

# Classification of Maltese Biology Examination Questions using Bloom's Revised Taxonomy

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## Abstract

This study investigates the question types according to Bloom's Revised Taxonomy in the final Paper 1 Advanced Biology examinations at a public post-secondary Institution and the National ones at the cognitive domain. The data of the study was obtained by examining the May/June 2017 and 2018 past papers. A total of 205 questions were analysed (97 Institution and 108 National). The questions were classified in terms of the cognitive levels of the Bloom's Revised Taxonomy. Data was given with tables as percentage. The study highlighted that not all objectives were present in every examination paper. The findings show that both types of examinations mostly include questions that do not promote higher levels of thinking. The Institution Paper 1 has two sections: Section A that tests the theoretical aspect, like the National examination while Section B tests the practical aspect. The highest percentage of questions in the National and Institution Section A examinations were from the remembering type of objective while from applying type in Section B. The percentage of questions in the cognitive domain, remembering type, were higher in the National examination. Analysis was also carried out to determine the marks being awarded to the different cognitive levels. When both examinations are considered, the bulk of the marks were in the remembering and understanding types of objectives. The percentage of marks allocated to the remembering type of objective in National examinations was 2.5X more in 2017 and 1.5X in 2018 than in the Institution Section A. In Section B, the applying type of objective was rewarded the highest marks. This study strongly highlights the narrow scope in terms of student achievement in high-stake examinations and shows how the present Maltese biology examination procedures promote low-level learning.

**Keywords:** *biology, bloom's revised taxonomy, cognitive domain, post-secondary*

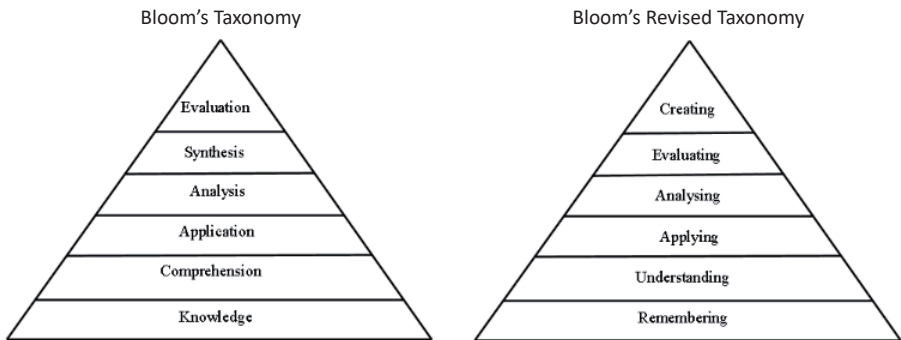
## Introduction

### **Bloom's Revised Taxonomy of educational objectives – Cognitive domain**

In 1956, Dr Benjamin Bloom compiled a taxonomy to help educators compose questions on different levels of thinking. Bloom's cognitive taxonomy was based on

six different domain levels (Figure 1), starting from the simplest to the most complex. The first one, for example knowledge, must normally be mastered before the next one, comprehension, can take place. The American educational psychologist David Krathwohl and some of his associates subsequently focused on the affective domain, which is concerned with student interests, attitudes, and feelings. These researchers renamed three categories, interchanged the order of two, and the names of those retained categories were changed to verb form to fit the way they are used in instructional objectives (Krathwohl 2002). The words 'Knowledge', 'Comprehension' and 'Synthesis' were replaced by 'Remember', 'Understand' and 'Create' respectively. Application, Analysis, and Evaluation were kept, but written as verbs, hence Apply, Analyse, and Evaluate. The Bloom's Revised Taxonomy was used as the theoretical framework for the present analysis.

**Figure 1: Bloom's Taxonomy and Bloom's Revised version of educational objectives cognitive domains**



Some educators have simplified and combined the levels of cognitive domain (Zoller 1993). They use the term 'lower-order cognitive skills' (LOCS) for memorisation and recall that require only a minimum level of understanding and 'higher-order cognitive skills' (HOCS) for the application of knowledge and critical thinking that require deep conceptual understanding. By using HOCS, students do not remember only factual knowledge, but use their knowledge to solve problems, to analyse, and to evaluate (Karamustafaoglu et al. 2011). It is widely believed that such questions reveal whether or not a student has truly grasped a concept. Bloom (1956) argues that it is important for examinations to measure higher-learning as well. Surely, this does not imply that all exam questions must focus on high-level questions; but it is important to assess students' understanding on a wide range of cognitive levels (Tobias, Raphael 1995).

