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# Implementation of Early Childhood Science Education Course Based on Inquiry-Based Learning and Phenomenon-Based Learning to Enhance Scientific Inquiry Teaching Ability of Pre-service Early Childhood Teachers

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**Abstract**

**Background and aim:** Scientific inquiry teaching ability is one of the key abilities of science teachers to carry out inquiry teaching. In reality, many teachers lack the will and ability to implement inquiry-based teaching independently, so the opportunities and quality of students' participation in inquiry learning will also be restricted (Meng Xiulan et al., 2012). Therefore, it is of great practical significance to strengthen the cultivation of the scientific inquiry teaching ability of pre-service early childhood teachers. This study focuses on the influence of early childhood science education courses based on inquiry-based learning and phenomenon-based learning on the scientific inquiry teaching ability of pre-service early childhood teachers. Expanding the breadth and depth of the research on students' core literacy in science education is helpful to the development of students' science teaching ability. The purpose of this study was to compare the scientific inquiry teaching ability and students' satisfaction of pre-service early childhood teachers after learning through the early childhood science education course based on inquiry-based learning and phenomenon-based learning, with the criterion set at 70%.

**Materials and methods:** In this experimental study, 30 third-year students majoring in preschool education at Taizhou College of Nanjing Normal University were investigated. This study used a scoring rubric of scientific inquiry teaching ability and students' satisfaction questionnaire, with the reliability of 0.93, 091 respectively. The measurement through the research instruments was conducted after the implementation of the early childhood science education course based on inquiry-based learning and phenomenon-based learning. Data were collected and analyzed by means, standard deviation, and the determined criterion of 70% by using a t-test for one sample.

**Results:** The study found that the mean score of students' scientific inquiry teaching ability after learning through an early childhood science education course based on inquiry-based learning and phenomenon-based learning was 19.83, out of a full score of 24, with a standard deviation of 1.72. The posttest scores of students' scientific inquiry teaching ability were greater than the criterion of 70% at.01 level of statistical significance (t = 9.64, p=0.001). The mean scores of students' satisfaction after learning through early childhood science education course based on inquiry-based learning and phenomenon-based learning was 4.55 from the full score of 5, and the standard deviation was 0.34 which was statistically higher than the criterion of 70% at.01 level of statistical significance (t = 16.68, p=0.001). It is considered to be a large effect of early childhood science education courses based on inquiry-based learning and phenomenon-based learning on the scientific inquiry teaching ability of pre-service early childhood teachers.

**Conclusion:** The developed early childhood science education course based on inquiry-based learning and phenomenon-based learning has a significant effect on enhancing the scientific inquiry teaching ability of pre-service early childhood teachers. The early childhood science education course, based on inquiry-based learning and phenomenon-based learning, has stimulated students' initiative and enthusiasm in learning and enhanced their ability and confidence in carrying out inquiry teaching to encourage early childhood exploration of the phenomenon through questions, experiments, and hands-on activities.

**Keywords:** Early Childhood Science Education Course; Inquiry-based Learning; Phenomenon-based Learning; Scientific Inquiry Teaching Ability



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## Introduction

As an important way and carrier to cultivate students' innovative spirit and practical ability, "inquiry-based learning" has become a new way of course learning widely recognized and implemented in the world. The national science education standards issued by the American Research Council clearly states that cultivating students' scientific literacy is one of the goals of national education, and the ability of inquiry, as one of the key abilities in scientific literacy, has also been an important goal of science education for early childhood children in the United States. In 2013, the New Generation of Science Education Standards formulated by the United States further emphasized the importance of "inquiry" in science teaching and its integration with science practice. In 2014, Finland launched a new round of national course reform framework and continued to attach importance to exploratory activities (Wang, 2016).

In the guide to learning and development for children aged 3-6, published by the ministry of education of China in 2012, scientific inquiry is regarded as a sub-goal in the field of science, and it is pointed out that children should be guided to learn science through direct perception, personal experience and practical operation (China Ministry of Education,2012). The General Office of the Ministry of Education of China, 2021, issued the Professional Competence Standards for Teachers of Pre-primary Education Students (Trial) to clarify the basic professional competence of teachers of Pre-primary education students. It puts forward four abilities, namely, the ability to practice teacher ethics, the ability to teach practice, the ability of comprehensive education, and the ability of independent development. In 2022, China's Ministry of Education issued a notice on strengthening the training of primary school science teachers, proposing to build a group of teacher-training majors for primary school science teachers, and attaching importance to early childhood science education as an important foundation stage for scientific literacy.

Inquiry-based teaching ability is one of the core abilities of science teachers to carry out inquiry-based teaching. At present, science education is relatively backward in five areas of kindergarten teaching (language, society, science, health, and art.). (Wang & Liu, 2020). Science education activities are mainly about the teaching of scientific knowledge, not promoting the development of scientific literacy in children. The main reason is that preschool teachers do not have a clear grasp of the concept and method of preschool science education, and the knowledge and skills needed to develop inquiry-based teaching for preschool teachers are even less. At present, in the subject teaching of normal colleges and universities, many teachers still use the traditional knowledge-infusing teaching method. Teachers lack the desire, awareness, and ability to independently carry out inquiring learning, which directly restricts the depth and breadth of students' participation in inquiring learning (Yu, 2021). Therefore, it is necessary to strengthen the cultivation of preschool teachers' science education ability and reform preschool science education courses.

