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Article

Cognitive domain, level of difficulty and topic distribution of the science stream in the national exit examination in Cambodia

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Abstract

In 2014, the Ministry of Education Youth and Sport (MoEYS) made a critical reform in order to improve the quality of general education through the strict control of the national exit examination at upper secondary schools. This paper is a desk review research based on the analysis of all the questions in the science subjects included in the 2015 examinations. It specifically focuses on the analysis of cognitive domain, level of difficulty and topic distribution of the question items in each subject in the science stream. The research found that; (1) The cognitive domain of the question items was relatively low (remembering and understanding level); these questions were implicitly designed to measure students' capacity. The absence of questions to measure students' ability to apply, analyze, evaluate and create new ideas was found in all science subjects; (2) The exam papers provided by examiners in 2015 were moderately difficult; but physics was found to be the most difficult if compared to chemistry and biology. (3) Topic distribution of the three subjects was not homogeneous. Questions were dominant in some sessions while others were skipped. For better planning and policy implications, further studies of this type will be needed since, although this shed some critical light on exam affairs, it has limitations of itself. With utmost caution, the study suggests that the

development of exam questions should focus on a wider spread of exam questions covering the content of the whole textbook and questions set each year should be analyzed against students' results in order to assess the reliability and validity of the questions for considering the inclusion or exclusion of those exam questions in the following years.

Keywords: Exam Review, Assessment in Science Subjects, Test Items in Science, National Exam.

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1. Introduction

Education is touted as a tool for achieving sustainable development and it means changing peoples' knowledge, innovation, attitudes and behaviors. The Hyogo Framework for Action, adopted by 168 nations in January 2005, has recognized and encouraged governments and civic society to apply education to build a culture of safety and resilience. Education is also essential for people at all levels in a life-long learning perspective (Nakileza, 2007). The Royal Government of Cambodia (RGoC) considers education as one of the most important sectors for poverty alleviation (MoP, 2004). The RGoC, therefore, has given a strong commitment and effort to enhance the educational sector by introducing a policy of 12 years of free general education (ADB, 2014). After its national policy reform in 1996, the formal educational structure of Cambodia has been divided into 6+3+3. This refers to 12 years for the completion of general education that formulates into six years for primary education (grade 1 to 6) and six years for secondary general education (grade 7 to 12). Secondary education includes three years each for lower secondary education (grade 7 to 9) and upper secondary education (grade 10 to 12). This system does not include at least one year for pre-school education (pre-school) for children from three to below six years old and university education of four to five years. The education system consists of the development of sport, information technology education, research development and technical education (MoEYS, 2012). The policy of the RGoC has been targeted to ensure all children have their rights to access quality education for at least nine years in public schools for free of charge (Chhinh and Dy, 2009).

The fifth mandate of the RGoC approached human resources as the capital for realizing the industrial development plan in order to drive Cambodia from a lower middle-income country to an upper middle-income country by 2030 and a high-income country by 2050 (MoP 2013). In line with the government reform, under the new leadership of the MoEYS in this fifth mandate, the Ministry has set up a very clear systematic reform program to improve the quality of education. In initial public appearances as the Minister of Education, H.E. Dr. Hang Chuon Naron, Minister of MoEYS reiterated his eight-point reform agenda in his speeches, keynote addresses and presentations. These measures are: strengthen in-depth reform of public finance management, strengthen personnel management, strengthen examinations across the board, create a think-tank for the education sector, reform higher education, raise quality, develop technical and soft skills, and reform physical education and sport. As a result, the educational sector has gradually improved under the efforts of the MoEYS though formulating clear policies and strategies (MoEYS, 2016).

The educational system is operated by state schools; but private education has been also provided with services at all levels. Furthermore, most of the private schools are offering pre-school education and general education; they have been operated by the communities of ethnic and religious minorities including Chinese, Muslim, French, English and Vietnamese. The private schools are available mainly in the capital of Cambodia, but they are recently also providing their educational services in various provinces (Bray, 1999). Cambodian general education is based on a national school curriculum that consists of two main parts: basic education and upper secondary education. The basic education curriculum is divided into three cycles of three years each (UNESCO, 2011). The MoEYS has administered basic education in Cambodia from national to local level. According to the Constitution of Cambodia under Article 65, page 14, the state shall protect and upgrade citizen's rights to quality of education at all levels, guaranteeing that all citizens have equal opportunity to earn a living. The State shall respect physical education and sports for the welfare of all Khmer citizens (Constitutional Assembly, 1993, p. 14). In efforts to enhance schools and supply better learning for students, education policymakers and planners have sought to increase schools' public accountability, measured particularly by students' test or national examination scores (Robinson, 2010).

