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UNPACKING THE SOUTH AFRICAN PHYSICS-EXAMINATION QUESTIONS ACCORDING TO BLOOMS' REVISED TAXONOMY

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Abstract. *The quality and standard of South African examination questions for the grade 12 examination have become an important issue for the South African education system. So far, the focus of empirical research has been on factors that lead to poor performance in the Physical sciences as well as the alignment of the grade 12 Physical Sciences examination with the core curriculum in South Africa. On the contrary, this research paper focuses on a different aspect: the weaknesses and the strengths of the Physics examination questions. It addresses the question of how the Physics examination questions cover higher and lower order level questions in the Bloom's revised taxonomy. To answer this question, the Physics examination questions of the year 2014 and 2015 were analysed using Bloom's revised taxonomy of learning objectives. The examination questions were codified and the frequencies and percentages of occurrence of different learning objectives were calculated. The results show that third level cognitive skills were more prevalent than other ones. Furthermore, examiners asked questions that require application and few questions requiring the recall of knowledge.*

Keywords: *physics examination, revised Bloom's taxonomy, quality of education.*

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Introduction

The analysis of the South African final year grade 12 Physics examination questions using the revised Bloom's taxonomy is not a well-researched area. Various studies have used the revised Bloom's taxonomy in their different fields of research apart from final grade 12 Physics examination questions. For example, the research by Zareian, Davoudi, Heshmatifar, Rahimi (2015) evaluated the questions in two English for Specific Purposes (ESP) textbooks, namely, English for the Students of Sciences (ESS) and English for the Students of Engineering (ESE) taught in Iranian universities for several academic years based on Bloom's new taxonomy of cognitive learning domain. The results of the research (Zareian et al., 2015) showed that most of the questions were aligned with remembering, understanding and applying as the three lower-level categories, while analysing, evaluating, and creating as the three higher-level categories constituted the lowest frequency in the two textbooks. A content analysis by Ulum (2016) was conducted on the extent of Bloom's taxonomy in the reading comprehension questions of the course book Q: Skills for success 4 reading and writing. Findings of the research (Ulum, 2016) suggested that this analyzed course book lacked the higher level cognitive skills involved in Bloom's taxonomy. A review was done by Cullinane and Liston (2016) on the leaving certificate Biology examination questions (1999-2008) using Bloom's taxonomy. The findings (Cullinane & Liston, 2016) showed that the examination predominately included questions that do not promote higher levels of thinking. Lee, Kim and Yoon (2015) examined the intended primary science curricula from Korea and Singapore using revised Bloom's taxonomy. The results show that students in Singapore (Lee et al., 2015) experienced a 59% increase in learning objectives as they move from the lower to upper primary, whereas their Korean counterparts experience a 15% increase. In the research by Fiegel (2013), the revised taxonomy was used to develop learning outcomes that were linked to lesson plans and assignments. The results (Fiegel, 2013) suggest that students value this approach especially to course design. Kidwell, Fisher, Braun and Swanson (2012)

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used the taxonomy to teach a set of core knowledge learning objectives for accounting ethics education, and it was found to be beneficial to the course. In South Africa, the research by Edwards (2010) documented findings on the analysis related to the alignment of the grade 12 Physical Sciences examination with the core curriculum. The research (Edwards, 2010) found that, the cognitive level "Remember" is under-represented in the Chemistry and Physics examinations, whereas the cognitive levels Understand and Apply were over-represented in Chemistry. In view of the research already done, this research used the revised Bloom's taxonomy to analyse the final grade 12 Physics examination questions.

This research is important as it gives light into the assessment standards in the grade 12 Physics exit examination so as to provide examiners with a tool with which to look at shortcomings of the examination question or the assessment standards (Edwards, 2010). Similarly, when assessment is aligned (Herman & Webb, 2007) to the standards, an analysis such as this can provide sound information about both how well learners are doing and how well schools and their teachers are doing in helping students to attain the standards. Furthermore, Olson (2003) when an examination question is used to measure the achievement of curriculum standards, it is essential to evaluate and document both the relevance of the examination to the standards and the extent to which it represents those standards. Therefore, this research fills the gap in the scholarship in this area and serves as a future reference for further research on the analysis of Physics examinations.