Inquiry-based learning means that, under the guidance of teachers, students take the situation as the orientation, give full play to their subjectivity, make students become the masters of the classroom, and students are willing to take the initiative to carry out activities similar to scientific inquiry (Gou, 2022). It has instilled interest among educational researchers and practitioners for a long time. It is also an encouraging teaching-learning method that makes learning more meaningful and conducive to higher-order thinking and active knowledge construction (Edelson et al,1999). Inquiry learning is compatible with the constructivist approach, which emphasizes that knowledge is actively developed by the student but not transmitted directly from the teacher to the student. Several studies reported the effects of inquiry-based learning on students and teachers. Walan and Rundgren conducted studies on the effects of the inquiry-based learning model on students and teachers (Walan & Rundgren,2015). Based on their findings, students were found to give better responses when inquiry-based learning was used in the teaching and learning sessions. Research has also reported the positive effect of inquiry-based learning on teachers and teaching. Inquiry-based learning improved teachers' performance, understanding, science process skills, and inquiry (Ucar & Trundle, 2011).


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Phenomenon-based Learning is an education movement launched in Finland in 2016. Phenomenon-based learning is a way that Finland has applied multiple pedagogical models into one idea, and has therefore become somewhat of an umbrella term encompassing a variety of different approaches. Instead of passive learning approaches, it seeks to expand students into learning experiences that apply knowledge and skills from multiple disciplines while further deepening them into environmental situations that are compatible with real-life problems (Akkas & Eker, 2021). The phenomenon-based learning approach is defined as a student-led, multidisciplinary model based on inquiry and problem-solving skills (Funfuengfu, 2022). However, one of the driving forces behind phenomenon-based learning has been constructivism, where students are active participants in their learning, as well as constructors of information being covered by problem-solving activities. Using this strategy, students connect a multitude of the little pieces of knowledge they knew previously, as well as the information they gather within the unit, and connect it to the phenomenon being covered. Phenomenon-based learning emphasizes the importance of having learning be student-centered, while the teachers play their role as facilitators who use their expertise to create learning tasks that help guide students to finding their answers instead of just transmitting facts (Karlsson, 2017).

In implementing a phenomenon-based learning approach, teacher educators designed the lessons around holistic views of phenomena that urge students 'engagement (Sahlberg, 2014). Phenomenon-based learning is based on multiple theories: autonomous learning, active learning, constructivism, and transformative learning, which correspond to the growing trends in education. In implementing phenomenon-based learning in the classroom, learners construct their knowledge rather than just passively receiving information. Nongluck et al (2022) revealed that phenomenon-based teaching competency development for teacher educators in higher education in Thailand. By acknowledging the teacher educators' background knowledge, modules were designed emphasizing key differences of phenomenon-based learning, to develop teacher educators' teaching competency by synthesizing the phenomenon-based learning components (Lukman et al., 2022).

This study aimed to develop an early childhood science education course based on inquiry-based learning and phenomenon-based learning to enhance the scientific inquiry teaching ability of pre-service early childhood teachers. The research on the cultivation of inquiry-based teaching ability of pre-service early childhood teachers is not only related to the reform and development of teacher education, but also related to the cultivation of students' scientific literacy and the growth of lifelong learning.

## Research Question

The research question addressed by this research is:

Does the scientific inquiry teaching ability of pre-service early childhood teachers improve after implementing an early childhood science education course based on inquiry-based learning and phenomenon-based learning?

## Research Objective

The objective of this research was to compare the scientific inquiry teaching ability of pre-service early childhood teachers after implementing through course with the criterion set at 70%. To compare the pre-service early childhood teachers' satisfaction with the early childhood science education course based on inquiry-based learning and phenomenon-based learning, with the criterion set at 70%.

## Literature Review

### Early Childhood Science Education Course

As the core course of preschool education, early childhood science education is one of the teaching methods directly related to the design and organization of kindergarten educational activities, with strong practicability and application (Wang, 2016). As one of the five teaching methods, early childhood science education is a more difficult course in the discipline system of preschool education compared to the other


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four fields (Yu, 2021). The early childhood Science education course is a specialized course for third-grade students majoring in preschool education in colleges and universities. Discuss the theory and practice of early childhood science education, the goal and content of science education, the significance of observation and evaluation, the methods of science education, the design and organization of science education activities, etc., so that students can strengthen their ability of designing, organizing and evaluating educational activities based on gradually mastering relevant theories and combining practical activities in and out of class. Acquire and practice the professional core qualities of preschool teachers, and provide strong theoretical support and practical help for them to consolidate and deepen their professional affection, accumulate professional knowledge, continuously improve professional skills, and successfully obtain practicing ability (Li et al, 2019).

