Characterizing Instructional Practices in the Laboratory: The Laboratory Observation Protocol for Undergraduate STEM (LOPUS)

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Table A. TAs' instructional behaviors captured in LOPUS

Bolded codes were co-coded with the nature of verbal interactions (Table C, Supporting information). Asterisks indicate codes were modified from or added to COPUS.

Type of behavior	Code	Definition
Typical instructional behaviors	**Lec**	Lecturing to the class
	RtW	Real-time writing on the board, document camera, etc.
	FUp	Providing follow-up/feedback on activity (after quizzes, lab work, etc.)
	D/V	Showing or conducting a demonstration (such as proper use of equipment), simulation, animation, video, or manipulating a physical model (*e.g.* molecular models)
	M*	Monitoring class or individual groups without interacting with students for at least 5 seconds; TA may or may not be moving while doing so
Interactive behaviors	**PQ**	Posing lab-related question or request to student/s with entire class listening (non-rhetorical)
	1o1-Talk*	Talking to individual student or group of students one-on-one
	1o1-TPQ*	Posing a question to an individual student or group of students in a one-on-one interaction
	VP*	Verbal monitoring ("how's it going"-like statements) and positive reinforcement
	TI*	Initiating a one-on-one interaction with an individual student or group of students, coded in conjunction with 1o1-Talk or 1o1-TPQ
Non-instructive behaviors	Adm	Performing administrative tasks, such as lab set-up or clean-up, handing out/retrieving assignments and materials, including laboratory equipment
	W	Waiting, not interacting with students, generally unavailable to students for at least 5 seconds, for example reading notes to self
	O	Other behaviors (see Table C)

Table B. Students' instructional behaviors captured on LOPUS

Bolded codes were co-coded with the nature of verbal itneractions (Table C, Supporting Information). Asterisks indicate codes were modified from or added to COPUS.

Type of behavior	Code	Definition
Typical instructional behavior	L	Listening to TA, video, or student presentations as a class and obviously paying attention (looking at TA)
	Lab*	Performing the lab activity
	TQ	Taking a test or quiz
Interactive behaviors	**SQ**	Asking the TA a lab-related question with entire class listening
	1o1-SQ*	Individual student or a group of students asking the TA a lab-related question
	WC	Engaging in whole-class discussion, including explanations, opinions, and judgments, often facilitated by the TA
	Prd	Making a prediction about the outcome of a demonstration or experiment, including thought experiments
	SP	Giving verbal presentations that require students to explain their data/experiment/results to the rest of the class
	SI*	Initiating one-on-one interaction with the TA, coded in conjunction with 1o1-SQ
Non-instructive behaviors	SL*	Leaving the lab for the day
	W	All students are waiting and not performing any kind of activity due to technical difficulties, waiting for instrument to operate or reactions to occur, TA otherwise occupied, etc.
	O	Other behaviors (see Table C)

Table C. Other behaviors

Behaviors that were not directly related to the instruction of the laboratory were coded as Other (*O*). For example, coders used *O* to describe students and TAs engaging in off-task conversations, such as the weather or an upcoming sporting event. Assignment- or grade-related matters, such as submitting reports or online homework, were also coded as *O*. A list of *O*-coded behaviors are provided below.

Behaviors coded as 'Other' (*O*)
Students • **Reading and signing a safety protocol** • **Retrieving assignments or laboratory reports** **TAs** • **Listening to a student read the safety protocol out loud** • **Speaking to another TA, the lab coordinator, or one of the authors** • **Leaving the room** • **Reminding students about class meetings or upcoming exams** **Students and TAs** • **Engaging in conversations about grading matters or homework** • **Engaging in off-task conversations**

Table D. Nature of verbal interactions

The following codes are used along with bolded codes in Tables A and B in the Supporting Information.

