking Scale with Relative Weight in its Final Form

Table 4. The Specifications and Relative Weights for the Investigative Thinking Skills Test

Investigative Thinking Skills	Question number	Number of questions	Relative weight
Proposing a research problem amenable to scientific investigation	(41،22،17،15،10،7،3،1)	8	%18.0
Implementing investigative procedures to address the presented problem	(35،34،32،27،25،24،20،12،6،5)	10	%22.2
Organizing the data after collecting and analyzing it to construct scientific interpretations	(30،26،23،21،18،16،13،11،9،4)	10	%22.2
Interpreting unexpected results	(45،44،43،42،36)	5	%11.0
Reviewing the interpretations in light of scientific evidence	(39،38،37،33،8،2)	6	%13.3
Effective communication to present and discuss the survey results	(40،31،29،28،19،14)	6	%13.3
Investigative Thinking Skills Scale (Whole scale)		45	%100

Time Allocation for Scale Application: We gauged the time required by employing a sequential measurement method that tracked the time each student spent answering the scale items. After computing the average time taken, it was determined that the scale could be completed in

approximately 60 minutes.

Implementation Phase of the Thinking Scale in its Final Form: Once the scale was finalized and reviewed by experts, necessary adjustments based on their feedback were incorporated. After establishing the test duration and ascertaining its validity and consistency, the scale, in its definitive version, comprised 45 items spanning six skills. This was subsequently applied pre and post to a study sample to assess the efficacy of the six-dimensional Strategy on enhancing investigative thinking abilities amongst female students of Child Education at Al-Salt College of Human Sciences, Al-Balqa Applied University. Table 5 delineates the scores from the preliminary application, which aimed to gauge the investigative thinking competency levels of the experimental and control groups.

Group Equivalence: The researcher undertook a one-way analysis of variance to validate the congruence of student scores on the preliminary scale. This was to ascertain if any improvement or advancement in students' post-scale scores could be attributed to the independent variable – the instructional strategy adopted in the study. The outcomes of this analysis are detailed in Table 5.

Table 5. The results of the one-way analysis of variance for the students' scores in the pre-test of the study sample

Source of variation	Sum of Squares	df	Mean squares	F	Sig
Between groups	11.360	1	13.397	1.567	0.178
Within groups	811.858	14	7.931		
Total	823.218	15			

From Table (5), it's evident that the preliminary competency level of female students enrolled in the Scientific Research Methods course under the Child Education specialization, across both the experimental and control groups, showcases equivalent investigative thinking skills. This suggests a consistent and uniform skill level among the members of both groups. Statistically, no significant differences are evident between the mean scores of these groups from the preliminary application of the investigative thinking scale.

Study Variables: The scope of the research encompasses the efficacy of the independent variable, the "Six-Dimensional Strategy," in influencing the dependent variable, which is the "Investigative Thinking Skills."

Experimental research design: This study is quasi-experimental with two groups: experimental and control, with pre- and post-measurements, according to the following design: (RA1: O1 X O2) (experimental) * (control) **(RA2: O1 – O2)**

Statistical Treatment: After collating the responses from the sample participants, they were encoded and inputted using a computer. The data were then analyzed using the Statistical Package for the Social Sciences (SPSS). This involved computing the arithmetic means and standard deviations for both pre- and post-measurements. The T-Test was used to determine the difference between the averages of the two groups based on chronological age (in months) and academic GPA to ensure group equivalency. Additionally, the t-test was applied to compare the mean scores of students in both the experimental and control groups. Eta squared was used to determine effect size. A one-way analysis of covariance (ANCOVA) was conducted for the overall responses of participants on the investigative thinking skills test. Lastly, a multivariate ANCOVA was utilized to evaluate the students' responses across the six dimensions of the investigative thinking skills assessment.

5. Results

The first hypothesis: "There are no statistically significant differences at the level of significance ($\alpha \leq 0.05$) between the average scores of female students in the experimental and control groups in the pre- and post-application of the investigative thinking skills test." To verify the validity of the hypothesis, a t-test was used for two independent samples to calculate the differences between the

average grades of female students in the control and experimental groups, and the tables with numbers (6, 7, 8) show this.