The present situation and problems of preschool science education course mainly include: students' lack of scientific knowledge and their inability not deeply internalize the concept of preschool science education; The teaching hours of the course are too few, and the teaching methods are simple. Students have fewer practice opportunities and teaching places; Preschool education teachers are weak (Yu, 2021). The teaching content of the current course of "early childhood science education" is outdated and does not match the job demand; The practical training project is simulated, ignoring the students' main position; The level of scientific literacy is poor, and the sense of effectiveness of science teaching is low; Weak autonomous learning ability, lack of effective learning supervision and other problems (An, 2023).

The key points to improve the current teaching situation of early childhood science education in colleges and universities include: The practical teaching reform of early childhood science education course can be explored from the following aspects: relying on typical teaching cases, enriching classroom practical teaching; Rely on the education internship field visit, research reflection and analysis; Relying on simulated trial lecture, practice activity design organization; Relying on several practical activities, parallel vocational skills assessment (Wang, 2016). The combination of online and offline teaching in early childhood science education courses can give full play to the leading role of teachers in supporting, guiding and facilitating the course, and fully mobilize the enthusiasm, initiative and creativity of students' learning activities, to achieve the best teaching effect of early childhood science education courses (Jia et al, 2021).

**Inquiry-based learning**

The earliest idea of inquiry-based teaching originated from the midwifery of ancient Greek scholars in 400 BC, who believed that teaching should be presented in the form of "question and answer". Through teachers' continuous questioning, students' independent thinking and reflection were triggered, thus acquiring knowledge and reflecting on the interaction of knowledge. Inquiry-based learning is an educational strategy in which students follow methods and practices similar to those of professional scientists to construct knowledge (Keselman, 2003). The inquiry-based learning refers to the learning conducted by students in a way similar to or simulating scientific research (Jin, 2002). Inquiry-based learning means that, under the guidance of teachers, students take the situation as the orientation, give full play to their subjectivity, make students become the masters of the classroom, and students are willing to take the initiative to carry out activities similar to scientific inquiry (Gou, 2022).

There are different types of inquiry models designed for various purposes. However, the review of learning cycles in science inquiry education was limited to using the four models: the three phases (3E) (Marek, 2008), the five phases (5E) (Bybee, 2009), the seven phases (7E) (Eisenkraft, 2003), and the nine phases (9E) (Kaur & Gakhar, 2014). Exploration, explanation, and elaboration make up the 3E learning cycle (Marek, 2008). Engagement, exploration, explanation, elaboration, and evaluation are the five phases of the 5E instructional approach (Putra et al,2016). The 5E learning cycle, which was later enlarged to the 7E learning cycle, is the most widely used improved variant of the learning cycle. Eisenkraft (2003) extended the 5E learning model into the 7E learning cycle model, with elicitation and extension at the beginning and the end, respectively. Elicitation, engagement, exploration, explanation, elaboration, evaluation, and extension are the seven successive stages of the 7E instructional approach (Putra et al,2016). Kaur and Gakhar (2014) extended the 7E learning model into the 9E learning cycle model. Elicitation,


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engagement, exploration, explanation, echo, elaboration, evaluation, emend, and e-search are the phases of the 9E learning cycle (Kaur & Gakhar, 2014).

Based on the research of inquiry-based learning mode, this study will use the 6 steps of inquiry-based learning:

Step 1 Elicitation

This is the beginning of the teaching process. Elicitation involves eliciting students' prior knowledge and understanding of the topic to assess their current level of comprehension about the subject matter, and generating interest in the topic to be studied (Putra et al, 2016; Kaur & Gakhar, 2014).

Step 2 Engagement

Engagement aims to capture students' interest and stimulate their curiosity about the topic being studied, while establishing connections between the lesson and students' existing knowledge and experiences, and motivating them to participate actively in the learning process (Bybee, 2009; Kaur & Gakhar, 2014).

Step3 Exploration

Exploration involves students actively engaging with the material, asking questions, making observations to develop their understanding, gathering data, and fostering a sense of inquiry and discovery. This phase encourages curiosity and discovery, allowing students to explore the topic in hands-on experiments and investigations (Marek, 2008; Putra et al., 2016).

Step 4 Explanation

The explanation phase involves the students explaining the concepts they explored in the previous phase and demonstrating their understanding of the new terms that were introduced. Teachers and other students can raise questions to support the discussion, helping students connect their exploratory experiences to formalized knowledge and theories (Kaur & Gakhar, 2014; Putra et al.,2016).

Step 5 Elaboration

Elaboration encourages students to expand upon their understanding by applying the concepts in new contexts, discussing the material with peers, and making connections to real-world situations. This phase deepens their understanding and helps solidify the knowledge gained during the exploration and explanation phases (Marek, 2008; Bybee, 2009).

Step 6 Evaluation

Multi-subject evaluation methods, including intra-group self-evaluation, mutual evaluation, and inter-group mutual evaluation, are adopted to comprehensively evaluate students' learning process and completed homework, including students' classroom participation, discussion performance, task products, and teaching activity design. (Putra et al, 2016; Kaur & Gakhar, 2014).