## **Aims and Objectives**

The main research question for this study was: How do Advanced Biology level examination questions at a public post-secondary Institution and the National ones (2017-2018) classify on Bloom's Revised Taxonomy? This question raises further queries; mostly, what is the proportion of low-order and high-order questions in such examinations? Did the examinations challenge the students intellectually? How do the Institution examinations compare with the National one?

Thus, the main objectives of this study were:

1. Classification of question types using the Bloom's Revised Taxonomy of educational objectives-cognitive domain.
2. Determining the percentage of low- and high-order questions in Paper 1 Institution and National examinations.
3. Determining the percentage of marks allocated to each educational objectives-cognitive domain in the Bloom's Revised Taxonomy.

The significance of the present research is in its reference to and reliance on Bloom's Revised Taxonomy, which has the potential to examine the merits and demerits of local examinations. The findings can help paper setters to compose questions with the appropriate proportion of low- and high-order cognitive level.

## **Methodology**

### **The Examination Paper Layout**

Students sit for the Institution examination (in June) after one year of instruction and for the National one (in May) after two years of learning. Thus, the Institution examination covers half of the Advanced level syllabus, while the National one covers all of it. The Institution examination consists of two papers: Paper 1 consists of 10 compulsory short-questions and Paper 2 consists of a comprehension, unstructured and structured essays where students have a choice. The National examination consists of four papers: Papers 1 and 2 are similar to those at the Institution, paper 3 deals with the written part of the practical and Paper 4 is the hands-on practical paper.

The examination papers chosen for this study consist of short-answer questions that are answered on the lines provided in the paper. Papers from both examinations are to be completed in three hours and each carries a maximum of 100 marks. However, the two examinations differ in their layout and material covered from the syllabus. The Institution examination is divided into two sections: Section A and Section B, but there are no sections in the National one. Section A covers theory, is worth 70 marks and consists of 7 questions (10 marks each) while Section B covers the practical aspect, is worth 30 marks and consists of 3 questions (10 marks each).

Paper 1 of the National examination examines the theoretical part of the subject since Paper 3 covers the practical component.

Analysis of the Advanced-level Biology papers was performed on the following areas:

1. Classification of question types using Bloom's Revised Taxonomy of educational objectives-cognitive domain.
2. Comparing the percentage of marks allocated to each objective and the percentage of questions in each objective to investigate if questions were awarded more marks as they progressed up the hierarchy.

### 1. Classifying the question types using Bloom's Revised Taxonomy

The examination papers were analysed in a manner adapted from Bloom's work. The questions were examined using the table of verbs associated with each objective of the cognitive domain (Table 1). These verbs describe the complexity of behaviour needed to answer the question (Dalton, Smith 1986).

**Table 1: Bloom's Revised Taxonomy of educational objectives  
(Anderson, Krathwohl et al. 2001): cognitive domain with associated verbs**

Category	Key verbs (keywords)
<b>Remembering</b> [low-order] – Retrieving relevant knowledge from long-term memory. List, Name, Recognise, State, Describe, Recall, Repeat, Retrieve	
<b>Understanding</b> [low-order] – Determining the meaning of instructional messages, including oral, written, and graphic communication.	Conclude, Define, Illustrate, Predict, Tell, Identify, Summarise, Categorise, Classify, Discuss, Compare, Contrast, Explain
<b>Applying</b> [low-order] – Carrying out or using a procedure in a given situation.	Generalise, Infer, Show, Use
<b>Analysing</b> [high-order] – Breaking material into its constituent parts and detecting how the parts relate to one another and to an overall structure or purpose.	Distinguish, Select, Arrange, Organise, Outline
<b>Evaluating</b> [high-order] – Making judgments based on criteria and standards.	Assess, Justify, Critique, Judge
<b>Creating</b> [high-order] – Putting elements together to form a novel, coherent whole or make an original product.	Design, Compose, Plan, Hypothesise, Revise

## **2. Comparing the percentage of marks allocated for each objective and the percentage of questions in each objective.**

The data gathered from identifying the questions into the different objectives were used to identify how many marks each objective received. In the case of a question being composed of two parts, the marks were divided evenly. The examination papers from both examinations were marked out of 100 marks. Since Section A in Institution papers carries 70 marks and Section B carries 30 marks, the marks allocated for each section were calculated as a percentage to allow comparison.

