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Patterns of chemical identity thinking among students of the Faculty of Education for Pure Sciences - Ibn Al-Haytham in Iraq

By

Alyaa Abdul Ameer Jasim
University of Baghdad/Faculty of Education for Pure Sciences - Ibn Al-Haythem/Iraq
Email: alyaa77ameer@gmail.com

Basma Mohammed Ahmed
University of Baghdad/Faculty of Education for Pure Sciences - Ibn Al-Haythem/Iraq
Email: basma.m.a@ihcoedu.uobaghdad.edu.iq

Abstract

The aim of the research is to identify the patterns of chemical identity thinking and the significance of the difference in these patterns between the students of the research sample.The research sample consisted of (200) students from the fourth year of the University of Baghdad, College of Education for Pure Sciences / Ibn Al-Haythem/ Department of Chemistry in the morning and evening studies. That is, by (50%) of the research community, and the research tool was a test of chemical identity thinking patterns from (20) items with four patterns: (objectivization thinking pattern, principlsim thinking pattern, compositionism thinking pattern, interactionism thinking pattern). To verify its validity and reliability , the statistical results of the research showed a discrepancy in the students' thinking patterns , as the principlsim thinking pattern got the first rank with (79%) of the sample, and the objectivization thinking style came in the second place and its percentage was (21%) of the sample, while it was the compositionism & interactionism thinking patterns ranked third and obtained a percentage (0%), and the results showed a statistically significant difference in the patterns of chemical identity thinking among the students of the research sample in the interest of the novice thinking pattern, and the research recommended the need for the faculties of education to pay attention to patterns in the thinking of the chemical identity.

Keywords: Chemical Thinking, Chemical Identity Thinking patterns, compositionism Thinking, Chemistry Students, Faculty of education for Pure Sciences.

Problem of the Research

The reality of the prevailing teaching methods of chemistry from secondary stage to university education in Iraq indicates the lack of interest in teaching chemical thinking patterns, whether for the design of chemical experiments or the interpretation, hypothesis and explanation of phenomena. The teaching methods of chemistry are not based on expressing views to understand the nature of chemistry and its importance, but rather emphasize the description of the chemical composition of the material and the characteristics of chemical processes and explain ideas and concepts about chemicals and their interactions in an incoherent manner instead of chemical questions,which constitute the starting point for thinking processes that address (What is there?, Why is it happening?, How do you know?) The focus of teaching is on the content and general chemical skills that are in the form of big ideas and general principles, which causes a shortage of students in the appropriate perception of ways to think about chemical identity, so the research problem was identified by answering the question: "What are chemical identity thinking patterns among students of the Faculty of Education for Pure Sciences/ Ibn Al-Haythem in Iraq?"

