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A Longitudinal Study of Cognitive Perceptions of High School Students in the Case of Quantum Concepts

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Abstract: This descriptive study is a longitudinal survey. And it was done to assess the conceptual ideas about quantum concepts of high school students. Due to the length of the study, the population of the study consisted of all high school students in Tehran in academic year 2011-12 and in 2014-15. To assess students' understanding of a concept, evaluation method was used. In this way, the options chosen in four categories: full understanding, partial understanding, misunderstanding and lack of understanding. Comparison of conceptual imagery about the concepts of quantum students in academic year 2011-12 with students in 2014-15 indicate that older students face more misunderstood, during the last few years, new graduates have understood better and this is the signs of changes in curriculum and curriculum development and better statement of the quantum content in new textbooks. Finding of this study showed new misunderstandings about the concepts of quantum. It is recommended that curriculum specialists, review school curricula to suit the existing misunderstandings.

Key words: Longitudinal survey, conceptual ideas, high school students, concepts of quantum, Tehran

INTRODUCTION

By definition, curriculum is a scientific field that included at least elements of the objectives, content, teaching methods and assessment methods. Teaching is the activity that its define with the apparent ease is difficult, the undeniable role in the processes of education leads to thinking about the ideal situation and presenting models, these efforts have been associated with various achievements and consequently, evidence for the defense of the patterns have been produced but "can we defend a method, pattern or appropriate teaching strategies confidently that the method or model or strategy leads a teacher (from teacher to university professor) on its purpose? "teaching "of the action is in a unique position for such an act" method capable of producing knowledge", plays a central role (Mousapour, 2013).

Those who have honor of teacher should identify one of the strategies of teaching and learning, learner's conceptual notions about the material presented in class and then apply the patterns and specific way to fix it. Curriculum design may reflect the important belief of learners that is they not only intellectual skills to rise up their ability to learn but use it as a basic skill in classrooms and other areas of their lives to pass this important matter. Secondary education is the most important training courses as the transition period from primary school and objective thinking and enter the stage of abstract thinking and entry into adulthood is an important period in the life of all human beings. Men with higher education or enter the labor market and associated to undertake great responsibilities (Alipur *et al*., 2013).

In this study, to review the conceptual ideas of the students topics in the mathematics of quantum physics textbooks in the final year of secondary school) and high school offered basic chemistry in terms of creating a full understanding, partial understanding, misunderstanding and lack of understanding of education have been addressed. Need to be raised in order to align curriculum schools in accordance with the national curriculum gradually in the coming years, the year 2016, the tenth grade or the second high school grade textbooks and in2018, the twelfth grade textbooks, needed to be changed And these studies could lead to better explain subjects in school education. Content is one of the elements of the curriculum; it includes knowledge (facts, explanations, principles, definitions), skills and processes (read, write, calculate, logical thinking, decision making, communication) and values (good and bad, right and wrong, ugly and beautiful) (Maleki, 2010) in addition to educating students interact with it as well. Any content, to be provided to others need tools to transmit and store that information and data. These tools; called educational media (APA, 2008). Textbook are the most common and most educational media in educational systems around the world, especially in the Islamic Republic of Iran

education system that the written documents is education and the activities and experiences of learners, organized around it.

Study and analysis of theses case helps the authorities and authors of textbooks to be more careful in making, picking and choosing the content of textbooks that facilitate the learning and provide students academic progress. In Iran education system as intensive curricula, textbooks, despite all the constraints is the main symbol of opportunities and learning experiences for teachers and students. In fact, the main medium for transmitting messages and the textbook is an important tool to achieve educational goals. It seems that in such a system, using varied and diverse experiences and opportunities while increasing the diversity and attractiveness of curriculum, capacity and ability to influence them in the areas of knowledge, skills and attitudes of students increased. A variety of experiences and learning opportunities can be used to develop intelligence capabilities and diverse students in different courses of designers and authors of books and textbooks (Amini *et al*., 2009).

