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Using"Question-Observation-Doing-Explanation" Inquiry Model to Develop Pre-Service Chemistry Teachers' Chemical Abilities and Academic Self-efficacy

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Abstract

The aim of the study is to determine the influence of (QODE) inquiry model on pre-service chemistry teachers' chemical abilities and academic self-efficacy. The quasi-experimental design with pre-post-test group was used as an experimental approach in this research. The sample of the study included 30 pre-service chemistry teachers. Data were collected using academic Self-Efficacy Scale, The test of chemical abilities and observation checklist. According to results, the positive influences of (QODE) inquiry model on pre-service chemistry teachers' academic self-efficacy perceptions and chemical abilities have been observed. participants showed positive attitudes towards using inquiry-based teaching approach

Key words: *Preservice chemistry teacher, inquiry-based instruction and (QODE) model, chemical abilities, academic self-efficacy*

الملخص :

هدف البحث الحالي للتعرف على اثر استخدام نموذج (اسأل-لاحظ – اعمل –فسر) الاستقصاءي لتنمية القدرات الكيميائية وكفاءة الذات الأكاديمية لدى الطلاب المعلمين وقد استخدام الباحث المنهج التجريبي ذو التصميم شبة التجريبي وتكونت عينة البحث من ٣٠ طلاب معلمي الكيمياء ولتحقيق هدف البحث تم استخدام اختبار للقدرات الكيميائية وبطاقه ملاحظة ومقياس للكفاءة الذاتيه واعداد دليل للمتدرب وكراسة نشاط وتم تطبيق الادوات على عينة واحده قبلي وبعدي وقدر اسفرت النتائج على وجود علاقة ارتباطية موجبه بين النموذج الاستقصاءي والقدرات الكيميائيه وكفاءه الذات الاكاديمية

Introduction

A teacher's job includes knowing their students and how they learn; including their previous and current knowledge. This represents the teacher professional knowledge and skills. Until a couple or more of decades ago, education thinkers interested in the question, "What should be included in the chemistry curriculum?" (Bettino, 1979; Davenport, 1985). Since 1975 there has been an interest in the question "What is learned?". The focus shifted from the curriculum to the student, provided the way to experimental research, the questioners were mostly "chemistry teachers"not just chemists, and in a few cases were researchers in chemistry departments (Bucat, 2004).

In the field of science education, scientific inquiry has been considered an integral and valuable part of teaching and learning. (National Research Council (NRC, 1996). Scientific knowledge is built on the basis of patterns of scientific inquiry. Most of the laws of science are constructed on the basis of experimentation and observation(Otifa &Srour,2011)

Developing students' scientific abilities has been emphasized as a major goal of science learning in many official documents (NRC, 2000). These scientific abilities help students to acquire skills and knowledge to reach meaningful scientific conclusions and to participate successfully in inquiry.

Accordingly, chemical abilities could be defined as those capabilities, procedures, processes, and methods that scientists use when building knowledge and when solving experimental problems, so that students can take step by step to build arguments and proofs about something new and can provide a logical explanation based on experience (Suastika & Hartanto, 2016).

Many discussions are argued around making the teaching and learning process a success. The learning process needs models and strategies that are expected to create or explore the scientific abilities of students. Whereas science classes today lack opportunities for students to explore and there are still signs of students 'inability to understand scientific theories (Nie & Lau, 2010). However, student interest is strengthened when using inquiry-based education and problem solving. (Antonietti & Cantoia, 2000; Price & Rogers, 2004).

According to (Question-Observation-Doing-Explanation) inquiry Model, which focuses on the value of doing in the educational engagement process (Martin, 2008), is used by teachers to explore students' knowledge by asking them to perform four main tasks: the question, Observation, practice, and interpretation.

The first stage of the model is to ask a question, and in the second stage students use their senses to get an evidence related to the current situation. As for the critical stage, it is the students' awareness of the tasks through hands-on practice. Then we come to last stage in which provides explanation and clarification of the previous tasks (Yang et al., 2020)

On the other hand, perceptions of self-efficacy are among the most important factors in using innovative teaching methods, as many studies indicate that teachers with high self-efficacy are more creative with new ideas, and show greater willingness to learn new teaching methods, design and organize their classrooms better, and more satisfaction with their teaching method (Allinder, 1994)

According to Bandura's Motivational Theory (Bandura, 1982), self-efficacy of learning could be defined as: "a subjective judgment of people as to whether they can succeed in learning". Learning behavior in humans is influenced by factors of behavior outcome, where the former is the expectation of learning results, and the latter is the expectation of learning efficiency (Bandura, 1989).

Galleon et al. (2011) investigated the relationship between self-efficacy beliefs and a number of variables such as exam score, course scores, and grade point average (GPA). Longo conducted a study that revealed the impact of inquiry-based learning and determined that students learn in laboratory environments where research and inquiry activities are done, had better perceptions of self-efficacy compared to students who learn through the traditional curriculum (2011).

The current research aims to determine the effect of this inquiry-based model (QODE) on the realization of self-efficacy and chemical abilities of pre-service chemistry teachers. The main contribution of this study relates to how inquiry-based education affects the chemical abilities of pre-service chemistry teachers and perceptions of self-efficacy in undergraduate chemistry student.

