Using Writing Support and Assessment to Scaffold Quantitative Reasoning Communication

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THE NEUROBIOLOGY OF WRITING

How it's supposed to work:

- Process Language
  - Temporal Lobes
- Control Hands
  - Motor cortex
- Transmit Command
  - Brain stem
- Activate Muscles
  - Motor neuron
- Execute Command
  - Prefrontal cortex
- Success!
  - Words
- Type
  - Flexor digitorum

How it usually works:

- Confusion
  - Prefrontal cortex
- Insecurity
  - Limbic System
- Fear
  - Amygdala
- Panic
  - Sympathetic System
- No Motivation
  - Anterior cingulate cortex
- Hesitation
  - Inferior frontal gyrus

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Cognitive Load Theory

• There’s only so much room to process information (bandwidth)
• If you add more information, something else has to “spill” out or slow down
What’s happening when students write?


- Cognitive Processing Theory of Writing
  - Task environment (what you have to do)
  - Long Term Memory (what you know)
  - Process of writing (how you will do it)
Section level organization

- Abstract
- Introduction
- Methods
- Results
- Discussion

Narrative
Descriptive
Persuasive argument
Analytical
Section level organization

- Abstract
- Introduction
- Methods
- Results
- Discussion

• Claim
• Evidence
• Reasoning
Consider a lab report your students might write

• Describe the measurement
• Describe the conditions
• Make up representative data
• How do you calculate the quantitative relationship?
• Write a statement that describes the quantitative relationship in your data
The $K_m$ of $\beta$-galactosidase increases 30% in the presence of galactose compared to control.

Galactose is a competitive inhibitor of $\beta$-galactosidase.

$K_m$ is a measure of binding affinity and higher $K_m$ values mean lower affinity.
Quantitative Comparative statements are common in the scientific literature

- **RED** Physical Science
- **BLUE** Natural Science
- **GREEN** Social Science
The rate of mutant cell movement is 10-fold lower than the wildtype cells (Table 1).

**Calculation** - relational phrase that quantifies the comparison

**Context** - what measurement does the relational phrase refer to?

**Comparison** - what conditions are being compared?

**Clarity** - Nothing missing or redundant
The rate of mutant cell movement is 10-fold lower than the wildtype cells, which move at 3 µm/min while the mutants move at 30 µm/min.

**Calculation** - relational phrase that quantifies the comparison

**Context** - what measurement does the relational phrase refer to?

**Comparison** - what conditions are being compared?

**Clarity** - Nothing missing or redundant
The rate of mutant cell movement is 10-fold lower than the wildtype cells (Table 1).

<table>
<thead>
<tr>
<th>Calculation</th>
<th>Magnitude and direction</th>
<th>✓</th>
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</thead>
<tbody>
<tr>
<td>Context</td>
<td>Referred to explicitly</td>
<td>✓</td>
</tr>
<tr>
<td>Comparison</td>
<td>Two and only two conditions</td>
<td>✓</td>
</tr>
<tr>
<td>Clarity</td>
<td>All elements present Nothing extra</td>
<td>✓</td>
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</table>

4C score = 4
The rate of mutant cell movement is much lower.

<table>
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<td>Context</td>
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<tr>
<td>Comparison</td>
<td>✗</td>
</tr>
<tr>
<td>Clarity</td>
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</table>

= 1
Score your own statement
Practice at the sentence level improves QC syntax

* p < 0.001
We found that there is no statistically significant difference between the $K_m$ values of 25 mM glucose and no sugar added ($t_{43}, p = 0.789$).

There was also no statistically significant difference between the $V_{max}$ values of 25 mM glucose and no sugar added ($t_{43}, p = 0.626$).

Therefore, we can conclude that the addition of the glucose to the assay buffer affects neither the $\beta$-galactosidase binding affinity or catalysis.

We concluded that galactose does not have a significant effect on catalysis ($V_{max}$) ($t_{44}, p = 0.064$). However, the difference in binding affinity, $K_m$, is statistically significant. The $K_m$ in 25 mM galactose is 68% larger than the $K_m$ of no sugar added assay ($t_{44}, p < 0.0001$). We can conclude that galactose affects both binding affinity and catalysis for $E. coli$ $\beta$-galactosidase.
Practice improves QC syntax in lab reports

Lab Report #1

Student Cohorts

* p < 0.05
Complexity impairs QC writing

**Lab Report #1**

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<tr>
<th>Year</th>
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<td>2016</td>
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</table>

* p < 0.05

**Lab Report #2**

<table>
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<th>Year</th>
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<th>With writing practice</th>
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<tbody>
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<tr>
<td>2016</td>
<td>3</td>
<td>3</td>
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</tbody>
</table>

* p < 0.001

* p < 0.05
Specific prompts can reduce complexity
Complexity impairs QC writing

Lab Report #1

Lab Report #2

* p < 0.05

* p < 0.001
Experts manage complexity to keep cognitive load low.
Complexity impacts writing quality
Writing is sensitive to complexity after intervention

* p < 0.05
Abstract

Introduction

Methods

Results

Discussion

- Claim
- Evidence (4C)
- Reasoning
We found that there is no statistically significant difference between the Km values of 25 mM glucose and no sugar added (t43 p=0.789). There was also no statistically significant difference between the Vmax values of 25 mM glucose and no sugar added (t43 p=0.626). Therefore, we can conclude that the addition of the glucose to the assay buffer affects neither β-galactosidase binding affinity or catalysis.
We found that there is no statistically significant difference between the Km values of 25 mM glucose and no sugar added (t43 p=0.789). There was also no statistically significant difference between the Vmax values of 25 mM glucose and no sugar added (t43 p=0.626). Therefore, we can conclude that the addition of the glucose to the assay buffer affects neither β-galactosidase binding affinity or catalysis.
Viruses are obligate intracellular pathogens and require host organisms to proliferate. Over the course of a day, viruses may encounter host environments that are more or less conducive to replication and dissemination (5, 9, 10). We hypothesized that the time of day of infection would influence viral replication. To test this, we infected WT mice intranasally with a recombinant luciferase-expressing virus, Murid Herpesvirus 4 (M3:luc MuHV-4), at two times of day (Fig. 1A and Fig. S1A). As a rodent pathogen, this virus elicits natural host immune responses and implements evasion strategies in laboratory mice (11, 12), which allow it to establish latent (or quiescent) infection after primary infection. WT mice infected intranasally at the onset of resting phase [Zeitgeber Time 0 (ZT0); lights on], exhibited 10-fold higher viral replication than mice infected just before their active phase (ZT10) (Fig. 1A). This time-of-day effect required a functional clock because Bmal1−/− mice, which have no overt circadian rhythms (2), showed no difference when infected at different times (Fig. 1B and Fig. S1B). Furthermore, Bmal1−/− mice exhibited high levels of MuHV-4 infection when inoculated at either time of day (Fig. S1 C–F). Together, these results indicate that the timing of infection in relation the circadian cycle has major effects on herpesvirus pathogenesis.
Thank you!

Katie Krueger
David McMillan
Erika Sweet

ASM Biology Research Scholar Program (T.R.)
Assessment Office (T.R. and C.S.)
Faculty Development Office (T.R. and C.S.)
Practice writing QC statements improves reasoning

**p < 0.0001**
Decreasing cognitive load will improve writing quality.