Learning variously attributed to misunderstanding perceptions that includes former understanding, alternative frameworks and understandings. However, there may be the fundamental differences between these terms, but in this article "misunderstanding" is used for the students' misconception to determined the Conceptual image of misunderstanding of scientific explanation of quantum concepts and by recognition of the issue of quantum their misunderstanding be guided to a regular pattern in solving problems. It is clear that students have taken their ideas from somewhere, probably from the words that have heard, have understood without them an Image is created in their minds and try to use those ideas. It is also clear concepts of the course content those students in the classroom in front of the reception they maintain their initial ideas in response to some questions, change their answers but often instead of getting a wrong answer change to the correct answer, change the wrong answer to the other wrong answers that is the resulting of their mental images.

Quantum mechanics is something quite abstract (Shiland, 1995). Nature of the subject, make its teaching to become more competitive and to the importance of quantum mechanics, such topics have been considered as the chemistry, physics and biology (Singh *et al*., 2006). Quantum which is plural word of quanta in Persian dictionaries is in the main form of the word, quantum and as word means "small amount" (Griffiths, 1995). In physics, especially quantum mechanics when the quantum is pointed, it means small and dismiss packets of energy this theory attributes to some physical quantities such as energy, the energy of an atom at rest, under certain conditions, gives discrete values (Shankar, 1994). Fundamental aspects of the foundations of quantum mechanics are still in progress (Sakurai, 1967). In our country, the topic of quantum concepts is in the curriculum of tenth grade's chemistry and last grade of high school's physics. The basic physics curriculum in high school (secondary end basis) quantum science is used to simplify the expression of the concept of duality wave-particle of light and quantum science in the curriculum of basic chemistry in high school I predict the chemical behavior and expression of the ground state atoms and molecules, excited states and developments the material. The quantum theory of atomic and molecular structure, taught especially in introductory courses in physics, inorganic chemistry and other sciences and were I n the curriculum of many countries (Tsaparlis and Papaphotis, 2002).

Research on students' misconceptions in science education has been a central issue in the past two decades Because misunderstandings are the main obstacles to education and scientific concepts (Nakiboglu, 2003). During the past 20 years, extensive studies have been conducted in the field of quantum and misconceptions. The field has attracted the attention of many researchers. In continue we study some of them. Shiland (1997), assess the number of high school chemistry textbooks and came to the conclusion that they cannot provide a sufficient basis for the expression of Bohr's atomic model according to the theory of quantum mechanics. Ireson (2001), did a study among students who were studying in England and found most of them are with misunderstandings and misconceptions in electron energy levels in the quantum concepts and understanding the makeup of substrates.

Vokos *et al*. (2000) for students ages 21-17 years in America had done research in the field of quantum physics to understand the concept of duality wave-particle and came to the conclusion that most of these students have spent quantum foundation course with little understanding. However, they have gone higher course. Cervellati and Perugini (1981) in Italy have assessed the confusion of high school students about orbital realization and attributed this confusion to the way teachers teach and inappropriate content textbooks.

Zollman *et al*. (2002), Cataloglu and Robinett (2002) as well as a perception of low student of quantum concepts to teachers knew and with this view, research aimed at training teachers around the world to serve the education about mechanics, the results of research in this field has shown that most high school students at several levels in scientific fields listed a series of

misunderstanding and lack of understanding or comprehension are lacking (Allen, 2010). When students come into the classroom, ideas are the result of daily experiences, observation of scientific phenomena and their study. This idea may be consistent with the explanations put forward by the teacher in the classroom. But too often, these ideas are the result of misconceptions that surround the personal beliefs or by carelessness in the words of the teacher. Therefore, this problem can have a negative impact on the process of teaching and learning left and educational activities with a serious injury to face the future. Some of the ideas that students bring to the classroom empirically for the formation of knowledge can affect their future (Cross and Bowden, 2009).