Review of literature and Related Studies

Section one: Inquiry-based learning and (QODE) model

A) Inquiry-based learning

For years, inquiry-based learning (IBL) has been considered to be one of the most appropriate educational approaches to learning science. Recent science education reforms have placed a large emphasis on inquiry-based teaching strategies as an effective way for improving conceptual understanding of science. The National Research Council has also strongly supported the use of inquiry learning in classrooms. (NRC, 1996) which produced the National Science Education Standards,

Learning with the inquiry model provides an opportunity for learners to discover and investigate the concept of a procedural, systematic, and interconnected between one concept with another concept (Af'idayani et al., 2018,178) Therefore, teaching according to inquiry model ensures learning to be learner-centered where the learner performs an effective role in the learning process and be responsible for it

Inquiry Defined:

Inquiry has played a significant role in the reform literature in defining the nature of science and important learning outcomes for students. The concept of ‘‘inquiry’’ has been used to describe the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world (NRC, 1996, p.23).

The term "inquiry" has different meanings in different contexts. In the context of science, it refers to scientific inquiry that scientists do. In this view, students were considered as junior scientists with less sophisticated knowledge. In other words, "it refers to the abilities students should develop to be able to design and conduct scientific investigations and to the understandings they should gain about the nature of scientific inquiry" (NRC, 2000, p.XV) . Another way describes inquiry within the context of instruction. It refers to "the teaching and learning strategies that enable scientific concepts to be mastered through investigations" (NRC, 2000, p.XV).

"inquiry-oriented" instruction as an active process, involving making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence; using tools to gather, analyze, and interpret data; proposing answers, explanations, and predictions; and communicating the results. Inquiry requires the "identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations" (National Research Council, 1996, p. 23). Scientific inquiry refers to learners' self-discovery of scientific findings derived from their design practices and experiments (Moon et al., 2021) from this definition Scientific inquiry needs a form of creativity. In addition to science learning, scientific inquiry refers to the act of seeking science findings.

According to these definitions, the aim of this study is that the researcher can define inquiry in this research **as the activities of PCTs, which develop the scientific abilities as well as involve making observations; pose questions; plan investigations; review what is**

already known in light of experimental evidence; usie tools to gather, analyze, and interpret data; propose answers, explanations, and predictions; and communicate the results.

B) (QODE) inquiry model:

Development of QODE inquiry model:

Learning takes place in the community through the interaction of cognitive presence, social presence, and teaching presence, according to the Community of Inquiry (CoI)model (Garrison et al. 1999 ,88; Remesal and Friesen 2014,1). in the inquiry learning community, individuals generate meaning via continual critical reflection and debate (Garrison 2011,15). Many studies have found that the CoI model can improve the interaction of members by creating an open inquiry learning atmosphere and strengthen community cohesion (Selcan and Zahide 2018,54).

The idea for POE model which later develop to QODE model started with woods Robin, when Woods met Thorley Richard, who is a professor in Physics, (who runs a workshop by the University of Rochester on learning science and correcting misconception), and their discussion resulted in the selection of a topic in electricity, and they prepared questions to reveal the child's innate theories about science in electricity as dissipation Fusing a lamp, or cutting a wire from an electrical circuit, and teaching was in Small groups according to the following steps (woods, 1994):

- Predicting the phenomenon to be studied.
- Observe the results
- If their theories conflict with the empirical evidence, they should be helped to move from wrong theories to the correct scientific explanation

The result of this study showed that their own vision of POE model Which called later (woods model).

According to Pedaste et al. (2015), the validity of inquiry learning models varies depending on the educational situation. such as the 5E learning model proposed by Bybee et al. (2006), the POE inquiry learning model proposed by Hong et al. (2014), and the fve-step inquiry cycle proposed by White and Frederiksen (1998). However, the value of Doing of inquiry is not refected in these models. (yang et al ,2020,381).

According to theory of learning-by-doing .doing with hands and brain is the tentacle of scientific exploration, which connects learners’ thinking and objective world). Learning-by-doing environments have promoted participants' physical, social, and cognitive engagement (Gardner 2011,3). However, the above three scientific learning models did not highlight the value of Doing. Therefore, (Yang et al 2020) developed the QODE model, which includes four steps of question, observation, doing, and explanation.

Phases of the QODE Inquiry Instructional Model:

1. **Question**

Science begins with a question, such as "Why is the sky blue?" or "What causes cancer?" and strives to build theories that can provide explanatory answers to these questions. (NRC,2012,50). Scientific questions arise in several ways. They can be driven by curiosity about the world (for example, why is the sky blue?). they Can be inspired by a model or theory (for example, how does the particle model of matter explain the incompressibility of liquids?). Or it can result from the need to provide better solutions to a problem

The question phase of the QODE begins with the teacher identifying student curiosity and interest, eliciting students' questions, and discovering students' prior understanding of the concept(s) to be taught. It is vital to determine what pupils already know about the issue (prior knowledge) while simultaneously creating curiosity or motivating students to want to learn more about their own ideas and those that will be explored during this stage

Fruitful inquiries evolve from questions that are meaningful and relevant to students, but they also must be able to be answered by students' observations. The knowledge and procedures students use to answer the questions must be accessible and manageable, as well as appropriate to the students' developmental level (NRC,2000,25)

2. **Observation:**

Observation is a complex activity; that teachers of science should know how to make observation and how to apply it at all grade. According to (Oguz & Yurumezoglu, 2007,2) we can use observation at every level of the inquiry: as a stimulant for questioning, in connecting previous experiences to new encounters, in obtaining information, and in identifying patterns and links between events and objects. As a result, inquiry-based science teaching IBST is a collection of observations and doing experiments.