Importance of Research

Faculties of Education aims to prepare graduates who are able to apply their scientific knowledge and thinking to deal with different life situations in society, which calls for adopting a new teaching methodology that will prepare students in a **well-planned** manner. Applicable understanding with a view to expanding chemical knowledge (Cooper, 2015:1279). The traditional educational systems from the secondary stage to the level of higher education and at the level of teaching chemistry present the topics in a non-coherent manner, as they emphasize the main ideas, for example (the naming of chemicals, atomic structure, chemical measurements, etc.) (Ngai & Sevian, 2017:3-4), as well as providing the skills needed to solve academic problems separately from the other. Achieved in chemistry such as analysis, synthesis and transformation of materials. (Chamizo, 2013:170-157) which weakens students' processes of inferring relationships between concepts and objectives of chemistry. Previous studies have shown that many students do not use the concepts they have learned to develop their chemical knowledge or apply them outside chemistry classes. Therefore, educational reform efforts in teaching Science is based on the need for the educational process to pay attention to the student's learning to understand, apply, analyze and discuss scientific ideas and then develop them (Ngai & Sevian,2017: 4-3). In general, and chemical thinking in particular, it can be important to contribute to solving theoretical problems such as understanding behavior when students interact. With the chemical nature of the substance, which provides new knowledge of chemistry, as well as it contributes to the development of intelligence, efficiency and creativity and plays a role in solving chemical problems in secret. Subtlety and Accuracy (Volkova, 2019:688-687) called "understanding or knowing a chemical by thinking chemical identity" (Ridwan & et al, 2019:363). Which consists of four modes of thinking, including what is tangible (Objectivization) by observation, or Princibilism, which is based on the presence or absence of principles that have certain characteristics, including what is synthetic (compositionism) Which refers to thinking about substances as a mixture of (atoms of elements) and the other as an interactive thinking (interactionism) based on the tendency of matter to chemical interaction with substances Other (Negai&Sevian, 2017:28). Students' information about the chemical identity of materials enables them to use and deal with chemicals correctly in life, as it is closely related to the daily contexts of business, whether in factories, laboratories, homes, and others, and that these daily life situations require chemical identification (Negai & Sevian, 2016:137), In addition to that it contributes to improving students' attitudes to occupy a particular future profession in chemistry, so the 6 teaching methods should pay attention to chemical thinking that leads to verifying the students' chemical identity thinking, by paying attention to the types of questions, attitudes and chemical practices that contribute to improving students' assumptions and their application 6 It has in different contexts (Ngai & Sevian,2017:11). In addition, it provides information for chemistry teachers about how students think about chemicals and reveals the methods they use in thinking of classification and discrimination, and thus this information can be used in knowing and evaluating the results of classroom or laboratory teaching. (Ngai & Sevian, 2016:137-148). Based on that, when teaching chemistry, students' thinking should be directed towards the basic ways of thinking in chemistry to determine chemical identity, by paying attention to mental processes such as analysis, synthesis, comparison, classification, and determining the relationships between cause and effect. the changes The research is important as: 1- It presents a clear vision of chemical identity thinking, its objectives, tools and characteristics, and describes the patterns of thinking used in it and the role of chemistry departments in adopting it 2- It is useful in studying chemical identity thinking among chemistry teachers before service in order to develop their preparation in colleges of education in Iraqi universities, as they are responsible in the future for Raising the generations that will be most affected With future changes 3- It highlights the capabilities of pre-service chemistry teachers on the patterns of

thinking of the chemical identity and how to use it, which contributes to the development of their abilities in their preparation programs in the faculties of education. 4- It provides the chemical identity thinking tool that was prepared in this research to reveal it to the studentsWhich refers to thinking about substances as a mixture of (atoms of elements) and the other as an interactive thinking (interactionism) based on the tendency of matter to chemical interaction with substances Other (Negai&Sevian,2017:28). Students' information about the chemical identity of materials enables them to use and deal with chemicals correctly in life, as it is closely related to the daily contexts of business, whether in factories, laboratories, homes, and others, and that these daily life situations require chemical identification (Ngai & Sevian,2016:137) In addition to that it contributes to improving students' attitudes to occupy a particular future profession in chemistry, so the 6 teaching methods should pay attention to chemical thinking that leads to verifying the students' chemical identity thinking, by paying attention to the types of questions, attitudes and chemical practices that contribute to improving students' assumptions and their application 6 It has in different contexts (Ngai&Sevian, 2017:11,). In addition, it provides information for chemistry teachers about how students think about chemicals and reveals the methods they use in thinking of classification and discrimination, and thus this information can be used in knowing and evaluating the results of classroom or laboratory teaching. (Ngai & Sevian,2016; Água & Morgado, 2020). Based on that, when teaching chemistry, students' thinking should be directed towards the basic ways of thinking in chemistry to determine chemical identity, by paying attention to mental processes such as analysis, synthesis, comparison, classification, and determining the relationships between cause and effect the changes The research is significant as:

