Supplemental Material

CBE—Life Sciences Education

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Supplemental Material 1. Instructions for using the taxonomy as a guide to document classroom practices and provide instructor feedback

Rationale

During the course of conducting classroom observations for taxonomy development and validation purposes, several instructors asked for feedback on their classes. We found that the taxonomy served as a useful framework for facilitating dialogue with course instructors on their teaching practices. Here, we outline a general procedure for an outside observer to use the taxonomy to guide instructional feedback.

Procedure

1. Make arrangements with the course instructor to conduct a classroom observation. Particular class sessions may be atypical (e.g., first day, test days, student presentations, etc.), and care should be taken to schedule the observation in light of the instructor's feedback needs.
2. Prior to class, become familiar with the goals and practices listed on the taxonomy. It is also helpful to speak with the instructor before class to learn more about student demographics, course content, and class goals.
3. Upon arriving in class, sit in an inconspicuous location in the classroom. In smaller classes, the instructor should introduce the observer to students and explain why the observer is attending class.
4. During class, record detailed field notes on instructor and student activities, including time stamps for the start of each new topic or activity. Highlight periods in which ST practices were utilized by the instructor.
5. Immediately after class, review the list of ST practices and mark any practices observed.[a] Write a short narrative description of the context in which each practice was observed. In cases where practices are observed multiple times, make notes regarding each unique practice implementation.
6. Prior to the next class session, meet with the instructor to discuss the observation. Share the ST taxonomy and accompanying notes with the instructor, and highlight instances in which ST practices were observed.[b] Some practices (e.g., summative assessments) may not be applicable for the given class session.

[a] When documenting ST practices, it is important to note the student-centered language of each practice. The taxonomy is intended to capture opportunities provided to students by the instructor, and thus most practices cannot occur while the instructor is lecturing. For example, only instances of students—not instructors—solving interdisciplinary problems would be marked as "students apply knowledge from mathematics, computer science, biology, chemistry, physics, or other disciplines within the context of a different discipline."

[b] Often times, the practices that are not observed are just as important as the practices that are observed. For example, students may be asked to make experimental predictions, but perhaps not in a graphical format. The instructor may wish to incorporate this additional layer in subsequent activities.

Supplemental Material 2. A reformatted version of the taxonomy for use as a guide to document classroom practices and provide instructor feedback

Pedagogical Goal and General Approach:	*Supporting Practices:*	*Observed: yes/no*	*Description and Comments:*
COURSE ALIGNMENT			
Students understand learning and performance expectations based on information from the instructor that defines what students should know and be able to do at course completion.	1. Students are provided learning goals detailing conceptual understandings, content knowledge, and process skills they are expected to master.		
Students work to accomplish course objectives by participating in exercises and formative assessments that align with the desired outcomes.	2. Students are able to connect activities and formative assessments with specific learning objectives.		
Student achievement of course objectives is accurately measured using summative assessments that are aligned with the desired outcomes.	3. Students are able to connect material on summative assessments to specific learning objectives.		
	4. Student summative assessments use different formats or multiple types of answer input.		
Students inform course curriculum decisions by providing feedback and performance data to the instructor.	5. Students are given the opportunity to provide feedback on course structure and content.		
	6. Students ask questions or state interests that are pursued during class.		
	7. Students are given supporting activities when assessment reveals a problem area.		

SCIENCE PRACTICES			
Students explore the relationship between science and society by reflecting upon science in the context of society throughout history and in the present day.	8. Students use historical information to recognize why certain discoveries represent paradigm shifts or major technological advancements.		
	9. Students relate scientific concepts to everyday phenomena or human experiences.		
	10. Students utilize scientific judgment to address challenges facing nature or society.		
Students use science process skills by engaging in practices integral to the performance of science.	11. Students identify, construct, or evaluate hypotheses and make predictions based on their hypotheses.		
	12. Students design and evaluate experimental strategies.		
	13. Students analyze data using appropriate methods, such as descriptive or inductive statistics.		
	14. Students construct graphs or tables and analyze results presented in these formats.		

Students synthesize experimental results by critically evaluating multiple pieces of data and drawing conclusions based on evidence and reasoning.	15. Students formulate or evaluate conceptual models based on data and inference.		
	16. Students attempt to reconcile conflicting pieces of data.		
	17. Students develop arguments or make decisions based on experimental data.		
Students engage in formal scientific discourse by interpreting and communicating scientific ideas.	18. Students read and evaluate scientific literature, including peer-reviewed and popular media articles.		
	19. Students present scientific ideas in written or oral formats.		
STUDENT PARTICIPATION			
Students engage in class by participating in active learning exercises that serve as formative assessments.	20. Students answer questions, solve problems, or construct representations.		
	21. Students complete formative assessment activities and receive feedback on their answers.		

Students refine their knowledge through peer interactions by participating in small group activities that require discussion.	22. Students complete worksheets, discuss problems, and perform other activities in groups of two or more.		
	23. Students provide peer feedback on projects, assessments, or other activities.		
	24. Students complete tasks where the success of the group involves the participation of each group member.		
Students participate at the whole-class level because the instructor provides mechanisms and formats that facilitate class-wide participation.	25. Students use an audience response system or other polling method to answer content questions.		
	26. Students report the results of group work to the whole class.		
	27. Students are encouraged to respond to other student ideas.		

Students of diverse backgrounds are affirmed as members of the class and scientific community by considering the perspectives and contributions of people with different origins, genders, and affiliations.	28. Students consider contributions of diverse people and perspectives in the realm of scientific discovery.		
	29. Students utilize examples and analogies that reflect diverse people and cultures.		
	30. Students are grouped using mechanisms that enhance the diversity of each group.		
	31. Students are aware of instructor sensitivity to socially controversial issues.		
COGNITIVE PROCESSES			
Students practice higher-order cognitive skills by applying, analyzing, synthesizing, or evaluating evidence, concepts, or arguments.	32. Students incorporate lower-order knowledge into higher-order cognitive skills development.		
	33. Students interpret or construct conceptual representations in a variety of formats, including video, pictorial, graphic, or mathematical.		
	34. Students engage in structured, open-ended inquiry exercises, such as case-based or problem-based activities.		

Students transfer knowledge and skills across disciplines by utilizing skills or concepts from multiple disciplines to solve scientific problems.	35. Students apply knowledge from mathematics, computer science, biology, chemistry, physics, or other disciplines within the context of a different discipline.		
Students learn to think metacognitively by reflecting on the effectiveness of their learning and problem-solving strategies.	36. Students consider assumptions, appropriateness of skills utilized, or thought processes when solving problems or answering questions.		
	37. Students reflect on the effectiveness of their study habits.		