According to the introduction, this study aims to investigate students' misconceptions of their quantum concepts and then propose methods and strategies to correct this misunderstanding (Cross and Bowden, 2009).

Research questions: The main objective of the study: The study of cognitive conceptions of basic concepts of quantum students, including basic concepts of it. According to the study, this research attempts to answer the following questions. The first questions: Dose the last grade students of high school, after school education; have received a proper understanding of the basic concepts of quantum? Second question: Dose the students understanding of the basic concepts of quantum perception change by aligning textbooks with the national curriculum?

MATERIALS AND METHODS

This study is drawn from a longitudinal field study and survey was conducted in two phases in Tehran. Or long-term longitudinal study of its kind in the country is unmatched. Longitudinal design involves repeated measurements of variables together a group category during a long period of time. This longitudinal study is the process study. In these studies, examples of different groups of people, the same population can be examined at different times. One study process, to describe the long-term changes in a society can be useful. With this study as a model for understanding some of the issues and phenomena change over time, including students achieved cognitive thought. In this research method to fit the tool according to the research question and the need to cover long-time research and selection are made. Given the longitudinal nature of the study population included all high school students in Tehran last base in the academic year 2011-12 and 2014-15.

The sample consisted of 255 students of basic high school seniors have been 125 of these students (68 Mathematics and 57 Experimental field) in the academic year 2011-12 and 130 of them (68 Mathematics and 62 Experimental field) 2014-15 academic year, at the base of high school seniors have been studying. In Table 1 student's features in the academic year 2011-12and in Table 2 student's features in academic year 2014-15 in terms of demographic presented. In this study used diagnostic test is multiple choices. Questionnaire contains 6 multiple-choice questions in regards to quantum issues raised in (school education), have been the basic physics of tenth grade of high school seniors basic chemistry textbook. To determine the content validity of the tool, with 18 tons of gathering opinions physics teacher with a BA and two teachers with a master's degree and PhD of the questions on the questionnaire, content validity of the questionnaire was confirmed. To examine the reliability tooling questionnaires among 30 Foreign students of the sample, the test was conducted. Then their comments were collected and then statistically calculated through Cronbach's alpha and 0.87 validity, reliability test was confirmed.

The test was done in normal circumstances and without prior notice. Disciples class test sample was conducted during 25-20 min they were assured that the tests are conducted for the purpose of research and its results confidential and have no effect on their grades. After a test run in the description of the frequency, frequency percentage and tables and related charts are used. Then, using the Software SPSS relative frequency

Table 1: Demographic data analysis students by gender and field of study (Academic year 2011-12)

				Field of study	
Study areas	The number of students	Gender of students	Type of school	Experimental	Math
Tehran	68	Girl	Governmental	34	34
	57	Boy	Governmental	30	37

Table 2: The analysis of demographic data of students based on gender and field of study (academic year 2014-15)

				Field of study	
Study areas	The number of students	Gender of students	Type of school	Experimental	Math
Tehran	68	Girl	Governmental	35	33
	62	Boy	Governmental	35	27

performance of the students were questions for different options. To evaluate the student perception, contextual assessment method is used. In this way, the choice of options are in four categories: full understanding (acceptable answers include all components are answered), understood the details (acceptable answers include at least one of the components of answers), misunderstandings (answers, including answers, unreasonable and unscientific) and lack of understanding (where the respondent answers questions clearly points out that the concept of not understanding).

RESULTS AND DISCUSSION

Review responses to the questionnaire showed that students have basic high school senior's misconceptions much about the quantum (Appendix 1). This misunderstanding is misconceptions that were created surround over the years to be subtle and even teachers without experience and resources through unfamiliar with the true teaching method. The students learned many years ago, being abstract concepts and scientific content provided disproportion with their level of cognitive development are all the causes of misunderstanding among students. The system of common knowledge for various types of imagination alternative that can compete scientific thinking and knowledge and in the process, most of the ideas rooted more strongly in the cognitive structure of learners have been dominant and will develop (Szabo and Ostlund, 1982).

