ARTICLE
Teaching Scientific Literature Analysis: A Systematic Adoption of Skill-Building Methods to Enrich Research Training for Undergraduate Students

Sharmila Venugopal[1, 2]
[1]Department of Integrative Biology and Physiology, Division of Life Sciences; [2]Department of Neurology, David Geffen School of Medicine, University of California Los Angeles, Los Angeles, CA 90095.
https://doi.org/10.59390/AWCF3324

Teaching scientific literature analysis skills is a critical step in research training. Here I describe a 6-week skill-building module on understanding scientific literature, incorporated into a 10-week undergraduate honors research practice course in Neuroscience. Key pedagogical components include: 1) student-centered active-learning, skill-building and community-building activities; 2) persistent adoption of a proven CREATE method and a novel curate scientific summary (CSS) method for teaching scientific literature analysis skills; 3) collaborative class organization consisting of persistent learning pods (PLPs) to facilitate student-driven participation and peer learning; and, 4) role play of a real research lab. Skill development was assessed using a self-assessment survey (SAS) and longitudinal evaluation of the CREATE and CSS methods application by the PLPs to analyze primary research articles (PRAs) over four weeks. Outcomes demonstrate alleviation of pre-existing student anxiety to read complex scientific literature and advancement of critical-thinking and collaborative skills. Specifically, the SAS responses indicate that student perception about reading scientific literature transformed from being a daunting task to an enjoyable activity; this enhanced their confidence in evaluating scientific literature. PLPs fostered student engagement, peer instruction, and community building, and contributed to skill development. Weekly assessment of CREATE and CSS application highlighted marked improvements in students' abilities to analyze and critique complicated scientific material. Role playing a research lab setting with a focused research theme facilitated integrative understanding of a frontier topic in Neuroscience. The outlined innovative approach can be adopted in Course-based Undergraduate Research Experience (CURE) and should help contribute to systematizing didactic practices to train neuroscientists.

Key words: CREATE method; scientific literature analysis; undergraduate pedagogy; research practice; knowledge graphs

---

Research practice coursework are an integral part of undergraduate and graduate training. Such courses often cover a broad range of topics relevant to research training including understanding and critiquing scientific literature; proposal writing; effective scientific communication; research design; and ethical, social, and humanitarian considerations in research. Often, those courses are conducted in a seminar style and/or incorporate journal clubs and faculty-facilitated, student-driven class discussions. Considering the heterogenous structure of such courses, benchmarks are essential to teach and evaluate scientific skill development. Previously, the CREATE (**C**onsider, **R**ead, **E**lucidate hypotheses, **A**nalyze and interpret data, and **T**hink of the next **E**xperiment) method was developed for teaching science and the nature of science through primary literature analysis (Hoskins et al., 2007). This method requires students to create pedagogical tools such as concept maps, methods diagrams, and results annotations to facilitate understanding of primary research articles (PRAs). The method was first demonstrated to examine a set of PRAs sequentially published from the same lab, to appreciate how a research project evolves over the years. Subsequent creative application of this method in a developmental neuroscience class enabled teaching students the evolving paradigm shifts in scientific theories (Hoskins, 2008). The same group also showed that the CREATE approach to primary literature can shift self-assessed ability of undergraduates to read and analyze journal articles, attitudes about science, and their epistemic beliefs (Hoskins et al., 2011).

Extending these applications and outcomes, here I show an innovative application of the CREATE method and supplement it with a curated scientific summary (CSS) that allows learning and integration of discoveries more broadly and enables longitudinal assessment of skill development in scientific literature analysis. While the CREATE method enabled students to delve deep into a PRA, the CSS helped to assemble scientific excerpts from each PRA, pertinent to the research theme. Consolidation of CSS through repeated offerings of the research theme can further help build a widely usable knowledge repository and scientific tools such as semantic and molecular network models (see Figure 9). Pedagogical details relevant to course module implementation highlight skill improvement. This combined approach, together with active-learning methods of class presentations with peer and instructor feedback is suitable to prepare students for graduate schools and as independent researchers. Future suggestions of rubrics for objective skill evaluation are proposed with the hope that these methods can be widely incorporated and extended to systematize research training in Neuroscience.

MATERIALS AND METHODS

Course Module Design, Class Expectations and Products

In a 10-week honors research practice course, 6 weeks were dedicated to implementing the module focused on analysis of scientific literature. Table 1 shows weekly activities of the module. The learning goals included development of: 1) scientific comprehension, 2) critical evaluation of primary scientific literature including methods and data analysis, 3) scientific communication skills, and, 4) team-building and community building values.

