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Learning Quantum Physics: An Effort to Overcome the Difficulties of Changing Concepts in Atomic Model Materials

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Abstract. *The study of quantum physics becomes more difficult because of the concept of classical physics that has been firmly embedded in the student's cognitive system. The material of the atomic model is one of the key materials in understanding quantum physics where there is a paradigm of thinking from classical physics to quantum physics. This study aims to produce step of atomic model learning to form the concept of quantum physics is right on students through literature analysis method. Questions about the cognitive theory of concepts become the main reference in the design of the steps (syntax) of learning the atomic model.*

Keywords: *Learning, Quantum Physics, Concept, Atom Model's*

I.INTRODUCTION

The paradigm of thinking that changes from a deterministic view of Classical Physics to a probabilistic view of the concept of Quantum Physics raises one of the problems of understanding concepts among students that needs to be resolved in learning Physics. Students' perceptions regarding the difficulty of studying Quantum Physics material are due to the fact that Quantum Physics is a science that requires understanding. The discipline of Modern Physics which contains changes to physics concepts that previously existed in Classical Physics, this later became an important part of studying Quantum Physics.

Since the 1980s, many studies have raised problems regarding the learning of Quantum Physics, including research by Schecker in 1985, Bethge in 1988, and Meyling in 1990, which sequentially examined understanding. students about Quantum Physics related to its conception and epistemology. The research that had a qualitative approach describing the learning process by individuals (students) was carried out by Niedderer and Schecker in 1992, producing findings related to the complexity of individual cognitive processes which were then used by Juergen Petri and Hans Niedderer in 1996 in their research to document and analyze a learning process. student in quantum atomic physics in grade 13 at a German gymnasium.

Learning is defined as changes in the stable elements of a student's cognitive system. A cognitive system is a model of a student's mind built by researchers. Thus, a cognitive system consists of a stable inner structure and the topical current construction or formation of its cognitive system (Niedderer and Schecker 1992, Niedderer 1996). Stable cognitive elements are described by forms such as conceptions, interests, frameworks of thought, and language elements. Cognitive elements are theoretical constructs that meet the main criteria: namely they must have great potential to explain thinking and learning processes (Petri 1996). This cognitive element is an important part of learning Quantum Physics to build a concept of Quantum Physics which is very different from Classical Physics.

Concepts are one type of stable cognitive element. The research literature on students' conceptions shows that descriptions of particular conceptions are a powerful way to describe

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content-specific cognitive elements as part of students' cognitive systems (Pfundt and Duit 1994). So a description of the conception of learning material by students will be able to explain well the cognitive elements of the students themselves. But we do not think of conceptions as being represented 'as such' in the mind. The conception itself is the result of construction in a particular context. They can be analyzed in more detail and explained by more basic production systems such as cognitive tools (Petri 1996).

Petri (1996) defines cognitive tools as a type of basic cognitive element that is stable and permanent in the student's cognitive system before learning. Petri (1996) uses cognitive tools such as the ‘particle view of electrons’ or the ‘idea that particles can move’ to explain students' prior conceptions and their interaction with teaching input that results in the learning process. So in learning Quantum Physics which involves a process of changing concepts, you are required to review previous concepts related to the existing material before learning is carried out.

Based on the research above, the author then reconstructs a step in learning Quantum Physics, material on the development of atomic theory which will be taught in class 12 high school in final semester.

II.METHOD

This research uses a descriptive analysis method from various research articles and research results from researchers. The results of the analysis were used to study the material and design a learning step for Quantum Physics, sub-material on the development of atomic theory for high school students in class 12, in the final semester. The learning that is made only focuses on the conception of the material. development of atomic theory and trying not to get too involved in mathematical formulations.

III.RESULTS AND DISCUSSION

The learning design is based on references, namely material on the development of atomic theory in general in high school physics books which are adapted to the 2013 curriculum and the results of various research related to learning Quantum Physics. Focus on the expected development of student concepts refers to the cognitive element theory of quantum atomic physics (Petri 1996) which consists of:

Elements related to the content of physics:

- (intuitive) conceptions (e.g. electrons, atoms or energy concepts); Knowledge (formal) (for example principle uncertainty or Schrodinger's equation).