Books chemistry and physics in high school I Secondary twelfth, quantum theory has been proposed. According to the textbooks for educational purposes Questionnaire were prepared and were available to students. This topic is a common misunderstanding. A large number of studies and articles focused on understanding and lack of understanding of quantum concepts. In recent years, much research on effective teaching methods, especially the issue of quantum physics concepts as well as misconceptions and also correcting misconceptions their children in this regard was conducted. The results of investigations of this nature by Vokos *et al*. (2000), Zollmen *et al*. (2002) and Planinic *et al*. (2006) have been carried out confirmed the findings of this study.

The first question of this study was to investigate the most poorly understood and least understood concepts related to quantum last grade high school students of academic year 2011-12. However, changing the curriculum of school education leads more demand from the performance of the students in the academic year 2014-15. But both groups have been misunderstood and frequency of the sample in terms of the misunderstandings was very close to each other. This result Cervellati and Perugini (1981) which found confusion orbital high school students is from the lack of understanding and have been aligned with Ireson study which showed students uncomprehending and misunderstanding many of orbital quantum concepts. The results of this study second question answer showed, the most poorly understood and least fully understand the students of secondary grade students last school year was 2011-12; this means that students have misconceptions about orbital energy are Ireson this finding which showed that students understand the arrangement of electron energy levels in the substrate misunderstanding and misunderstood are synchronized. The third question of this study was to investigate the most poorly understood and least complete understanding of quantum mechanics and Newtonian related to secondary grade students last school year, 91 in 1390. This is in line with previous findings that Planininc *et al*. (2006) and found that students due to quantum concepts are misunderstood, lack of understanding on the issues related to the topic of quantum concepts that have been taught to them is consistent.

Answer of the question four study shows that more than half of the study sample -0.56% are somewhat misunderstood And did not understand the concept of quantum correctly only have to maintain it and These results are consistent with the findings of Ireson which showed students, many did not understand quantum concepts as well. In response to this question, high performance grade students last academic year 2011-12 to function as the base year is closely related 2014-15. But as was shown in the survey questions also the highest misunderstanding of the students in the academic year 2011-12.

By examining the answer of questions fifth study showed that the greatest misunderstanding about the behavior of light particles wave of students in the academic year 2011-12. And the greatest lack of understanding of the students in the school year and concludes with findings 2014-15 which showed students in the field of quantum physics understanding the concept of duality wave-particle has a lot of misunderstanding. By examining the answer of the sixth study that is examining how students understand the concept of energy levels, new misconceptions due to lack of understanding of the topic energy. Overall, more than half of the participants are misunderstood or a complete lack of understanding. The answer can be concluded from

this that the basic chemistry already during my training in high school, it was taught by teachers to students but they still have a misunderstanding or a lack of full understanding of the quantum topic in school education, teachers have not been able to fully understand the cause of this discussion for students and the results of the studies Cervellati and Perugini (1981), Zollmen *et al.* (2002), Cataloglu and Robinett (2002) were consistent, they showed that the teaching methods of teachers can increase misunderstanding in the abstract matters like quantum.

CONCLUSION

The results of the study show that students' answers to questions posed at the base of the last grade of high school in academic year of 2011-12 has more misunderstandings. This result, however in one hand, seems to be the disaster and on the other hand is happiness. Because, it represents an improvement of curriculum and curriculum changes represent a better expression quantum content in textbooks in new Compilation (4 years) and provide the correct teaching methods teachers in recent years (less than a decade). With regard to existing misconceptions, it is essential in planning and writing textbooks, all concepts, challenging and prone to perceptual misunderstanding in the imagination of students be assessed in order to improve the quality of teaching-learning concepts related to quantum. Based on the results obtained in this study are suggested:

