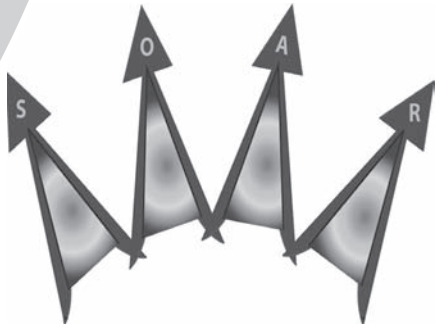
TIPS, TRICKS & TECHNIQUES

Helping Students SOAR: Quizfolio Tips to Engage First-Generation, Under-Represented Minority Undergraduates in Scientific Inquiry



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Abstract

Engaging and gauging (engauging) first-generation, under-represented minority undergraduate general biology students through processes of inquiry, critical thinking, and affective learning is vital as they develop their scientific identity. An important challenge is how we can establish communities of practice and instill in our first-generation students self-awareness and reflection as they apply, analyze, and evaluate data on biological principles. In my article, I describe an innovative weekly assignment for my first generation Hispanic and Native Indigenous students called Quizfolio: quiz and mini-portfolios on biological principles and themes outlined in Vision and Change. Within a SOAR framework that will be introduced in my article, quizfolios provide an active learning space for students to integrate inclusive student-centered, in-class discussions and longitudinal lab inquiries in a first-year undergraduate biology course through metacognition and reflection-in-action. This transformative, culturally responsive mentoring approach encourages first-generation undergraduates to bring self-awareness to unclear or confusing topics that are clarified at the start of class or lab settings, and provides future framework for long-term retention of biological concepts.

Key Words: *quizfolio; course-based undergraduate research experiences (CUREs); spiral curricula and inquiry (spiralquiry); culturally responsive mentoring for research; affective learning; SOAR; metacognition; resiliency; self-confidence; self-efficacy; mandala; community of learners and scholars.*

○ Introduction

One of the important aspects of developing underrepresented minority student's self-confidence and resiliency is to create an inclusive class and lab environment (Rendon, 1994; Aikenhead, 1997; Bandura, 1997; Zimmerman, 2000; Ross, 2016). In particular, fostering the ability for first-generation college students to gain confidence in succeeding in different learning situations, or self-efficacy (Trujillo & Tanner, 2014; Herman & Hilton, 2017) is developed through student-faculty relationship (Valdez, 2016). Furthermore, there is pressing need to find innovative teaching approaches, such as Jo Handelsman and colleagues' scientific teaching approach called engaging and guaging, or *engauging*, (Handelsman et al., 2007), to aid under-represented minority, undergraduate students in the process of inquiry, especially improving retention of both Hispanic and Native Indigenous students in science, technology, engineering, mathematics, and medical science career paths. To engage first-generation Hispanic and Native Indigenous undergraduate students in general biology class and lab settings at Heritage University in Toppenish, Washington, I sought to develop a transformative assignment that blended a quiz and a mini-portfolio, or *quizfolio*. The quizfolio aims to foster students' self-awareness and self-confidence in pursuing the process of scientific inquiry. In addition, it also provides each student a place for reflection and metacognition (Modell et al., 2005; Tanner, 2012; Figure 1). By helping develop students' scientific inquiry and reflection, quizfolio assignments help to develop their critical thinking skills in both class and lab experiences during the academic year.

One of the important aspects of developing underrepresented minority student's self-confidence and resiliency is to create an inclusive class and lab environment.

○ SOAR: Integrated Conceptual Frameworks to Establish a Community of Learners

The quizfolio assignment rests within an integrated SOAR conceptual framework (Figure 2, Table 1) for in-class discussions and lab group discussions that links the following: spiral curricula (Johnston, 2012) and radical pedagogy using Vella's dialogic instruction (Vella, 1995, 2002) combined with Cajete's mandala, or *relationship circle* (Cajete, 1999) for scientific inquiry. Vella's dialogic instruction within the framework of radical