1. It presents a clear vision of chemical identity thinking, its objectives, tools and characteristics, and describes the patterns of thinking used in it and the role of chemistry departments in adopting it
2. It is useful in studying chemical identity thinking among chemistry teachers before service in order to develop their preparation in colleges of education in Iraqi universities, as they are responsible in the future for Raising the generations that will be most affected with future changes
3. 3- It highlights the capabilities of pre-teaching chemistry teachers on the patterns of thinking of the chemical identity and how to use it, which contributes to the development of their abilities in their preparation programs in the faculties of education. 4- It provides the chemical identity thinking tool that was prepared in this research to reveal it to the students

Research Objectives: The research aims to find out:

1. patterns of chemical identity thinking among students of the Faculty of Education for Pure Sciences -Ibn Al-Haytham.
2. The significance of the difference in the thinking patterns of chemical identity among students of the Faculty of Education for Pure Sciences - Ibn Al-Haytham.

***Research Limits*:** The search is defined by:

1- ***Spatial Limit***: Faculty of Education for Pure Sciences - Ibn Al-Haytham / University of Baghdad.

2- Human limit: Students of the Chemistry Department – 4th Year (Government Morning and Evening Study).

3- Time limit: Academic year (2021-2022)/ 1443AH.

Terminology

Chemical Identity Thinking:

Defined by:

Talanquer, 2009): "Distinguishing between substances by using their properties in order to assign them to categories (types of substance) **(Talanquer**, 2009; Areias & Eiriz, 2020; Briard et al., 2020).

Sevian & Talanquer, 2014): "A dynamic and organized cognitive practice that expresses the student's framework in chemistry, which constantly interacts with the environment, builds new assumptions in a cumulative way, develops his ability based on his experience, and passes through hierarchical levels in the learning of chemistry, and moves from the pattern of physical thinking to the novice and then to the pattern of interactive thinking. **Sevian&Talanquer, 2014: p72)**

Procedural definition of chemical identity thinking: A systematic and comprehensive mental activity that includes the knowledge, reasoning and practices related to the classification and distinction of chemicals, including the four patterns of chemical identity thinking represented by (objective, initial, synthetic, interactive), **and** is measured by the score to which the students of the research sample obtain a test prepared by the researcher for this purpose.

***The concept of chemical identity thinking*:** Chemical identity thinking, which refers to how students use thinking based on relationships between materials and types of thinking patterns, is based on "basic theory", which has become increasingly common in research, especially educational research, over the past decades (Thornberg,2012:243).Thinking is a mental process that includes cognition, previous experience, conscious processing, and intuition, and the student does it by mentally processing sensory inputs and translated information to form new ideas, replace what exists, or infer through data or judge it (Groan, 200265:). Chemical thinking is defined as "the development and application of chemical knowledge and practices with the main objective of analyzing the composition and transformation of materials for practical purposes".(NRC, 2011: p37). Educational reform efforts call for the need to change teaching practices from the processes of describing knowledge to the effective participation of students in the generation of knowledge by building causal explanations of chemical phenomena, predicting their results, modelling them and building meaning (NRC, 2011: p112). The concept of chemical thinking can be used to describe the acquisition of knowledge, reasoning and practices that distinguish the chemical (Talanquer & Polard, 2010: p80). Chemical identity has been defined as "a classification or differentiation of the chemical where each chemical has at least one characteristic or characteristic that makes it unique to distinguish it from the rest of the materials" (Enke, 2001: p83). It is also defined as "the essence or basic idea of chemistry" to answer the question (What is this material?) (Schummer, 2002: p66).

Chemical Identity Thinking patterns

The results of the studies indicate that students are affected by their thinking about chemical identity in key categories. These are the assumptions of chemical identity thinking represented by (the external appearance of the material, the functional use of the material, the dating or origin of the material, the intrinsic characteristics, the addition of materials, and the synthetic characteristics). They are similar to the thinking of people about the identity of an object and its application for the purpose of distinguishing or differentiating it from other materials (Negai & Evian, 2017:28). Understanding the basic assumptions about chemical identity contributes to developing strategies for effectively involving students in practices and methods of thinking about chemistry (sevian & Talanquer, 2014: p58). The results of the studies showed that the novice thinking of students in the chemical identity depends heavily on the objective characteristics such as (color of the sample, state of matter: solid, liquid and gas or smell of the material.... etc.), and then develops more complex thinking on inferences

based on (Ngai & sevian, 2017:193). Empirical studies of students' ideas related to chemical identity led to supposed educational progress related to " How students perceive the types of material, the types of characteristics adopted in making decisions about chemical identity, and the main thinking patterns applied by students in making decisions (Alonzo,2012:312) .