Table 1. Development of atomic theory in Indonesian literature

Learning Materials	Sub-matter
Dalton's Atomic Model	-
Thomson's Atomic Model	-
Rutherford's Atomic Model	-
Hydrogen Atomic Spectrum	-
Bohr's Atomic Model	-
Electron Energy Levels	-

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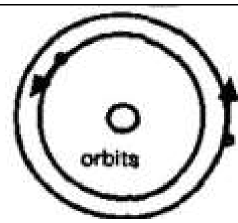
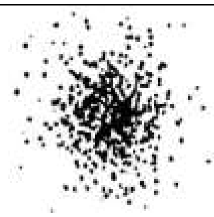
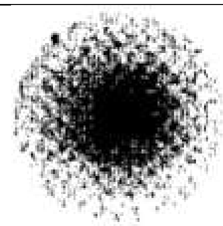
Quantum Theory of Atoms	Quantum Numbers
Zeeman Effect	-

The new concept of quantum physics was developed after discussing electron energy levels, where electron energy is quantized and not continuous like the view of classical physics. The matter of electron energy levels became a turning point in the view of classical physics in atomic modeling. The results of Petri's (1996) research on the cognitive elements of the atomic model, one of the subjects of his research, which serves as a comparison to the material structure above and as a reference for the formation of the quantum physics concept of the atomic model, can be seen in table 2 below:

Table 2. Shown that condition of Students' Cognitive Systems Results from Petri's Research (1996)

Cognitive Systems View		***Strength***	***Status***
Planetary models		high	low
State-electron model		middle	Middle
Electron cloud model		middle	high

The results of the research regarding cognitive elements above describe the final conception and state of these concepts in the subject's cognitive system after carrying out a series of learning designed by Petri (1996). It can be seen that the initial concept that is strong among students from Petri's research (1996) is the planetary model theory which is Rutherford's atomic theory, which fails to explain the stability of electron orbits. This is not in line with the order of material in physics books in Indonesia in general which starts from the explanation of Dalton's atomic theory, so in designing the syntax for atomic learning that will be carried out researchers must adapt both.

Understanding of conceptual theory can be further clarified from Muhammad Nur Hudha's (2016) statement that conceptual change is a change in the conception of a concept from before to after learning processes. Conceptual changes can be made through the process of thinking and changing thinking. This change requires various learning processes that enable students to develop new concepts and formulate existing ways of thinking. This is in accordance with Tatang Suratno's (2008) statement that in the process of conceptual change there are several processes including the process of recognizing, evaluating conceptions and beliefs, then deciding whether or not it is

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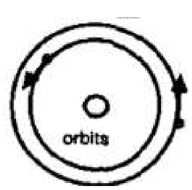
necessary to reconstruct conceptions and beliefs. with the new one. The basic steps for achieving concepts as a basis for designing learning syntax are as follows:

1. **First Phase** : Data Presentation and Identification concept
    1). The teacher presents examples that have been labeled.
    2). Students compare the characteristics in positive examples and negative examples.
    3). Students create and test hypotheses.
    4). Students make definitions of concepts based on the main essential characteristics.
2. **Second Phase**: Testing Concept Achievement
    1). Students identify additional unlabeled examples by stating yes or no.
    2). The teacher confirms the hypothesis, names the concept, and restates the definition of the concept according to the essential characteristics.
3. **Third Phase**: Analyzing Thinking Strategies
    1).Students express their thoughts
    2). Students discuss hypotheses and concept characteristics.
    3). Students discuss the types and number of hypotheses.

From the parameters that have been seen, quantum learning about atomic concepts can be formulated as in table 3.

Table 3. Syntax for Learning Quantum Physics Atomic Model Material

Learning Phase	**Atomic Conceptions (Cognitive System)**	**Learning Material**	**Activities**	
			Teacher	**Student**
Phase 1		• Dalton Atomic Theory • Thompson Atomic Theory • Rutherford Atomic Theory • Bohr's Atomic Theory	• Serves fourth theory atom for compared and confirmed concepts. Which understood by student	• Identify each theory and analyze concepts which served

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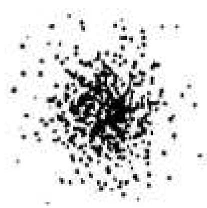
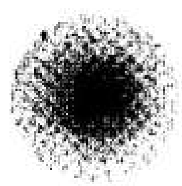
Phase 2		• Bohr's Atomic Theory • Quantum Atomic Theory • Principles of Probability (development material)	• Presents both atomic theories to compare and confirm the concept which understood by student • Introduces the principles of probability as an introduction quantum atomic theory	• Identify each theory and analyze concepts which served
Phase 3		• Quantum Atomic Theory	• Presenting concepts atom quantum as a whole within eliminates orbital view electron and *electron state*	• Inferring concepts already understoodand confirm the correctness of each concept to the teacher

IV.CONCLUSION

Learning quantum physics must involve conditioning concepts in students' cognitive systems so that the conception of quantum material is in accordance with actual concepts, especially in atomic theory material. This conditioning involves meta-cognitive beliefs in physics, for example deterministic and robabilistic views because in quantum physics changes occur.The view that previously had a deterministic view in classical physics has become a probabilistic view.

It is important for teachers to provide concrete modeling so that students can have a clearer concept about atoms. The learning syntax produced in this article takes into account the parameters that influence the conception of the cognitive system of atomic matter.

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