### **Results and Discussion**

#### ***Analysis of the examination papers using Bloom's Revised Taxonomy cognitive domain.***

Tables 2-4 and Figures 2-5 present the quantitative analysis of the 2017–2018 examination papers. This analysis revealed that, excluding Section B, examinations at the Institution and National levels were dominated by questions from the remembering and understanding objectives (Figure 2). When considering the entire Institution examination, questions belonging to the remembering (34.0% in 2017; 44.9% in 2018) and applying (27.7% in 2017; 22.4% in 2018) objectives dominate. However, in the National examinations, remembering and understanding carried the highest percentages. Results show that the National examinations have a higher percentage of questions from the remembering objective (59.2% in 2017; 67.8% in 2018) compared to the Institution. The percentage of understanding objective questions in the National examination (18.4% in 2017; 22.0% in 2018) is comparable to that at the Institution (23.4% in 2017; 18.4% in 2018).

Results from the National examination will be compared to those from the Institution Section A, since both deal with the theoretical aspect. When comparing Section A questions with the National ones (Table 1), none belonging to the 'creating' objective were set. Cullinane and Liston (2016) reported a similar result when analysing the Leaving Certificate Biology examination papers between 1999–2008 in Ireland. They reported no questions from the creating and evaluating objectives.

The percentage of recall questions (59.2% in 2017; 67.8% in 2018) in the National examination were higher than those at the Institution (38.7% in 2017; 52.6% in 2018). Mercieca (2014) reported a high amount of recall-based questions (50-95%) in the National Maltese Advanced Biology papers from 1998 to 2011. However, no studies have been done on the Institution papers for comparison. From transcripts and analysis of National past examination papers, Mercieca (2014) concluded that Paper 1 could have included more reasoning-based questions, indicating that the trend of a high percentage of low-order questions has persisted over time.

In the present study, verbs were classified according to the hierarchy in Bloom's Revised Taxonomy. However, this did not necessarily reflect the nature of the question. For example, in the 2018 National paper Question 9: "With reference to Figure 4, distinguish which organism is an ectotherm and which organism is an endotherm.", the term 'distinguish' falls under the Analysis section (Bloom's Revised Taxonomy Verbs 2001), which is a high-order domain. Nonetheless, the syllabus specified that students needed to know the terms 'ectotherm and endotherm' respectively. The graph presented is not a novel situation since it is discussed in lectures, being part of the syllabus. Allen and Tanner (2002) state that if students are explicitly given an answer to an analysis question in class and then given that same question on an exam, then that question only requires recall. This renders the question a low-order domain one. Thus, the percentage of low-order questions could actually be higher than that reported in this study and that by Mercieca (2014). This situation was also encountered in Institution papers, for example in the 2017 Question 1: "Distinguish between passive and active transport".

**Table 2: Frequency and percentage of questions per cognitive objective in Institution examinations (LO: low-order; HO: high-order)**

Cognitive objectives	2017						2018					
	Section A		Section B		All	All	Section A		Section B		All	All
	(/31)	(%)	(/17)	(%)	(/48)	(%)	(/38)	(%)	(/11)	(%)	(/49)	(%)
Remembering (LO)	12	38.7	4	25	16	34.0	20	52.6	2	18.2	22	44.9
Understanding (LO)	8	25.8	3	19	11	23.4	7	18.4	2	18.2	9	18.4
Applying (LO)	6	19.4	8	44	13	27.7	6	15.8	5	45.4	11	22.4
Analysing (HO)	1	3.2	1	6	3	4.3	2	5.3	0	0	2	4.1
Evaluating (HO)	4	12.9	1	6	5	10.6	3	7.9	0	0	3	6.1
Creating (HO)	0	0	0	0	0	0	0	0	2	18.2	2	4.1
Low order	27	87.1	15	83	41	85.1	33	86.4	9	82	42	85.7
High order	4	12.9	2	17	7	14.9	5	13.6	2	18	7	14.3