Figure (1) describes the evidence that supports assumptions in chemical identity thinking styles:
Advanced thinking, novice thinking.

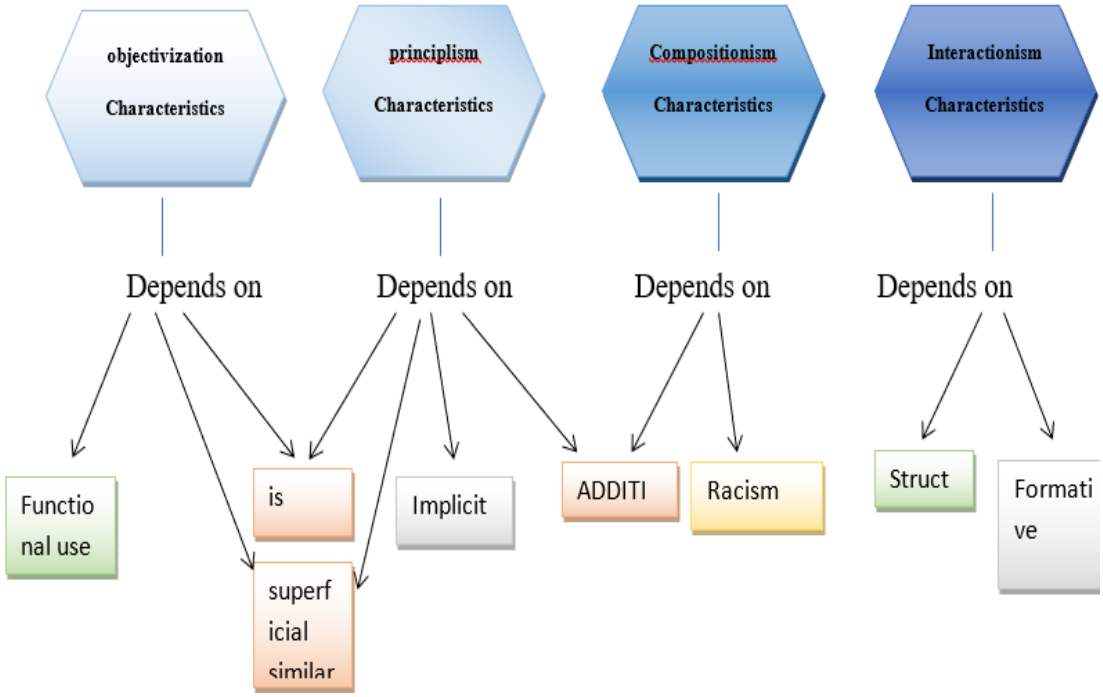

Figure (1) Patterns of Chemical Identity Thinking) Prepared by the researcher)
Novice Advanced

The figure shows that these assumptions enable chemistry teachers to anticipate the development of students' understanding and apply their main ideas and describe how students understand. It also shows that the idea of chemical identity evolves over time. Four main patterns or models of thinking can be distinguished based on empirical studies and have been proposed as distinct characteristics and thinking patterns that include (palpable,initial, synthetic,interactive) , and these patterns are described below:

1- The pattern of objectivization thinking: It depends on the characteristics that can be objective to identify or distinguish materials (such as size and color), and these materials are divided into categories and sometimes the existence of differentiation between materials of the same category (example: types of minerals).