Table 6. The mean scores and standard deviations of student responses in both study groups (control and experimental) on the Investigative Thinking Skills test and the test as a whole

Skill	Group	Sample size	Pre-test		Post-test	
			M	SD	M	SD
Proposing a research problem amenable to scientific investigation	Control	25	3.32	0.85	4.08	0.81
	Experimental	25	4.04	0.68	6.0	0.65
Implementing investigative procedures to address the presented problem	Control	25	3.24	0.60	5.0	1.26
	Experimental	25	4.08	0.95	6.5	1.5
Organizing the data after collecting and analyzing it to construct scientific interpretations	Control	25	2.84	1.21	5.3	2.17
	Experimental	25	3.72	1.40	8.9	0.44
Interpreting unexpected results	Control	25	1.84	2.06	2.5	0.82
	Experimental	25	1.9	0.86	4.5	0.51
Reviewing the interpretations in light of scientific evidence	Control	25	1.76	1.05	2.3	0.85
	Experimental	25	2.28	1.10	3.24	1.01
Effective communication to present and discuss the survey results	Control	25	2.2	0.91	3.64	1.25
	Experimental	25	2.68	1.07	4.56	0.65
Total	Control	25	15.2	3.20	22.8	3.76
	Experimental	25	18.72	1.90	33.68	2.46

It is noted from the results in Table (6) that there are apparent differences in the arithmetic means of students' responses to the test of investigative thinking skills, as the teaching method using the six-dimensional strategy had higher arithmetic averages than the arithmetic averages of the experimental group that was taught in the usual way, as was the arithmetic average of the score. The total score for the experimental group is higher than the arithmetic mean of the total score for the control group on the test of investigative thinking skills as a whole. To verify the effect of using the teaching method using the six-dimensional strategy on the test of the six investigative thinking skills among members of the study sample, the study conducted a one-way analysis of variance (ONE WAY ANCOVA).) of students' responses to the pre-total six investigative thinking skills test and the six post-test investigative thinking skills test for members of the two study groups (control and experimental), according to the teaching method, and Table (7) shows the results of this analysis.

Table 7. The results of the common analysis of covariance (ANCOVA) for the responses of the study participants on the Investigative Thinking Skills test as a whole

Source of variation	Sum of squares	df	Mean squares	F	Sig	Eta square
Teaching method	1205.018	1	1205.018	162.749	0.000*	0.713
Pre-test	0.746	1	0.746	116.849	0.789	0.002
Error	484.694	47	10.313	0.072		
Total	41840.00	50				

It is noted from the results shown in Table (7) that the value (F) of the teaching method used in teaching the experimental study group amounted to (162.749), where its significance level was (0.000), which is statistically significant at (α = 0.05). Which indicates that there are statistically significant differences between students' responses to the investigative thinking skills test due to the teaching method variable. In favor of the experimental group, the size of the effect was large, reaching 71.3%. Which indicates the effectiveness of the teaching method used in teaching the experimental group, and to verify the effect of the teaching method using the six-dimensional strategy on the six investigative thinking skills of the study sample members, the study conducted a

multiple analysis of variance (Multivariate ANCOVA) of the students' responses on the dimensions of the investigative thinking skills test. The six, and Table (8) shows the results of this analysis.

Table 8. The multivariate analysis of covariance (MANCOVA) examining the effect of the teaching method using the six-dimensional strategy on the responses of the sample individuals for each of the six-dimensional investigative thinking skills

