Departments of Integrated Sciences, Botany & Zoology

# A Deep Dive Beyond the Syllabus: Comparison of Cognitive Processes and Knowledge Dimensions Required in Upper & Lower Level UBC Undergraduate Biology courses

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## Abstract

Using the revised version of Bloom's taxonomy, we classified the assignments and assessments in two UBC Biology courses (BIOL 200 Fundamentals of Cell Biology and BIOL 463 Gene Regulation in Development) based on the type of cognitive process and knowledge dimension required by the student. Through this classification, we seek patterns or differences between cognitive processes and knowledge dimensions utilized in lower-level versus higher level biology courses.

## Introduction

Bloom's taxonomy is a universal framework used amongst educators. It has many uses, such as acting as a shared language for learning objectives and to inform curriculum development (Krathwohl, 2002). This framework was first developed by Benjamin S. Bloom in 1956, but since then, has undergone many changes reported by Anderson and Krathwohl, to create the revised taxonomy. The revised framework consists of four knowledge dimensions and six cognitive processes (Figure 1) .

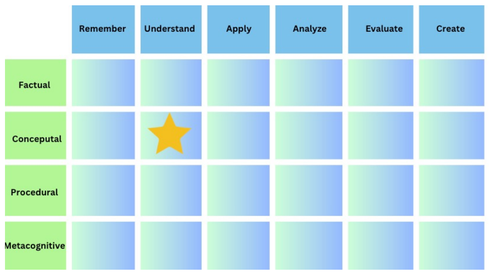


***Figure 1:*** *The revised taxonomy table. Blue boxes represent cognitive processes. Green boxes represent knowledge dimensions. Adapted from "A Taxonomy for Learning, Teaching and Assessing"*

**Within the framework, there are several sub-categories** that each dimension and process can be broken down into. Take the **cognitive process**, **understand,** for example. While 'understand' means to construct meaning from instructional messages, there are seven subdivisions, including; interpreting, exemplifying, classifying, summarizing, inferring, comparing and explaining (Figure 2).

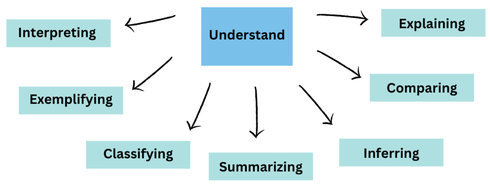


***Figure 2:*** *The subcategories of the cognitive process, 'understand'*

This underlying difference within 'understand' was apparent in our data analysis. An example of this includes:

- *Below are some of Lyko et al.'s data. What do they show? (BIOL 463, an example of interpreting)*
- *What can we directly conclude Lyko et al.'s data? (BIOL 463, an example of inferring)*
- *How do these data support/complement Kucharski et al.'s? What is the connection between them? (BIOL 463, an example of comparing)*
- *According to the author, what was the overall purpose of the study presented in the paper? (BIOL 463, an example of explaining)*

## Methodology

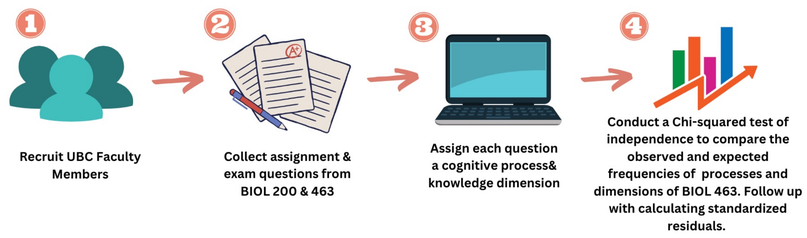


***Figure 3:*** *The methodology for this study*

## Results

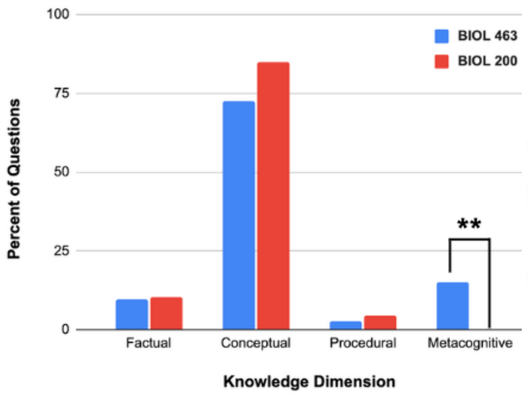


***Figure 4a:*** *A comparison of the percent of questions classified by knowledge dimension in BIOL 200 & 463. n= 113 for BIOL 200, n = 357 for BIOL 463. A significant difference was found in the metacognitive dimension*