2- The principlism thinking pattern: It is characterized by focusing on the classification of materials according to their characteristics, which are the principles of the material that can be added or removed in order to determine the observable characteristics of the body or material. (Example: the combustibility of some materials)

1- ***Compositionism Thinking pattern*** focuses on basic chemical building blocks (atoms or elements) that are grouped together to form a substance, each component

contributing a characteristic of the substance.

2- ***Interactionism Thinking pattern*:** It is the most thinking style and includes thinking about the properties of materials as a result of the dynamic interaction of components. (Negai &Evian, 2017:27)

Search Procedures:

Research Methodology: The descriptive, associative method was adopted to suit the research problem and objectives.

The **research community and** its sample**:** The research community consisted of all students of the fourth year of the chemistry department in the morning and evening studies from the University of Baghdad/ Faculty of Education for Pure Sciences - Ibn Al-Haytham in Iraq, total of (331) students. The research sample was chosen in a random sampling method from (200) students from the morning and evening studies by (50%) of the research community.

***Research Tool*:** One of the requirements of the research is to prepare a test to measure the thinking of the chemical identity. In the absence of an appropriate tool to collect information and data for undergraduate students, the researcher herself prepared the research tool with the following procedures:

***A-Determining the objective of the-test*: -** The objective of the-test is to measure the organized and comprehensive mental activity, which includes the set of dynamic and organized cognitive practices related to classification and discrimination between chemicals.

***B-Determining patterns of chemical identity thinking* :**In light of the theoretical definition of chemical identity thinking, which was defined by (Sevian&Talanquer,2014:p72) As "a dynamic and organized cognitive practice that expresses the student's framework in chemistry, which constantly interacts from the environment and builds new assumptions in a cumulative manner and develops his ability based on his experience, where the student moves from the pattern of physical thinking to the novice and then to the interactive thinking pattern". Thus, hierarchical levels are considered through which the student passes when learning chemistry, and thus four patterns were identified for thinking the chemical identity ranked from the lower to the higher pattern represented by: "The pattern of physical (objective) thinking, the pattern of novice thinking, the pattern of synthetic thinking, and the pattern of interactive thinking"

***C-Formulating the items of the chemical identity thinking test and its instructions* :** The test consisted of (20) items and each item consisted of an introduction with four alternatives, and each alternative represents a specific pattern of chemical identity thinking, and there is no right and wrong answer, all alternatives express possibilities that can be indicated to the student and he can choose all alternatives , and the test instructions **for students** and the instructions for **correcting** the **test were formulated** by that the student gets one score if he chooses the alternative that represents the pattern of physical thinking (objective), and on two score s if he chooses the alternative that represents the pattern of novice thinking, and on three score s if he chooses the alternative that represents the pattern of synthetic thinking, and the student gets four score s if he chooses the alternative that represents the pattern of interactive thinking, and whenever the student chooses more than one alternative he gets score s representing each alternative that he chose cumulatively, and the score s of each type will be as follows:

Objective thinking from (20-59).
The novice thinking pattern is 60-119.
Synthetic thinking pattern from (120-199).
Interactive Thinking Style from 200.

Thus, the lowest score of the test is (20) scores, and the maximum score on the-test is (200) scores, with a hypothetical average of the test (100) scores, and the validity of the test was verified by presenting it to a group of arbitrators and specialists in chemistry and-teaching methods of chemistry.

***Statistical analysis of the test items*:** The test was applied to the statistical analysis sample of (200) students, which is the same as the statistical analysis sample. After correction, the scores were arranged downward from the highest to the lowest score and (27%) of the highest and lowest scores were taken. The number of forms in each group was (54) forms, and the answers were analyzed statistically to find**:**

The **discriminatory power of each test** item: TheT-test was approved for " two independent samples", and the calculated T-values were (1.960) , which is higher than the tabular T-value at the level of (0.05), and a score of freedom (106), which indicates that all the items were distinctive .