This research analysed the final year grade 12 Physics examination questions. For this purpose, the revised Bloom's taxonomy was used. The rationale for using the revised Bloom's taxonomy introduced by Anderson, Krathwohl, Airiasian, Cruikshank, Mayer, and Pintrich (2001) includes the fact that it incorporates learner-centred prototypes into the original taxonomy, with the aim to evaluate learners' comprehension. The revised Bloom's taxonomy (Anderson et al., 2001) affixed the knowledge dimension to the skeletal structure, which provided for the description of learning activities and assessments at the intersection of knowledge and cognitive process categories. Consequently, the aim of this research is to use the revised Bloom's taxonomy as a framework to evaluate the extent to which the examination questions cover higher and lower level questions.

Bloom's Revised Taxonomy

Bloom's Taxonomy was first proposed in 1956 (Dam & Volman, 2004). The original taxonomy consisted of the well-known categories: knowledge, comprehension, application, analysis, synthesis and evaluation. His hierarchy has been a major aid to educators planning for and considering all levels of thinking and focusing on the inclusion of higher order thinking in lessons, units of instruction and national curricula. Its emphasis on cognitive objectives has helped educators create meaningful learning events and, consequently worthwhile learning outcomes in students. In 2001 Anderson et al., revised the taxonomy. From the lowest to the highest the new revised taxonomy is as follows (Anderson et al., 2001):

- *Remembering:* This is the lowest level, which asks a learner to define, duplicate, list, memorize, recall, repeat, and reproduce state.
- *Understanding:* This level asks learners if they can explain ideas or concepts by asking them to classify, describe, discuss, explain, identify, locate, recognize, report, select, translate, and paraphrase.
- *Applying:* It involves students in applying information in a new way which requires learners to choose, demonstrate, dramatize, employ, illustrate, interpret, operate, schedule, sketch, and solve.
- *Analyzing:* Class activities and assignments for this level require students to break information into parts to explore understandings and relationships by asking them to classify, compare, contrast, differentiate, and examine.
- *Evaluating:* Evaluation necessitates justifying a stand or decision by asking students to appraise, argue, defend, judge, select, support, and evaluate.
- *Creating:* This is the highest level of instructional outcome requiring students to compose, construct, devise, formulate, predict, and infer.

The aim of this research was to analyse the weaknesses and strengths of the Physics examination questions in terms of lower and higher order thinking skills under the revised Bloom's taxonomy. Although the research is limited to the 2014 and 2015 Physics examination, it sheds a light upon the efficiency of examination in developing cognitive skills as well as guiding examiners, educational policy-makers, science teachers and curriculum designers in terms of incorporating more higher-order questions in their materials in a way to achieve higher level cognition skills. Therefore, this research investigated the following research question, to what extent do the 2014 and 2015 Physics examination questions cover the lower and higher order cognition levels of the revised Bloom's taxonomy.

Methodology of the Research

General Background

Qualitative content analysis was used as a research method. The content of the examination questions was interpreted through the systematic classification process of coding and identifying themes or patterns (Hsieh, & Shannon, 2005). Generally, text data might be in verbal, print, or electronic form and might have been obtained from narrative responses, open-ended survey questions, interviews, focus groups, observations, or print media such as articles, books, or manuals (Kondracki, Wellman, & Amundson, 2002). However, the text in this research was available in print and electronic form. This qualitative content analysis went beyond merely counting words to examining content intensely for the purpose of classifying large amounts of text into an efficient number of categories that represent similar meanings (Weber, 1990). Therefore, the goal of using content analysis was to provide knowledge and understanding of the phenomenon under research (Downe-Wamboldt, 1992).

Sample Selection

The sample for this research comprised of the 2014 and 2015 final Physics examination questions. 10 examination questions consisting of 34 sub-questions from the 2014 grade 12 final examination as well as 11 examination questions consisting 26 sub questions from the 2015 examination were purposively selected. The examination questions were identified as information rich (McMillan &Schumacher, 1997) to be used for this research.