SUGGESTIONS

- Curriculum planners and textbook authors write physics and chemistry write quantum concepts to the content of education with new and updated review
- Program planners and authors of textbooks want physics and chemistry teachers to update their information by participating in seminars or follow-up research journals or event and be familiar with improve teaching ways and learning appropriate ways to operate
- Teachers while teaching quantum concepts, first recognize the misconceptions of students and attempt to overcome misconceptions
- The researchers or publishers of educational books and fair presentation of the concepts of quantum physics and chemistry must be careful in selecting quantum concepts and be aware of the misunderstanding about it

APPENDIX

Results respond to questions, shows that the performance of students in the field of quantum.

The aim of the question (1) is examining how students; understanding the concept of orbital.

Question 1. Which option expresses the concept of orbital?

A. A region of space where the probability of electrons is zero.

B. Orbital only obtained from the exact solution of the Schrodinger equation for the hydrogen atom or atoms like hydrogen (single electron).

C. Orbital is a mathematical concept of space means that the probability of presence of the particle in the space is >95%.

D. Options "b" and "c" is correct.

The correct answer is "D".

Orbital is a region of space around the nucleus that has the probability of finding the electron in there. The risk is highest near the core. And to all parts of space which certain distance from the nucleus, there is a certain probability.

"The probability of an electron in its region of space is 90%". This is the definition given in the textbooks.

According to the explanations of the orbital referred to "D" can offer a clear concept of orbital. If the definition of Orbital stated in textbook be just the "c" means "orbital is a mathematical concept of space means that the probability of the existence of bits is >95%" is actually part of the correct answer. The 44.5% of respondents chose this answer with a detailed understanding. The other part of right answers has been proposed option B which contains 13.4% of respondents. This number is also experiencing a partial understanding.

After reviewing the responses to this question show that a total of 57.9% with partial understanding and only 8.9% of the participants have chosen the correct answer "D" and have a full understanding and 7.23% of the participants in this did not answer the question means lack of understanding and 25.2% of participants have misunderstanding by choosing "A".

The results showed that forth grades students in high school academic year 2011-12 and forth grades students in high academic year 2011-12 option "c" as defined orbital put a priority choice. High school students in the academic year 2011 with a frequency of 7.26% compared to the performance of high school students in the academic year 2014-15 with frequency of 23.4 has been more misunderstood. Most of misunderstanding about high school students is in the academic year2011-12.

The purpose of Question (2) is to study students' understanding of electron configurations and thus increase energy levels in the substrate.

Question 2. Which of the substrate 6s, 5p, 4f and 4d are at a higher energy level?

A.6s B.5b C.4f D.4d

The correct answer is "A".

In the textbook in order of increasing energy electrons are in orbital. Electrons tend to be placed in the lowest energy level. Review the responses to these question shows that most students choose both options "A" means «6s» and «C», the «4f». Select the option 'A' indicates that students have grasped the wrong way to filling the substrate and have misunderstanding. According to an interview, they mistakenly believed that increasing the amount of energy orbital depends on n amount (numerical coefficient). Results indicated that 40.43% of respondents familiar with this concept and were completely understand. But 5.7% of respondents did not answer the question and who have no understanding.

The rest of the participants by choosing other options 93.5% "A", "B" and "D" are somehow misunderstood. Fourth grade high school students in the academic year 2011 with a frequency of 58.5% relative to the performance of high school students in the academic year 2014-15 with a frequency of 49.2% has been more misunderstood. Most of the misunderstanding is for high school students in academic year 2011-12.

The purpose of Question (3) is to study students' understanding of quantum mechanics and Newton.

Question 3. Which option on quantum mechanics and Newtonian is right?