3. **Doing:**

Learning science is something students do, not something that is done to them. The actual doing of science can pique students' curiosity, capture their interest, and motivate their continued study''(NRC,2012,43). Learning through doing helps students of all ages understand how scientific knowledge develops and gives them an appreciation of the wide range of approaches that are used by scientists to investigate, model, and explain the world

Science learning has three major aspects; a body of knowledge, a method or process and a way of knowing. Science as a body of knowledge refers to science products such as information, concepts, and facts. Science also involves a set of methods or processes. The method is the process in which a body of knowledge is produced. In the method or process, students learn how to do science through exploration by observing, classifying objects, measuring and so on. Furthermore, science also is as a way of knowing) (Mulyeni, Jamaris & Supriyati ,2019 ,188).

4. Explanation:

The purpose of science is to develop ideas that can provide explanatory accounts for the world's phenomena. According to (NRC,2012,52) Students must build coherent and logical explanations of phenomena that incorporate their present understanding of science, or a model that represents it, and are compatible with the evidence. Thus Scientific explanations are theories applied to a given situation or phenomena, sometimes through the use of a theory-based model for the system under investigation.

Acceptance of an explanation is ultimately a judgement of what data are accurate and important, as well as a decision regarding which explanation is the most satisfactory, since all concepts in science are weighed against alternative explanations and evidence. Students' understanding of the reasoning and empirical evidence for an explanation is enhanced when they engage in evidence-based debate about it, indicating that science is a body of knowledge based on evidence (NRC,2012,44)

As a result, it is important to analyze inquiry-based learning models like (QODE) in further detail and pinpoint its essential components. Such a look for the essential components of inquiry-based learning is presented in this research.

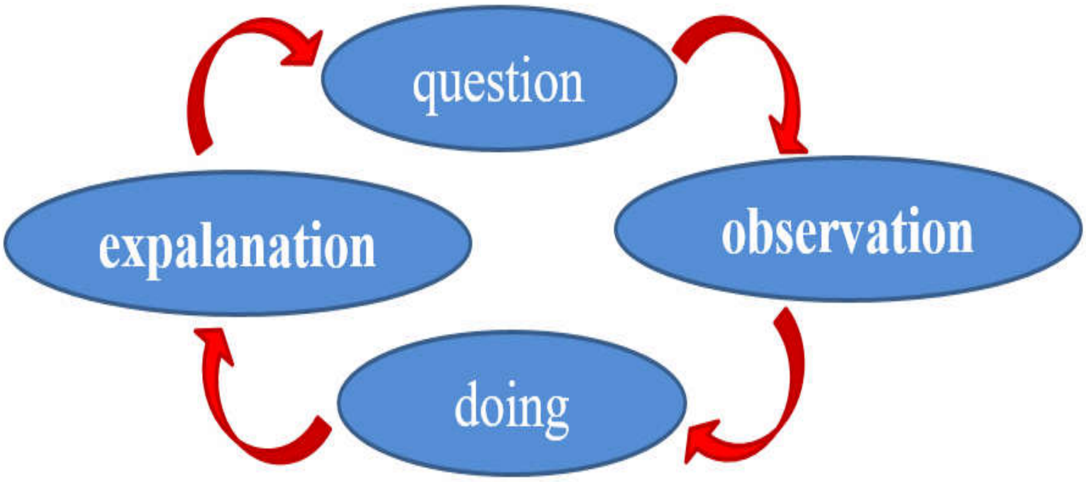

Fig 1 model of (QODE)

Section 2; Chemical abilities:

Chemical abilities (CAs) are an important learning outcome that students should acquire through learning chemistry. Science learning requires not only knowledge content, but also abilities that must be developed in order to succeed in the future (Basid & Rusli, 2018). Science educators have made great efforts to foster students' scientific abilities through their engagement in familiar phenomena in daily life contexts (Kind & Osborne, 2017; van der Graaf et al., 2019).

Providing students with scientific abilities is an important issue as it can assist students to think outside the box (Zulkipli et al., 2020) .Accordingly , there is a need for emphasizing developing students scientific abilities when teaching science on all levels. To achieve this objective, we should more emphasis on qualifying pre-service chemistry teacher

Definitions of chemical abilities

the word ability is not innate, not automatic skills, it requires training, so measuring temperature with a thermometer is a skill but evaluating uncertainty of measurement and minimizing the error is ability. We use the term "scientific abilities" to describe some of the most important procedures, processes, and methods that scientists use when constructing knowledge and when solving experimental problems. We use the term scientific abilities instead of science-process skills to underscore that these are not automatic skills, but are instead processes that students need to use reflectively and critical (Etkina et al., 2006,1). This research adopt the term scientific ability instead of "science process skill’’ as scientific abilities encompasses not only science process skills, but also it refers the need for thinking critically and reflectively.

We use the term scientific abilities to describe some of the most important procedures, processes, and methods that scientists can use when creating knowledge and explaining experimental problems. these abilities are internalized and become habits of mind used to approach new problems; they are scientists’ cognitive tools (NRC,2012,41). As previously noted, we use the term “abilities,” instead of a term such as “skills,” to stress that engaging in scientific inquiry requires coordination both of knowledge and skill simultaneously .The scientific ability that is expected in this case is an ability to understand the procedures, process, and methods that scientist use when constructing knowledge and when solving experimental problems, so that in the step by step students can do to constructing arguments about something new and they can provide a rational explanation from experiment (Suastika et al 2017,2)

In line with previous definitions scientific abilities could be classified according to field of science to biological, chemical and physical and this research will adopt the scientific capabilities specialized in the field of chemistry (chemical abilities), thus the researcher and for the purpose of the current research defined CAs as **procedures, processes, and methods that pre-service chemistry teachers can use reflectively and critically, when creating knowledge and solving the problems in chemistry field as a part of scientific method, so that in the step by step students can do to constructing arguments about something new and they can provide a rational explanation from experiment**. The profile of scientific ability of pre-service chemistry teachers in **Table (1)**.