**Table 3: Frequency and percentage of questions per cognitive objective in National examinations (LO: low-order; HO: high-order)**

Cognitive objectives	2017		2018	
	(/49)	%	(/59)	%
Remembering (LO)	29	59.2	40	67.8
Understanding (LO)	9	18.4	13	22.0
Applying (LO)	6	12.2	3	5.1
Analysing (HO)	3	6.1	1	1.7
Evaluating (HO)	2	4.1	2	3.4
Creating (HO)	0	0.0	0	0

Low order	44	89.8	46	94.9
High order	5	10.2	3	5.1

**Section B Questions at the Institution**

Table 2 and Figure 2 show that Section B questions are from the first three low-order cognitive objectives: remembering, understanding and applying. Three points emerge from this table when considering the percentage of questions in the applying objective in the years investigated: (1) a similar percentage was obtained, (2) the highest percentage of questions were from this objective and (3) the percentage of questions were more than double of those in Section A. This implies that the two sections in the institution are consistently focusing on different objectives. Nonetheless, questions from the high-order cognitive objectives, analysing, evaluating and creating, are poorly represented, where one or two of these objectives are totally missing. Questions from the creating objective were absent in 2017, while analysing and evaluating objectives were absent in 2018.

**Figure 2: Graph showing the percentages of questions from Institution and National examinations (2017-2018), classified according to Bloom's Revised Taxonomy (Anderson, Krathwohl et al. 2001)**

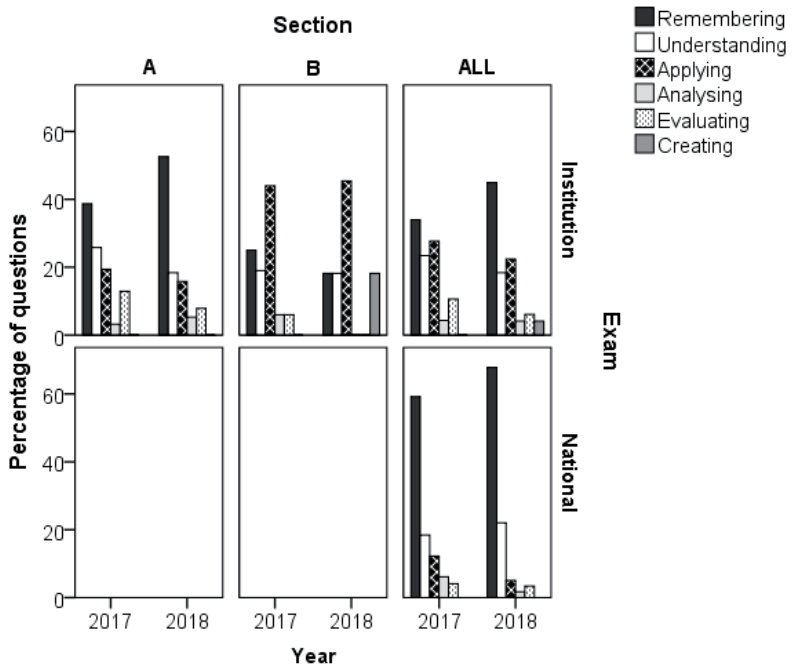
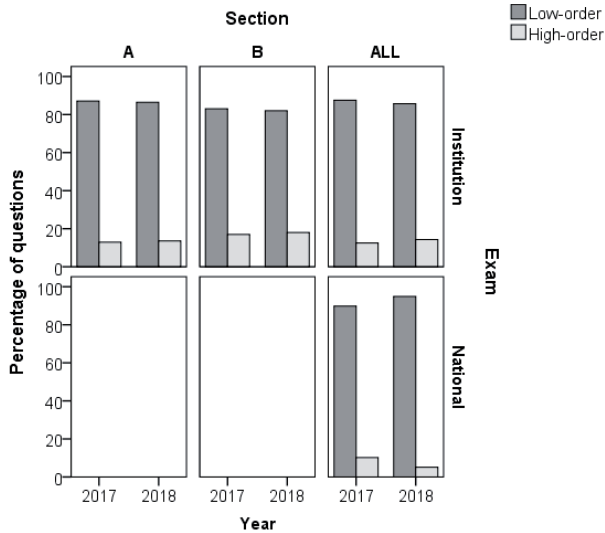


Table 2 shows that the number of questions asked at the Institution (48 in 2017; 49 in 2018) and National examinations in three hours is very similar (49 in 2017; 59 in 2018). However, when reviewing the questions, it was noted that in the National examinations, 11 instances were recorded where one question had two verbs (2 questions in 2017); (9 questions in 2018). This was observed once in the Institution papers, whereby the question asked for statements to be listed as True or False and to give a reason. In this respect, the Institution questions were better worded, as students may find two commands in one sentence confusing.

