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New Generation Learning Materials for Distance Education Students

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Abstract: ***This R & D research study on Atomic Physics course was completed in three years period in Indonesian Open University which implements a distance learning system. This paper was written at the end of the first year research in relation to the new generation of learning materials which were developed by Borg and Gall (2007) and Dick and Cary (1993) which put in a set of 15 steps. This research took three years to complete with the first year being started with the completion of step 1 to 7 covering 1) Research and Information Collection; 2) Identify Instructional Goals; 3) Conduct Instructional Analysis; 4) Analyze Learners and Contexts; 5) Write Performance Objectives; 6) Develop Assessment Instrument; 7) Develop Instructional Strategy. Next, in the second year, the only step completed was Step 8 which was Learning Materials Development and in the third year the steps completed covered Step 9 to 14 covering validation testing and try-out completion. The last step, Step 15, which was Research Findings dissemination, was then completed afterwards.***

Keywords: R&D, New Generation, Atomic Physics, Distance Education, characteristics

1. Introduction

Development of learning materials is one challenging task for lecturers in general. It is highly important since it requires a large amount of resources in preparing a distance education program. In this regard, Open University as an education institution which implements a distance education program has students that domicile in various regions in Indonesia. Furthermore, Physics Education, as one study program available under Faculty of Teachers and Education Science - Open University, has conducted an R & D research since 2016 on the implementation of a concept proposed in Dick and Carrey (1993) and Borg and Gall (2007) in Atomic Physics course PEFI 4421. The steps of development involved in this study are explained as follows.

In the first year, the research steps completed covered Step 1 to 7: 1) Research and Information Collection; 2) Instructional Objectives Identification; 3) Instructional Analysis Completion; 4) Learners and Contexts Analysis; 5) Performance Objectives Writing; 6) Assessment Instrument Development; 7) Instructional Strategy Development. Meanwhile, in the second year, the only step completed was Step 8, namely Instructional Material Selection and Development. The discussion covered in this paper covers only the first seven steps mentioned earlier which was completed in the first year of R & D research.

2. Findings and Discussion

In Step 1, the beginning of the Atomic Physics materials development was initiated by collecting information about the difficulties that the students experienced in understanding the pre-existing learning materials. The students considered that there were too many formulas which were very difficult to understand by most of the

students and the learning materials were hard to obtain by the students; this resulted in the number of the students who passed this course was below 50 as explained in the following table.

2014.1	2014.2	2015.1	2015.2
34,78	37,74	33,25	34,54

Some students from UPBJJ Ambon stated that it was difficult to obtain the learning materials for Atomic Physics course, and some other students from UPBJJ Purwokerto added that the tutorial that they were following did not get any immediate responses from the tutor; even if they could get some responses, the responses took a very long time. These were some of the identified reasons that made it hard for the students who wanted to get quick responses useful for the students to solve their learning problems. The issues were not supposed to happen. On the one hand, students of the Open University should be able to handle and overcome the issues that they encountered and, on the other hand, the Open University as the corresponding educational institution has to be able to accommodate and facilitate the students' needs to their maximum potentials. These should be conducted in order that this kind of situation not to happen again in the future and the students will no longer feel any disappointment with the services provided by the university, especially in the issue of the students in getting learning materials of Atomic Physics course. This can be completed by providing all the learning materials for all the courses available in the Open University as well as improving the distribution service to ensure that all the learning materials can be received by all the students in time. Also, the students are required to be readily independent in learning the instructional materials. In Step 2, the development continued to be conducted by arranging and identifying the general instructional goals of Atomic Physics course. Of the many concepts developed, the suitability between the test items and the operational wordings stated in the course objectives has already contained ABCD components (Audience, Behavior, Condition, and Degree) and the depth of the materials used.