These chemical abilities are:

1- Design an experiment:

carrying out an experiment by carefully following directions of the procedure so the results can be verified by repeating the procedure several times

To devise and test relationships and explanations students need to develop experimental abilities. For pedagogical purposes we have classified experimental investigations that students perform in introductory courses into three broad categories: observational experiments, testing experiments, and application experiments

2- Collect, and analyze data:

A process of giving a rational explanation of an object, event or patterns from the gathered information. The gathered information may come in different forms

3- Communicate:

An important ability in the work of scientists is their oral and written communication, using words, symbols, or graphics to describe an object, action or event.

Presenting information in varied modes such as orally, in written form, using graph, diagram, models, tables and symbols. it also involves ability to listen to other ideas and respond to the ideas

4-Classify objects

classification of these objects helps us to put them in specific categories, so we know immediately what they do and how they are different from other objects. grouping or ordering objects or events into categories based upon characteristics or defined criteria.

We classify things in science as well. We do this to better understand objects, but also to help keep us organized. Keeping classifications organized allows for others to expand upon the work that scientists do in researching and experimenting. It also allows us to communicate with other scientists and researchers because we all understand how the classification system is broken down and arranged

5- Evaluate experimental predictions and outcomes, conceptual claims, problem solutions

We define an evaluation as making judgments about information based on specific standards and criteria. More specifically, a given particular is judged by determining whether it satisfies a criterion well enough to pass a certain standard. Scientists constantly use evaluations to assess their own work and the work of others when conducting their own research, serving as referees for peer-reviewed journals, or serving on grant-review committees.

6- Represent processes in multiple ways

While constructing and using knowledge, scientists often represent the knowledge in different ways, check for consistency of the representations, and use one representation to help construct another

Rules were also developed for converting these diagrams into complicated scattering cross section equations. Such qualitative representations, particularly diagrammatic or in some cases graphical representations, help chemists reason qualitatively about chemical processes and to see patterns in data without engaging in difficult mathematical calculation

7-Make measurement:

Using standard measures or estimations to describe specific dimensions of an object or event. This information is considered quantitative data. Observing quantitatively using instruments with standardized unit.

Table (1) The profile of chemical abilities of chemistry education students University in this table

chemical Ability	sub-ability
1-Design an experiment	a-present problem and ask question b- form hypothesis based on that problem c-design the study d-identify independent and dependent variable d-collect and analyze data e- state a conclusion
2- collect, and analyze data	a-record and represent data in a meaningful way b-use variety of tools to analyze data c-recognize pattern and relationships in data d-analyze data appropriately
3-Communicate	a- communicate details of experimental procedures b-use scientific language to describe observations and communicate ideas (table-graph-chart) c-make a diagram to communicate ideas
4- evaluate experimental data	a- evaluate the results of an experiment b-make judgements about validity of data c- identify the challenges when carrying out experiment
5-Make measurement	a-decide chemical quantities to be measured b- use standard and nonstandard measures or tools
6-Classify objects	a-putting objects into groups b-sorting, grouping and arranging based similarities and difference c-find the basic grouping/classification
7-represent processes in multiple ways	a-extract information from representation b- evaluate the consistency of different representations and modify them when necessary

Section three Academic self-efficacy (ASE);

In recent years, there has been a growing interest in students' self-efficacy of their academic learning (Putwain et al., 2013,634). ASE is one of the topics that have received the attention of psychologists and educational researchers, Research by Bandura (1993) perceived that self-efficacy works as an important contributor of academic progress Currently, ASE is one of the most significant issues or predictors for learners to achieve learning success. This may mean that if a student's ASE is higher, the student may be able to achieve higher academic outcomes (Yokoyama, 2019, 2)

"Self-efficacy belief, introduced by Bandura as a part of his social cognitive theory, is defined as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391). (Bandura ,1989) defines academic self-efficacy as: an individual's beliefs about his or her ability to organize, implement, and manage methods required to accomplish tasks related to educational situations

or skills. Academic self-efficacy, however, can also refer to a student's perceived competence in a range of context-specific study-related skills and behaviors, typically those thought to contribute to self-regulated learning (Putwani et al., 2013,633)

ASE is defined as students' self-perceived confidence in their ability to accomplish their planned educational goals. It is grounded in Bandura's self-efficacy theory, which assumes that human achievements depend on the interactions between one's behaviors, beliefs, and environmental conditions. (Warshawski,2022)

According to that the researcher defined ASE as pre-service chemistry teacher`s belief that he can successfully achieve at a desired level on an academic task or a specific goal or refers to the structure of knowledge formed as a result of practices educational and which lead to the belief or expectation that the learner can to succeed in educational tasks, measured in the current study to the degree that obtained by the self-efficacy scale used by researcher , which is included four components

Statement of the problem

Based on the review of related literature the problem of the current study can be identified as follows:

Preservice chemistry teachers do not master chemical abilities necessary for them at this stage. Therefore, utilizing QODE model activities may enhance the chemical abilities and academic self-efficacy

Questions of the Study

1) What are the chemical abilities that the research seeks to develop?
2) To what extent are the chemical abilities exist on to pre-service chemistry teacher?
3) What is the effectiveness of using "QODE' 'model on developing chemical abilities of pre-service chemistry teacher?
4) What is the effectiveness of using "QODE' 'model on enhancing academic self-efficacy of pre-service chemistry teacher
5) Is there a correlation relationship between chemical abilities and academic self-efficacy of pre-service chemistry teacher?