Irrespective of the examination type or section, low-order questions predominated. This result fits in with the International literature. Allen and Tanner (2002) remark that in 1956, Bloom reported 70–95% of the questions presented to undergraduate students required them to think at low-order cognitive ability and that although Bloom's Taxonomy has been around for 40 years, the typical college-level objective test questions still assess predominantly the lower-order thinking levels. According to Harlen and James (1997), this low level of thinking promotes rote learning and regurgitation of facts, requiring little to no understanding of the topics. The Maltese papers analysed had a considerable number of closed questions, requiring one word or one sentence answers. For example, "What is the water potential of pure water at atmospheric pressure?" (Institution paper, 2017). These questions often required specific information favouring rote learning and memorisation of facts. Such questions were more numerous in the National papers compared to those in the Institution. For example, over the two-year period, the verbs 'Name' and 'What is' appeared 21 times in the National papers while 11 were present in the Institution ones. The number of open-ended questions that allow students to develop their answers in greater detail and show that they understood the topic were fewer in the National examinations. The lack of such questions was also observed by Cullinane and Liston (2016) in Higher Level Biology examination papers between 1999–2008 in Ireland. The National Syllabus states that: '*A minimum of 25% of the marks of the overall examination (papers I, II, III and IV) will be dedicated towards higher order thinking skills such as data analysis, synthesis and problem solving situations as indicated in the scheme of assessment.*' (MATSEC 2019 Syllabus, p. 5). The syllabus does not specify the percentage of low- and high-order questions per paper, however, the percentage of the latter form of questions (Table 3; Figure 4) were under-represented (10.2% in 2017; 5.1% in 2018).



**Figure 3: Graph showing the percentages of low- and high-order questions from Institution and National examinations (2017-2018)**



**Comparing the percentage of marks allocated for each objective and the percentage of questions in each objective.**

The second part of the study investigated the frequency of marks for each objective in the cognitive domain in order to establish which type of question was rewarded in the exam. Data is recorded in Tables 4-5 and Figures 4-6. When both examinations are considered, the bulk of the marks were in the remembering and understanding objectives types (Table 4). In the National examinations, the percentage of marks allocated to the remembering objective type (60% in 2017; 68% in 2018) by far exceeded that in Institution papers (24.3% in 2017; 47.1% in 2018) (Table 4). Thus, in this respect, the percentage of marks allocated to the remembering objective in the 2017 National examinations was more than twice those of the Institution paper, while those allocated in the 2018 National examinations were around 50% more than those in the Institution paper. In Section B, the applying objective was rewarded the highest marks (38.3% in 2017; 43.3% in 2018).

The general picture that emerges from Figure 5 is that the low-order objectives received a higher percentage of marks in all papers examined, ranging from 71.4% (Section A, 2017) to 96.5% (National paper, 2018). This result is comparable to that obtained by Cullinane and Liston (2016) who reported 81.85 % from Irish National Higher Level Biology papers. This study shows that the National papers award more marks (88% in 2017; 96.5% in 2018) to the low-order objectives compared to Section A at the Institution (71.4% in 2017; 60% in 2018).

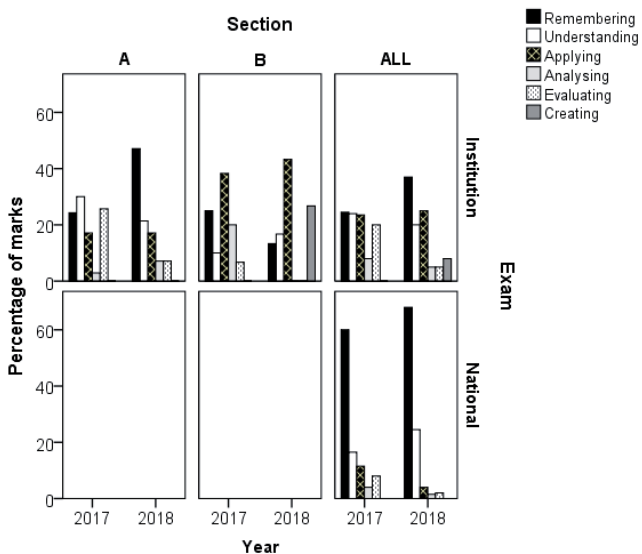
The final result in this investigation involves a comparison between the percentage of questions and percentage of marks rewarded (Table 5 and Figure 6). Table 5 highlights the imbalance between the percentage of questions and percentage of marks between the low-order and high-order objectives.