**Phenomenon-based learning**

Phenomenon-based Learning is an education movement launched in Finland in 2016. Instead of passive learning approaches, it seeks to expand students into learning experiences that apply knowledge and skills from multiple disciplines while further deepening them into environmental situations that are compatible with real-life problems (Akkas & Eker, 2021). Phenomenon-based Learning became a key innovation in the 2016-2017 revised Finnish National course Framework (Hakala & Kujala, 2021). This curricular method has been used in Finland for the past 16 years, and in doing so, their education system has transformed into being regarded as one of the leading countries in the world (Marsh et al., 2019).

The phenomenon-based learning approach is defined as a student-led, multidisciplinary model based on inquiry and problem-solving skills (Funfuengfu, 2022). Phenomenon-based learning is a way that Finland has applied multiple pedagogical models into one idea, and has therefore become somewhat of an umbrella term encompassing a variety of different approaches. Multidisciplinary learning modules, problem-based learning, theme studies, cross-curricular teaching, integrative teaching, explorative learning, constructivism, phenomenology, and cooperative learning are just a few examples of what it incorporates. It emphasizes the importance of having learning be student-centered, while the teachers play their role as


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facilitators who use their expertise to create learning tasks that help guide students to finding their answers instead of just transmitting facts (Karlsson, 2017).

The instructional strategy of phenomenon-based Learning mainly includes Islamiyah (2016) proposed that phenomenon-based Learning is divided into five steps. Adaktylou (2020) describes the teaching progression of the phenomenon-based learning that was used to introduce the UHI using remote sensing images and products. Steps include: Ask questions, provide materials to provide information, understand phenomena through field investigations, test the phenomenon, and provide conceptual explanations (Adaktylou, 2020). The didactical-based mathematics learning process through a scientific approach is guided by the steps of scientific learning: observing, asking, exploring, associating, and communicating. Simply put, didactic phenomenon-based learning through a scientific approach uses didactic phenomena teaching materials with scientific learning stages (Lukman et al, 2022). Based on the research of phenomenon-based learning mode, this study will use the 6 steps of phenomenon-based learning:

Step1 Observation

Observing is when students discover through phenomena around students that can be appointed as learning resources, students observe the phenomenon to study to make it easier to understand the formal concept (Islakhiyah, 2016; Lukman et al,2022)

Step2 Ask question

By observing a phenomenon, students initiate a discussion of the phenomenon, encouraging students to ask questions about what they have observed, or conflict with their own experience, and ask questions that arouse interest in exploration (Adaktylou, 2020; Lukman et al,2022).

Step3 Exploration

Exploration involves hands-on exploration, experimentation, and field investigations etc. Students are encouraged to actively engage with the subject matter, conduct practice, and discover answers to their questions, determine the process of phenomenon occurrence and related causality (Islakhiyah, 2016; Adaktylou, 2020; Lukman et al,2022).

Step4 Explanation

Students have a preliminary explanation of the process and cause of the phenomenon. The initial explanations are then evaluated in groups and a final explanation of the phenomenon is constructed (Islakhiyah, 2016; Adaktylou, 2020).

Step5 Communication

An interactive dialogue between students and students about the explanations that have been constructed. Communicating involves sharing findings, ideas, and questions with others. This step helps students to articulate their thoughts and learn from others (Islakhiyah, 2016; Lukman et al, 2022).

**Combination of inquiry-based learning and phenomenon-based learning**

Based on studying the relevant literature, combining the characteristics of early childhood science education courses, this study's instructional strategy of inquiry-based learning and phenomenon-based learning is divided into 6 steps:

**Table 1** The combination of inquiry-based learning and phenomenon-based learning

| **The steps of inquiry-based learning** | **The steps of phenomenon-based learning** | **Result of the combination of inquiry-based learning and phenomenon-based learning** |
|---|---|---|
| 1. Elicitation | | 1. Elicitation |
| 2. Engagement | 1. Observation<br>2. Ask a question | 2. Engagement through observation and asking questions |
| 3. Exploration | 3. Exploration | 3. Exploration |



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| The steps of inquiry-based learning | The steps of phenomenon-based learning | Result of the combination of inquiry-based learning and phenomenon-based learning |
|---|---|---|
| 4. Explanation | 4. Explanation<br>5. Communication | 4. Explanation and Communication |
| 5. Elaboration | | 5. Elaboration |
| 6. Evaluation | | 6. Evaluation |

Step 1 Elicitation

This is the beginning of the teaching process. Elicitation involves eliciting students' prior knowledge and understanding of the topic to assess their current level of comprehension about the subject matter and generating interest in the topic to be studied (Putra et al., 2016; Kaur & Gakhar, 2014).

Step 2 Engagement through observation and asking questions.

Students observe the phenomenon to make it easier to understand the formal concept， By observing phenomenon, students initiate a discussion of the phenomenon, encouraging students to ask questions about what they have observed, or conflict with their own experience, while establishing connections between the lesson and students' existing knowledge and experiences, and motivate them to participate actively in the learning process (Bybee, 2009; Kaur & Gakhar, 2014； Islakhiyah, 2016; Adaktylou, 2020; Lukman et al, 2022).