During week 1, the CREATE and CSS methods were introduced in the class. Students self-assembled into PLPs with 3 students each, which persisted throughout the module. To role play a research lab, a central research theme in neuroscience was provided for the whole class. The PLPs were asked to perform a PubMed search and assemble 4 primary research articles or PRAs relevant to the research theme. A total of 24 PRAs were gathered by the whole class (4 PRAs x 6 PLPs) and were consolidated into a list and shared in a Google sheet. For each article, PLPs also documented the PubMed ID (PMID) and the article web link in the National Center for Biotechnology Information (NCBI) database. Each PRA was scrutinized by the instructor (role playing Principal Investigator or PI) to ensure relevance to the assigned theme and alternatives were suggested as appropriate. Prior to demystifying the PRAs, all the students read three recent review articles assigned by the instructor (role playing PI) on the research theme and each PLP discussed those in week 2, during class by preparing slideshows. This step of beginning with PLPs reading and presenting review articles acquainted students to working with their PLP members, familiarized the research theme and provided a head start to expand their scientific knowledge, collaborative and presentation skills.

During weeks 3 – 6, each PLP collaboratively analyzed one of the four articles they had selected using the proven CREATE method (Hoskins, 2008; Hoskins et al., 2011; Hoskins et al., 2007). PLPs collaboratively deconstructed each article as a homework assignment and gave a 15 min slideshow presentation during the class discussion each week. In their presentations, each PLP shared a concept map that they created for the study's introduction section. The slideshow approach to present CREATE summaries facilitated creative integration of methods diagrams, experimental hypothesis in a "Since-If-Then" logic block, incorporating "Our title" for the results figure and elucidating the experimental hypothesis by highlighting key figure panels and statistical approaches used. Students further identified limitations and gaps in the articles and proposed a next experiment – **T**hink of next **E**xperiment. As a final step in PRA analysis using the CREATE method, PLPs created a **S**ynthesis map that summarized their analysis of the entire article. At the end of each PLPs' presentation, others were asked to provide oral feedback, both on presentation etiquette as well as the science.

Week	Class Activity	Participants	Assignment Due
1	❑ Understanding scientific literature: ➢ CREATES method ➢ CSS method ❑ Research theme introduction	Instructor's lecture	• PLP formation • PLP agreement
2	Class Discussion of 3 recent Review Articles pertaining to the research theme	PLPs	Selected list of PRAs
3	1st PRA presentation (CREATES analysis)	PLPs	1st PRA CSS
4	2nd PRA presentation (CREATES analysis)	PLPs	2nd PRA CSS
5	3rd PRA presentation (CREATES analysis)	PLPs	3rd PRA CSS
6	4th PRA presentation (CREATES analysis)	PLPs	4th PRA CSS

Table 1. Summary of week-by-week scientific literature analysis module activities. CREATES: Create, Read, Elucidate, Analyze, Think-of-next Experiment, Synthesize; CSS: Curated Scientific Summary; PLP: Persistent Learning Pods, PRA: Primary Research Article.

This process was augmented with a weekly take-home assignment to complete a curated scientific summary or CSS for each article that was presented in class. In the current course module, the research theme assigned was "Molecular Mediators of Neuron-Microglia Interactions". Students were asked to input information on causal associations between proteins and other signaling molecules reported in each PRA via a Google form. The structure of the form was compartmentalized to include article info, signaling entities info, methods info, and functional effects info (see CSS schema in Figure 1).

Additionally, the Google form required students to enter standard identifiers from scientific databases (e.g., UniProt IDs for proteins), emphasizing best practices in generating scientific metadata. CSS also cataloged diverse experimental approaches used to uncover evidence for causal associations between multicellular signaling entities and the resultant alterations in neural functions. Specifically, students examined multicellular molecular signaling associated with neurophysiological effects such as altered intrinsic, synaptic and structural plasticity, neurotoxicity and neuroprotection. The assigned research theme, mimicking a lab scenario in which lab members read published papers and derive findings relevant to their lab's research, taught advanced research skills to conduct a systematic literature review on a frontier topic. The lecture slides used to introduce the CREATE and CSS approaches as well as the Google form used for PRA curation are provided as Supplementary Materials 1 and 2.

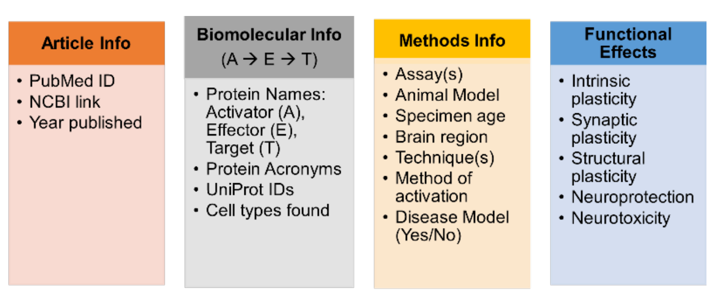

Figure 1. Curated Scientific Summary schema. A, E, and T are biomolecules such as proteins and arrows indicate functional associations between them, reported in the PRAs.