This research aims to determine the future of grade 12 students for continued learning and employment. Since procedural aspects of the exams have been significantly improved and applauded by the public, the next effort is to make use of the exam results by analyzing the strengths and weaknesses of the system to improve teaching and learning. Therefore, this paper examines only the exam questions by subjects in the year 2015. The purpose of the review exercise was to help the MoEYS to gain better design of test items in each exam paper, and to improve curriculum development, instruction and assessment in its on-going curriculum and teacher reform. In order to achieve our research objective, we review the exam questions in comparison to the textbooks, the level of difficulty of each question and the types of question words against the Bloom taxonomy in order to understand the level of thinking. The review reveals that the level of cognitive thinking are presented only at level one and two, the level of difficulty are easy and moderate and the distribution of the topic areas are not well distributed. Moreover, the exam papers lack several characteristics of good exam papers.

2. Experience of national exit examinations in Cambodia

According to Dempster (2012), public exit examinations arranged in the final year of schooling are used for a number of different purposes in most education systems. They formulate the standards to be accomplished by teachers throughout a nation by a central specification of the objectives and curriculum to be evaluated. Such a document becomes public knowledge, and permits comparability across countries. Moreover, the results are important to select students for further education, or for entry into the workforce. This role plays a crucial part in future careers and life chances for school leavers. Examinations provide certification of achievement at the end of schooling. In particular, job opportunities are often reliant upon possession of the certificate confirming successful completion of schooling. Examination results are released publicly and used to ensure accountability of schools and the educational system. Moreover, exit examinations are used to modify and manage curriculum and methods of teaching in positive and negative ways. In particular, curriculums are designed so that they are “examinable”, and teaching in the final years of schooling may be examination-dominated (Harlen, 2007).

In 2014, the MoEYS firstly took stringent measures to prevent cheating during the national exit examination at upper secondary school.

As the result, only one-fourth of 93,000 students passed while more than 22% received a grade E, fewer than 3% received grades B to D, and only 11 students received a grade A (MoEYS, 2014). Compared to the national exit examination in 2012 and in 2013, around 80% of the students passed. The experience of the differences has drawn attention to measures to be taken for preventing exam cheating and to enhance the quality of general education in Cambodia. For example, strict control of exit examinations and changing students' perceptions of cheating are required to convince the students that the main point is not passing the exam but acquiring real knowledge during their schooling (Khieng, 2015**)**. The quality of general education remains a key concern when considering the high rate of enrollment at higher grades. At lower secondary school, 87.4% of the students passed out from primary level. Almost 34% of the students discontinued their education even at lower-secondary school; the provinces with relatively poorer performance included Stung Treng, Rattanakiri, Mondolkiri, Kratie, Odtar Meanchey and Pailin (MoEYS, 2016).

According to Chhinh *at al.* (2015), the recent policy reform of the national exit examination at upper secondary school has focused the strong effort of the RGoC to eliminate or/and to stop irregularities such as cheating, and leakage of examinations. Under strict examinations, only 40% of students were capable to pass the national exit examination, as compared with passing rates of approximately 80% in the past decade (MoEYS, 2014). The use of observers from the Anti-Corruption Unit has provided the general public with uncontestable evidence that student learning outcomes are relatively poor. The poor performance of Cambodian students were initially and significantly recognized by the government and public when a series of national assessments were conducted starting in 2006 (MoEYS, 2006). In the past, students can copy answers from other students or obtain cheat sheets on their phones or from being thrown in through the window (Naren, 2004).