Step3 Exploration

Exploration involves hands-on exploration, experimentation, and field investigations etc. Students are encouraged to actively engage with the subject matter, conduct practice, making observations to develop their understanding, gathering data, and fostering a sense of inquiry and discovery, and discover answers to their questions, determine the process of phenomenon occurrence and related causality (Marek, 2008; Putra et al., 2016; Islakhiyah, 2016; Adaktylou, 2020; Lukman et al, 2022).

Step 4 Explanation and Communication

Explanation and communication are an important link for students to improve their exploration experience and cognitive structure. It involves the teacher providing clear explanations of the concepts, principles, or skills being learned, Students construct a final interpretation of the phenomenon by evaluating the initial interpretation， helping students connect their exploratory experiences to formalized knowledge and theories (Kaur & Gakhar, 2014; Putra et al., 2016; Islakhiyah, 2016; Adaktylou, 2020).

Step 5 Elaboration

Students are to expand upon their understanding by applying the concepts in new contexts, discussing the material with peers, Interactive dialogue between students and students about the explanations that have been constructed， sharing findings, ideas, and questions with others, and making connections to real-world situations. This phase deepens their understanding and helps solidify the knowledge gained during the exploration and explanation phases (Marek, 2008; Bybee, 2009; Islakhiyah, 2016; Lukman et al, 2022).

Step 6 Evaluation

Evaluation is the last part of the teaching process. This stage involves assessing students' level of understanding and learning outcomes, primarily evaluating students' ability to apply concepts to investigate and solve problems rather than their mastery of concepts, evaluating results as a means for teachers to measure teaching effectiveness, while providing feedback to support students' ongoing learning (Putra et al, 2016; Kaur & Gakhar, 2014).

**Scientific inquiry teaching ability**

The scientific inquiry teaching ability can be defined as the ability to plan and conduct subject matter learning through the inquiry approach. Scientific inquiry teaching ability design competency is defined as teachers' ability to identify and organize inquiry-based teaching resources and create a learning environment for students' inquiry-based learning (Ma, 2019). Inquiry-based science education is an important



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innovation. It is stimulating for pupils' application of research skills, construction of meaning, and acquisition of scientific knowledge (Tuenter & Biemans, 2012).

Scientific inquiry teaching ability is a complex structure including various ability elements, and its structural elements are built on the basis of the essence of scientific inquiry teaching ability and inquiry teaching practice. Domestic and foreign educational scholars also have different views on the elements of scientific inquiry and teaching ability. Beyer (2009) proposed that the inquiring teaching design competency includes six aspects, namely, the ability to analyze course standards, the ability to formulate learning objectives, the ability to probe students' pre-concepts and arouse students' conjecture, the ability to create inquiring activities, the ability to organize students' communication and discussion, and the ability to evaluate students' learning. Lu (2012) believes that teachers' inquiry teaching ability includes: scientific inquiry ability, inquiry teaching choice ability, inquiry teaching design ability, inquiry teaching implementation ability, and inquiry teaching evaluation ability. Ma (2019) divided inquiry instructional design ability into five aspects: teaching background analysis ability, learning objective preparation ability, teaching process presetting ability, learning evaluation design ability, and teaching tool selection ability. Based on researching the Components of scientific inquiry teaching ability, this research divides scientific inquiry teaching ability into 6 Components:

1) Teaching background analysis ability includes learning content and student situation analysis, learning content analysis is the analysis of curriculum standards and textbooks to determine the breadth, depth and structure of learning content, student situation analysis is the analysis of students' existing experience and cognitive level, the purpose is to ensure the feasibility and science of teaching (Beyer, 2009; Ma, 2019).

2) Formulate learning objectives. Ability refers to the development of clear and specific learning objectives that guide the instructional design process and define what students are expected to achieve based on the analysis of materials such as teaching materials and curriculum standards, and the situation of students (Beyer, 2009; Ma, 2019)

3) Teaching process presetting ability refers to the ability of teachers to choose inquiry-based teaching strategies according to inquiry-based teaching content, rationally plan the process of inquiry-based teaching activities, design activities, and arrange links under the guidance of learning objectives (Lu, 2012; Ma, 2019).

4) Inquiry teaching implementation ability refers to the ability of teachers to implement inquiry teaching according to the teaching design and to organize, guide, and regulate the whole process of inquiry learning. The capability to facilitate effective communication and collaboration among students, creating opportunities for them to share ideas, ask questions, and engage in discussions (Beyer, 2009; Lu, 2012).

5) Evaluate students' learning ability refers to the value judgment of real-time evaluation and feedback of students' achievement of learning objectives in the process of teaching and learning in class, understanding their progress, and identifying areas for improvement (Beyer, 2009; Ma, 2019).

6) Teaching tool selection ability is the ability to select and design materials needed to carry out inquiry-based teaching (Ma, 2019).

**Students' satisfaction**

Students' satisfaction refers to students' overall evaluation and subjective feeling on the quality of learning services (Jiang et al, 2017). Martin's interpretation of learner satisfaction refers to the matching degree between the expectation before formal learning and the experience in the learning process. If the self-feeling is greater than or equal to the expectation, it is considered satisfaction. Otherwise, dissatisfaction occurs (Martin, 1994).