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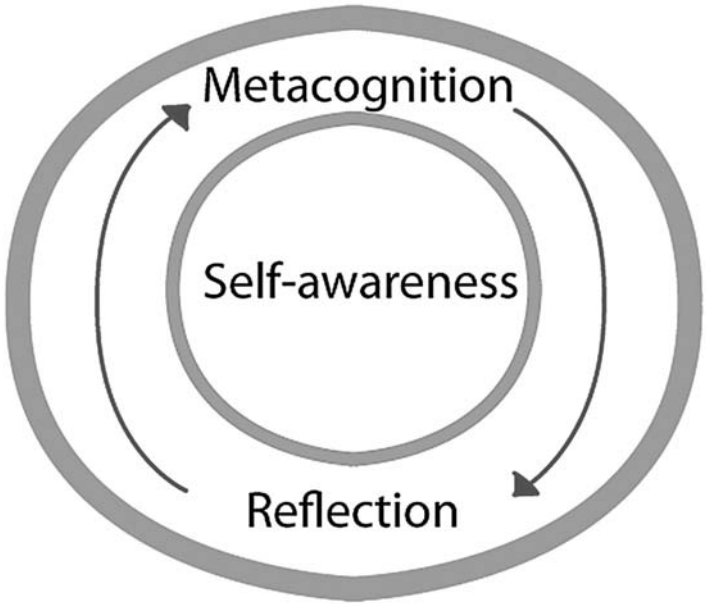

Figure 1. Quizfolios to foster metacognition and self-awareness of students' learning. Quizfolio aims to foster feedback response between metacognition and reflection, thereby fostering students' self-awareness and developing students' science identity.

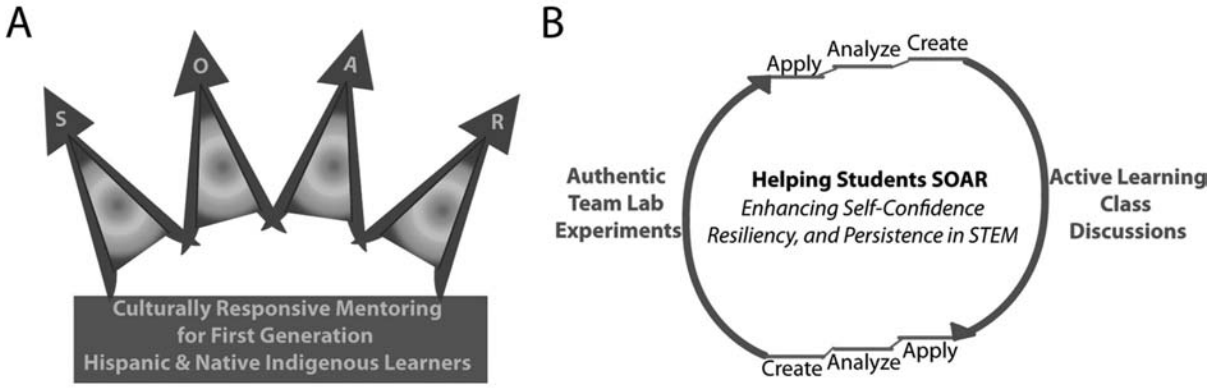

Figure 2. SOAR framework for culturally responsive mentoring in scientific inquiry. **(A)** SOAR approach stands for the following: *S*piral curricula and process of inquiry (*spiralquiry*); *O*bservations from experiments to Evaluation of Data; *A*ffective learning in active learning settings; and *R*esearch across high school and undergraduate curricula. **(B)** Cyclical feedback loop model on SOAR framework infused in authentic lab and active learning class discussion settings (magenta, Bloom's Taxonomy staircase; purple, lab and class settings) to help prepare for careers in science, technology, engineering, and mathematics (STEM).

pedagogy is when both students and instructor are part of the learning community (Guilar, 2006). Here, all participants' voices are part of the dialogic community as it relates to the content being discussed. Infusing dialogic instruction within Cajete's mandala (relationship circle) allows both instructor and learners to explore the interconnectedness among scientific inquiry, themes in biology, and cross-cultural and ethical dimensions of research. This integrated *SOAR*, culturally responsive mentoring approach stands for the following: ***S***piral curricula and process of inquiry (*spiralquiry*); ***O***bservations from experiments to evaluation of data; ***A***ffective learning in active learning settings; and ***R***esearch year-round across high school and undergraduate curricula (Figure 2A).

As students proceed into their authentic, team lab experiment space of learning and process of inquiry (Auchincloss et al., 2014), the instructor embraces published research on culturally responsive teaching and mentoring (Clutterbuck & Ragins, 2002; Matsui et al.,

Table 1. Aligning quizfolio question prompts with class learning goals and outcomes.