RESULTS

In the Neuroscience honors research practice seminar course, a key learning objective was to enhance scientific literature analysis skills. To meet this objective, the CREATE method, proven to enhance scientific literature analysis skills was employed, supplemented with a novel CSS for focused research, and PLPs for peer support and collaboration. Assessments to evaluate skill development included an anonymous self-assessment survey or SAS, longitudinal evaluation of weekly CREATE-based presentations and CSS of PRAs. Corresponding learning outcomes are presented in the following sections.

Learning Outcomes Based on SAS Highlights Student Engagement, Enhanced Skills and Confidence

During the first lecture, students were asked a free-response statement with a blank: "Reading a research paper is ________". Their one-word response was recorded as a pre-evaluation of what they felt about understanding scientific literature at the beginning of the module. At the end of 6-weeks, a detailed SAS consisting of free-responses and Likert-style questionnaire (Batterton and Hale, 2017) was administered and anonymous student responses were collected via a Google form. Comparing answers to the above blank statement at the end of the module indicated a dramatic alleviation of student anxiety and an improvement in student confidence to comprehend scientific literature (compare the before and after responses in Figure 2a). Figure 2b shows the effort level for the module indicating that the affect change in Figure 2a was not simply a result of less effort students input into the module. Additionally, students reported a significant enhancement of their skills after the module completion (see Figure 2c). Tables 2 and 3 show student responses to two free-response questions in the SAS, respectively. The responses in Table 2 to the question, "What aspects of this module were most useful or valuable for your skill development?", could be grouped into three emergent categories of impacted skills. These include scientific comprehension, presentation and collaborative skills. Note that a majority of the responses indicate enhancement in scientific skills. The responses in Table 3 to the question, "What did you learn about reading papers that you were not aware of before?" also, could be grouped into three emergent categories of impacted skills. This included comprehension, critiquing and statistical analysis. As noted in some of the individual responses on comprehension, students recognized the importance of the introduction section and found making concept maps very useful. They also appreciated that each experiment in a study is backed by a scientific rationale. They further noted that generating their own title for each result as suggested by the CREATE method enabled better comprehension of the results. Besides comprehension, ability to critique a study was a novel skill for many students. They now appreciated that literature evidence must be carefully evaluated and not blindly believed to be true (Hoskins et al., 2011). This realization was cautioned by recognizing the importance of using suitable statistical comparisons.