When different researchers evaluate students' satisfaction, there are certain differences in the indicators selected. In his research on the evaluation of SVCCI students' course satisfaction, Xu (2017) referred to other scholars' division of the dimensions of course satisfaction and proposed that the relevant indicators affecting course satisfaction mainly include six aspects: course system, course management, course resources, teacher teaching, learning cognition and learning environment. Hu et al. (2020) studied



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five aspects of course design objectives, design ideas, core content, optimization of teaching methods, and evaluation mechanisms. The results show that the students' sports knowledge and independent learning ability are improved; the Students' life safety knowledge and ability are improved; The students' sports thoughts were effectively stimulated, and their confidence in fighting the epidemic was improved. Improved communication between teachers and students; Students have a high degree of learning satisfaction.

Through literature review, it is found that in the process of course satisfaction survey, scholars generally adopt the questionnaire survey, and the interview method is also used. According to the basic theory of customer satisfaction, Zhang and Wang (2023) constructs a student satisfaction model of blended teaching, which includes four dimensions of student characteristics, teacher characteristics, course characteristics, system function characteristics and 19 independent variables. The analysis of the survey data shows that there are four independent variables that significantly affect students' satisfaction with blended learning, and on this basis, suggestions for improving student-centered and system-assisted blended teaching are put forward. Nongluck et al (2022) used a questionnaire survey to assess teacher educators' teaching performances; student teachers responded to the five-point Likert scale satisfaction questionnaire. To compare the usefulness and satisfaction between three groups (three regions), one-way ANOVA was used to analyze teacher educators using a phenomenon-based learning approach from student teachers' perspectives, learning process, usefulness of phenomenon-based learning, and course satisfaction.

**Conceptual Framework**

The research title "Implementation of Early Childhood Science Education Course Based on inquiry-based learning and phenomenon-based learning to Enhance Scientific Inquiry Teaching Ability of Pre-Service Early Childhood Teachers" was designed as the conceptual framework as follows:

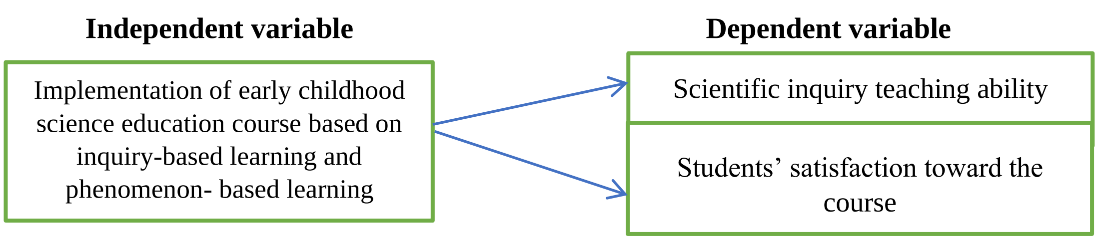


**Figure 1** Conceptual Framework of the Study

**Methodology**

**Population and samples:** The population of this study was 180 third-year students majoring in preschool education at Taizhou College of Nanjing Normal University, and the sample of this study was 30 students from the population, derived by the cluster sampling method.

**Research Instrument:** Research instruments were the tools for collecting data. The research instruments used in this study were:

1. Instruments for conducting the experiment

1.1 Early childhood science education course based on inquiry-based learning and phenomenon-based learning, which covered 6 components: course principle, course objectives, course structure, instructional strategy, course materials, and evaluation. In addition, the instructional strategy of the early childhood science education course based on inquiry-based learning and phenomenon-based learning included six steps: 1) Elicitation, 2) Engagement through observation and asking questions, 3) Exploration, 4) Explanation and Communication, 5) Elaboration, and 6) Evaluation

Five experts evaluated the draft course by using the training course evaluation form. It was found that the mean score was 4.76 (SD=0.40) and revealed that the early childhood science education course based on inquiry-based learning and phenomenon-based learning was at a very high level.

1.2 Lesson plans: Five experts evaluated the eight lesson plans by using the expert evaluation form, and it was found that the mean scores were 4.75 (SD=0.46) revealed that the lesson plan was at a very high level.



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2. Instruments for data collection

2.1 The research instrument for assessing students' scientific inquiry teaching ability was a scoring rubric of scientific inquiry teaching ability. Scientific inquiry teaching ability in this study included six dimensions: teaching background analysis ability, formulating learning objectives' ability, teaching process presetting ability, inquiry teaching implementation ability, evaluating students' learning ability, and teaching tool selection ability. The scoring rubric of scientific inquiry teaching ability was divided into six dimensions as mentioned above, and each dimension was divided into four levels, with 1-4 points respectively, with a full score of 24 points. Teachers then evaluated students' scientific inquiry teaching ability through the scoring rubric. The reliability of the scoring rubric was computed and should be more than 0.7. It was found that the reliability of the scoring rubric of scientific inquiry teaching ability was at 0.93, indicating that the scoring rubric was qualified and can be used to collect data.