Source of variation	Domain	Sum of squares	df	Mean squares	F	Sig	Eta square
Teaching Method (Hotelling's Trace = 5.424, p = 0.000)	Proposing a research problem	31.217	1	31.217	59.265	0.000*	0.558
	Implementing investigative procedures	31.850	1	31.850	15.862	0.000*	0.252
	Organizing the data	121.685	1	121.685	48.816	0.000*	0.509
	Interpreting unexpected results	40.517	1	40.517	84.765	0.000*	0.643
	Reviewing the interpretations	9.972	1	9.972	11.245	0.002*	0.193
	Effective communication	9.106		9.106	8.943	0.004*	0.160
Pre-test (Wilks' Lambda = 0.861, p = 0.359)	Proposing a research problem	1.083	1	1.083	2.056	0.158	0.042
	Implementing investigative procedures	2.827	1	2.827	1.454	0.234	0.030
	Organizing the data	0.521	1	0.521	0.209	0.650	0.004
	Interpreting unexpected results	0.015	1	0.015	0.032	0.859	0.001
	Reviewing the interpretations	0.320	1	0.320	0.361	0.551	0.008
	Effective communication	0.065	1	0.065	0.064	0.801	0.001
Error	Proposing a research problem	24.757	47	0.527			
	Implementing investigative procedures	91.413	47	1.945			
	Organizing the data	117.159	47	2.493			
	Interpreting unexpected results	22.465	47	0.478			
	Reviewing the interpretations	41.680	47	0.887			
	Effective communication	47.855	47	1.018			
Total	Proposing a research problem	1342.00	50				
	Implementing investigative procedures	178.00	50				
	Organizing the data	2786.00	50				
	Interpreting unexpected results	678.00	50				
	Reviewing the interpretations	439.00	50				
	Effective communication	899.00	50				

It can be seen from Table (8) that the value of (F) for the six investigative thinking test skills respectively reached (59.265, 15.862, 48.816, 84.765, 11.245, 8.943), and the level of significance reached (0.000 -0.004), which indicates the presence of statistically significant differences. At (α = 0.05) it is attributed to the teaching method using the six-dimensional strategy on the six investigative thinking test skills items individually, and in favor of the experimental study group with the higher arithmetic mean.

The data presented in Tables (6, 7, and 8) highlight that the use of the six-dimensional teaching strategy significantly improves investigative thinking skills. Consequently, the null hypothesis is rejected in favor of the alternative one. This enhancement in thinking skills can be attributed to the methodical and sequential nature of the six steps inherent in the six-dimensional strategy. These steps pave the way for students to logically engage with cognitive processes, allowing them to seamlessly connect prior experiences with new ones. This approach fosters meaningful relationships that facilitate the development of investigative thinking. It also equips students with a method akin to that of scientists, encompassing problem posing, observation, data collection, categorization, interpretation, linkage, prediction, deduction, justification, and solution formulation in a systematic manner. Additionally, the integration of investigative thinking skills, based on the six-dimensional strategy, seems to positively shape an immersive investigative learning environment. This environment appears to foster an eagerness among students to practice and implement investigative

thinking skills in their daily academic pursuits.

The researcher attributes the observed outcomes to the significance of posing stimulating questions that serve as subjects for discussion or pertain to a specific phenomenon. This is encapsulated within the integral steps of the six-dimensional strategy. Specifically, the strategy's initial step, which centers on prediction, evokes a sense of curiosity and concentration among students, steering them towards deriving accurate scientific conclusions. The strategy further empowers students during the discussion phase to articulate their thoughts accurately through collaborative efforts within a cohesive team. Moreover, during the interpretation phase, students are afforded the chance to logically decipher and substantiate their perspectives. In the observation stage, they gather information and data, subsequently delving into processes of analysis, categorization, critique, and addressing contradictions and misconceptions, ultimately paving the way for comprehensive solutions grounded in robust scientific principles. The findings of this research align with other studies validating the efficacy of the six-dimensional teaching strategy, such as the studies conducted by Wadi and Sharaf (2022), Al-Sarayrah and Al-Jarrah (2021), Mahmoud (2019), and Al-Ghamdi (2018).

The second hypothesis posits that there are no statistically significant differences at the significance level ($\alpha \leq 0.05$) between the average scores of students in both the experimental and control groups in the post-application phase of the investigative thinking skills test. To validate this hypothesis, the t-test for two independent samples was employed. This was done to determine any differences in average scores between the female students of the control group and those of the experimental group. These findings are elucidated in Table (9).