In summary, based on student responses in the SAS,

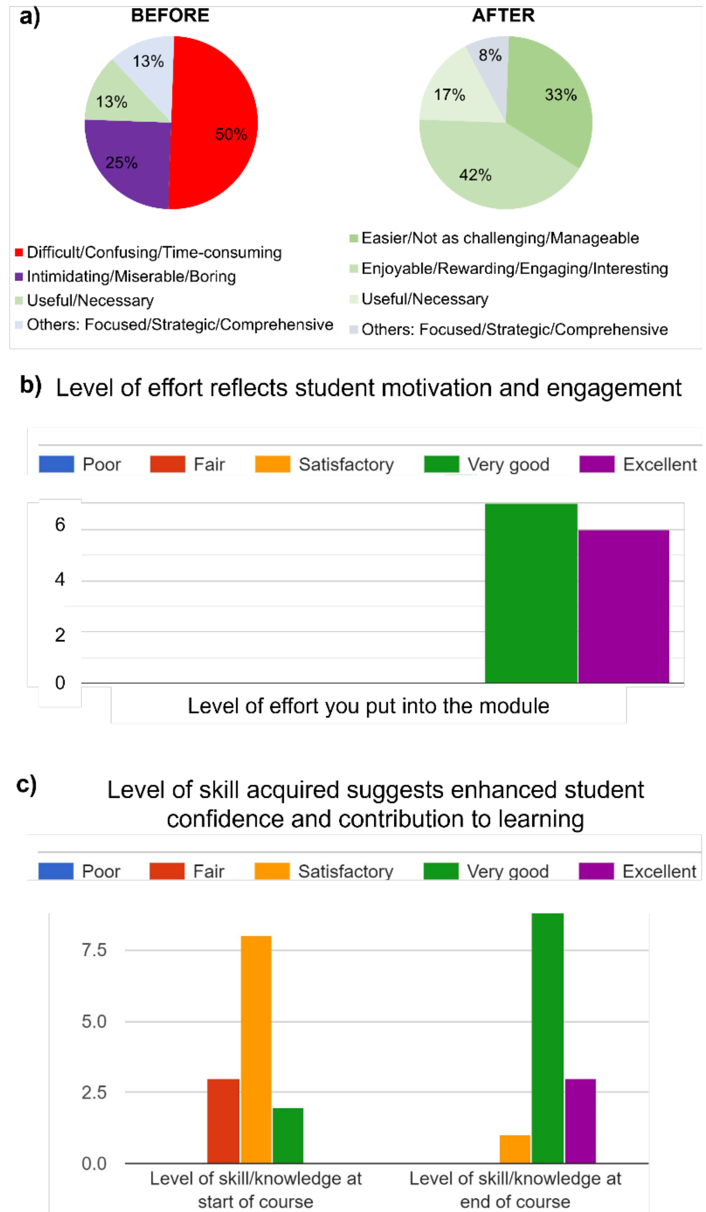

Figure 2: Key results of SAS. **a)** Pie charts showing the variety and proportion of student responses to the question "Reading a research article is …" before and after the 6-week module on literature analysis. The categories were based on the affect grouping (see results) of evident responses and percentages indicate proportion of responses in each category. **b)** Histogram showing the level of efforts students input for the module. **c)** Histogram showing student-evaluation of their skill levels before and after the module.

factors contributing to improved confidence included: 1) working with peers in PLPs, 2) CREATE and CSS methods for PRA analysis, 3) repeated activities over multiple weeks, and, 4) inclusive class participation. The SAS also consisted of a peer evaluation component in which students were sked to recognize improvements in their classmates' skills and abilities. This enhanced values such as fostering community, peer recognition, collaboration and self-learning (see Table 4). The diversity of student responses

STUDENT RESPONSES	SKILLS IMPACTED
• Finding and dissecting the scientific articles. • Utilizing CREATES and CSS as tools to evaluate and summarize scientific literature in the future. • Dissecting research articles into understandable components. • Critically evaluating experimental design and methods. • Greater appreciation for the Methods section. • In-depth understanding of nervous system function by focusing on a single research theme.	COMPREHENSION
• Weekly presentations. • Learning to effectively communicate complicated information in limited time. • Creatively presenting research articles using CREATE summaries. • Feedback received during class presentations.	PRESENTATION
• Working with classmates in learning PODs. • Learning from peer presentations.	COLLABORATION

Table 2. Left: Consolidated student responses to the question "What aspects of this module were most useful or valuable for your skill development?". *Right:* Post hoc classification of responses based on the impacted skills.

recognizing many of their peers (names not disclosed) on the SAS reflected that the class organization and activities fostered student engagement and community building. Furthermore, the process of continual peer engagement in all of the course activities further seemed to help students to reflect upon and refine their own perceptions on peer evaluation and team skills.

Longitudinal Evaluation of CREATE-Based and CSS-Based PRA Summaries Highlight Skill Improvement

Weekly PLP presentations of CREATE-based summaries of PRAs over four weeks (weeks 3 – 6) facilitated evaluation of progressive improvements in literature analysis skills. **Figure 3** (top panels) shows a PLP's concept map in week 3 (for article 1) and in week 6 (for article 4). Note that the concept map for article 1 lacked directional arrows to specify a logical flow in the conceptual framework. The same PLP's concept map for article 4 highlights arrows indicating logical flow with color codes and text annotations on the arrows; the question mark also highlights the gaps which were addressed in the corresponding PRA. The bottom panels in Figure 3 show a creative consolidation of experimental hypothesis, methods, results, and statistical analysis for a results figure from two PRAs presented by a PLP on their 1st article in week 3 (bottom-left) and 4th article in week 6 (bottom-right). Progressive improvement in analytical and critical-thinking skills is highlighted by green callouts in the week 6 summary.

Lastly, the CSS helped students to extract and consolidate meta information from each PRA concerning findings relevant to the research theme. For example, students examined whether a study showed empirical evidence for causal associations between two or more proteins as illustrated in Figure 4. At first, students found it challenging to identify such information since each article implemented diverse methodologies and focused on a variety of scientific questions. Therefore, PLPs were allowed to redo their CSS following instructor feedback (role playing PI's feedback), when the meta information was misconceived. Figure 4 shows excerpt from a CSS generated by a PLP in week 3 (1st attempt highlighting misinterpretation) and in week 4 (2nd attempt with corrected