Teaching and learning activities or teaching activities are often called instructional activities. Based on the understanding of the term "instructional", the term "instructional objective" is then developed. As cited by Suharsimi Arikunto (2013), "instructional objective" is defined as a goal which describes the knowledge, abilities, skills and attitudes which must be possessed by the students as the results of teaching manifested in the observable and measurable behaviors. Next, instructional objectives are divided into two types, namely: General Instructional Objectives or *Tujuan Instruksional Umum* (TIU) and Special Instructional Objectives or *Tujuan Instruksional Khusus* (TIK).

Benjamin S. Bloom (1999) divides instructional objectives into three areas in accordance to the type of abilities listed therein. Objectives that have the central point of thinking are classified in the area of Cognition. Those included in the area of Cognition are the ability to memorize, understand, implement, analyze, synthesize, and evaluate things. Meanwhile, goals that emphasize on physical movements are classified in the area of Psychomotor. Those included in the area of Psychomotor are the ability to imitate a motion, manipulate a motion, combine various motions, and do movements properly and reasonably. Meanwhile the third type of instructional objectives is in the area of Effective. Its center is on the ability to behave. In general, any instructional objectives that fall into any areas need to be formulated in sentences that consist of verbal and operational words or terms, as well as those that show visible actions. The sentence "*the students will be able to explain or describe things"* is more properly used than the sentence "*the students can understand, comprehend, or know things"*.

Next, in Step 3, instructional analysis was completed in more detailed versions in relation to the Audience, Behavior, Condition and Degree components and how to deliver it to the students whether in achieving the concept using approaches and methods corresponding to the materials discussed. Instructional analysis is a process stage of the whole, which explains how the designer determines the main component of instructional objectives through the use of goal analysis, and how every step involved in the objectives can be analyzed in order to identify subordinate or prerequisite skills as expressed by Dick and Carey (2005). Instructional analysis is a procedural instrument (a set of procedural instruments) that produces identification of appropriate steps to implement the objectives and subordinate skills for the learners in attempt to achieve the objectives (Dick and Carey, 2005). Instructional analysis is an instrument used by instructional designers or teachers to assist them in identifying each of the basic tasks that the students should master or complete and sub-tasks or basic tasks to assist students in completing the main task.

Suparman (2014) is more inclined to interpret instructional analysis as a process that describes general behavior to special behaviors which are logically and systematically arranged. This description is intended for identifying specific behaviors that can later describe general behaviors in details. Therefore, the specific behaviors will be logically and systematically arranged. Thus, arranging the specific behaviors logically and systematically is the stage of what should be done in advance viewed from various reasons such as because of its position as a prerequisite behavior, behaviors that according to the physical sequence took place earlier, behavior which according to the psychological process appears earlier or chronologically earlier. Meanwhile, the benefits of instructional analysis are: 1) assisting teachers/educators as well as instructional material designers to manage the main tasks and selected tasks which must be learned by the students, which is a logical sequence in accordance with the actual situation when the task is implemented. This process will give students a clear picture of what is expected and workable after completing a lesson; 2) assisting teachers in analyzing behaviors with respect to each main task or selected task. Thus, all the knowledge and skills necessary to carry out every major task identified; 3) assisting instructional material designers and teachers/ educators to estimate the allocation time required for learning so that the students can perform the task well. For example, when reading or listening (both are internal process, which are not clearly tangible behaviors), the steps

should indicate what the learners are expected to identify from what they read or listen. Every step should have observable outcomes: at least five steps involved in this stage cover no more than 15 outcomes for the duration of 1 to 2 hours.

Writing TIU (general target objectives) requires the designer to classify target skills based on the type of learning outcomes. This allows continuing to the next analysis, namely Task Analysis. However, beforehand, there are things to note such as testing every completed step in order to construct a robust final product of instructional analysis. Goal analysis is a skill diagram which provides an overview of what is being completed by the students when the TIU is shown. It is this framework that will become the basis for the analysis of prerequisite skills or subordinate skill analysis. Various approaches in conducting prerequisite skill analysis according to Dick and Carey (2005) include (a) hierarchical approach; (b) cluster approach; and (c) hierarchical and/or cluster approach. In describing instructional analysis method, the following steps are involved: a) identifying the main tasks and their relations to the subtasks, (b) sorting tasks in order, (c) clearly describing the instructional analysis in its actual state, (d) identifying behaviors necessary to perform each task, (e) estimating the allocated time needed to learn each task. An effective way to determine the main tasks is by writing all the tasks that pertain to each particular area to be achieved.