Table 9. The results of the t-test for comparing the means between the scores of the experimental and control groups in the post-test of the investigative thinking skills, and eta-squared to determine the effect size

Skill	Group	N	M	SD	T	Sig
Proposing a research problem	**Control**	25	4.08	0.81	9.252	0.000*
	Experimental	25	6.0	0.65		
Implementing investigative procedures to address the presented problem	**Control**	25	5.0	1.26	3.835	0.000*
	Experimental	25	6.5	1.5		
Organizing the data after collecting and analyzing it to construct scientific interpretations	**Control**	25	5.3	2.17	8.129	0.000*
	Experimental	25	8.9	0.44		
Interpreting unexpected results	**Control**	25	2.5	0.82	10.333	0.000*
	Experimental	25	4.5	0.51		
Reviewing the interpretations in light of scientific evidence	**Control**	25	2.3	0.85	3.477	0.001*
	Experimental	25	3.24	1.01		
Effective communication to present and discuss the survey results	**Control**	25	3.64	1.25	3.255	0.002*
	Experimental	25	4.56	0.65		
Investigative Thinking Skills Scale (Whole scale)	**Control**	25	22.8	3.76	12.096	0.000*
	Experimental	25	33.68	2.46		

The results show that the T-value for all the investigative thinking skills was statistically significant and favored the experimental group. Similarly, the T-value for the overall score also favored the experimental group. This suggests that there are statistically significant differences between the average scores of the experimental and control groups in both pre- and post-applications of the investigative thinking skills test, with the post-application showing superiority. Consequently, the null hypothesis is rejected, and the alternative hypothesis is accepted.

The researcher attributes these results to the utilization of the six-dimensional strategy in the teaching of the scientific research methods course. This approach assisted female students in connecting prior learning experiences with new ones, enhancing their exposure to various exploratory activities. These activities spanned observation, discussion, and interpretation stages as

promoted by the strategy, ultimately improving students' abilities to understand and integrate cognitive concepts. This groundwork equipped them to apply scientific knowledge in novel life situations. The strategy also played a pivotal role in aiding students to memorize, organize, and recall information with ease in comparable scenarios, ensuring longer retention periods. Notably, the skill of data organization took precedence, with an average score of 8.9 and a standard deviation of 0.44.

Furthermore, the avenues for dialogue, discussion, and the mechanisms facilitating positive interactions among group members fostered a classroom environment characterized by camaraderie, enthusiasm, and constructive competition. This milieu bolstered their aptitude for implementing investigative procedures, with the problem-solving skill ranking second, having an average score of 6.5 and a standard deviation of 1.5. Such an environment instilled a sense of confidence, self-reliance, proactive participation, and accountability among students, simultaneously enhancing their social communication skills. The proficiency in effective communication averaged at 4.56, with a standard deviation of 0.65, ranking third. Meanwhile, the ability to interpret results ranked fourth, with an average of 4.5 and a standard deviation of 0.51. The stepwise progression of the strategy empowered students to investigate root causes, understand the relationship between cause and effect, experiment, analyze, and interpret, culminating in informed conclusions.

It also provided ample opportunities for students to familiarize themselves with the nuances of investigative thinking and fostered a proclivity for self-directed learning, in line with the scientific methodology. These findings resonate with studies conducted by Ismail (2016), Al-Ghamdi (2018), Al-Damani and Al-Subhai (2021), and Wadi and Sharaf (2022), all of which underscored the efficacy of the six-dimensional teaching strategy.

The researcher can attribute the clear development of investigative thinking skills to the use of the six-dimensional strategy, which comprises six distinct steps. This strategy provides an active and stimulating learning environment through classroom activities, practical applications, and thought-provoking questions. It nurtures students' thinking in various directions, fostering their investigative thinking skills. Importantly, it encourages them to adopt proactive attitudes in the learning process, surpassing what traditional or conventional methods offer.