STUDENT RESPONSES	SKILLS IMPACTED
• Reading papers, even though daunting, can be very helpful if one knows how to focus their attention on relevant details. • Learned effective ways to dissect a scientific paper, compared to before this course when I often struggled to adequately understand long, complex papers. • How important the introduction can be to understand the rest of the paper (found the concept map very useful). • Making concept maps made me realize that a lot of the papers actually tell a story. • Drawing out a concept map for the introduction can really elucidate the rational of a study, especially in an unfamiliar field. • I learned that the introduction is a really good overview for the rest of the paper. Concept maps made things so much clearer in terms of actually understanding what was happening in the paper. • Understanding why experiments are performed is a very important aspect of understanding scientific methods. • Generating your own interpretation is helpful in comprehending and critiquing papers.	COMPREHENSION
• Learned to be more critical of the science and the material rather than accepting the results just because it is published. • Learned that scientific literature (even though it is published!!!) can be imperfect and being able to provide insightful critiques is a useful skill.	CRITIQUING
• The importance of paying attention to statistical tests in results figures. • Learned more about the statistical portion of collecting data.	STATISTICAL ANALYSIS

Table 3. Left: Consolidated student responses to the question "What did you learn about reading papers that you were not aware of before?". *Right:* Post hoc classification of responses based on the impacted skills.

information) for the same PLP.

Corrected protein associations demonstrate student

PEER EVALUATION QUESTIONNAIRE	VALUES IMPACTED
Which PLP would you rate as the best and consistent in their presentations over the 4 weeks?	• Student engagement fostered community building • Recognition of peer expertise • Value of collaboration • Self-evaluation and correction
Which PLP showed the most growth in their skills?	
Which classmate showed the most improvement in their literature analysis and presentation skills?	
What is a skill that you learned from your PLP members that you were not aware of or good at before?	

Table 4. Peer evaluation questions and impacted values.

learning of the scientific process in a research lab. Together with the CREATE summary which enabled detailed PRA analysis and the CSS which helped extract and consolidate findings relevant to the research theme, students experienced the rigorous and iterative process involved in conducting research, similar to a real lab setting.

Pedagogical Components for Module Implementation and Extension

In future implementation of the module, a conceptual quiz on the research theme could be incorporated to evaluate the scientific knowledge gained by students through group activities and presentations. Indeed, active-learning approaches such as class discussions of scientific material have been shown to significantly improve student performance in physiology classrooms (e.g., Asem and Rajwa, 2023; Ghorbani and Ghazvini, 2016). Secondly, semantic graphs can be generated by students as a culminating activity by consolidating the meta summaries in