2.2 The research instrument for assessing students' satisfaction with the course was a students' satisfaction questionnaire toward the early childhood science education course. The satisfaction questionnaire was a 5-point Likert scale, which included 12 questions. The reliability of the students' satisfaction questionnaire was computed and should be more than 0.7. It was found that the reliability of the students' satisfaction questionnaire toward the course was at 0.91, indicating that the students' satisfaction questionnaire was qualified and can be used to collect data.

**Data Collection**

The procedures of data collection during the course implementation process were as follows:

1) The experimental group, which was 30 third-year students, learned through an early childhood science education course based on inquiry-based learning and phenomenon-based learning.

During the teaching process of the early childhood science education course, the researcher observed and recorded the data of the teaching process, the learning process, the classroom atmosphere, and student behaviors in the classroom.

2) After completing the instructions, the samples were assessed for scientific inquiry teaching ability through a scoring rubric and students' satisfaction questionnaire toward the early childhood science education course.

**Data Analysis**

In this study, quantitative data were analyzed by using mean, standard deviation, and t-test for one sample as follows;

1) The t-test for one sample was used to compare the mean difference of the scientific inquiry teaching ability of pre-service early childhood teachers with the determined criterion set of 70%.

2) The t-test for one sample was used to compare the mean difference of student satisfaction toward the course with the determined criterion of 70%.

## Results

According to the research objectives, the results were as follows:

1) The mean scores comparison of the scientific inquiry teaching ability of pre-service early childhood teachers with the determined criterion set of 70% by using a t-test for one sample

**Table 2** The findings of comparing the different scores of scientific inquiry teaching ability of pre-service early childhood teachers after implementation of the early childhood science education course based on inquiry-based learning and phenomenon-based learning (n=30)

| | **N** | **Fu ll score** | **Cri teria score** | **M** | **S.D.** | **t** | **p** |
|---|---|---|---|---|---|---|---|
| Experimental group | 30 | 24 | 16.8 | 19.83 | 1.72 | 9.64** | 0.001 |

** $p < 0.01$

As presented in Table 2, the mean scores of 30 students' scientific inquiry teaching ability after implementation of the early childhood science education course based on inquiry-based learning and phenomenon-based learning were 19.83 out of a full score of 24， and the standard deviation was 1.72.

Moreover, it aimed to examine the different scores after the implementation of an early childhood science education course based on inquiry-based learning and phenomenon-based learning to enhance students' scientific inquiry teaching ability. The findings of this table revealed that after implementation of early childhood science educationcourses based on inquiry-based learning and phenomenon-based



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learning, posttest scores of students' scientific inquiry teaching ability were greater than the criterion of 70% at.01 level of statistical significance (t29 = 9.64, p = 0.001). The mean scores of the study developed increasingly higher than the 70% criterion.

2) The mean scores comparison of the student satisfaction toward the course with the determined criterion of 70% by using a t-test for one sample.

**Table 3** The findings of comparing the different scores of students' satisfaction after the implementation of the early childhood science education course based on inquiry-based learning and phenomenon-based learning

| Group | N | Full score | Criteria score | M | S.D. | t | p |
|---|---|---|---|---|---|---|---|
| Experimental group | 30 | 5 | 3.51 | 4.55 | 0.34 | 16.68** | 0.001 |

** p < 0.01

As presented in table 3, the mean scores of 30 students' satisfaction after implementation of early childhood science education course based on inquiry-based learning and phenomenon-based learning was 4.55 from the full score of 5, and the standard deviation was 0.34 which was statistically higher than the criterion of 70% at.01 level of statistical significance (t29= 16.68, p= 0.001).

## Discussion

The early childhood science education course is based on inquiry-based learning andphenomenon-based learning to cultivate students' scientific inquiry teaching ability. The nature of the course has changed from "teaching-centered" to "learning-centered", and the teaching design has changed from ) "teaching" to "learning"Sun, 2007 Through students' hands-on operation and discussion, learning .( initiative, learning interest and learning efficiency can be enhanced, which is helpful to understand the content of preschool science teaching course, combine boring knowledge with real life, and enable students to build their understanding of the nature of science, the goals of preschool science education .and the teaching methods of scientific inquiry

The early childhood science education course, based on inquiry-based learning and phenomenon-based learning, has stimulated students' initiative and enthusiasm in learning and enhanced their ability and confidence in developing early childhood science education. First of all, inquiry-based learning and phenomenon-based learning put students in the position of active exploration, which stimulated their learning enthusiasm and curiosity. Students actively participate in the whole learning process through ,hands-on operation, discussion, and communication, which improves their learning initiative. Second ,relying on natural phenomena and common resources in lifec hoose scientific topics close to life, provide natural resources and living materials, and encourage students to observe and ask questions (Walan & Rundgren, 2015) .W e should carry out practical exploration activities, experience inquiry learning by ourselves, and construct the purpose, goal, and method of science education. Roth (2012) pointed out that teachers should also learn how to teach science by scientific inquiry, which helps teachers to construct the goals and methods of science education. Thirdly, by designing various practical activities, students have .the opportunity to experience the specific implementation methods of early childhood science education ,Hands-on operation and group cooperation have trained students' practical skills and cooperation ability and preparedthem for future teaching work. Students constantly solve problems and gain a sense of .accomplishment in practice, which enhances their confidence in engaging in preschool science education Finally, the evaluation mechanism of the course allows students to conduct self-reflection, peer .evaluation, and teacher feedback, so as to further improve the activity design