Construct validity: To extract the correlation coefficient between the score of each item and the total score of the test, the Pearson correlation coefficient was adopted, and it was found that all correlation coefficients are statistically significant when compared to the tabular value (098.0) at the significance level (05.0) and with a degree of freedom (198), as the range of correlation coefficients scores reached between (0.213 - 0.539)

Confirmatory **Factor Validity:** The validity of the affirmative factor composition was calculated by testing the chemical identity thinking by subjecting the model to the confirmatory factor analysis using the statistical program Amos 24 and using the Maximum Likelihood method in the analysis, and the indicators of conformity quality of the assumed model were in the ideal range, which indicates that the single factor model achieves good data conformity, and Table (1) shows

The standard deviation weight for each chemical identity thinking pattern as indicators of a single underlying factor.

Table (1) *Standard deviation Weight for Chemical Identity Thinking patterns*

Chemical Identity Thinking patterns	The standard gradient weight
The objective	0.896
The Novice	0.833
The Synthetic	0.724
The Interactive	0.872

It is clear from Table (1) that the thinking patterns have indicative saturations, as the validity coefficients (standard regression weight) ranged between (0.724-0.896), which confirms the validity of the thinking patterns of the test and their saturation on one potential factor, which is the thinking of chemical identity.

Test reliability: Two methods were adopted to find reliability as follows:

***1. Cronbach's Alpha Equation*:** The Alpha-Cronbach equation was adopted for each of the chemical identity thought patterns in Table (2).

Table (2). The persistence coefficient in the Vikronbach method for testing chemical identity thinking patterns

Models	Reliability coefficient
The objective.	0.788
The Novice	0.692
The Synthetic	0.688
INTERACTIVE	0.623

Table (2) shows that all the reliability coefficients for the four patterns were good, if the value of reliability is 0.60 or more, then it can be adopted.

***2- Half Split Method: (Half Split)*:** The test items were divided into two parts, each part contains (10) items, then a correlation coefficient (Pearson) was calculated, and when correcting the correlation coefficient with the Spearman-correction equation, the reliability coefficient became as shown in Table (3)

Table (3). Reliability coefficient by the method of the halving of the testing of thinking patterns of the chemical identity

Models	The value of thecorrelation coefficient	Reliability coefficient
Objective	0.699	0.822
The Novice	0.648	0.786
The Synthetic	0.687	0.814
INTERACTIVE	0.699	0.822

***Presentation of results*:** The results are presented according to the sequence of research objectives as follows:

***The first objective*:** Knowing the thinking patterns of the chemical identity of chemistry students in the Faculty of Education for Pure Sciences - Ibn Al-Haytham

To find out the prevailing pattern of chemical identity thinking among the students of the research sample, the frequency and percentage of each type of chemical identity thinking was calculated in Table (4).

Table (4). *Distribution of the numbers of the research sample according to each of the thinking patterns of the chemical identity*

The thinking patterns	Number ofSample	ThePercentage
Objective	41	21%
Novice	158	79%
Synthetic	1	0%
INTERACTIVE	0	0%
Total	200	100%

Table (4) shows that the novice thinking pattern was ranked first, as the percentage was (79%), and the number of individuals in the sample of this pattern was (158) of the total research sample, then the pattern of physical (objective) thinking came in second place, and obtained a percentage of (21%), and the number of individuals in this pattern was (41) of the total research sample, where the pattern of synthetic thinking was ranked third, and the number of students was (1) and obtained a percentage (0%), as well as the interactive thinking pattern, which did not get any score, and the percentage was (0%)

***The second objective*:** Knowing the significance of the difference in the thinking patterns of the chemical identity among the students of the research sample

To determine whether there is a statistically significant difference between the patterns of chemical identity thinking among the students of the research sample, the test scores for the sample of (200) students were analyzed, and the one-way analysis of Variance was adopted, Table (5)

Table (5). *Analysis of Unilateral Variation of Chemical Identity Thinking patterns*

Source of variance	Sum of squares	Degree of freedom	Average set of squares	Alkaline value Calculated	tabular	Significance
Between Groups	23162.763	2	11581.382	87.841	3.86	Significant
Within Groups	25,973.457	197	131.845			
Total	49136.220	199				

Table (5) shows that the calculated value (87.841) is greater than the table value (3.86) at the level of (0.05) and with two score s of freedom (2- 199), that is, there was a difference in chemical identity thinking patterns among the students of the research sample in favor of the novice thinking pattern of (78.145), which is the highest arithmetic average among chemical identity thinking patterns.