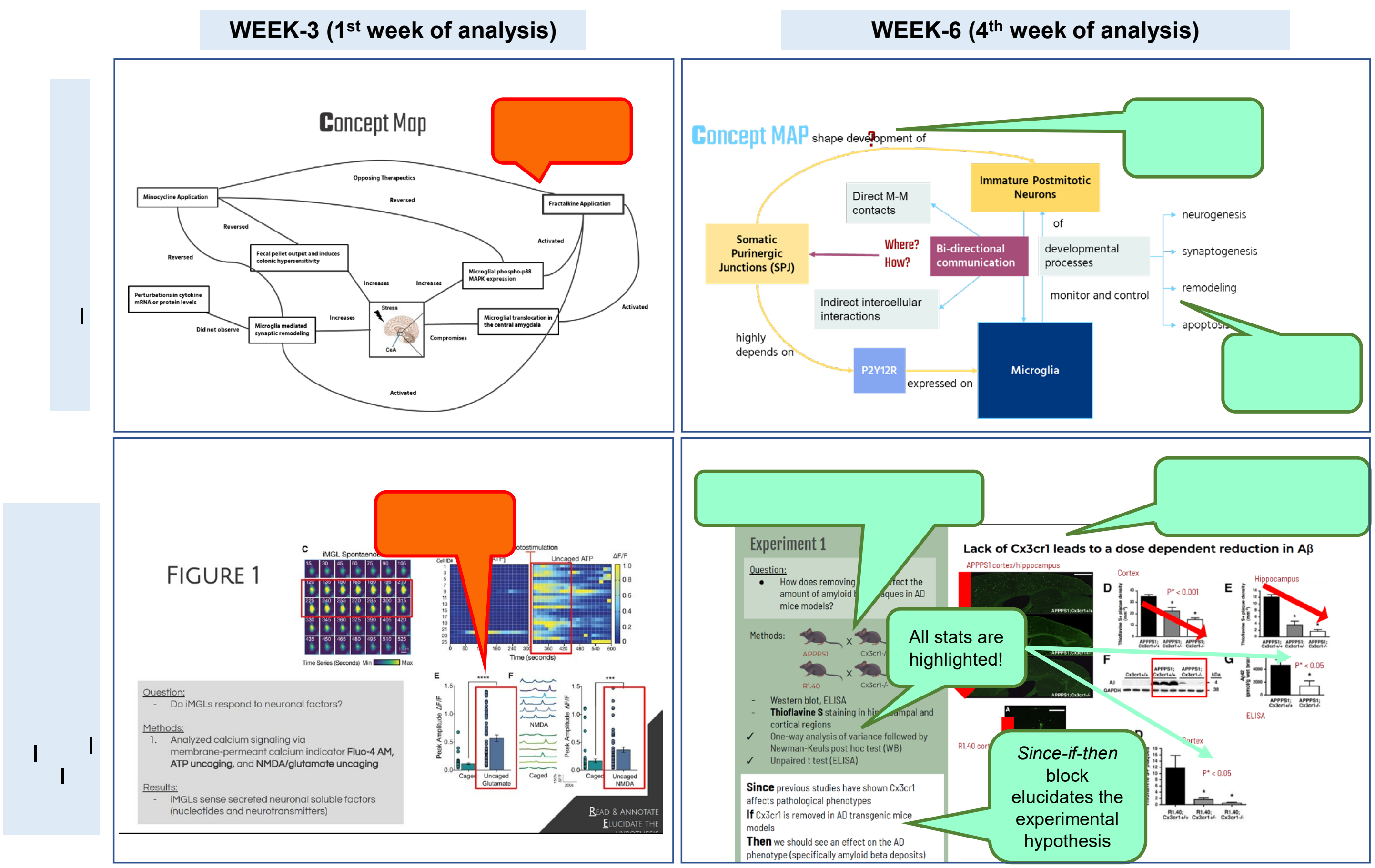

Figure 3. Progressive improvement in student skills to comprehend and critique PRAs. Top panels show concept maps and bottom panels show an integrated analysis of experiment 1 methods and results. Left columns indicate work produced in week 3 (1st week of PRA analysis) and right columns indicate work produced in week 6 (4th week of PRA analysis). Red callouts indicate missing or inadequate evaluations. Green callouts highlight greater details and improvements. Top and bottom figure panels are work from two different PLPs. Left and right panels are produced by the same PLP and demonstrate progressive improvements.

graphical format. For example, Figure 5a shows an alluvial diagram of the protein associations evident from all the student-generated CSS. Figure 5b demonstrates a protein-protein interaction network graph generated for those proteins using the STRING online tool (Snel et al., 2000). repeated offerings of the course could help develop widely applicable research tools such as knowledge graphs on Neuron-Microglia interactions (e.g., (Dang et al., 2021; Santos et al., 2022). Alternatively, unique research themes for future offerings and integration of knowledge graphs into the coursework can help build widely usable pedagogical tools by students and contribute to additional skill development.

DISCUSSION

Training undergraduate researchers requires systematic pedagogical practices for teaching and assessing scientific skill development. In this regard, comprehending complicated scientific literature and deducing integrative knowledge is an evolving process. Furthermore, the process of scientific inquiry can become even more daunting for trainees seeking to develop into independent researchers due to an explosion in scientific information. For example, a quick search on the NCBI PubMed database, using keywords "*(Neuron) AND (Microglia)*" yielded exponentially increasing numbers of published articles in this frontier field, over the years. The list spanned more than 2,175 pages with

Article Info	
PMID	35931030
Link	https://pubmed.ncbi.nlm.nih.gov/35931030/
Year	2022

Protein Info			
		1st attempt in week 3 (misconceived)	**2nd attempt in week 4 (corrected)**
Activator	Protein A	Tumor Necrosis Factor – A	Mutant Alpha Synuclein
Activator	Protein A acronym	TNF-a	A53T
Activator	Protein A cell type	Microglia	Neuron
Effector(s)	Protein B	Matrix Metalloproteinase 13	Matrix Metalloproteinase 13
Effector(s)	Protein B acronym	MMP13	MMP13
Effector(s)	Protein B cell type	Microglia	Microglia
Target(s)	Protein C	Interleukin-1 beta	Nuclear transcriptional activator
Target(s)	Protein C acronym	IL-1b	NF-kB
Target(s)	Protein C cell type	Microglia	Microglia

Figure 4. An excerpt of CSS highlighting student misconception of protein associations in the PRA (see article info) in week 3 (1st attempt), which was corrected by week 4 (2nd attempt). Red font indicates misconceptions and corresponding corrections are in the right column.