Instrument and Procedures

A coding scheme for classifying and evaluating the examination questions using the revised Bloom's taxonomy was developed. Frequencies and reporting percentages took place as a quantitative research design. This research used a descriptive content analysis style that describes the occurrence of the coding categories of analysis precisely. Content analysis was used to make replicable and valid inferences by interpreting and coding textual material in the grade 12 examination questions. Content analysis was used because it provides new insights and increases the understanding of the particular phenomena and informs practical actions (Krippendorff, 1989). The text was systematically evaluated, and qualitative data was converted into quantitative data. The most important aspects of the examination questions were identified and presented clearly and effectively. This helped in guiding the coding and analysis. Themes and patterns were identified to describe the situation. The cognitive levels of Bloom's revised taxonomy were used to categorise the examination questions.

Data Analysis

Coding as a process of organizing and sorting data was used. The codes served as a way to label, compile and organize the data. Initial coding and marginal remarks were done on hard copies of examination questions. The marginal codes were helpful when thinking about how codes fit together. To ensure reliability of data, the coding practice/training was used to enhance the consistent interpretation of data and reduce individual interpretive bias (Creswell, 2007). Hence, before coding the examination questions, three researchers were requested to practice coding independently until 90% or greater reliability of coding was achieved. Differences in coding were constantly compared, discussed, and resolved to meet this level of consistency. At that point, a coding book was developed for use during the remaining data analysis. Additional coding rules were defined to establish consistency in segmenting the descriptions for coding.

Bloom's definitions of different levels of the cognitive domain were carefully studied and the key word examples were extracted and used. The coding scheme represented the six levels of learning objectives from the simple recall or recognition of facts, as the lowest level, through increasingly more complex and abstract mental levels of analysing and creating. The coding categories were labelled as (Anderson et al., 2001): remembering,

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understanding, applying, analysing, evaluating, and creating. Each coding category included examples for each level, key words that represented intellectual activity on each level and excerpt of the examination questions.

Once the data had been coded, regularities, variations and peculiarities were examined and patterns identified. The process of identifying substantive connections by associating codes or linking data was done (Dey, 2003). Correlations or relations between different codes were studied and a picture of the data was built.

This research attempted to examine the levels of Bloom's revised taxonomy used in the Physics examination of 2014 and 2015. Question 1 in all the examinations was multiple choice and it was not included in this research. Generally, each question was matched with the cognitive thinking levels of the Bloom's Revised taxonomy and in this particular research, question key words were used. Key words in each examination questions were identified to determine to what extent the questions involve cognitive thinking levels. In order to do this, descriptive analysis for each question was done. All the questions in the 2014 and 2015 examination questions were collected, listed, and analysed according to Bloom's Revised taxonomy: low order thinking skills: remembering, understanding, and applying, and high order thinking skills: analysis, evaluating, and creating. The percentage and frequencies were calculated for each level of cognition.

Bloom's revised taxonomy was used because it can be a proper benchmark to assess learning and teaching activities with the cognitive learning domain like remembering, understanding, applying, analysing, evaluating, and creating (Zareian at al. 2015). Every coding category involved including examples of key words for each question and the level representing cognitive domain was analysed. The data is presented in the form of tables for ease of reference. In each table, raw frequencies as well as the percentage for each cognitive level is provided. Bloom's revised taxonomy has been used as a theoretical framework of this research and as a result the findings were tabulated accordingly. Question stems focusing on each level and key words exemplifying the steps of the taxonomy were used to come to a conclusion on which levels of thinking order were available in the examination questions. The data that emerged from descriptive analysis, for example frequencies and percentages, were employed in the inferential component of data analysis.

Results of Research

The descriptive analysis covered the six categories of the cognitive level of Bloom's taxonomy, the frequencies and percentages. The results of this research are classified according to the lower and higher-level coding categories. The percentages were calculated to find out the extent to which the examination questions emphasis both the lower and higher-levels of the Bloom's revised taxonomy. In the following tables, the data obtained from examination questions are analysed.

Table 1. Frequencies and percentages of the six levels of the cognitive domain in Bloom's revised taxonomy in the 2014 physics examination.