In Atomic Physics course, competency mapping starts from Module 1 which still uses operational words to explain and understand or in the level of C1 and C2 ability. The order of capability on topics or materials is as follows.

1) Having the knowledge of Old Atomic Theories and Early Physics Experiment, Pre-Modern Physics which involves Dalton Atomic Theory, Thomson Model, Cathode Ray Tubes Discovery (1869), and JJ. Thomson Experiments (1897), Milikan's Oil Drop Experiment (1910), Rutherford Experiment (1911), X-Ray Discovery (1895), Milikan's Virtual Laboratory Experiment.
2) Having the knowledge of Old Quantum Theory include: Radiation of Black Objects, Electric Photo Effect, and Theory of Atom
3) Having the knowledge of and being able to apply New Quantum Theory, including De Broglie's Hypothesis (1924), Schrodinger's Equation (1926), and Principles of Quantum Mechanics
4) Having an understanding of and being able to apply New Atomic Theory, including Hydrogenic Atom Schrodinger's Equation Solution to identify energy levels
5) Having solving skills on multi-electron atom problems, including: The Pauli Exclusion Principles, Electron Configuration, Hund's Rules, and Periodic Table
6) Having solving skills of Zeeman Effect problems: Hydrogenic Atoms in magnetic fields (breakdown of energy levels)
7) Having the knowledge of important experiments of X-ray, which covers: (1) Thomas Edison (1895): X-ray for medical; (2) Wan Pulyi (1896): high resolution X-ray; (3) Max von Laue (1912): X-ray Diffraction for Crystal Structure Test; (4) Brag (1907): Diffraction for Crystallography
8) Having skills in doing X-Ray Diffraction Analysis (ability to explain Davisson-Germer Experiment (1925) as the confirmation of de Brogli's Hypothesis)
9) Being able to apply Atomic Physics concepts to various areas of contemporary life such as: Molecular Physics, Structural Physics, Crystal Structure Test, Radiology, etc.

The above mentioned sequence is the sequence of New Generation Instructional Materials developed in accordance with the order of the modules taught in the course program. The Atomic Physics course in the university consists of 9 (nine) modules with the following module's names: (1) Module 1: Atomic Model; (2) Module 2: Cathode Ray and Milikan's Experiment; (3) Module 3: Schrodinger's Equation; (4) Module 4: Quantum Numbers; (5) Module 5: Zeeman Effect; (6) Module 6: Hydrogen Spectrum; (7) Module 7: The Pauli Exclusion Principles; (8) Module 8: X-rays; and (9) Module 9: Laser. The sequence of these modules refers to the basic knowledge that must be possessed, starting from the lowest competence to higher competences until the highest one for the students who take the Atomic Physics major. In addition, the competence also refers to the birth year of the physicists and the year they discover the theories. Therefore, the arrangement of competences was completed coherently providing a historical sense of the development of atomic physics itself.

The next step followed is Step 4, namely Learner Analysis. According to Piuas Partanto Dahlan (1994), the term "characteristics" derived from the word "character" which refers to "personality", such as innate or habit possessed by an individual and is relatively constant. Meanwhile, according to Usman (1991), characteristic refers to the individual's characters and lifestyles as well as values that are regularly developed so that the behaviors become more consistent and easy to notice. According to Sardiman (2011), the students' characteristics are the overall pattern of behaviors and abilities that exist in the students as a result of the nature of social environment so as to determine the pattern of activities in achieving their goals. According to Hamzah B. Uno (2007), the characteristics of students are defined as individual aspects or qualities of the students which consist of their interest, attitude, learning motivation, learning style, thinking ability, and initial ability. Students are individuals that receive influences from another individual or group of people who are educated. Students play an important role and are considered to be one fundamental element in educational interaction activities because they are the central concern of all kinds of learning activities (Saiful Bahri Djamarah, 2000). In sum, according to our research group, the general characteristics of a learner are their individual lifestyles which are generally influenced by their age, gender, and background from birth and their social environment to determine their quality of life.