3. Methodology and analysis

This is a desk review research where the researchers worked to review each question which appeared during the national exit examination of upper secondary school in 2015. In these recent years, Science, Technology, Engineering and Mathematics (STEM) education have been promoted in Cambodia; the analysis of the science stream becomes, therefore, valid in this research. It is a fact that subjects such as physics, chemistry and

biology are the core subjects of STEM subjects. In Cambodia and other countries around the world, STEM careers are quickly becoming highly sought after and employment positions are no exception.

Produced by Saint Blanquat & Associates, Co., Ltd and funded by the British Embassy Phnom Penh, a 31-page booklet identifies the top 20 STEM careers in Cambodia over the next 10 years and includes information on education/training required, where to study, and what salary to expect. For the analysis, the author reviewed the level of cognitive thinking using Bloom's taxonomy, the level of difficulty, and the topic distribution of text books at upper secondary school level. The result of this research is very crucial for the MoEYS to promote STEM education because Cambodia needs more young people skilled and qualified in these subjects to develop our human resources, the economy, and drive our nation's development. As Cambodia develops and the economy grows, the Cambodian populace must adapt by shifting toward the jobs that the job market offers. And for Cambodia to continue growing, we must encourage our young students to explore the demand of skills.

4. Results and Findings

4.1. Cognitive domain of test items in the science stream

In general, learning is a cognitive process. Therefore, the domain people link most to "learning" is the cognitive domain; this is the mental skills domain. It is the domain where you process information, create knowledge, and think. There are, however, other ways of learning. In addition to knowledge, people can learn attitudes, behaviors, and physical skills. These different types of learning create three distinct domains of learning. These three domains can be categorized as cognitive (knowledge), psychomotor (skills) and affective (attitudes). The various levels have often been depicted as a stairway to reference a progressive climb to a higher level of thinking. According to Bloom, each level must be mastered before moving to the next higher level (Table 1). Bloom believes a learner would have to first recall data and then understand it before he or she is able to apply it. Each level becomes more challenging as people move higher. The higher the level, one requires more complex mental operation. The original Taxonomy has been changed over the years. The most notable change is the terms used to describe the levels. The revised version changes the names of each of the six levels. The levels have also changed from nouns to verbs. The new version is as follows: remembering, understanding; applying, analyzing, evaluating, and creating.

Table 1. Description of cognitive domain

Domain	Description
Comprehension	The ability to understand and to grasp the meaning of information.
Knowledge	The ability to recall or recognize data/information.
Application	The ability to use learned information in a new situation.
Analysis	The ability to break down material into its parts so that its organizational structure may be understood.
Synthesis	The ability to put parts together to form a new whole.
Evaluation	The ability to judge the value or importance of material.

Adopted by Bloom *et al.* (1956)

Figure 1. Cognitive domain of the test items in the national exit examination in 2015

