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Analysis of Student Learning Gains in a Biochemistry CURE course during the mandatory COVID-19 shift to online learning

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Abstract

Due to the ongoing COVID-19 pandemic, institutions across the world have had to make modifications to existing curricula, especially in the experimental science lab. There is a need to better understand student learning in this environment. Using the Participant Perception Indicator (PPI) survey, we measure the students' knowledge, experience, and confidence (KEC) growth over the course of a fully online biochemistry course. Using a combination of video explanations, experimental procedure documents and sample data students completed the Biochemistry Authentic Scientific Inquiry Lab (BASIL) Course-based Undergraduate Experience (CURE) in summer 2020. The results and analysis of the survey data gave light to three main findings. We found students learned more about bioinformatic experiments and concepts than about their wet-lab counterparts. Students did report greater gains in learning outcome KEC than in wet lab and computational techniques. Finally, students report experience and confidence gains lagged their knowledge of the techniques. Students are not as confident in their understanding of techniques when unable to perform them in the physical laboratory. Thus, even though they had great knowledge and understanding of the structure, protocols, and purpose of the experiments and techniques, their responses indicated that their experience and confidence was not on par with their knowledge.

Introduction

Winter 2020 semester data, published in Sikora et al JCE 2020, shows the effects that a mid-semester shift to an online format had on student learning. This current study focuses on the Summer 2020 semester, where the instruction was completely online. After the development of the ALOs, a PPI survey was created based on the 7 most relevant and top- rated learning outcomes (Figure 1). After developing the PPI survey, it was distributed to students at both the beginning and the end of the semester, and analysis of the survey responses were done based on reviewing the gain scores and overall perceived student-indicated improvement. We are pursuing several research goals in this study:

- Convert Anticipated Learning Outcomes (ALOs) identified by Irby et al. CBE, 2018 to verified learning Outcomes (VLOs) through assessment methodology with new online courses
- Use a participant perception indicator (PPI) survey to evaluate student knowledge, experience, and confidence (KEC)
- Design targeted assessments to improve areas showing poor student understanding

Table 2. ALOs previously identified for the BASIL curriculum[6,11] and used to create the BASIL PPI survey (from which this table is replicated).[13]

ALOs	Description	BASIL CURE Components	BASIL CURE Protocol(s)
ALO1	Explain how the colorimetric enzyme assay works to allow detection of protein function	Biochem (B)	Enzyme Activity
ALO2	Identify an enzyme active site using appropriate computational programs	Comp (C)	Pfam, ProMOL, PyRx
ALO3	Determine the appropriate factors to consider when optimizing or interpreting an enzyme assay	Biochem (B)	Enzyme Activity
ALO4	Determine using computational software whether, and where, a ligand may be binding to a protein	Comp (C)	PyRx
ALO5	Compare enzymatic results with those computationally predicted	Both (B/C)	Not limited to any single protocol
ALO6	Design an enzyme assay to elucidate protein function	Biochem (B)	Enzyme Activity
ALO7	Explain how the purification of tagged proteins work and ways the process can be optimized	Biochem (B)	Protein Purification

Figure 1: (Sikora et al. JCE, 2020)