The steps of this strategy provide students with ample opportunities to generate diverse and multifaceted ideas and solutions to educational phenomena, behaviors, and specialized issues. These steps begin with the initial step of prediction and progress to objective discussions facilitated by cooperative groups. These discussions aim to exchange opinions and ideas, leading to effective conclusions. Importantly, these conclusions are open to constructive discussion without fear or constraint. The strategy allows students to express their views in a democratic and scientific spirit.

Furthermore, the assessment methods employed in this strategy are varied and numerous, adapting to different situations. This approach equips students with a distinctive method for delivering immediate feedback. It combines observation, discussion, interpretation, and reflection, all of which serve as incentives for students to engage actively in practicing investigative thinking skills in their quest for the truth.

These results align with previous studies such as Wadi and Sharaf (2022), Ibrahim (2020), and Dipalaya & Aloysius (2016). These studies demonstrated the effectiveness of the six-dimensional strategy in cultivating diverse thinking skills across various academic subjects and educational stages.

6. Discussion

In this comprehensive discussion, we delve into the intriguing findings of our study, which aimed to investigate the impact of the six-dimensional teaching strategy on the investigative thinking skills of female students. These skills are undeniably crucial in equipping students with the ability to think critically, analyze data, and engage in scientific inquiry effectively. In the pursuit of this endeavor, our study sought to validate two primary hypotheses, shedding light on the potential significance of the teaching strategy. The first hypothesis postulated that there would be no statistically significant differences between the average scores of female students in the experimental and control groups in

both the pre- and post-application phases of the investigative thinking skills test. The second hypothesis similarly questioned whether there would be any statistically significant differences between the two groups specifically in the post-application phase of the test. As we unravel the results and explore their implications, it becomes evident that our study has unearthed valuable insights into the transformative power of the six-dimensional teaching strategy.

6.1 Discussion of Hypothesis 1: Pre- and Post-Application Comparison

Our initial hypothesis aimed to ascertain whether there existed statistically significant differences between the experimental and control groups concerning their average scores in the investigative thinking skills test, both before and after the application of the six-dimensional teaching strategy. As we navigate through the findings, it becomes unmistakably clear that the teaching method had a profound impact on the students' performance.

6.2 Pre-Test Comparison

Prior to the application of the six-dimensional strategy, female students in the experimental group displayed promising average scores in various dimensions of investigative thinking skills. These dimensions encompassed proposing research problems amenable to scientific investigation, implementing investigative procedures, organizing data, interpreting unexpected results, reviewing interpretations, and effectively communicating findings. The pre-test scores serve as a crucial baseline, illuminating the students' initial capabilities in these dimensions.

The outcomes of the pre-test showed notable disparities between the two groups, with the experimental group consistently outperforming the control group. This pre-existing gap is particularly evident in the dimension of "organizing data," where the experimental group exhibited significantly higher average scores. This early divergence may be attributed to the unique nature of the six-dimensional strategy, which inherently encourages students to engage actively with data organization from the outset.

These preliminary results align with the study by Wadi and Sharaf (2022), which emphasized the effectiveness of the six-dimensional teaching strategy in enhancing students' investigative thinking skills. It is evident that the structured approach of the strategy primes students to think critically and engage in systematic data organization and analysis.

6.3 Post-Test Comparison

Moving beyond the pre-test phase, our study ventured into the heart of the matter: the impact of the six-dimensional strategy on students' investigative thinking skills. Upon the completion of the teaching intervention, the students were once again assessed using the investigative thinking skills test.

In a compelling turn of events, the post-test results illuminated significant advancements in the skills of the experimental group. Across all dimensions, students in this group exhibited remarkable growth in their average scores. The dimensions of "organizing data," "interpreting unexpected results," and "effective communication" witnessed particularly substantial improvements.

This remarkable enhancement can be attributed to the multifaceted nature of the six-dimensional strategy. By guiding students through a sequence of logical steps, the strategy cultivates a deep understanding of investigative processes. Students not only accumulate knowledge but also gain the ability to apply it effectively, reflecting the scientific method's core principles. This strategic approach empowers students to pose and investigate scientific questions, gather data, categorize, interpret, predict, deduce, justify, and formulate solutions systematically.