SOAR Framework	Learning Outcomes	Learning Goals	Quizfolio Sample Question
Spiral curricula and process of inquiry	Understand the importance of using model organisms to address research questions.	Distinguish and analyze cellular movements of cancer cells and a unicellular freshwater organism, *Tetrahymena thermophila*.	Compare and contrast the movements of the breast tumor cell and *Tetrahymena*, and write down similarities and differences. You may include concepts from chapters 6 and 7 of *Campbell Biology* (11th ed.). Finally, write down one possible research question. Write down all your answers.
Observations from experiments to Evaluation of Data	Analyze, interpret, and evaluate original data from research papers.	Analyze and evaluate original data on human disease research.	Review Figure Facts approach to evaluating collective migration research paper (Round & Campbell, 2013).
Affective Learning in active learning settings	Incorporate and reflect on core biological principles in the context of human disease. Incorporate and reflect on cross-cultural and ethical dimensions of molecular therapies for improving human health.	Grasp the significance of how music, art, and photography impact the lives of research scientists.	Pick one of the short videos on the scientific journeys of Drs. Ramirez (2012), Jarvis (2012), and Villa-Komaroff (2011), and reflect on how their stories impact your own journey toward your career goal(s).
Research Proposals as platform before and after summer research experience	Create and present an original team research mini-proposal on human disease.	Distinguish between negative control and experimental groups in research.	Read chapters 1 and 2 of *Campbell Biology* (11th ed. Metacognition question: After completing the quiz section and reading chapters 1 and 2, what terms or concepts were confusing? Write down all your answers. We will clarify these in class and in lab next week.

2003; Gay, 2010; Haeger & Fresquez, 2016; Jackson et al., 2016; Matsui, 2017), and mentors each student of the research teams throughout the semester (Figure 1B). Here, culturally responsive mentoring is defined as affirming each student's lived experience within one's culture, values, and socioeconomic dimensions, and the instructor is actively listening to the students' inner voice to help facilitate their journey in their pursuit in scientific research setting. By affirming the lived experiences of the student and providing space for reflection, the mentor is part of the students' journey to help each student develop self-confidence, resiliency, and persistence in scientific research. This is used as a stepping stone for future applications for summer research internships throughout the state of Washington and beyond. I will highlight how quizfolios are constructed within a flexible SOAR framework aligned with the course learning outcomes and objectives.

○ Tips for Constructing Quizfolios

To design quizfolio questions, I align them to the learning outcomes of my general biology course and incorporate both affective learning and biology core learning objectives (Tables 1 and 2A, Appendices 1 and 2). In particular, BioCore Guide (Brownell et al., 2014) was utilized to create linked *Vision and Change* principles within each module of the 15-week, semester-long general biology course (Table 2B). Below are some key tips to keep in mind when constructing your quizfolio:

1. During the first two weeks of class, foster student-teacher relationship by meeting with students at a common meeting place on campus, such as the cafeteria. Based upon Valdez's research, fostering these relationships with first-generation undergraduates is important. It can also help foster a community of learners and scholars.
2. Develop place-based and social-emotional learning by integrating environmental and health with topics discussed in class (Hatano & Inagaki, 1999; Greenwood, 2009; Bang, 2015). These can be developed into some of the mini-portfolio reflection questions in the quizfolio for in class discussions.
3. Integrate two or three model organisms into lab-inquiry settings for your team research groups to pursue throughout

Table 2A. Learning outcomes and assessment methods within flexible SOAR framework.

Learning Outcomes	Assessment Methods
Analyze, interpret, and evaluate original data from research papers.	Quizfolios, Formative Dialogue, Essay-based cumulative exams, Pre-/Post-Gallery Walk (Francek, 2006)
Distinguish, apply, and integrate biological concepts in the context of human health and disease progression.	Quizfolios, Formative Dialogue, Essay-based cumulative exams
Incorporate and reflect on core biological principles in the context of human disease.	Quizfolios, Formative Dialogue, Essay-based cumulative exams
Create and present an original, community-centered team research mini-proposal on human disease.	Quizfolios, Formative Dialogue, mini-proposal
Incorporate and reflect on cross-cultural and ethical dimensions of molecular therapies for improving human health.	Quizfolios, Formative Dialogue, Essay-based cumulative exams, Pre-/Post-Gallery Walk*

Table 2B. Aligning *Vision and Change* with flexible SOAR framework.