Purpose of the Study

The current study aimed to:

1. Determine chemical abilities which need to be developed of pre-service chemistry teacher
2. Identify the effectiveness of using "QODE" inquiry model on developing chemical abilities of pre-service chemistry teacher
3. Identify the effectiveness of using "QODE" inquiry model on developing academic self-efficacy of pre-service chemistry teacher.
4. Determine the correlation relationship between chemical abilities and academic self-efficacy of pre-service chemistry teacher.

Hypotheses

The current study attempted to verify the following hypotheses:

1. there are no statistically significant differences between the means of scores of the study group on the pre-post administrations of the chemical ability test
2. There is no a statistically significant difference at the.05 level between the pre and post study group mean score on the pre-post chemical abilities observation checklist”
3. There is no a statistically significant difference between the mean score of the study group pre-post administration of the academic self-efficacy scale
4. There is no correlation relationship between chemical abilities and academic self-efficacy

Significance of the Study

It was hoped that the present study would contribute to:

1. The present study keeps pace with new trends in the field of education by focusing on chemical abilities, which may be useful in planning science curricula, and focusing in activities that practiced in chemistry curriculum.
2. It is expected that, this study will contribute to science teaching by using (questioning-observing-doing-explaining) model, which benefits educational supervisors and pedagogues.
3. The study will provide rubric for measuring chemical abilities that will benefit students of scientific research when preparing their research tools.
4. The study will be useful to science teachers in identifying academic self-efficacy of students and how it can be achieved it in the classroom.

Delimitations of the Study

This study was delimited to:

1) Objective limit:

the use of (QODE) inquiry model for teaching a unit of chemistry from secondary stage in teaching method application.

chemical abilities such as (the ability to represent chemical knowledge in multiple ways- the ability to design experiments – the ability to investigate new chemistry phenomena-and the ability to test hypotheses and solve experimental problems in chemistry)

2) Human limit:

Third level chemistry students enrolled at the Faculty of Education Mansoura University as the sample

3) Temporal limits:

This study was carried out in the first semester of the academic year

Methodology

Design

This study adopted the analytical, descriptive method for reviewing related literature, determining the chemical abilities needed for pre-service chemistry teacher, and the quasi-experimental pre-post test design for examining the effect of the proposed training program on developing chemical abilities and academic self-efficacy of pre-service chemistry teachers. one study group was used

The researcher administered pre and post-administration of the chemical abilities test , observation checklist and self – efficacy scale.

Participants

Participants of the study were were a group of 30 pre-service chemistry teachers of the third year in the department of English Chemistry, Faculty of Education Mansoura University. The students selected for the experiment. It was expected that if those students are trained in such a proposed way, their chemical abilities and their self-efficacy would be improved

Instruments

The following instruments were designed and used by the researcher in order to collect data:

The following instruments were used in order to fulfill the purpose of the study:

1. A checklist for determining the chemical abilities necessary for developing preservice chemistry teachers.
2. Chemical abilities test for assessing third year preservice chemistry teacher chemical abilities.
3. A rating scale (rubric) for measuring chemical abilities.
4. Academic self- efficacy scale for assessing preservice chemistry teacher's self- efficacy

procedures

The present study proceeded as follows:

1) Reviewing educational literature and previous studies related to the subject of the study to establish theoretical framework and research tools.
2) Selecting the scientific content (a unit of chemistry) and preparing the teacher guide and student activity book which include the steps of (QODE) model.
3) Preparaing the list of chemical abilities which related to chemistry unit to be developed by using this model.
4) Preparating a rubric to measure chemical abilities of pre-service chemistry teacher and presenting it to the arbitrator.
5) Preparating self-efficacy scale and presenting it to the arbitrators.
6) Determing the psychometric parameters of the instruments.
7) Applying the pre-assessment tools of the study.
8) Teaching the studty group by using (QODE) model.
9) Applying study instruments to the students of studty group.
10) Analyzing data by using appropriate statistical methods in the light of nature of variables and sample size.
11) Discussing and interpreting the results.
12) Presenting a set of recommendations and suggestions in the light of the research findings.

Results and Discussion

The statistical methods used to verify the hypotheses were T-test to compare between the mean score of the study group in the pre and post application, Pearson correlation coefficient, Kuder Richardson Equation 21 and Eta square ($\eta 2$) to identify the effect size of the treatment on the improvement of the students' chemical abilities and academic self-efficacy after implementation of the treatment

Testing the Hypotheses

1) The first hypothesis: **"there are no statistically significant differences among the means of scores of the study group on the pre-post administrations of the chemical ability test**

For the purpose of verifying this hypothesis, the researcher used the t-test of the paired groups to determine the significance of the differences between the mean scores of the pre- and post- administrations of the CAs test to the study group. This is illustrated in the following table.