Figure 6 shows that in all papers except in the 2018 National examinations, the high-order objectives received more marks compared to the percentage of questions. This indicates that students were being rewarded more for higher order thinking, but the difference was small to have a significant impact on the final grade. This finding concurs with the Irish study (Cullinane, Liston 2016).

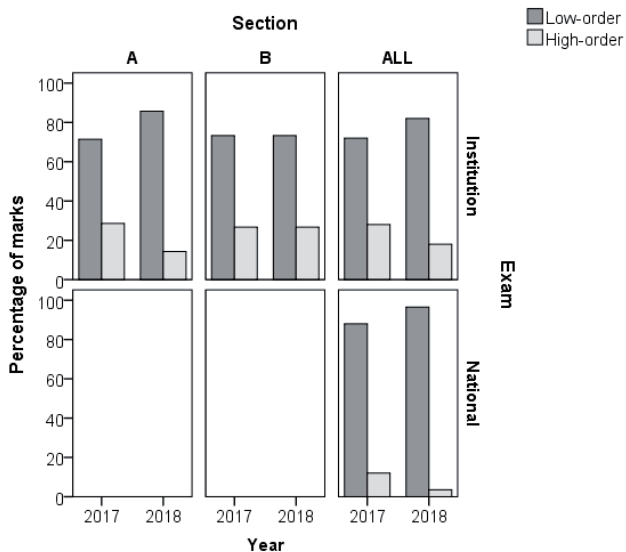
**Table 4: Number of marks (/70) in Section A and (/30) in Section B together with the percentage of marks per cognitive objective in Institution and National examinations. (LO: low-order; HO: high-order)**

Cognitive objectives	2017						2018					
	Institution					National	Institution					National
	Section A		Section B		All	All (%)	Section A		Section B		All	All (%)
	(/70)	(%)	(/30)	(%)	(%)		(/70)	(%)	(/30)	(%)	(%)	
Remembering (LO)	17	24.3	7.5	25.0	24.5	60	33	47.1	4	13.3	37	68
Understanding (LO)	21	30.0	3	10.0	24	16.5	15	21.4	5	16.7	20	24.5
Applying (LO)	12	17.1	11.5	38.3	23.5	11.5	12	17.1	13	43.3	25	4
Analysing (HO)	2	2.9	6	20.0	8	4	5	7.1	0	0.0	5	1.5
Evaluating (HO)	18	25.7	2	6.7	20	8	5	7.1	0	0.0	5	2
Creating (HO)	0	0.0	0	0.0	0	0	0	0.0	8	26.7	8	0
Low order	50	71.4	22	73.3	72	88	60	85.7	22	73.3	82	96.5
High order	20	28.6	8	26.7	28	12	10	14.3	8	26.7	18	3.5

**Figure 4: Graph showing the percentages of marks from Institution and National examinations (2017-2018), classified according to the Bloom's Revised Taxonomy (Anderson, Krathwohl et al. 2001). Values are worked as a percentage for each section**



