

# Honors Capstone Research (HCR) Summer Program 2022

## Assessing Undergraduate Expression of Biochemical Mechanisms

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### Overview

**Research Question:** When given a prompt to explain processes relating to metabolic pathways, how specifically do students explain relationships between biochemical *entities* and *activities*?

**Significance:** Information from this study can be utilized to alter teaching strategies based on a better understanding of how students express biochemical relationships.

### Methods

**Approach:** We analyzed student data within Dedoose to assess how specifically students described biochemical relationships. To do this, we categorized relevant *entities* and *activities* within three levels of specificity<sup>1</sup>.

<b>L-2</b>	Lowest Specificity; "Body-Level" Entities and Activities
<b>L-1</b>	Intermediate Specificity; "Pathway-Level" Entities and Activities
<b>L</b>	Highest Specificity; "Molecular-Level" Entities and Activities

L-2 Activity	L-1 Activity	L Activity
Produce	Upregulate	Phosphorylate
Break Down	Downregulate	Hydrolyze
Use	Increase	Decarboxylate
Utilize	Decrease	Oxidize
Make	Divert	Reduce
Burn	Overproduction	Convert
Cause	Overconsumption	Secrete
Allow	Inhibit	Transport

### Analysis:

- Found a frequency count of *activities* and *entities*, respectively, within each category of specificity
- Calculated the percentage of each category of specificity (i.e., L, L-1, L-2)
- Cross-compared each category of specificity between the *activities* and *entities*; calculated an average ratio relative to each other

### References

1. van Mil, M.H.W., Boerwinkel, D.J. & Waarlo, A.J. Modelling Molecular Mechanisms: A Framework of Scientific Reasoning to Construct Molecular-Level Explanations for Cellular Behaviour. *Sci & Educ* 22, 93–118 (2013). <https://doi.org/10.1007/s11191-011-9379-7>