Table 2

T-Values for the differences between the mean scores of the pre- and post- administrations of the study group in chemical abilities test

Sign.	Chemical Abilities	test	M	SD	t	df	Sign.
0.01	Design an experiment	Pre	2.7333	1.28475	11.894	29	0.01
		Post	5.2667	0.90719			
0.01	Collect, and analyze data	Pre	2.4333	1.22287	10.115	29	0.01
		Post	5.0667	0.90719			
0.01	Communicate	Pre	1.6333	0.92786	11.00	29	0.01
		Post	3.4667	0.57135			
0.01	Evaluate experimental predictions and outcomes, conceptual claims, problem solutions	Pre	1.2667	0.90719	7.374	29	0.01
		Post	2.2667	0.78492			
0.01	Make measurement	Pre	1.9667	0.99943	10.933	29	0.01
		Post	4.1333	0.77608			
0.01	Classify objects	Pre	1.6333	0.85029	7.370	29	0.01
		Post	2.6000	0.67466			
0.01	Represent chemical processes in multiple ways	Pre	1.2667	0.98027	7.990	29	0.01
		Post	2.5333	0.62881			

From the previous table, it is obvious that there were statistically significant differences between the mean scores of the pre- and post- administrations of the study group in CAs test in favor of the post- administration, the t-value was (28.118) which were statistically significant values at the 0.01 level. The improvement in students` level was due to the use of the treatment. As a result, the first hypothesis was rejected.

Effect Size (η2)

In order to show the strength of the effect of the treatment for developing chemical abilities of pre-service chemistry teachers , the effect size (η2) was calculated as shown in the following table:

Table 3

The effect size of QODE inquiry model for developing chemical abilities

Abilities	t	η^2	d	Effect Size
Design an experiment	**11.894**	**0.83**	**4.42**	**Great**
Collect, and analyze data:	**10.115**	**0.78**	**3.76**	**Great**
Communicate	**11.000**	**0.81**	**4.09**	**Great**
Evaluate experimental predictions and outcomes, conceptual claims, problem solutions	**7.374**	**0.65**	**2.74**	**Great**
Make measurement	**10.933**	**0.80**	**4.06**	**Great**
Classify objects	**7.370**	**0.65**	**2.74**	**Great**
Represent chemical processes in multiple ways	**7.990**	**0.69**	**2.97**	**Great**
Total	**28.118**	**0.96**	**10.44**	**Great**

Table(3) indicates that the effect size of the inquiry model for developing chemical abilities of students was high, as the values of (η2) ranged between (0.65 - 0.96).

Results of the previous table show that all the (η2) values were high Also, the total effect size was (0.96) on the CAs test which indicates a high effect. Consequently, the researcher concluded that (0.96) of the variance in the study group chemical abilities could be attributed to the use of QODE inquiry model

2) The second hypothesis: **"There is no a statistically significant difference at the.05 level between the pre and post study group mean score on the pre-post chemical abilities observation checklist".**

To verify this hypothesis, the Wilcoxon Signed Ranks Test was used to calculate the difference between the research group performance on the pre and that on the post administration of the observation checklist. The results are presented here in table (3) as follows:

Table 3 Comparing the performance of the research group on the pre-post observation checklist N=15

Dimensions	No of Ranks		Mean rank		Sum of ranks		Z	Sign.
	W (-)	W (+)	W (-)	W (+)	W (-)	W (+)		
Design an experiment	**0**	**15**	**0**	**8**	**0**	**120**	**3.423**	**0.01**
Collect, and analyze data	**0**	**15**	**0**	**8**	**0**	**120**	**3.423**	**0.01**
Communicate	**0**	**15**	**0**	**8**	**0**	**120**	**3.429**	**0.01**
Evaluate experimental predictions and outcomes, conceptual claims, problem solutions	**0**	**15**	**0**	**8**	**0**	**120**	**3.426**	**0.01**
Make measurement	**0**	**15**	**0**	**8**	**0**	**120**	**3.422**	**0.01**
Classify objects	**0**	**15**	**0**	**8**	**0**	**120**	**3.497**	**0.01**
Represent chemical processes in multiple ways	**0**	**15**	**0**	**8**	**0**	**120**	**3.422**	**0.01**
total	**0**	**15**	**0**	**8**	**0**	**120**	**3.413**	**0.01**

Results in table (3) indicate that the estimated t-value is significant at the 0.01 level. This means that there is a statistically significant difference between the mean scores of the study group on the pre - post administration of the chemical abilities' observation checklist in favor of the post-administration. This means that QODE inquiry program was effective in enhancing and improving the participants' chemical abilities. Hence, the second hypothesis is rejected and alternative hypothesis is accepted

3) The third hypothesis:**" There is no a statistically significant difference between the mean score of the study group pre-post administration of the academic self-efficacy scale ".**

In order to verify this hypothesis, the researcher used the t-test for the paired groups to determine the significance of the differences between the mean scores of the pre- and post- administrations of the engagement in ASE scale to the one group. The following table illustrates the results.

Table 4

T-Value and its statistical significance for the differences between the mean scores of the pre -and post- administrations of the group in the engagement in ASE scale.

Dimensions	test	M	SD	t	df	Sign.
Academic performance	Pre	21.9667	2.48420	13.580	29	0.01
	Post	28.1000	2.26442			
Teaching self-efficacy	Pre	26.9000	2.59110	15.824	29	0.01
	Post	36.2333	2.40235			
persistence	Pre	13.4000	1.97571	12.684	29	0.01
	Post	17.9000	1.78789			
Self-regulated learning	Pre	15.4000	2.19089	11.817	29	0.01
	Post	19.5667	2.23889			
total	Pre	77.6667	4.53594	29.419	29	0.01
	Post	101.8000	4.86649			

The preceding table indicates that there were statistically significant differences between the mean scores of the pre- and post-administrations of the study group on the engagement in ASE scale in favor of the post- administration ,the "t" values were statistically significant values at the 0.01 level. As a result, the third hypothesis was rejected.