Methods

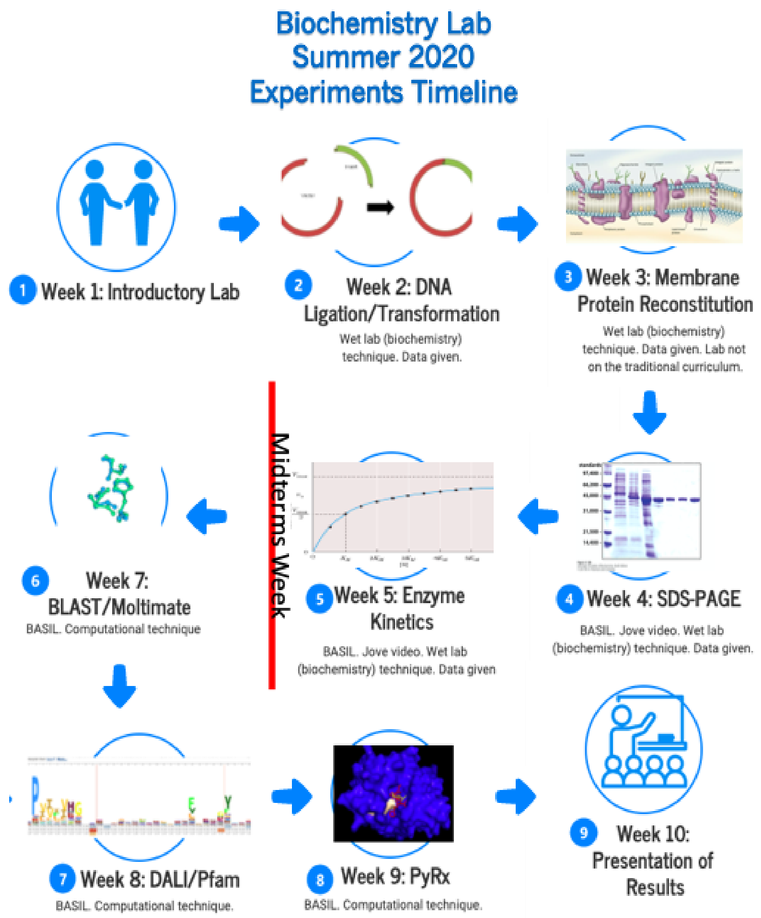

Figure 2: Schematic sequence of experiments conducted, and techniques employed during the Summer 2020 term. All procedures, both experimental and computational, were conducted in an online learning environment. Students were provided with educational videos to help explain wet-lab experiments and the instructor was present to lead them through computational techniques and explain any questions or concerns.

Student Results

PPI results for Summer 2020 compared to Winter 2020 results										
Metric	ALO 1 (B)[b]	ALO 2 *(C)*[b]	ALO 3 *(B)*[b]	ALO 4 *(C)*[b]	ALO 5 (B/C)[b]	ALO 6 (B)[b]	ALO 7 (B)[b]	Average ALO	Comp. Tech.	Biochem. Tech.
Summer 2020 Data; n = 26										
Pre-PPI Score [a]	1.36	1.42	1.46	1.33	1.64	1.35	1.82	1.48	1.19	1.66
Post-PPI Score[a]	2.88	4.32	3.71	4.32	3.81	3.32	3.64	3.71	4.16	3.2
Δ score	1.53	2.9	2.24	2.99	2.17	1.97	1.82	2.23	2.97	1.54
Gain Score	42%	81%	63%	81%	65%	54%	57%	63%	78%	46%
Cohen's D	1.62	3.87	2.62	5.09	2.03	2.18	1.72	3.62	6.74	1.99
p-value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.0001	< 0.001	< 0.001	
Winter 2020 Data; n = 9										
Pre-PPI Score [a]	1.37	1.44	1.37	1.19	1.7	1.7	1.67	1.49	1.12	1.73
Post-PPI Score[a]	3.67	4.07	3.59	3.74	3.96	3.3	3.89	3.75	3.97	3.11
Δ score	2.3	2.63	2.22	2.56	2.26	1.59	2.22	2.25	2.85	1.38
Gain Score	63%	74%	61%	67%	69%	48%	67%	64%	73%	42%
Cohen's D	4.67	3.84	4.83	3.95	3.68	1.87	2.97	5.98	7.07	3.21
p-value	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.006	0.0012	< 0.001	< 0.001	< 0.001

Figure 3: The scores reflect participants' ratings of their knowledge, experience, and confidence (KEC) regarding each item based on the following scale: 1-"None"; 2-"A Little"; 3-"Some"; 4-"Much" and 5-"A Great Deal". B Indicates that an ALO pertains to techniques that are biochemical wet lab (B), computational (C), or both (B/C).

- There were higher gains seen in Computational techniques in comparison to wet-lab techniques (Figure 3)
- Learning objectives served as a bridge between the instruction of techniques and student learning
- When techniques are taught paired with their respective ALOs, there was an increase in knowledge, experience, and confidence
- The gain in experience and confidence is less that the gain in knowledge (Figure 4)

Classification	Avg. Gain Score (%)	Knowledge	Experience	Confidence
Wet lab ALOs	53.98	58.88	50.79	52.79
Computational ALOs	81.24	84.27	81.63	78.01
Wet lab techniques	46.07	34.38	45.38	47.71
Computational techniques	77.92	81.24	77.71	74.94

Figure 4: The reported Knowledge, Experience and Confidence gains also varied based on the trends described above. Notably, all categories showed greater increases in computational sections over the biochemical ones and in ALO understanding over technique mastery. In each of these categories, the knowledge gain score is highest, representing the information students gained from lectures, lab assignments, and additional resources.

Future Works

- Further testing on neurodiverse populations
- Adding new collaborators to the project
- Contact us to find out more!

Contact

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Email paul.craig@rit.edu for information and collaboration opportunities.