Revised Bloom's taxonomy	Remembering	Understanding	Applying	Analysing	Evaluating	Creating	Total
Frequencies	8	7	27	0	0	0	42
Percentages	19	16	64	0	0	0	100

As it can be seen in Table 1, 64% of the questions in the 2014 examination were third level questions (applying) according to Bloom's revised taxonomy. The results show that the first three levels of the revised Bloom's taxonomy, that is level 1 (remembering), level 2 (understanding) and level 3 applying were incorporated in the 2014 examination questions. In fact, level 3 questions (applying), which is a medium order thinking according to the revised Bloom's taxonomy was in the majority with 64% of questions. With two lower order thinking questions of the revised Bloom's taxonomy, that is remembering and understanding represented by 19% and 16% respectively. The percentage recorded for the first level questions (remembering 19%) is very close to the percentage captured for the second level questions (understanding 16%). The results also show that there were no instances of any use of higher order thinking skills (analysing, evaluating and creating). The possibility of exclusion of higher order questions maybe that, they are not relevant for grade 12 learners. Sample excerpts from the 2014 examination questions are indicated below.

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QUESTION 4 (Start on a new page.)

Dancers have to learn many skills, including how to land correctly. A dancer of mass 50 kg leaps into the air and lands feet first on the ground. She lands on the ground with a velocity of 5 $m \cdot s^{-1}$. As she lands, she bends her knees and comes to a complete stop in 0,2 seconds.

4.1 Calculate the momentum with which the dancer reaches the ground. (3)

4.2 Define the term *impulse* of a force. (2)

4.3 Calculate the magnitude of the net force acting on the dancer as she lands. (3)

Assume that the dancer performs the same jump as before but lands without bending her knees.

4.4 Will the force now be GREATER THAN, SMALLER THAN or EQUAL TO the force calculated in QUESTION 4.3? (1)

4.5 Give a reason for the answer to QUESTION 4.4. (3)
[12]

Figure 1: sample excerpts from the 2014 examination.

The excerpt in Figure 1 shows that, in most cases learners are asked questions that require application. The questions are phrased such that learners are required to solve a problem. For instance, question 4 above, requires that the learners must be proficient in problem-solving.

The next table analysed in detail the key words used in each of the questions in the 2014 examination.

Table 2. The 2014 examination question analysis with key words used for each question and the level of Bloom's taxonomy.

Examination	Question	The verbs used in each of the questions	The level of Bloom's Taxonomy
2014	1	Multiple choice not included	Multiple choice not included
	2	State	First Level: Remembering
		Draw	Second level: Understanding
		Calculate	Third level: Applying
		Which one	First Level: Remembering
	3	Explain	Second level: Understanding
		Calculate	Third level: Applying
		Sketch	Third level: Applying
		Show	Third level: Applying
	4	Calculate	Third level: Applying
		Define	First Level: Remembering
		Give a reason	Second level: Understanding
	5	State	First Level: Remembering
		Choose	First Level: Remembering
		Calculate	Third level: Applying
	6	State	First Level: Remembering
		Give a reason	Second level: Understanding
		Calculate	Third level: Applying
		Explain	Second level: Understanding

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Examination	Question	The verbs used in each of the questions	The level of Bloom's Taxonomy
	7	Explain	Second level: Understanding
		Calculate	Third level: Applying
		Draw	Second level: Understanding
		Define	First Level: Remembering
	8	State	First Level: Remembering
		Draw	Second level: Understanding
		Determine	Third level: Applying
		Calculate	Third level: Applying
	9	Name	First Level: Remembering
		State	First Level: Remembering
		Define	First Level: Remembering
		Calculate	Third level: Applying
	10	Define	First Level: Remembering
		Calculate	Third level: Applying
		How	Second level: Understanding
		Explain	Second level: Understanding

The majority of the questions in the 2014 examination required learners to calculate.
For the 2015 examination questions, the frequencies and percentages are provided below.

Table 3. Frequencies and percentages of the six levels of the cognitive domain in Bloom's Taxonomy in the 2015 Physics examination.