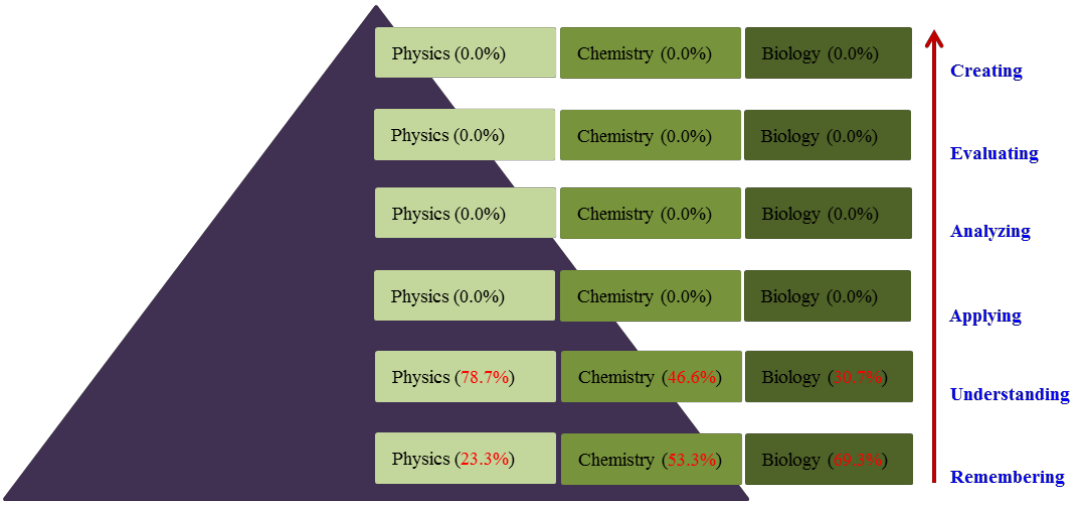

Figure 1 illustrates the cognitive domain which appeared in the national exit examination at upper secondary school in 2015. Three different subjects in the science stream were investigated, including biology, chemistry and physics. In general, the level of cognitive domain among the test items were relatively low; they were only at the levels of remembering and understanding. Many countries adopted Bloom *et al.* (1956) in the

curriculums of students at upper secondary level because they wish to equip their students with mental skills (knowledge), affective: growth in feelings or emotional areas (attitude or self), and psychomotor: manual or physical skills (skills). One of the eight-points of the reform agenda proposed by the Minister of Education, Youth and Sport, Hang Chuon Naron in 2014 reiterated the strengthening of examinations across the board. In recent years, the MoEYS has encouraged and motivated students to attend classes regularly, and not give them permission to stop during harvesting and the rainy season. Each school was also able to implement an education policy so that when students have missed class many times, they fail the exam or repeat the grade. Teachers should not take money from students for extra classes or to buy class materials (Sem and Hem, 2016).

Level of difficulty of test items in the science stream

The results of the review in the fields of physics, chemistry, and biology are shown in Table 2. In general, the examination papers were moderate. Out of the total, 40% of the test items in physics were the most difficult; none of them rated this level for chemistry and biology. For biology, the majority of the test items (80.0%) were assessed as at a moderate degree while more than half of the items confirmed the chemistry paper as at an easy level.

Table 2. Level of difficulty of the test items in the national exit examination in 2015

Level	**Science Stream in the National Exit Examination in 2015**		
	Physics (%)	Chemistry (%)	Biology (%)
Easy	29.3	60.0	20.0
Moderate	30.7	40.0	80.0
Difficult	40.0	0.0%	0.0

Cambodia is no exception. The national exit examination at upper secondary school is a form of an assessment of learning and measurement of education system performance. This aims to determine the future of students who completed the upper secondary in respect to continued learning and employment. This denotes both a mixed feeling of anxiety and excitement and a result of an educational outcome of 12 years of

schooling. The national exit examination for completion at upper secondary school is treated like a judgment day for the students at grade 12. For those who are confident on the exam day there is an expectation mixed with excitement. For those who are less confident, there is anxiety. In an experiment conducted during the examination in 2014 prior to the national education reforms, the students did not find it difficult to prepare for the examination.

4.2. Topic distribution of test items in the science stream

As you can see in the Table 3, the topic content for the three subjects in grade 12 text books were distributed into: four chapters for physics, six chapters for chemistry and eight chapters for biology. Overall, the test items were not homogenously distributed; some chapters were more while other was less. For physics, out of the six questions, (66.7%) were related to thermodynamics while equal proportion was distributed to waves (16.7%) and electricity and magnetism (16.6%). However, while modern physics were included in the curriculum at upper secondary school, there were no questions regarding this chapter. But the disappearance of modern physics in the test items was due to this chapter not being taught in schools. In past experience, some parts of modern physics could not be completed in rural or remote areas due to floods, rains and the engagement of students with parents' agricultural activities. On the other hand, missing this part has affected students' enrollment in higher education. In particular, the national exit examination in 2015 seemed to be worried about students' difficulty in getting a high score if more questions were given from chapter two to four.

In reality, Gases and Organic Chemistry were not fully taught; so many students would have faced difficulty if the exercise were provided during the examination. The curriculums designed by the MoEYS were not fully applied by schools. An insufficiency of resources (finance and human) was the main challenge. Most students at schools located in the capital, towns and cities undertook shadow education in order to get more lessons from their own teachers as well as to have more practice on exercises in each section. The majority of students felt that they would not having enough time or be able to learn all the lessons as proposed in the curriculum if they did not take shadow education. In comparison, the students with poor living conditions could not catch up well with science because they did not learn all the sections as well because they did not have much chance to practice. In addition, many sessions which require laboratory work were skipped because there were no chemical subsistence,

expertise and equipment to allow students to practice. Many teachers only used some simple teaching materials prepared by themselves or via donations from Non-governmental Organizations (NGOs) to show the students. Without practice in laboratories, many students found it hard to understand the lessons as well as learning how to apply, analyze, evaluate, and create new ideas. They were mainly learning by memorizing and understanding.