	General Biology Modules with Cell Developmental Biology and Physiology Emphasis	*Vision and Change* Principles Aligned to Course Modules in Consultation with BioCore Guide (Brownell et al., 2014)
Week 1	Process of Inquiry: From Molecules, Cells, to Organ Function	Structure/Function, Evolution, Information Flow, Systems
Week 2	Molecular Tetris: Building Blocks of Life	Structure/Function, Information Flow, Transformations of Energy and Matter
Week 3	Molecular Movement, Flow, and Function	Structure/Function, Information Flow, Transformations of Energy and Matter, Systems
Weeks 4 & 5	Structure and Function of Molecules & Metabolism	Structure/Function, Transformations of Energy and Matter
Weeks 6–8	Inside-Outside: Molecular Zip Codes & Signaling	Structure/Function, Information Flow
Weeks 9–10	Blood, Circulation, and the Immune System	Structure/Function, Information Flow, Systems, Evolution
Week 11	Heart and Kidneys	Systems, Evolution, and Structure/Function
Week 12	Genetic Inheritance and Reproduction	Information Flow, Structure/Function, Systems
Week 13	Nerves & Muscle Cell Function	Information Flow, Structure/Function, Systems
Weeks 14–15	Molecules, Cells, Organs Integration Module	Evolution, Information Flow, Structure/Function, Transformation of energy and matter, Systems

the quarter or semester. As the late Nobel Prize winner Barbara McClintock once said, "Develop a feeling for the organism" (Bang, 2015). Create lab inquiries that cultivate students' curiosity, self-confidence, and resiliency in the process of scientific investigations.

4. Infuse cross-cultural and ethical dimensions of biological research into learner outcomes of the course, and actively listen to students during lab inquiry and in-class dialogic interactions. Keeping an active journal of your reflections on these activities is highly recommended (Schön, 1984).
5. Pick important themes and develop them into spiral curricula that circle back to these important principles of your course. The themes of evolution, structure and function, systems, information flow, exchange, storage, pathways, and transformations of energy and matter can be integrated within the themes of your course.

The quiz section may contain modified questions from Pearson's *Mastering Biology* or created by the instructor. Appendices 1 and 2 are quizfolios that contain open-ended questions to help integrate and synthesize concepts from readings or iBiology research videos. A total of ten quizfolio assignments were then integrated within the modules of the course with an example weekly schedule format (Table 3). For instance, to provide opportunities to reflect on how the process of scientific inquiry relates to how scientific identity is cultivated, I include reflection questions that incorporate a scientist's own path to becoming a scientist, available

Table 3. Scheduling of quizfolio assignments within in-class discussion and lab settings.

	Monday	Tuesday	Wednesday	Thursday	Friday
Clarify terms and concepts from quizfolio assigned the previous Friday					
In-class worksheets for class discussions	x		x		x
Apply concepts in lab setting on model organisms					
Apply, analyze, and evaluate data	x		x		x

through iBiology, and connect this with lab inquiry on model organisms and how scientific discoveries were made, such as the molecular and cellular basis of tumor collective cell migration (Cheung et al., 2013; Cheung & Ewald, 2016). Finally, concepts or terms that are confusing can be pre-read by the instructor to ensure they are clarified at the start of class discussions.

Upon completion of quizfolios, I invite students to work in small groups and ask them what terms and concepts were confusing from the quizfolio assignment (Table 1, and example quizfolios in Appendices 1 and 2). After fielding their responses, I then clarify these concepts, then refine and apply these clarified concepts to research data to enable students to interpret, analyze, and evaluate the data. Experimental design, such as distinguishing between a negative control group and experimental group, are emphasized throughout the semester on all topics outlined in *Vision and Change* (AAAS, 2011).

○ Quizfolios: An Invitation for Students to Investigate Team Research Projects Using Model Organisms

The quizfolio also serves as a framework for students to develop research questions and testable hypotheses in the laboratory during the semester. For instance, during the first week of our general Biology II class with an emphasis on structure/function and cell and tissue physiology, the lab had been restructured to include model organisms. In research groups, students distinguish among different model organisms, such as *C. elegans*, planaria, and zebrafish, and develop a working research question to help them formulate a testable hypothesis. With reflection and feedback from the instructor, students apply and revise their experimental plan throughout the semester. This framework culminates in each research group's development of an original mini-research proposal and research presentation. By introducing these concepts in general biology, students will be prepared to further refine and create their individual research proposals in future upper-level division courses, such as genetics/epigenetics and developmental biology.