Revised Bloom's taxonomy	Remembering	Understanding	Applying	Analyzing	Evaluating	Creating	Total
Frequencies	11	6	30	0	0	0	46
Percentages	23	12	64	0	0	0	100

64% of questions (Table 3) accounted for the medium level questions of Bloom's taxonomy in the 2015 examination. Interestingly the same percentage was recorded in the 2014 examination. Lower level questions according to Bloom's taxonomy, namely remembering and understanding recorded 23% and 12% respectively. A lower percentage of 12% is recorded for understanding, while the remembering level stands at 23%. This means just over 60% of the questions were medium level questions (level 3) and just over 30 % (level 1 and 2 combined) were lower level questions. Contrary to the research by Edwards (2010) on exemplar examination questions of 2008 and final examination questions of 2008 and 2009, level 1 (remembering) constituted the largest proportion (38.9%), followed by understand (29.9%) and apply (26.4%). There is a significant difference between the proportion of application (26.4%) in the research by Edwards (2010) and this research 64% (application). This may be due to the guidelines given to examiners before they set examination questions. In addition, the curriculum has since changed significantly from 2008. Sample excerpts from the 2015 examination questions are indicated below.

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QUESTION 3 (Start on a new page.)

Ball **A** is projected vertically upwards at a velocity of 16 $m \cdot s^{-1}$ from the ground. Ignore the effects of air resistance. **Use the ground as zero reference.**

3.1 Calculate the time taken by ball **A** to return to the ground. (4)

3.2 Sketch a velocity-time graph for ball **A**.

Show the following on the graph:

(a) Initial velocity of ball **A**
(b) Time taken to reach the highest point of the motion
(c) Time taken to return to the ground (3)

Figure 2: Sample excerpts from the 2015 examination.

In the next table, the 2015 examination questions are analysed in detail with the key words used in each of the questions and the level according to Bloom's taxonomy.

Table 4. The 2015 examination question analysis with key words used for each question and the level of Bloom's revised taxonomy.

Examination	Question	The verbs used in each of the questions	The level of Bloom's taxonomy
2015	1	Multiple choice not included	Multiple choice not included
	2	State	First Level: Remembering
		Calculate	Third level: Applying
	3	Calculate	Third level: Applying
		Sketch	Third level: Applying
	4	Calculate	Third level: Applying
		How	First level: Remembering
	5	Calculate	Third level: Applying
		Draw	Third level: Applying
		State	First level: Remembering
	6	Write	First level: Remembering
		State	First level: Remembering
		Give a reason	First Level: Remembering
		Calculate	Third level: Applying
	7	Calculate	Third level: Applying
		Draw	Third level: Applying
		State	First level: Remembering
	8	Calculate	Third level: Applying
		Determine	Third level: Applying

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Examination	Question	The verbs used in each of the questions	The level of Bloom's taxonomy
	9	State	First level: Remembering
		Calculation	Third level: Applying
	10	Describe	Second level: Understanding
		Write	First level: Remembering
		Calculate	Third level: Applying
	11	Define	First level: Remembering
		Draw	Third level: Applying
		Determine	Third level: Applying

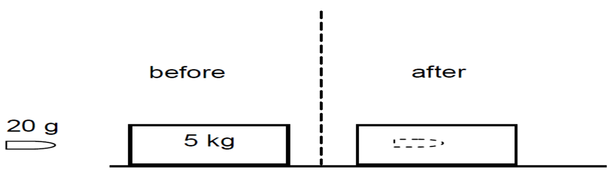
The verb that is prevalent in both examinations is "calculate" (see Table 4) which is in the third level (applying). Calculations involve reading the question, selecting the correct formula, doing the necessary substitution from the data given and finally calculating what is required. The examination questions included the first three levels with applying being the more dominant in the two examinations than all other levels. Applying according to Bloom's revised taxonomy is the capacity to employ acquired data in recent and actual cases. As a result, it covers implementing principles, methods, terms and theories in proper circumstances. Since Physics involves, employing data in recent and actual cases and learners should implement Physics principles, methods, terms and theories. In the assessment of learners, examiners and teachers tend to focus more level 3 questions (applying) more than any other level. The examination is characterised with questions that require application. As indicated in the excerpt below.

QUESTION 4 (Start on a new page.)

A bullet of mass 20 g is fired from a stationary rifle of mass 3 kg. Assume that the bullet moves horizontally. Immediately after firing, the rifle recoils (moves back) with a velocity of 1,4 $m \cdot s^{-1}$.