Moreover, the six steps of the teaching process based on inquiry-based learning and phenomenon-based learning can improve the scientific inquiry teaching ability according to the following explanation;

The first step, Elicitation, was the beginning of the teaching process, in which teachers try to choose a scientific theme that is close to students' lives. Life-oriented situations can stimulate the desire to explore, related questions can develop thinking, and interactive communication is the driving force to promote innovation. The materials needed for exploration need to be prepared in advance, which can mobilize students to participate in the preparation of materials, make students become the main body of learning, stimulate students' curiosity and desire to explore, encourage students to share existing relevant knowledge and experience, diagnose students' cognitive basis, and prepare for subsequent learning.



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The second step: Engagement through observation and asking questions. Teachers should guide students to observe phenomena and think about the laws and problems contained in them. They need to create an open, safe, and interactive classroom atmosphere that encourages students to observe and ask questions, so that students can dare to express their thoughts and questions. At the same time, teachers should be good at discovering the relationship between students' questions and their existing knowledge and experience, and organize discussions to encourage them to ask their questions. Participation through observation and questioning requires teachers' patience and wisdom. They should not only guide students to explore actively, but also provide necessary support in time to make students' learning more targeted and effective. The third step:Exploration was .hands-on exploration, experiment, and field investigation Piaget's cognitive development theory points out that students' cognitive ability is constantly developed through active exploration and practice. Teachers should create a good classroom atmosphere, stimulate students' curiosity and desire to explore, and guide them to ask questions and try to solve them. Students can be given some independent time and space. In this process, students are the main body, and students ,are in groupscombining ideas, planning exploration steps, and analyzing collected data and observation results. Teachers can give timely hints and guidance, encourage students to be good at finding problems in the process of exploration, cultivate their critical thinking, and continue to explore, discuss, and solve the problems found. Minner et al. (2010) made a comprehensive analysis of the research on inquiry-based science teaching in recent 20 years. The results show that inquiry-based teaching can significantly .improve students' scientific concept understanding and scientific practice ability.

The fourth step, Explanation and Communication, was an important link for students to improve their exploration experience and cognitive structure. What needs to be emphasized is to explain and communicate with students as the main body, give full play to students' initiative and creativity, and improve the learning effect. Teachers should fully respect students, create a democratic and interactive classroom atmosphere, and guide students to actively participate in discussion and practice. Teachers should give students more opportunities to speak, encourage students to explore, exchange, and discuss independently, and give feedback in time. This student-centered teaching method can promote the development of students' language skills and critical thinking (Wang, et al, 2021).

The fifth step: Elaboration can help students reflect on their learning process, find problems, and actively seek solutions, thus deepening their understanding of what they have learned. Encourage students to associate the concepts they have learned with real-life situations, and help students to associate new knowledge with existing experiences, emotions, and values, so as to deepen their understanding of knowledge. In the elaboration stage, teachers should encourage students to communicate and discuss with their peers, share their findings and ideas, and apply what they have learned to new situations, which can significantly improve students' understanding and application ability (Zhou & Zhang, 2018).

The sixth step:Evaluation was the process of comprehensively evaluating students' learning process and completed homework, whichwas accompanied by the whole learning process, including ,students' classroom participation, discussion performance, questions, students' contribution in the group cooperation ability, communication skills, and the completion and quality of homework. Evaluation should pay attention to students' innovative thinking and practical operation ability, and encourage students to participate in self-evaluation to improve their self-reflection and autonomous learning ability )Li & Wu, 2021).

After teachers adopt the teaching methods based on inquiry-based learning and phenomenon-based learning, students' scientific inquiry teaching ability and satisfaction are improved, which increases students' interest in learning and confidence in carrying out scientific education for children. It can be popularized in future teaching, so that students can love and devote themselves to early childhood science education, carry out high-quality early childhood science education, explore and cultivate future scientific and technological innovative talents, and lay the foundation for enhancing the scientific quality of the whole people and the long-term development of the country (Li Junhua, et, 2019).

**Recommendations**

1) ,Cultivating scientific inquiry teaching ability is the core goal of course reform. Therefore 'researchers should focus on the development of "student-centered" teaching mode and cultivate students scientific inquiry teaching ability on the basis of inquiry-based learning and phenomenon-based learning mode. In this study, the researcher developeda teaching model based on inquiry-based learning and phenomenon-based learning to improve the scientific inquiry teaching ability of pre-service early childhood teachers. However, there are many other potential methods to improve students' scientific .inquiry teaching ability, which are worth developing and studying



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2) Expand the scope of the research by exploring the different influences of inquiry-based learning and phenomenon-based learning activity framework on learners at different ages and in different disciplines.

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