Table 3. Topic distribution of the test items in the national exit examination in 2015

Topic distribution	**Number of Questions**	**Percentage**
Physics subject		
Chapter 1: Thermodynamics	4	66.7
Chapter 2: Waves	1	16.7
Chapter 3: Electricity and Magnetism	1	16.6
Chapter 4: Modern Physics	0	0.0
Chemistry subject		
Chapter 1: Kinetic Chemistry	1	16.7
Chapter 2: Solution and intermolecular force	1	16.7
Chapter 3: Acid and Base	3	50.0
Chapter 4: Chemical Equilibrium	0	0.0
Chapter 5: Gases	0	0.0
Chapter 6: Organic Chemistry	1	16.7
Biology subject		
Chapter 1: Gymnosperms and Angiosperms	0	0.0
Chapter 2: Growth and Response of Plants	0	0.0
Chapter 3: The needs of the body	3	30.7
Chapter 4: Function of the protein in the body	1	12.0
Chapter 5: Genetic material and Gens expression	2	45.3
Chapter 6: Evolution of living things	1	12.0
Chapter 7: Population and Community	0	0.0
Chapter 8: Ecology	0	0.0

In relation to biology, Growth and Response of Plants, Population and Community, and Ecology were skipped by the schools or teachers due to various reasons. The most common were insufficient time and lack of

expertise and equipment. For the safety of the students, the examination did not include that section because the examiners were aware that the students could not do well with questions about chapter 2, 7 and 8. Interestingly, the examiners did not include any questions about the gymnosperms and angiosperms; they may believe that those questions were too easy for the students. More questions were given in relation to the needs of the body (30.7%) and genetic material and gens expression (45.3%); the examiners considered the two chapters to be the must-have knowledge that students were required to know for their daily life, their job opportunity and their general knowledge. Similar to other papers, questions related to biology were more based on memorization rather than application, analysis, evaluation and innovation. In Cambodia, many students got up early in the morning at 4am in order to learn hard to memorize things before the examination. It has become common practice that students learn hard for the examination; but they need to commit to put their knowledge into action.

5. Planning and policy implication

To make better plans, the next examination paper should include three dimensions for improving the quality of the examination; they include cognitive domain, level of difficulty, and topic distribution. Similarly, attention should also be paid to the validity and reliability of the exam questions in each subject in order to ensure the exam if fair as an accurate and acceptable tool to measure student learning. Based on the TIMSS assessment frameworks in science, every item written for science measures the two things, the content topics or performance objectives, and its related cognitive domains. For natural science (physics, chemistry, and biology) assessments are organized in two dimensions: a content dimension specifying the domains to be assessed and a cognitive dimension specifying the thinking processes to be assessed (i.e., knowing, applying, and reasoning). Therefore, the assessment will respond to the expected learning outcomes and science curriculum standards at grade 12. The following recommendations can be made, with the aim to contribute to improving test item construction in the grade 12 examination:

Item types. In order to measure the level of achievements students have learned, test items should be classified into two categories, including constructed response items and problems that require demonstration for solutions. In constructed response items, students can construct and prepare their own responses to the questions based on knowledge and skills

developed during a course of study. Constructed response items allow students to explain their answers with reasons or based on evidence, draw diagrams, or display data. Meanwhile, the problems for solution item should also include the items tested in order to measure the skills in problem solving and critical thinking.

Cognitive domains. The set of skills and abilities to be demonstrated by candidates in responding to items across the topic areas should organized into the three different levels (i.e. knowledge, applying and reasoning) or six levels of Bloom's revised cognitive domains. The knowledge domain presents students' ability to recall, recognize, describe facts, concepts, and procedures that are a foundation in science. The applying domain requires students to engage in applying knowledge of facts, relationships, processes, concepts, equipment, and methods in contexts likely to be familiar in the teaching and learning in the text books. The reasoning domain requires students to engage in scientific reasoning to analyze data, draw conclusions, solve problems, and extend their understandings to new situations.