4.1 Calculate the speed at which the bullet leaves the rifle. (4)

The bullet strikes a stationary 5 kg wooden block **fixed** to a flat, horizontal table. The bullet is brought to rest after travelling a distance of 0,4 m **into the block**. Refer to the diagram below.



4.2 Calculate the magnitude of the average force exerted by the block on the bullet. (5)

4.3 How does the magnitude of the force calculated in QUESTION 4.2 compare to the magnitude of the force exerted by the bullet on the block? Write down only LARGER THAN, SMALLER THAN or THE SAME. (1)

[10]

Figure 3: Excerpt from 2015 Physics examination.

In principle learners are given a Physics scenario. In this scenario the data is provided. The learners must read, understand, use and apply the data appropriately using the correct formulae. In the question above (question 4) learners must calculate which is a level 3 question (applying) according to Bloom's revised taxonomy. All the questions in the 2014 and 2015 are similar to the above. Hence the majority of questions are application.

The first level (remembering) that appears in the two examinations includes questions that require learners to state the laws or defining a concept. Examples extracted from both the 2014 and 2015 are indicated below

2.1	State Newton's Second Law of Motion in words.	(2)
4.2	Define the term *impulse* of a force.	(2)
5.3	State the WORK-ENERGY theorem in words.	(2)
5.1.1	State the *principle of conservation of mechanical energy* in words.	(2)
6.1.2	State the Doppler effect in words.	(2)

Figure 4: **Examples extracted from both the 2014 and 2015 examination.**

Learners seem to perform well in the topic of Doppler effect, question 6. In 2014 learners performed well in the same question on the topic of Doppler effect.

The excerpt of question 6 from the 2014 is indicated below.

QUESTION 6 (Start on a new page.)

6.1 The siren of a stationary ambulance emits a note of frequency 1 130 Hz. When the ambulance moves at a constant speed, a stationary observer detects a frequency that is 70 Hz **higher** than that emitted by the siren.

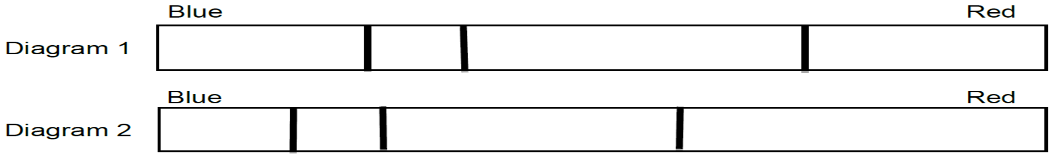
6.1.1 State the Doppler effect in words. (2)

6.1.2 Is the ambulance moving *towards* or *away from* the observer? Give a reason for the answer. (2)

6.1.3 Calculate the speed at which the ambulance is travelling. Take the speed of sound in air as 343 $m \cdot s^{-1}$. (5)

6.2 A study of spectral lines obtained from various stars can provide valuable information about the movement of the stars.

The two diagrams below represent different spectral lines of an element. Diagram **1** represents the spectrum of the element in a laboratory on Earth. Diagram **2** represents the spectrum of the same element from a distant star.



Is the star moving *towards* or *away from* the Earth? Explain the answer by referring to the shifts in the spectral lines in the two diagrams above. (2)
[11]

Figure 5: **Excerpt of question 6 from 2014 examination.**

As can be seen from the above excerpt, question 6 consisted of the level 1 questions (remembering) with only one question at a third level (applying). In addition, question 6 also required learners to explain and give reasons for their answers which is level 2 (understanding).

The results show that in question 5 and question 7 the learner's performance was very low. Below is the excerpt of question 5 from 2014 examination.

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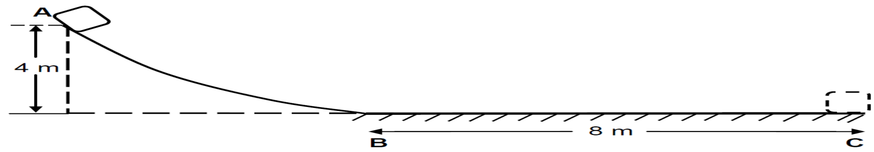
QUESTION 5 (Start on a new page.)