Next, the step following that is Step 5, which is Writing Performance Objectives. The activity of developing lesson plan is one of the important tasks of teachers in processing student learning activities. In the perspective of national education policy as outlined in Permendiknas RI No. 52 in 2008 on The Standard of Process, it is mentioned that one of the components in developing Lesson Plans is the clear statement of learning objectives in which the description of

the learning process and learning outcomes expected to be achieved by the students in accordance with basic competencies. Meanwhile Oemar Hamalik (2005) asserts that the purpose of learning is a description of the behavior that is expected to be achieved by the students after the learning. Basic Competence is an elaboration of the Standard of Competence of each subject course which is expected to be achieved in every learning process based on corresponding learning indicators, which are the objectives of each lesson. Thus, Basic Competence is the basic reference in developing learning indicators expected to be achieved in every learning activity.

Performance objectives are detailed descriptions of what students will be capable of doing after completing a teaching unit. First, it should be pointed out that there are three terms that are often used as synonyms in describing the students' performance. Therefore, based on the researcher's literature review of educational documents, the two most common terms are "performance objectives" (performance goals, performance purposes, work performance) and "instructional objectives" (teaching goals, learning objectives). It should then be expected that the readers are not to be misled because the terms altogether refer to what is also called "behavioral objectives". It should not be misunderstood to think that instructional objectives describe things to be completed by the instructor. Instead, the term describes the kinds of knowledge, skills, or behaviors that the students must learn.

Learning objectives explain what the students will be able to do when they complete the lesson. It further describes the context in real world situations, beyond the learning situations where the students will use their skills and knowledge. When learning objectives are changed into performance goals, these are later called terminal objectives. The terminal objectives exactly describe what the students are able to do when they complete a teaching unit. The context for carrying out the ultimate goal is created in the learning situations, not in the real world situations. Performance goals are based on the skills identified in the learning analysis. They can be obtained through analyzing the lesson. For each skill to be acknowledged in the learning analysis at least covers one formulated objective or more. This includes goals for skills known as entry skills. The main reason why the goals need to be formulated as entry skills at the beginning if not included in the learning is because they are necessary for arranging test items which will later be used in determining whether the students have already had the initially expected behaviors. Therefore, it is necessary to have initial identifications on the skills mentioned in the performance objectives as initial capabilities. Especially for instructional objective designers, this purpose is resourceful in essence that the students can be determined whether or not they possess the initial abilities necessary for developing learning situations that promote behaviors which have not been possessed by the students.

Performance objectives have very different functions for designers, instructors, and students; it is essentially important to keep in mind these differences. For the designers, the objectives are an integral part of the designing process, which means that the skills in instructional analysis are outlined in the full description of what students can do after completing the instructions given. Objectives serve as input documentation for designers or test construction experts as they design tests and learning strategies. It is important for the designers to have as much detail as possible for this activity. After the instructions have been prepared for general use, it is used for communication between the instructors and students about what is learned from the materials. To achieve this, it is necessary to express clear ideas to the students based on their knowledge of the content of the learning materials.

By looking at the characteristics of Physics Education students across the nation from the geographical viewpoint, it can be determined that the students' learning patterns and behaviors are also diverse. Some of the differences cover the students' access to the internet: some of them live in a village which is far from any internet access which in turn requires them to study using hard copies/conventionally printed modules as learning materials. Students who are situated in urban areas are very likely to have reliable internet access, making it be not necessary for them to have hard copies/printed modules as learning materials since they can access the materials online (soft copies) from their electronic devices. Also, for students who live in sub-urban areas, a blended mode of learning materials which covers both conventionally and digitally printed materials (both hard copies and soft copies of the learning materials). Therefore, it is necessary for the university to develop instructional materials that can answer this issue by developing the instructional materials for Atomic Physics course either conventionally, blended, or digitally.