### Acknowledgements

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### Results

Distribution of Activity Specificity

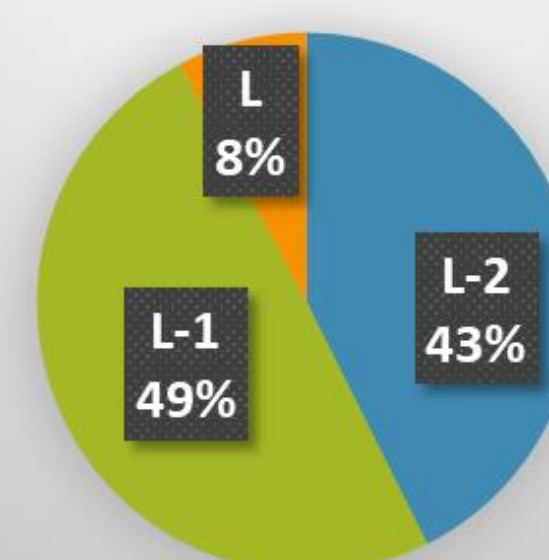


Figure 1a

Distribution of Entity Specificity

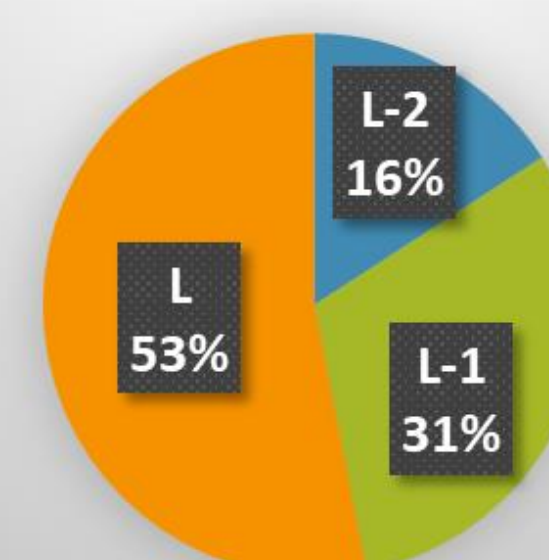


Figure 1b

AVERAGE NUMBER OF L-2, L-1, AND L ACTIVITIES VS. L-2, L-1, AND L ENTITIES

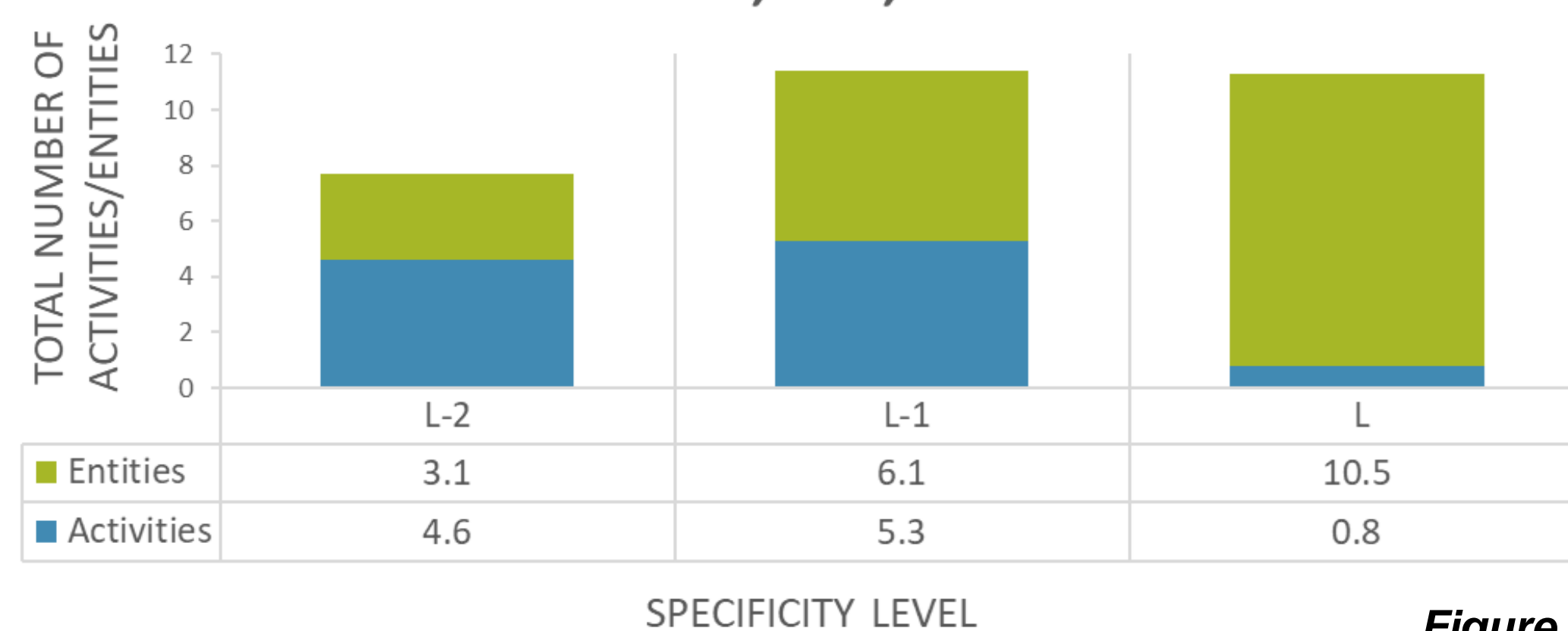


Figure 2

Student Example	Level Correlation
" <b>Ketones</b> are <u>produced</u> from <b>fatty acids</b> ."	Entity/Activity Mismatch
" <b>Acetyl-CoA</b> that is formed during fatty acid oxidation would normally be <u>oxidized</u> to <b>CO2</b> and <b>H2O</b> ..."	Entity/Activity Match
<b>Key</b>	
Color = L Level	
Color = L-2 Level	
Bold = Entity	
Underline = Activity	

### Discussion

#### Findings:

- The majority of entities are L-level; the minority of activities are L-level
  - Suggests that students do not struggle with identifying specific *entities* as they do utilizing appropriate *activities*
- Weak match observed between L-level *entities/activities*
  - Suggests that students struggle to mechanistically explaining molecule-level relationships with appropriate specificity
- Moderate match observed between L-1 level *entities/activities* and L-2 *entities/activities*
  - Suggests that students struggle less mechanistically explaining pathway-level and body-level relationships with appropriate specificity