Results and discussion

1. The statistical results showed that there is a discrepancy between the chemical identity thinking patterns and that there was a statistically significant difference in chemical identity thinking patterns among the students of the research sample in favor of the novice thinking pattern. (79%) of the sample showed that they have the pattern of novice chemical thinking (Principilism). This means that students can classify materials according to their characteristics based on the principles of the material. This can be explained by the fact that the teaching of the content of chemicals includes the textual contexts of most principles related to chemicals, which is based on the presence or absence of principles that bear certain characteristics such as (boiling point, melting point, solubility) and others.
2. The statistical results showed that (21%) of the sample depended on the pattern of physical chemical thinking.
3. (Objective) This means that students have moved beyond the novice thinking style of classifying materials and distinguishing them based on characteristics that can be objective through observation that depends on visual perception (such as size, color, etc.).
4. The statistical results showed that students did not adopt the pattern of synthetic chemical thinking (compositionisim) It was (0%) of the sample, which means that students do not adopt the distinction of materials and classifying them by thinking of materials as a mixture of (atoms – elements) and the explanation for this is not to use microscopes in chemistry laboratories (Negai & Evian, 2017:148.
5. The statistical results showed that students did not adopt the pattern of interactive chemical thinking (Interactionism) in classifying and distinguishing materials, which indicates the tendency of the material to chemical interaction with other materials, and it was (0%) of the sample. This means that the students in the research sample do not

use the higher thinking style, which is the result of the interaction between the components of the materials and the interpretation of this is the lack of use of the necessary materials andtools to conduct chemical interactions due to the lack of availability of some materials on the one hand or reliance on theoretical courses more than in practice, which leads to the weakness of the emergence of this pattern (Negai & Sevian, 2017:150).

Conclusions

1. According to the research results, the following conclusions were reached:
2. There was a discrepancy in the patterns of students' thinking, as the novice pattern of thinking was ranked first with (79%) of the sample, and the second was the pattern of sensory thinking and was (21%) of the sample, while the two patterns of synthetic and interactive thinking were ranked third and received a percentage of (0%).
3. There was a statistically significant difference in the thinking patterns of the chemical identity among the students of the research sample in favor of the novice thinking pattern and by (79%) of the sample.
4. The students of the research sample exceeded the pattern of novice thinking based on objective thinking when classifying and distinguishing chemicals, as it was (21%) of the sample.
5. The students of the research sample do not adopt the patterns of composition and Interactive chemical thinking.

Recommendations

In light of the findings and conclusions of the study, the following recommendations can be made:

1- The need for the faculties of education to pay attention to the student's chemical identity thinking patterns through their continuous training in the field of specialization.
2- Directing the faculty members in the departments of chemistry to integrate the patterns of chemical identity thinking into the content of the courses of chemistry on the theoretical and practical aspects.
3- Organizing courses and seminars for faculty members in faculties of education to inform them about the purposes of chemical identity thinking and the way to achieve it.
4- Utilizing the chemical identity thinking test as a tool to detect it among university students.
5- Providing laboratories equipped with the latest equipment that will help students in detecting the identity of chemicals using scientific problem-solving skills and allocating them to students at all levels of university.
6- Directing faculty members to pay attention to the pattern of synthetic and interactive thinking by providing all the necessary chemicals and devices so that the student can carry out all the necessary interactions to classify and distinguish chemicals.

Suggestions

To complete the research, the researcher proposes the following:

1-Conducting another similar study at different study years and subjects.
2. Conducting a study on the chemical identity thinking of chemistry teachers at the secondary

level.

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