In addition to general biology course and lab settings, quizfolio assignments can also be adapted to upper-level biology courses, as well as for undergraduate nursing students in genetics and epigenetics workshop. Future course curriculum design will expand this approach into additional settings, such as preparing undergraduate students for yearly summer research experiences and long-term tracking in their chosen science career fields.

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Appendix 1. Quizfolio Assignment #1: Process of scientific inquiry and chemistry of life

Student's Name: _____

Directions

Please answer the following quiz questions and mini-portfolio questions on the process of scientific inquiry and chemistry of life. Refer to Chapters 1 and 2 of *Campbell Biology* (11th ed., 2017) for reference as you complete the questions below. *You may work in small groups, but be sure to write down your own original answer.* We will review and discuss your answers in class, and will reinforce these concepts in class and lab next week.

Part 1: Quiz Questions (pages 1–9, worth 21 points)

From *Mastering Biology*, quizzes for chapters 1 and 2. Retrieved from https://www.pearsonmylabandmastering.com/northamerica/masteringbiology/

Part 2: Mini-Portfolio (3 questions, 19 total points)

1. After completing the quiz section and reading chapters 1 and 2, what terms or concepts were confusing? Write down all your answers. We will clarify these in class and in lab next week (3 points).
2. **Signals in the Brain Cell and Pain Perception.** After analyzing Figure 2.16 from chapter 2 (page 40) of *Campbell Biology*, how are natural endorphin and morphine able to bind to different types of endorphin receptors in brain cells? Write down all your answers.
3. Pick one of the short videos on the scientific journeys of Drs. Ramirez, Jarvis, and Villa-Komaroff below, and reflect on how their stories impact your own journey toward your career goal(s).

Robert Ramirez, "How I became a scientist: From ranch to research" (2012, December). Retrieved from https://www.ibiology.org/profiles/ranch-to-research/

Erich Jarvis, "How I became a scientist: From dancing to science" (2012, April). Retrieved from https://www.ibiology.org/profiles/dancing-to-science/

Lydia Villa-Komaroff, "How I became a scientist: Family, mentors, and SACNAS" (2011, September). Retrieved from https://www.ibiology.org/profiles/sacnas/

Appendix 2. Quizfolio Assignment #5: Of Cellular Structure & Function: Insights into Human Diseases

Student's Name: _____

Directions

Please answer the following quiz questions and mini-portfolio (quizfolio) questions on cell structure and function. Focus on key concepts emphasized in Quizfolio 5, and refer to Chapters 6 and 7 of *Campbell Biology* (11th ed., 2017) for reference. You may also review Chapters 17 and 20. Mini-portfolio question on molecular control of cell migration in normal cell function and cancer cell spreading. *You may work in small groups, but be sure to write down your own original answer.* We will review and discuss your answers in class, and will reinforce these concepts in class and lab next week.

Part I: Quiz Questions (20 points)

From *Mastering Biology*, quizzes for Chapters 6 and 7. Retrieved from https://www.pearsonmylabandmastering.com/northamerica/masteringbiology/

Part II: Mini-Portfolio Section (3 questions, 20 total points).

1. **Mechanisms of Cell Migration.** After watching Dr. Julie Theriot's short video on *Actin and Cell Motility* (https://www.youtube.com/watch?v=f5TVKPorqFs) and reflecting on our readings from Chapters 6 and 7, write a short reflection essay on what you are learning, what you would like to learn more about, and include one research question and hypothesis. Write down all your answers.
2. **Unicellular Organisms & Breast Tumor Cell Migration.** Recall from earlier this semester that we began to explore how breast tumor cells migrate and invade other tissues in the body. This video can be found here: http://www.cell.com/cms/attachment/2021777353/2041660697/mmc1.mp4

   After comparing this video with an unicellular organism called *Tetrahymena* that we will work with on Tuesday's lab, distinguish the movements of the breast tumor cell and *Tetrahymena*, and write down similarities and differences. You may include concepts from Chapters 6 and 7 of *Campbell Biology*. Finally, write down one possible research question. Write down all your answers.
3. After completing the chapter readings and viewing Dr. Julie Theriot's talk on actin and cell movement, what terms or concepts are confusing or unclear? Write down all your answers, and we will review them in lab & class next week. (5 points).