Nature of verbal interaction code	Definition
Cpt	Underlying scientific principles, such as macro/microscopic perspectives; definitions do not count
Ana	Data analysis and calculations, including equations
Exp	Experimental procedures, equipment (including reagents) and laboratory techniques
Sft	Safety or cleanup procedures in the laboratory
Pvs	Previous laboratory activities, quizzes, or exams; not to be cross-coded with Cpt, Ana, and Exp

Figure A – Snapshot of LOPUS in the Generalized Observation Reflection Platform (GORP)

LOPUS has been integrated into the Generalized Observation Reflection Platform (GORP) - http://tea.ucdavis.edu. This web platform permits live or video-based coding with LOPUS. It also provides a basic analytical report and an excel spreadsheet that can be used for more complex analyses.

Students' behavior codes (Table B, Supporting Information) are represented with orange buttons, and TAs' behavior codes (Table A, Supporting Information) are represented with green buttons. Content codes (Table C, Supporting Information) are presented as sub-options when selecting *Lec, SQ, PQ, 1o1-Talk, 1o1-TPQ,* or *1o1-SQ.*

Figure B – Intersection of the codes describing the nature of verbal interaction and TA-students verbal interactions at the whole-class level

Percentage of 2-min intervals coded for *Lec, PQ,* or *SQ* coded with nature of verbal interaction codes (Table D, Supporting Information). Error bars represent standard deviations.
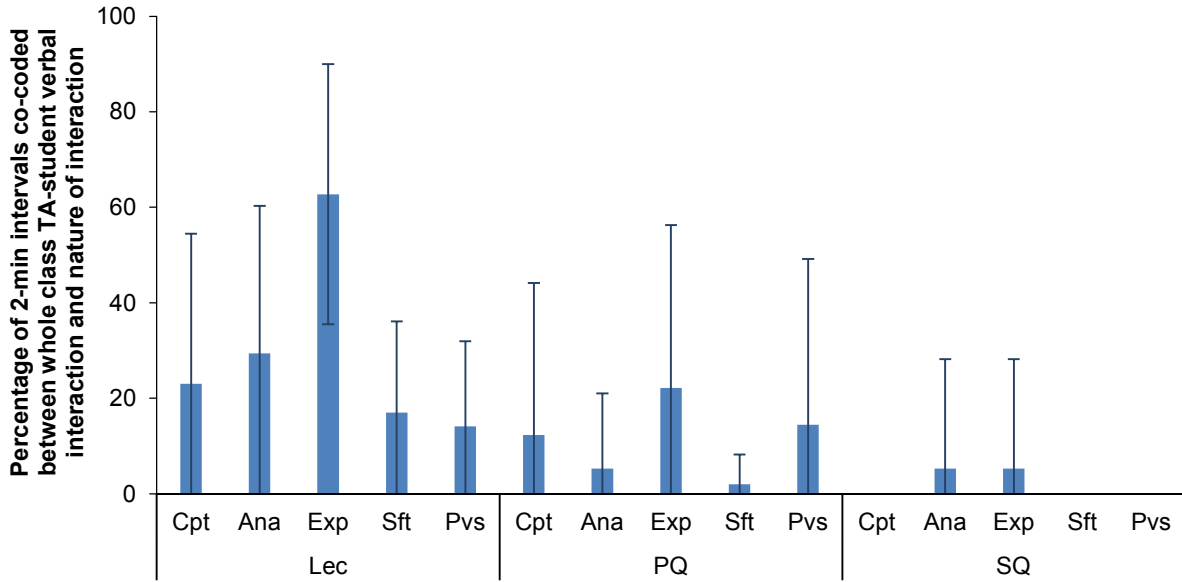
Figure C – Intersection of the codes describing the nature of verbal interaction and one-on-one TA-student verbal interactions

Percentage of 2-min intervals coded as *1o1-Talk*, *1o1-TPQ*, or *1o1-SQ* coded with nature of verbal interaction codes (Table D, Supporting Information). Error bars represent standard deviations.