Results in table (4) indicate that the study group scores on the post-administration of the engagement in scale were higher than their scores on the pre-administration. The enlargement in the research group students` level proved that the treatment had a positive effect on students` engagement in academic self-efficacy.

4) The fourth hypothesis**: There is no a statistically significant difference between the scores of the post - administration for both of the chemical abilities test and the academic self-efficacy scale for pre-service chemistry teachers**

The researcher used Pearson Simple Correlation Coefficient in order to calculate the correlation coefficient between the scores of the post-administration for both of the chemical abilities test and the academic self-efficacy scale of pre-service chemistry teachers

The results indicated that there was a positive correlation between the scores of the post-administration for both the chemical abilities test and the academic self-efficacy scale of pre-service chemistry teachers, where the t-value was (0.389) which was a statistically significant value at the 0.05 level. As a consequence, the fourth hypothesis was rejected.

The positive correlation between the scores of the post- administration of the test and the scale means that the improvement of students` performance in the chemical abilities corresponded to the improvement of their academic self-efficacy.

These results could be explained and attributed to the pre-service chemistry teachers receiving the teaching training program on inquiry approach to develop chemical abilities where:

- The program contains many facts and concepts related to the abilities, comprehensive educational modules for knowledge and related activities and learning resources
- Each module included a set of formative evaluation questions, which helped Pre-service chemistry teachers to learn about chemical abilities, and increase their Conceptual comprehension by providing feedback and tracking progress in studying the module.
- Combine a theoretical training inside university, and practical training inside laboratories at practical education, help to link information in a constructive manner.
- The novelty of the educational content provided during the training program, attracted the interest of the trainees while training them on the chemical abilities during teaching chemistry and increasing their motivation.
- Provide continuous feedback and effective reinforcement by the trainer, whether by asking open-ended questions or by responding to their inquiries during their implementation of the training with a focus on developing mental processes (such as interpretation, observation, classification, and analyzing the data.

Conclusion

The current study concluded that using inquiry models and activities could develop chemical abilities and academic self-efficacy of pre-service teachers. Also, it was obvious that the treatment was fruitful in encouraging all students to apply inquiry-based teaching in the future.

Moreover, the study results came in accordance with the results of other studies discussing similar aspects. the application of Inquiry based instruction approach had positive effects on academic self-efficacy perception levels of the pre-service chemistry teachers

Recommendations

Based on the results and the conclusion of this study, the following recommendations were suggested:

a. Teaching approaches allowing the development of chemical abilities within the laboratory environment should be applied and activities should be prepared to develop these abilities.

b. Research on inquiry models can be adapted to different lecture contents and it can be ensured for students to reach the information themselves instead of theoretical knowledge.

c. Students could be encouraged to access true knowledge by allowing them to research and question instead of presenting them readily available and acceptable knowledge.

d. Self-efficacy perceptions of the students can be improved by including activities to the learning environment during which students take responsibilities.

e. Ministry of education should provide teachers with adequate training to use activities in the classroom to enhance chemical abilities

f. Curriculum planners should concentrate on the necessity of combining activities that develop chemical abilities in science curricula at all levels of education.

g. Researchers should give more attention to QODE model as a new approach for developing students' abilities and akills.

References

Af'idayani, N., Setiadi, I., & Fahmi, F. (2018). The effect of inquiry model on science process skills and learning outcomes. *European Journal of Education Studies*.

Allinder, R. M. (1994). The relationship between efficacy and the instructional practices of special education teachers and consultants. *Teacher education and special education*, *17*(2), 86-95.

Antonietti, A., & Cantoia, M. (2000). To see a painting versus to walk in a painting: an experiment on sense-making through virtual reality. *Computers & Education, 34(3-4), 213-223*.

Bandura, A. (1982). The assessment and predictive generality of self-percepts of efficacy. *Journal of behavior therapy and experimental psychiatry*, 13(3), 195-199.

Bandura, A. (1986). Social foundations of thought and action. *Englewood Cliffs, NJ: Prentice-Hall.*

Bandura, A. (1989). Regulation of cognitive processes through perceived self-efficacy. *Developmental psychology*, *25*(5), 729.

Bandura, A. (1989). Regulation of cognitive processes through perceived self-efficacy. *Developmental psychology*, *25*(5), 729.

Bandura, A. (1991). Social cognitive theory of self-regulation. Organ. Behavi. Hum. Decis. Process. 50, 248–287. doi: 10.1016/0749-5978(91)90022-L

Bettino, R. (1979). Why thermodynamics should not be taught to freshmen or who owns the problem? *Journal of Chemical Education* , 56, 520-522

Bucat, R. (2004). Pedagogical content knowledge as a way forward: Applied research in chemistry education. *Chemistry Education Research and Practice*, *5*(3), 215-228.

Davenport, J., & Davenport, J. A. (1985). A chronology and analysis of the andragogy debate. *Adult education quarterly*, *35*(3), 152-159.