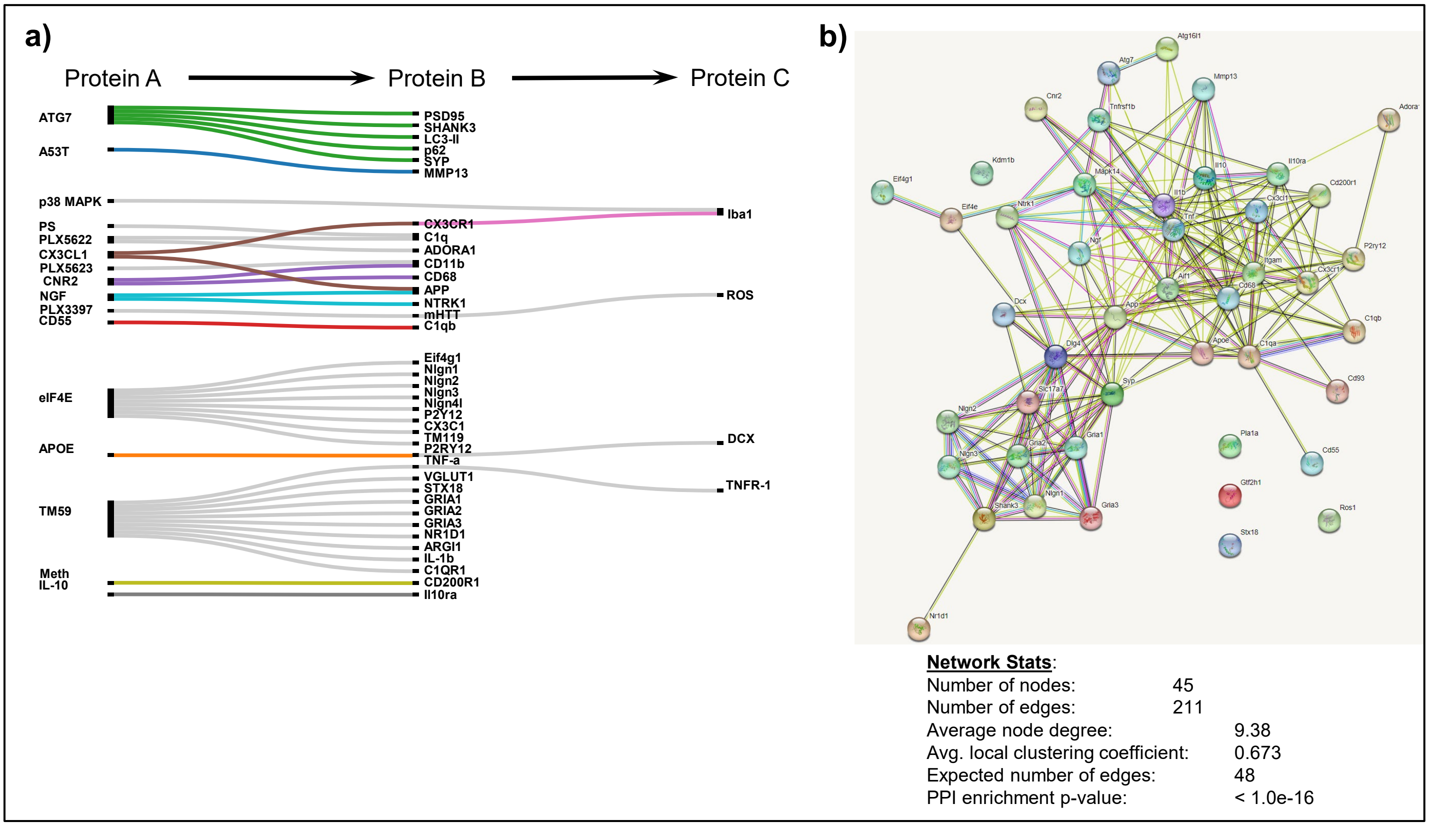

Figure 5. Knowledge graphs of consolidated metadata from the CSS. *a)* Alluvial diagram showing protein associations consolidated from the 24 articles analyzed by all the PLPs over four weeks. Left column indicates activator proteins, middle column indicates effector proteins and right column indicates effector-modulated target proteins. *b)* Protein-protein interaction network generated in STRING software using the list of proteins consolidated in the CSS. The annotations at the bottom indicate the network statistics from STRING.

>2,000 articles published in 2022 alone! Addressing this, the research practice module presented here strives to fill gaps in research training pedagogy and provides a systematic way to teach scientific literature analysis, extending proven methods. Importantly, the module design incorporated innovative components aiming to enhance assessable skills in research practice. Students not only gained knowledge and skills in their discipline; they further developed an understanding of how knowledge is created and integrated. From a pedagogical standpoint, co-implementation of the proven CREATE method and the novel CSS method facilitated gradual skill development which was assessable from week to week. These methods also aided in alleviating student anxiety to comprehend scientific literature.