5.1 The diagram below shows a track, **ABC**. The curved section, **AB**, is frictionless. The rough horizontal section, **BC**, is 8 m long.



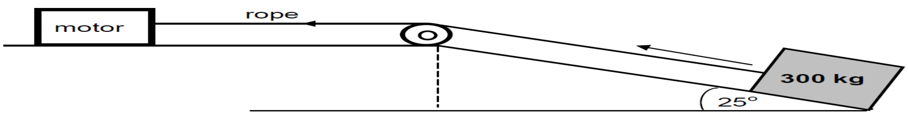
An object of mass 10 kg is released from point **A** which is 4 m above the ground. It slides down the track and comes to rest at point **C**.

5.1.1 State the *principle of conservation of mechanical energy* in words. (2)

5.1.2 Is mechanical energy conserved as the object slides from **A** to **C**? Write only YES or NO. (1)

5.1.3 Using ENERGY PRINCIPLES only, calculate the magnitude of the frictional force exerted on the object as it moves along **BC**. (6)

5.2 A motor pulls a crate of mass 300 kg with a constant force by means of a light inextensible rope running over a light frictionless pulley as shown below. The coefficient of kinetic friction between the crate and the surface of the inclined plane is 0,19.



5.2.1 Calculate the magnitude of the frictional force acting between the crate and the surface of the inclined plane. (3)

The crate moves up the incline at a constant speed of 0,5 $m \cdot s^{-1}$.

5.2.2 Calculate the average power delivered by the motor while pulling the crate up the incline. (6)
[18]

Figure 6: Excerpt of question 5 from 2014 examination.

In actual fact question 5 required learners to think at a higher level to be able to answer this question. Learners had to make sense of the scenario described and illustrated by the diagrams in 5.1 and 5.2. Although the questions may be regarded as application according Bloom's taxonomy, careful analyses and evaluation of the scenario is required before attempting to answer the questions. Some parts of the question are first level questions (remembering), for instance section 5.1.1, state the principle of conservation of energy in words. It should be noted that 5.1.2 may look like it is just a simple multiple choice, however the learner needs to think carefully and apply Physics knowledge appropriately. Learners performed very well in answering questions on vertical Projectile motion, momentum and Doppler effect (question 3, 4 and 6). Despite the relatively stronger performance in question 3, 4 and 6 in comparison to other question, many learners lacked understanding of the basic conceptual interpretation of question and basic calculation skills. The majority of learners battled with definitions, particularly in question 9.4.1. As a result, they earned very low marks.

Discussion

Physics is known as a difficult subject to comprehend by lots of learners. As a result, success of learners is rather low in physics questions that are asked in high school and final year exit examinations (Çepni & Azar, 1998; Çepni et al., 2003). Because, physics teachers think that physics is difficult to understand as a subject, they generally ask lower-order and superficial questions (Azar, 2005). However, if the questions are prepared and asked without the teacher taking into consideration the cognitive levels of Bloom's taxonomy, the students' achievement in final Physics examinations may be affected negatively (Azar, 2005).

Therefore, if the aim is to make learners solve high-order physics questions in final year Physics examinations then they should be encouraged to improve their system of thinking, and appropriate education should be provided (Azar, 2005). The results of this research agree with Azar (2005) that lower-order questions neither develop intelligence capacity of students nor lead them to learning parrot fashion. Similarly, Physics questions should be based on analysis and problem solving (Azar, 2005). Therefore, the main purpose for determining success of learners has to be determining and developing their level of cognitive progress by asking well-prepared questions (Azar, 2005). On the contrary, the teachers in secondary schools don't have experience of asking questions by considering the Bloom's taxonomy (Azar, 2005). The research by Hand, Prain and Wallace (2002) showed that learners prefer low-order questions and don't prefer questions which need to be thought on. Similar results in the literature show that teachers rarely tend to use higher level questions such as analysis, synthesis and evaluation which help learners to progress in their scientific thinking (Azar, 2005). Findings of this research are consistent with Azar (2005) and Cepni (2003) who also found that most questions in their studies were at application level. According to Azar (2005) application level is generally preferred by teachers to evaluate their students' understanding.