Level of difficulty. To understand a full range of cognitive domain, fundamental scientific literacy and problem solving and critical thinking skills should be included in the test items. Therefore, the overall test items should include some relatively easy items and some challenging items, moderate items or hard items.

Content domains. According to science text books at grade 12, the test items should include all main topic areas that are to be included in the assessment. The structure of the test items should highlight the development of knowledge and abilities across the grade 12 or below. Each of the content domains in the Science Framework must be divided into topic areas and include several topics in each topic area. Each topic must receive approximately equal weight in terms of time allocated.

Validity. As the name indicates, the grade 12 exam is meant to measure student knowledge at the grade 12 level on all the subjects. However, it fails this objective due the nature of the exam questions. The exam papers were developed in an absence of validity. Exam papers have been prepared by sacrificing quality over quantity to increase the pass rate. The preliminary analysis of the exam questions indicates that there are only a few questions in each paper and most questions only require students to recall knowledge or a formula in order to solve problems. As per practices in other systems, exam papers usually consist of around 10 pages with

questions ranging from easy to hard content and methods (CDE, 2008; SACE, 2012; BOSTES, 2015).

Reliability. Reliability is one of the most important elements of exam quality. It deals with consistency of the exam candidate. There has been no attempt to analyze the exam questions in the past years in order to understand which exam questions provide reliable results. Most questions appear in the exam papers in a similar format from year to year with changes only in the numbering of the questions. In order to ensure that the grade 12 exam responds to its purpose, it requires a systematic review of the assessment practices at all levels of education. By using expected learning outcomes of students at each school level, assessments and examinations should move from a norm-reference test indicating who scored higher than who to a criterion-reference test/exam indicating how much knowledge a student has gained over a course of study. Exam papers that can measure students' knowledge on the subject must be rich and diversified in content and format. There must be questions that require different levels of thinking, as stipulated in the Bloom Taxonomy.

6. Conclusion

High-stakes examinations have been practiced around the world for as long as formal schooling has been established in each country. The practice serves different purposes. In Cambodia, the national exit examination at upper secondary school is a form of an assessment of learning and a measurement of education system performance. In order to have a high standard of exam test items, several actions must be implemented: first at both the classroom level and ministry level such as teaching and learning domain, and in the classroom-based assessment and test item preparation domain. In brief, we need to redefine learning outcomes (based on the Bloom Taxonomy and 21st century competencies) in school curriculums, review lesson planning towards learning outcomes, and review applicable teaching methods and activities in inquiry-based learning. Then we apply the new instruction and assessment methods at classroom level. Finally, it is better to prepare the test items bank with details of the characteristics of each item first so the exam test items can then easily be selected from the items bank. Based on the result of desk review analysis, we can conclude that the cognitive domain of the test items in the science stream during the national exit examination at upper secondary in 2015 remained at a low level. The finding reflects that the current general education was constrained into remembering and understanding. In this light, the capacity

of students at upper secondary level was not at the level of applying or analyzing to evaluate and create new ideas. The name (grade 12 exam) indicates that this examination is a high-stakes exam determining the examinees' future. Those who fail the Bac II exam would be tainted in their education history as poor students. However, the exam papers poorly reflect students' competence. The exam papers lack several characteristics of good exam papers. In conclusion, the questions that appeared in the tests were not suitable for students to appreciate the basic concepts in science and its connectivity in daily life and facts. This situation will only encourage students to remember scientific concepts from the textbook without understanding their practical meaning either for study or for daily application. We provide our recommendation in two domains, including exam test items and teaching and learning processes and environment. In order to have a high standard of exam test items as per the above recommendation, several actions must be implemented first at both classroom level and ministry level such as the teaching and learning domain, and classroom-based assessment and test item preparation domain. In brief, we need to redefine learning outcomes in school curriculum, review lesson planning towards learning outcomes, and review applicable teaching methods and activities in inquiry-based learning. We should apply the new instruction and assessment methods at classroom level. Finally, we should prepare the items bank first with the details of the characteristics of each item then the exit national examination test items can be easily selected from the items bank.

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