A. Quantum mechanics and Newtonian mechanics are two widely separated.

B. Newtonian mechanics to quantum mechanics subsets are then linked together.

C. Newtonian mechanics is a subset of quantum mechanics so are interdependent.
D. Quantum mechanics and Newtonian mechanics cannot be compared.
The correct answer is option "A".
As we know from classical mechanics and quantum mechanics are interdependent.
However, because the laws of classical mechanics obtained from studies of large objects it is inappropriate to justify atomic phenomena and issues related to atomic physics to Newtonian mechanics that cannot be solved by classical mechanics. It is noteworthy the textbook does not point out that much.
The results show that a total of only 20.33% of students know and fully understand Newtonian mechanics to quantum mechanics are subsidiaries. 29.56% of respondents did not understand the questions and answers are not correct and have no understanding. The other participants are 49.53% by choosing other options have some kind of misunderstanding.
According to information obtained, fourth grades high school students in the academic year 2011-12 with a frequency of 58.5% compared to the performance of fourth grades high school students in the academic year 2014-15 with a frequency of 40.2% have been more misunderstood. In this case the maximum amount of misunderstanding is about fourth grades high school students in the academic year 2011-12.
The purpose of this Question (4) is to study students' understanding of a quantum concept.
Question 4. Which of the quantum concept is not correct?
A. A microscopic receives certain amount of particle quantum energy that it given to it.
B. A macroscopic particles receives all energy that given to it.
C. Moving electrons at different energy levels provided allowing different users and different spectroscopy.
D. Quantum quantity is a continuous quantity.
The correct answer is "D".
Most students choose option "b" means "a microscopic particle receives all energies that given to it". If that is not the case. According to an interview participants believed that since the term all the energy levels they were wrong.
The results show that a total of a few of the participants of 16.83% correct option "D" were selected with this option, it became clear that they do not know the quantity and continuous quantum well understood concept questions. The 27.17% of respondents did not answer the question because of lack of understanding. The rest of the participants 56.00% by choosing other options are a kind of misunderstanding or, in other words they do not understand the concept of quantum well and just kept it. According to information obtained performance of students in high school in academic year 2011 with a frequency of 57.00% of the performance of high school students in the academic year 2014-15 with the frequency of 55.00% in response to this question is closely related and in an amount slightly differs.
The aim of the Question (5) is how to assess students' understanding of the concept of wave and particle.
Question 5. Which of the wave-particle case is not true?
A. Each particle in the nature discontinuous particle and wave properties simultaneously is continuous.
B. Classical mechanics of the wave-particle could explain the light.
C. The particles means mass and energy both together transfer from one place to another.
D. But the mass of the object is not moving and wave energy alone is transmitted in all directions.
The correct answer option "B" is.
According to the definitions expressed in this question about the wave and particle exactly the same as the definitions in the textbook it is clear that most participants could choose the correct answer. Students choose the option "A" and have most undergraduates. They have problems in understanding that a particle can have both the properties of a wave and particle. In total, only 21.36% of participants choose the correct answer, showed that they fully understand the question. The 32.6% of the participants left unanswered the question of who actually does the lack of understanding of the question. And the rest of the participants to a 64.35% of the other options are misunderstood. The data show that high school students in the academic year 2011-12 with a frequency 52.5% compared to the performance of high school students in the academic year 2014-15 with a frequency of 40.2% have been more misunderstood.
The purpose of this Question (6) is to check How the students' understanding of energy levels.
6. If you getting bigger and bigger the microscopic particles in quantum mechanics, energy the levels are getting smaller and smaller as far as we can say that energy levels are interconnected (true or false?).
1) True 2) false
The correct answer option 'True'.
According to the results of question 6, 37.5% of participants chose the correct answer which shows their full understanding of the concept of energy levels. 34.06% of participants chose the wrong option has a misinterpretation and the remaining 28.43% of participants refused to answer the question that this reflects a lack of understanding of the question. According to information obtained, high school students in the academic year 2011-12 with a lot 35% compared to the performance of high school students in the academic year 2014-15 with a frequency 33.2% were more misunderstood. In this case the maximum amount of misunderstanding is for fourth grades high school students in the academic year 2011-12.

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