Since the module focused on a central research theme, all the students gained cohesive knowledge and showed excellent scientific critiquing and collaborative skills. To assess the success of the module, one approach included the SAS, collected anonymously at the end of the 6-week literature analysis module in a 10-week course. A second approach included week-by-week evaluation of skill improvements in the application of CREATE and CSS. The unique integration of the lab-role playing and systematic CSSs further facilitated learning advanced scientific skills in preparation for graduate and medical schools.

To implement the module, Table 1 provides week-by-week design of class activities. The schema in Figure 1 provides structure for the CSS. In the current implementation, learning outcomes were assessed based on evaluating how student skills in critically evaluating each article improved each week based on the clarity and creativity of their concept maps, methods diagrams, elucidating the hypothesis of each experiment, highlighting results with statistics. Further analysis of student responses in the SAS enabled identifying the learning goals which were met (see Tables 2, 3). In the future, systematic rubrics can be incorporated to identify the level of understanding based on the class presentations of essential details of the study. This could necessitate either the instructor or a graduate teaching assistant to evaluate each PRA in parallel; Based on the course context, this may or may not be feasible. Secondly, rubrics can be incorporated to assess the CSS. Indeed, due to the fact that CSS involves extracting meta data from each PRA, a grader could assess learning by, i) evaluating the accuracy of information in the CSS, and, ii) the number of attempts students take to make corrections if needed. In my current assessment, it took students 1-2 weeks of iterations to gather the CSS as expected. Future implementation can further include a component to develop molecular network graphs as shown in Figure 5 and teach valuable network graph theory-based analytical approaches. Such extensions would enhance quantitative skills and further enable students to generate evidence-based novel theories and hypothesis for new experiments.

The course can also be implemented using a project-based course design with equal emphasis on scientific comprehension and knowledge integration via graph models. In summary, the present study offers a systematic pedagogical approach to teach advanced research skills which can be implemented in classrooms and in research labs widely.

REFERENCES

Asem EK, Rajwa B (2023) Impact of combination of short lecture and group discussion on the learning of physiology by nonmajor undergraduates. Adv Physiol Educ 47(1):1-12. doi: 10.1152/advan.00022.2022

Batterton KA, Hale KN (2017) The Likert Scale What It Is and How To Use It. Phalanx 50(2):32–39. doi: http://www.jstor.org/stable/26296382

Dang FR, Tang JT, Pang KY, Wang T, Li SS, Li X (2021) Constructing an Educational Knowledge Graph with Concepts Linked to Wikipedia. Journal of Computer Science and Technology 36:1200–1211. doi: https://link.springer.com/article/10.1007/s11390-020-0328-2

Ghorbani A, Ghazvini K (2016) Using paper presentation breaks during didactic lectures improves learning of physiology in undergraduate students. Adv Physiol Educ 40(1):93-97. doi: https://doi.org/10.1152/advan.00137.2015

Hoskins SG (2008) Using a Paradigm Shift to Teach Neurobiology and the Nature of Science-a C.R.E.A.T.E.-based Approach. J Undergrad Neurosci Educ 6(2):A40-52. doi: https://www.ncbi.nlm.nih.gov/pubmed/23493428

Hoskins SG, Lopatto D, Stevens LM (2011) The C.R.E.A.T.E. approach to primary literature shifts undergraduates' self-assessed ability to read and analyze journal articles, attitudes about science, and epistemological beliefs. CBE Life Sci Educ 10(4):368-378. doi: https://doi.org/10.1187/cbe.11-03-0027

Hoskins SG, Stevens LM, Nehm RH (2007) Selective use of the primary literature transforms the classroom into a virtual laboratory. Genetics 176(3):1381-1389. doi: https://doi.org/10.1534/genetics.107.071183

Santos A, Colaco AR, Nielsen AB, Niu L, Strauss M, Geyer PE, Coscia F, Albrechtsen NJW, Mundt F, Jensen LJ, Mann M (2022) A knowledge graph to interpret clinical proteomics data. Nat Biotechnol 40(5):692-702. doi: https://doi.org/10.1038/s41587-021-01145-6

Snel B, Lehmann G, Bork P, Huynen MA (2000) STRING: a web-server to retrieve and display the repeatedly occurring neighbourhood of a gene. Nucleic Acids Res 28(18):3442-3444. doi: https://doi.org/10.1093/nar/28.18.3442

Received May, 5, 2023; revised October 24, 2023; accepted November 14, 2023.

I thank the Undergraduate Neuroscience Interdepartmental Program at UCLA and Dr. Stephanie White for the opportunity to conduct this course and implement creative ways to improve its impact on student learning.

Address correspondence to: Dr. Sharmila Venugopal, Department of Neurology, David Geffen School of Medicine, University of California Los Angeles, 635 Charles E Young Drive South, Los Angeles, CA 90095. Email: vsharmila@ucla.edu