Similarly, studies by Zareian et al., (2015) found that most of the questions in the textbooks evaluated, were aligned with remembering, understanding and applying as the three lower-level categories, while analysing, evaluating, and creating as the three higher-level categories constituted the lowest frequency in the two textbooks.

The examination consisted of questions that required using mathematical skills to solve physics problem (Tuminaro & Redish, 2007). However, learners lack the mathematical skills needed to solve problems in physics and students do not know how to apply the mathematical skills they have to particular problem situations in physics. For example, most of the questions required learners to calculate, however if students simply do not possess the requisite mathematical knowledge (Tuminaro & Redish, 2007), learners will find it difficult to answer these questions. As pointed out by Redish (2005), mathematics is commonly referred to as "the language of science" and is typically required of our physics learners to take mathematics as prerequisites to their study of physics. However, using math in science (and particularly in physics) (Redish, 2005) is not just doing math. It has a different purpose – representing meaning about physical systems rather than expressing abstract relationships – and it even has a distinct semiotics – the way meaning is put into symbols – from pure mathematics.

The questions in these examinations may be difficult to the learners because most students find it considerably easier to acquire knowledge about science than to acquire the abilities for applying this knowledge flexibly to solve diverse problems (Larkin & Reif, 1979). This is partly because problem-solving is a very sophisticated cognitive skill. Hence understanding and teaching scientific problem-solving is both practically important and intellectually challenging. This is because problem solving is an integral part of physics classes (Tuminaro & Redish, 2007).

In line with the suggestions in the diagnostic report (DoBE, 2015) teachers are advised to make greater use of short formative assessment tasks in order to reinforce basic concepts and principles. This can be used to good effect in content relating to definitions listed in the examinations. The prescribed experiments should be done by the learners so that they are able to enhance the applicable skills for example in the analysis of data.

Conclusions and Recommendations

The aim of this research was to analyse examination questions in order to determine the extent to which the examination questions cover higher and lower order questions according to Bloom's revised taxonomy. This research used the 2014 and 2015 Physics final year examination questions as data sources. The results of this research aim to enable teachers and examiners to identify the gaps in the level of assessment questions used. The findings reveal that only the first three levels of Bloom's revised taxonomy were used. The first level remembering involved learners recalling relevant knowledge from long term memory. It included learners remembering how to state the laws and principles of physics as well as defining physics concepts. The second level understanding involved learners making sense of what they have learnt. The verbs used for level 2 questions included describing, explaining and drawing. A very small percentage of questions on level 1 and level 2 were incorporated. On the contrary, level 3 questions (applying) accounted for the majority of questions in the examination. The verb used in most of the level 3 questions was calculate. This research concludes that higher order questions were not included in the examination questions. It is recommended that workshops be held with teachers and examiners to familiarise them with assessment strategies that are inclusive of Bloom's revised taxonomy. Such workshops should put more emphasis on the importance of using frameworks such as Bloom's revised taxonomy to construct examination questions. Such an initiative should place more emphasis on generating questions that go beyond just remembering laws and principles but breaking physics concepts into parts and understanding how each part is related to one another. Making judgements based on a set of guidelines as well as putting information together in an innovative way. It is suggested that teachers and examiners carefully look at the examination questions to check if they cover all of the levels of Bloom's revised taxonomy. This should be done before examination questions are finalised. Furthermore, classroom teaching should be improved to incorporate teaching and learning activities that include different levels of the revised Bloom's taxonomy. Assessment workshops should emphasize the teachers and examiners' awareness of the Bloom's revised taxonomy. Similarly, this research is making a contribution in enlightening the stakeholders on the standard and quality of the final Physics examination questions. This research

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calls for a thorough introspection, reflection and rethinking of Physics examination questions. All educators (teachers and examiners, corresponding university professors) should undertake training on the assessment of pupils' achievement by considering the cognitive levels of Bloom's taxonomy.

Moreover, examiners of grade 12 Physics examinations should take courses about what Bloom's taxonomy is and how they should consider it while preparing exam questions. Further research is required to investigate the assessment practices of Physics teachers in their daily classroom activities.

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