Etkina, E., Van Heuvelen, A., White-Brahmia, S., Brookes, D. T., Gentile, M., Murthy, S., ... & Warren, A. (2006). Scientific abilities and their assessment. *Physical Review special topics-physics education research*, *2*(2), 020103.Isbell, T., & Raines, C. (2013). *Creativity and the arts with young children* (3rd ed.). USA: Wadsworth Publishing.

Galyon C. E., Blondin C. A., Yaw J. S., Nalls M. L. and Williams R. L., (2011), The relationship of academic self-efficacy to class participation and exam performance, *Soc. Psychol. Educ.*, 15, 233–249.

Gardner, C. M. (2011). Supporting cognitive engagement in a learning-by-doing learning environment: Case studies of participant engagement and social confgurations in Kitchen Science

Investigators. Georgia Institute of Technology

Garrison, D. R., Anderson, T., Archer, W. (1999). Critical inquiry in a text-based environment: computer conferencing in higher education. *Internet & Higher Education, 2(2–3), 87–105*

Garrison, D. R. (2011). Understanding cognitive presence in an online and blended community of inquiry: Assessing outcomes and processes for deep approaches to learning. *British Journal of Educational Technology*, *42*(2), 233-250.

Kind, P. M., & Osborne, J. (2017). Styles of scientific reasoning: A cultural rationale for science education? *Science Education, 101(1), 8-31*

Longo, C. M. (2011). Designing inquiry oriented science lab activities. *Middle School Journal*, September, 43 (1) 6-15.

Martin, A. J. (2008). *How domain specific is motivation and engagement across school, sport, and music? A substantive-methodological synergy assessing young sportspeople and musicians*.

Moon, J., Lee, S., & Xu, X. (2021). Exploring pre-service teachers' technology-integration belief and scientific inquiry in a teacher-development course. *International Journal of Technology and Design Education*, *0123456789*.

Mulyeni, T., Jamaris, M., & Supriyati, Y. (2019). Improving basic science process skills through inquiry-based approach in learning science for early elementary students. *Journal of Turkish Science Education*, *16*(2), 187-201.

National Research Council. (1996). National science education standards. Washington, *DC: National Academy Press.*

National Research Council. (2000). Inquiry and the national science education standards: A guide for teaching and learning. Washington, DC: *National Academy Press*.

National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. *National Academies Press.*

Nie, Y., & Lau, S. (2010). *Differential relations of constructivist and didactic instruction to students' cognition, motivation, and* *achievement*. *Learning and Instruction*, *20*(5), 411-423.

Oguz, A., & Yurumezoglu, K. (2007). The Primacy of Observation in Inquiry-Based Science Teaching. *Online Submission*, 11.

Price, S., & Rogers, Y. (2004). Let's get physical: The learning benefits of interacting in digitally augmented physical spaces. *Computers & Education, 43(1-2), 137-151.*

Putwain, D., Sander, P., & Larkin, D. (2013). Academic self-efficacy in study-related skills and behaviours: Relations with learning-related emotions and academic success. British Journal of Educational Psychology, 83, 633–650

Remesal, A., & Friesen, N. (2014). Inquiry into 'communities of inquiry': Knowledge, communication, presence, community. *E-Learning and Digital Media*, *11*(1), 1-4.

Selcan, K., & Zahide, Y. (2018). Investigation of community of inquiry framework in regard to self-regulation, metacognition and motivation. Computers & Education, 126, 53–64.

Suastika K G, and Hartanto T J 2016 Buku Ajar Lab Based Education "Arus Listrik, Hukum Ohm, Rangkaian Hambatan, *dan Daya Listrik (Papua: Penerbit aseni)*

Suastika, K. G., Sudyana, I. N., Lasiani, L., Pebriyanto, Y., & Kurniawati, N. (2017). Profile of Scientific Ability of Chemistry Education Students in Basic Physics Course. *Journal of Physics: Conference Series*, *895*(1).

Van der Graaf, J. Van de Sande, E. Gijsel, M. & Segers, E. (2019). A combined approach to strengthen children's scientific thinking: direct instruction on scientific reasoning and training of teacher's verbal support. *International Journal of Science Education, 41(9), 1119-1138.*

Warshawski, S. (2022). Academic self-efficacy, resilience and social support among first-year Israeli nursing students learning in online environments during COVID-19 pandemic. *Nurse Education Today*, *110*.١٠٥٢٦٧ ،

Woods, J. (1994). Woods, from page one. *Inquiry: Critical Thinking Across the Disciplines*, *13*(3/4), 41-46.

Yang, X., Zhang, M., Kong, L., Wang, Q., & Hong, J. C. (2020). The Effects of Scientific Self-efficacy and Cognitive Anxiety on Science Engagement with the "Question-Observation-Doing-Explanation" Model during School Disruption in COVID-19 Pandemic. *Journal of Science Education and Technology*, 1-14.

Yokoyama, S. (2019). Academic self-efficacy and academic performance in online learning: A mini review. *Frontiers in psychology*, *9*, 2794.

Zulkipli, Z. A., Mohd Yusof, M. M., Ibrahim, N., & Dalim, S. F. (2020). Identifying Scientific Reasoning Skills of Science Education Students. *Asian Journal of University Education*, *16*(3), 275–280.

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عطيفه ، حمدي ابوالفتوح ؛ سرور ، عايدة عبد الحميد (٢٠١١). *تعليم العلوم في ضوء ثقافة الجوده : الاهداف والاستراتيجيات . دار النشر للجامعات*

Otifa, H., & Srour, A. (2011). Teaching science in terms of quality education: objectives and strategies. *Universities Publishing House, Cairo*.