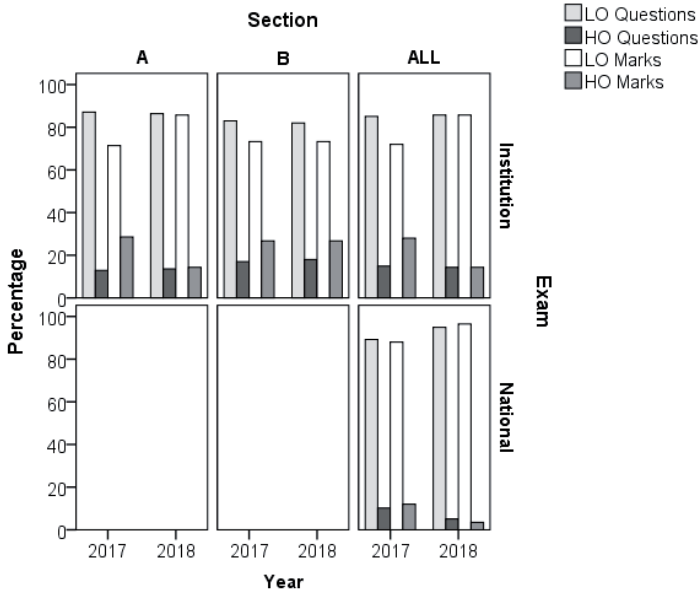
**Figure 5: Graph showing the percentage of marks allocated to low- and high-order question Institution and National examinations (2017-2018). Values are worked as a percentage for each section.**



**Table 5: The percentage of the cognitive objectives and the marks per cognitive objective for the Institution and National examinations**

Year	Exam	Section	Question/Marks	Low-order	High-order
2017	Institution	A	%Q	87.1	12.9
			%M	71.4	28.6
		B	%Q	83.0	17.0
			%M	73.3	26.7
		All	%Q	85.1	14.9
			%M	72.0	28.0
	National	All	%Q	89.2	10.2
			%M	88.0	12.0
2018	Institution	A	%Q	86.4	13.6
			%M	85.7	14.3
		B	%Q	82.0	18.0
			%M	73.3	26.7
		All	%Q	85.7	14.3
			%M	82.0	18.0
	National	All	%Q	94.9	5.1
			%M	96.5	3.5

**Figure 6: Graph showing the percentage of questions and marks allocated to low-order (LO) and high-order (HO) cognitive objectives in Institution and National examinations (2017-2018)**



## Conclusion

The research questions are answered in this part:

1. What is the proportion of low-level (knowledge, comprehension, application) or high-level of cognitive domain (analysis, synthesis and evaluation levels) questions in Advanced Biology level examinations at a public post-secondary Institution and the National ones between 2017 and 2018?

The study highlighted that not all objectives were present on every examination paper. The highest percentage of questions in the National and Institution Section A examinations were from the remembering objective type while they were from the applying type in Institution Section B. The percentage of questions in the cognitive domain, remembering, were higher in the National examination.

It was observed that low-order questions dominated in both examination types, being more pronounced in the National paper. A higher percentage of low-order questions were recorded from the institution Section A compared to Section B. The percentage of low-order questions could actually be higher than that reported in this investigation; certain verbs categorised as being in the high-order domain were actually recall since the material asked is covered in lectures.

2. Did the examinations challenge the students intellectually?

The question levels asked in the examinations have an important role while assessing students' achievement and developing their critical thinking skills. According to Brualdi (1998), high-level questions can make students think more creatively and multi-dimensionally. Low-level questions do not improve student conceptual development; on the contrary, they direct students to memorise knowledge. Comparing the results obtained from 1998-2011 National examinations by Mercieca (2014) with those in 2017-2018, there seems to be no variation in the cognitive structure of the questions. The assessments to determine student achievement are slow to change. The results of this analysis, considering analysis of examination papers with a two-decade difference, are proof of this.

3. Were the Institution examinations preparing students for the National Biology examination?

Results from the findings suggest that the Institution examinations not only prepare students for the National examination to be taken a year later, but are even better in various aspects. To mention a few, the questions set at the Institution are more open-ended, having a minimal number whereby each has two parts (for example, 'list and explain') and a higher percentage of marks compared to the percentage of high-order questions.

## Pedagogical Implications

As most of the questions in the Institution are based on lower learning levels of Bloom's Revised Taxonomy and this prevents students from accessing higher learning levels, paper setters can improve by formulating more questions from the higher learning levels.

## Recommendations for further research

1. Another study can be conducted on comprehension and essay-type of questions in Paper 2 Institution and National papers.
2. Bloom's Revised Taxonomy could be applied to Paper 3 that tests the practical aspect of Biology and compare it to Section B in Institution papers.
3. Although the majority of the questions examined were of the low-order cognitive domain, this does not mean that they are easy. Investigating the difficulty level of the low and high-order questions is the next project.

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