The next step is Step 6 which is Developing Assessment Instrument. In developing instrument for assessment, there were some changes in the modules. The names of the modules remained the same but the instructional objectives experienced several changes such as that in Module 1: the name of the module remains the same but the ICT formulation changed from four into one instructional objective which is drawn from the main concept in order that all the existing concept are covered. Besides, Module 2 which was formerly titled The Schrodinger's Equation was changed into the Carthode Ray and Milikan Experiment. The number of instructional objectives of Module 2 was previously three points and was converted into two points which were more complex than the previous points. As for Module 3, the module title was formerly the Spin Electron and the revised module title was the Schrodinger's Equation with the previous instructional objectives of two being converted into three points by adding the instructional objective on the application in determining the energy level of hydrogen atom in Bohr Theory. Likewise, almost all modules underwent changes from the module title, number of old instructional objectives in attempt to be adjusted for the new generation of instructional objectives. They reflect the changes of the old module and become a new generation of instructional materials and, most importantly, the change in presentation to students that is conventional, blended, and fully online. These three available modes can be selected by the students according to the students' characteristics and the internet access available to them in their environment.

In developing an instrument for assessment, every module author and researcher need to discuss between themselves to write the blueprints. For the module materials of which assessment instrument consists of objective questions, it was concluded that every learning activity there should be ten objective question items for the purpose of instructional objectives: utilizing learning resources and ICT to obtain information related to the development of the Dalton, Thomson, Rutherford, and Bohr. For any assessment instrument that requires subjective answers or in-depth explanations, the instructional objectives are arranged starting from Module 1 to Module 9. For example, Module 4 which is Quantum Theory Based Atom, the objective assessment instrument is aimed at achieving the following instructional objectives: (1) describing the types of quantum numbers; (2) calculating particle energy quantum, namely kinetic energy (orbital and radial) as well as potential energy; (3) explaining the concept of Eigen function and interpreting it in the form of orbital and radial image or momentum projection with various sub skins (4) being knowledgeable of the concept of Spinor and being able to identify the internal properties of particles (mass or charge).

Next, the step that follows that is Step 7, namely Developing Instructional Strategies. In developing an instructional strategy, the following table is constructed to contain the title and instructional objectives as well as strategies as represented by Module 1 and 2 out of the existing nine modules in Atomic Physics course.

No.	Title And Instructional Objectives	Strategies				
		Text	Audio	Video	Audio Video	Suplement
1.	**Atomic Model**					
	1. The students are able to describe the characteristics of atomic model proposed by Dalton, Thomson, Rutherford and Bohr	X				X
2.	**Cathode Rays and Milikan's Experiment**	X				X
	1. The students are able to identify the characteristics of cathode rays based on various pressures, magnetic fields, and electric fields	X			X	
	1. The students are able to demonstrate Milikan's experiment and virtual laboratory as well as formulate the value of e/m	X			X	

In the table, it can be seen that in the new generation instructional materials of Atomic Physics, the learning strategies are made equipped with the conventionally printed , blended, and fully online learning materials adjusted to the students' characteristics. This proves that the new generation of learning materials is equipped with media such as audio, video, and other supplementary materials, which are all expected to be professionally well-developed to help students easily learn the new generation learning materials for Atomic Physics course.

3. Conclusion

The instructional materials for the new generation of Open University are the materials developed by using an R & D research study of which steps follow the suggestions proposed by Borg and Gall (2007) and Dick and Cary (1993) arranged in total of 15 steps. The research took about three years to complete. During the first year, the completed steps covered Step 1 to 7, and within the second year there was only one step completed namely Step 8. In the third year, the steps completed were Step 9 to 14 covering the validating and trying-out activities. As for the final step, Step 15, was the dissemination of the research results obtained after the three year period when the research was claimed to be completed.

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