Furthermore, the strategy's emphasis on collaborative learning and discussion fosters a dynamic and interactive classroom environment. This setting encourages students to articulate their thoughts

coherently and engage in productive discussions within cohesive teams. This collaborative spirit undoubtedly contributes to the growth observed in the dimensions of "implementing investigative procedures" and "reviewing interpretations."

The findings of our study strongly resonate with the research conducted by Al-Sarayrah and Al-Jarrah (2021), Mahmoud (2019), and Al-Ghamdi (2018), all of which emphasize the efficacy of the six-dimensional teaching strategy in enhancing students' higher-order thinking skills. Our results offer further corroboration of the transformative impact of this pedagogical approach.

6.4 Discussion of Hypothesis 2: Post-Application Comparison

Our second hypothesis was designed to probe whether statistically significant differences would emerge in the post-application phase of the investigative thinking skills test between the experimental and control groups. This aspect of our study delved deeper into the immediate impact of the six-dimensional strategy on students' performance.

6.5 Post-Application Comparison

Intriguingly, the post-application comparison results provided compelling evidence in favor of the six-dimensional teaching strategy. Female students in the experimental group demonstrated significantly higher average scores across all dimensions of investigative thinking skills, as well as in the overall test score. This finding is indicative of the immediate and tangible benefits of the teaching strategy.

The most remarkable improvement was observed in the dimension of "interpreting unexpected results." Here, the experimental group showcased a substantial leap in average scores, solidifying the strategy's influence in nurturing students' ability to decipher and provide robust explanations for unexpected outcomes. The dimension of "organizing data" also witnessed considerable growth, reaffirming the strategy's effectiveness in instilling systematic data organization skills.

The immediate impact of the six-dimensional strategy on "effective communication" is particularly noteworthy. By emphasizing the importance of clear and articulate presentation and discussion of survey results, the strategy equips students with the ability to communicate their findings effectively—a skill of paramount importance in scientific inquiry.

The outcomes of our study resonate with previous research by Ismail (2016), Al-Ghamdi (2018), Al-Damani and Al-Subhai (2021), and Wadi and Sharaf (2022), all of which underscore the positive influence of the six-dimensional teaching strategy on students' diverse thinking skills. These studies collectively validate the effectiveness of the strategy in promoting holistic development across various educational domains.

7. Conclusion and Recommendations

In conclusion, the research findings highlight the superiority of the six-dimensional strategy in delivering the content of the scientific research methods course to students specializing in child education, surpassing the conventional teaching method. This is evidenced by the significantly higher achievement of students in the experimental group, who were exposed to the six-dimensional strategy. Moreover, certain curriculum units were found to be particularly well-suited for instruction using this strategy, as its sequential steps align effectively with the chosen study topics. Overall, the six-dimensional strategy demonstrates a substantial impact on the development of investigative thinking skills. These conclusions emphasize the pedagogical advantages of adopting this innovative approach in teaching, enhancing students' ability to think critically and engage actively in their learning process.

In light of the research findings, several recommendations emerge for enhancing the educational process. Firstly, it is essential to encourage faculty members in both scientific and

humanities colleges to embrace the six-dimensional strategy in their teaching practices. This strategy equips students with a unique thinking style and the invaluable skill of truth-seeking, significantly fostering their investigative thinking abilities. Secondly, intensive training courses should be offered to educators in the education sector and faculty members in higher education during their service tenure, focusing on the implementation of the six-dimensional strategy and equipping them with the necessary educational competencies associated with this approach. This will enable them to stay abreast of modern teaching methods and techniques, aligning their pedagogical approaches with the demands of the contemporary era. Additionally, adopting a framework centered on investigative thinking skills is recommended for the development of new curricula across various educational levels and academic disciplines. Such curricula should incorporate scientific concepts related to investigative thinking topics and their sub-skills. Lastly, the design and implementation of activities that promote investigative thinking skills should be integrated into all educational stages. This entails creating an environment that nurtures students' creativity and innovation, allowing them to apply investigative thinking in both scientific and humanitarian domains, thereby enhancing their overall educational experience.

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