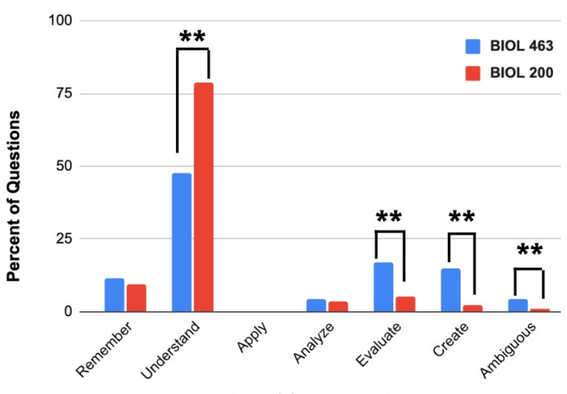


***Figure 4b:*** *A comparison of the percent of questions classified by cognitive dimension in BIOL 200 & 463. A significant difference was found in the following cognitive processes: understand, evaluate, create and ambiguous.*

Given that the revised version of Bloom's Taxonomy views knowledge dimensions and cognitive processes as intertwined (Larsen et al., 2022) we looked for any significant deviations from the expected frequency of these pairs in both courses. The expected frequency was calculated by dividing the number of questions that fell into the knowledge dimension by the total number of cognitive dimensions- therefore, the expected frequency of observing a pair is equal amongst all the cognitive dimensions. We used a chi-squared test to assess if there is a difference, followed by standardized residuals to determine which pairs were higher than, lower than or fell within the range of the expected frequencies (Figure 5)

| BIOL 200 | Remember | Understand | Apply | Analyze | Evaluate | Create | Ambiguous | Row total |
|---|---|---|---|---|---|---|---|---|
| Factual | 75.68 | 24.32 | 0 | 0 | 0 | 0 | 0 | 100 |
| Conceptual | 1.65 | 86.47 | 0.33 | 3.96 | 4.62 | 2.64 | 0.33 | 100 |
| Procedural | 0 | 62.5 | 0 | 0 | 18.75 | 0 | 18.75 | 100 |
| Metacognitive | 0 | 0 | 0 | 0 | 100 | 0 | 0 | 100 |

| BIOL 463 | Remember | Understand | Apply | Analyze | Evaluate | Create | Ambiguous | Row total |
|---|---|---|---|---|---|---|---|---|
| Factual | 45.46 | 54.54 | 0 | 0 | 0 | 0 | 0 | 100 |
| Conceptual | 1.22 | 56.1 | 0 | 4.88 | 17.07 | 17.07 | 3.66 | 100 |
| Procedural | 33.33 | 0 | 0 | 33.33 | 0 | 33.33 | 0 | 100 |
| Metacognitive | 35.3 | 11.76 | 0 | 0 | 29.412 | 11.76 | 11.76 | 100 |

| LEGEND |
|---|
| Significantly greater than expected |
| Moderately greater than expected |
| Slightly greater than expected |
| Within the expected value |
| Slightly lower than expected |
| Moderately lower than expected |
| Signficantly lower than expected |

***Figure 5:*** *The observed frequency of each knowledge dimension and cognitive process pair in BIOL 200 (top) and 463 (bottom). The observed frequency was compared to the expected frequency and assigned a colour based on this. Row totals are based on the frequencies of cognitive processes within each knowledge dimension. Frequencies were rounded therefore the row total is approximately equal to 100. Refer to the legend on the left to interpret the colour coded regions.*

## Discussion

Understanding the cognitive and knowledge dimensions in course assessments has many implications on teaching and curriculum development. This information can…

- Encourage educators to examine if the course assessments are reflective of learning objectives
- Spark changes or flexibility in course assessments, given that students exhibit unique strengths and weaknesses when it comes to demonstrating learning
- Aid students in their studying process. Along with a syllabus, educators can highlight the types of cognitive and knowledge domains present in each major course assessment. Knowing this information may change the way that a student chooses to prepare for an assessment.

## Future Work

We classified the questions based on the six cognitive processes and four knowledge dimensions. However, it would be interesting to classify these questions based on the subcategories within each domain, to gain a detailed understanding of the types of cognitive and knowledge dimensions required by a student taking the course. Furthermore, it would be interesting to examine different types of courses, including those beyond the realm of biology.

## Limitations

While a variety of assessment items were included in our analysis, we did not include iclicker questions and final exams (both applicable to BIOL 200). Additionally, two courses were analyzed to come to the conclusions in this study; BIOL 200 as the lower-level course, and BIOL 463 as the upper-level course. Although there were many assessment items in both courses, the conclusions made in this study are based on a relatively small sample size.

## Scan me for more information on this study!

## References

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