A two-dimensional, non-hierarchical framework of Bloom’s taxonomy for biology

UC STEM Lecturer Education Consortium
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Biological Sciences
where discovery comes to life
UC San Diego
Rationale: Why bother with a developed framework?

1. Biology discipline-based education literature focuses on original Bloom’s taxonomy
   
   • Original Bloom’s taxonomy is psychometrically invalid
Underlying structure of original Bloom’s taxonomy

Knowledge: 0.073
Comprehension: 0.249
Analysis: 0.170
Application: 0.049

Evaluation: 0.205
Synthesis: 0.134

General factor:

Instrument: 95 items
Sample: n = 1,128
10 schools
9th to 12th grades
“Knowledge” is not consistent with the taxonomy

Model 1
Knowledge → Comprehension → Application → Analysis → Synthesis → Evaluation

<table>
<thead>
<tr>
<th>Model</th>
<th>$\chi^2$</th>
<th>p</th>
<th>RMSD</th>
<th>Largest first derivative</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>380.34</td>
<td>&lt;0.05</td>
<td>0.041</td>
<td>Knowledge → Synthesis</td>
</tr>
<tr>
<td>2</td>
<td>124.77</td>
<td>&lt;0.05</td>
<td>0.018</td>
<td>Knowledge → Analysis</td>
</tr>
<tr>
<td>3</td>
<td>42.00</td>
<td>&lt;0.05</td>
<td>0.017</td>
<td>Knowledge → Evaluation</td>
</tr>
<tr>
<td>4</td>
<td>23.10</td>
<td>&lt;0.05</td>
<td>0.007</td>
<td>Comprehension → Analysis</td>
</tr>
</tbody>
</table>

Model 4
Comprehension → Application → Analysis → Synthesis → Evaluation
## Revised Bloom’s taxonomy: Two dimensions

<table>
<thead>
<tr>
<th></th>
<th>A. Factual</th>
<th>B. Conceptual</th>
<th>C. Procedural</th>
<th>D. Metacognitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Remember</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Understand</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Apply</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Analyze</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Evaluate</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Create</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- A. Factual
- B. Conceptual
- C. Procedural
- D. Metacognitive

*Anderson and Krathwohl 2001*
1. Biology discipline-based education literature focuses on original Bloom’s taxonomy

2. Develop guidelines and rubric for revised Bloom’s taxonomy for biology

3. Analyze underlying structure to revised Bloom’s taxonomy (at least in biology)
Data collection and analysis

Data source
- Total of 1,432 items
- Public sources: AP Biology and MCAT practice problems
- Introductory and advanced biology courses at Northwestern: biochemistry, cell biology, genetics, immunology, molecular biology, plant biology, and physiology

Coders
- Undergraduates who completed at least half of the introductory biology course sequence at beginning of project
- Selected from an application based on course grades and written responses to open-ended questions
Coders training and reliability

Training:
• Read literature
• Write our own problems
• Develop coding scheme
• Discuss 110 items

Coding:
• Adjust coding scheme (1st rubric)
• Code and discuss 718 items
• Revise coding scheme (2nd rubric)
• Code and discuss 604 items

Reliability: Inter-rater agreement | Cohen’s $\kappa$

<table>
<thead>
<tr>
<th></th>
<th>Training 1</th>
<th>Coding 1</th>
<th>Coding 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive process</td>
<td>0.44</td>
<td>0.23</td>
<td>0.76</td>
</tr>
<tr>
<td>Knowledge dimension</td>
<td>0.43</td>
<td>0.14</td>
<td>0.70</td>
</tr>
</tbody>
</table>
Dataset: Distribution in the two dimensions

Cognitive process: 1, 2, 3, 4, 5, 6, ?

Knowledge: A, B, C, D, ?

1st rubric (n = 828)
2nd rubric (n = 604)
## Anatomy of Bloom’s taxonomy for biology

### 1. Remember: Retrieve relevant information

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>Definition</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 Recognizing</td>
<td>Identifying</td>
<td>Identify something in an unaltered form</td>
</tr>
<tr>
<td>1.2 Recalling</td>
<td>Retrieving</td>
<td>Retrieve relevant information from memory</td>
</tr>
</tbody>
</table>

### 2. Understand: Construct meaning from given information

<table>
<thead>
<tr>
<th>Alternatives</th>
<th>Definition</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 Interpreting</td>
<td>Paraphrasing, converting, translating</td>
<td>Change from one form of representation to another</td>
</tr>
</tbody>
</table>
Examples for Bloom’s taxonomy for biology

6. Create: Put elements together into a novel pattern; use knowledge to solve novel problems or situations related to topic (6.1 generating, 6.2 planning, 6.3 producing)
Understand vs. analyze: How are they different?

2. Understand: Construct meaning from given information
   - 2.3 Classifying
   - 2.6 Comparing
   - 2.7 Explaining

4. Analyze: Deconstruct material and understand parts and relationships
   - 4.2 Organizing
   - 4.1 Differentiating
   - 4.3 Attributing
Knowledge dimension of Bloom’s taxonomy

A. Factual knowledge
   • Aa. Terminology
   • Ab. Specific detail or element

B. Conceptual knowledge
   • Ba. Classifications and categories
   • Bb. Principles and generalizations
   • Bc. Theories

C. Procedural knowledge
   • Ca. Discipline-specific skills and algorithms
   • Cb. Discipline-specific techniques and methods
   • Cc. Criteria for determining when to use a procedure

D. Metacognitive knowledge
   • Da. Strategic knowledge
   • Db. Cognitive tasks, contextual and conditional knowledge
   • Dc. Self-knowledge
Acknowledgements

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