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Feature
Approaches to Biology Teaching and Learning

Talking to Learn: Why Biology Students Should Be Talking in Classrooms and How to Make It Happen

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INTRODUCTION

Many 50-min biology lectures occur every day all around our country, with the majority of students listening but never uttering a word. Why do the majority of undergraduate biology students primarily experience biology teaching, particularly in introductory courses, by listening, listening, and listening some more? I've had numerous discussions with earnest colleagues about how to improve biology teaching and increase student learning in undergraduate courses, especially big lecture courses. Often, I inquire about whether students are talking in their classrooms, and the answer is generally no. Most instructors aren't resistant to promoting Student Talk, as I'll refer to it, but they aren't sure about how to make it happen.

Encouraging Student Talk in classrooms is a good place to begin working on your own teaching for two reasons. First, most instructors seem to agree that Student Talk is an important part of learning. Resistance to this idea is rarely encountered, in contrast to the skepticism encountered in response to suggestions of more complex teaching approaches. Getting students talking seems, for the most part, uncontroversial among instructors, and it is widely recognized as an important way for students to process new information. Second, and more importantly, teaching strategies that can encourage and structure Student Talk are some of the simplest teaching techniques that we encounter. Sure, these techniques can be made quite complex, usually by embedding them in a larger, more elaborate approach to teaching. But almost any "named" pedagogy or teaching strategy currently in use—cooperative learning, case-based learning, clicker questioning, process-oriented guided inquiry learning, just in time teaching, and peer-led team learning, to name just a few—has Student Talk as a core requirement. Student Talk can be thought of as the common denominator of many innovative, active, inquiry-based approaches to teaching. And importantly, the most common strategies for getting students to talk are those with which most undergraduate biology instructors can have quick success.

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Currently, many undergraduate biology students are more likely to experience Student Talk outside of the formal classroom setting than in it. Supplemental courses, tutoring sessions, and informal study groups are where Student Talk is most common. Although this is fortunate for students involved in these activities outside of class time, it is unfortunate that Student Talk is not currently a systematic part of the biology course experience for every student. Those students who may need to talk out their ideas the most may also be those who are least comfortable forming an informal study group or seeking out a tutor or extra class. These students may, in fact, not even view talking as a part of learning, largely because we as instructors don't show that we value Student Talk, either implicitly by integrating it into our curricular activities or explicitly by telling students that talking about their ideas, confusions, and wonderments out loud is a part of learning.

If instructors in general value Student Talk, why isn't Student Talk a bigger part of undergraduate biology teaching? Below, I consider research evidence that suggests that Student Talk is important in learning, address common challenges that instructors face in getting students talking, and describe some simple teaching strategies that anyone can use tomorrow in their classroom to make Student Talk happen.

WHY IS IT IMPORTANT FOR STUDENTS TO BE TALKING IN BIOLOGY CLASSROOMS?

As mentioned, there seems to be common ground among instructors with many different teaching styles that talking is key to student learning. In general, there are four categories of reasons offered by instructors about why they value Student Talk, and many readers will have additional reasons to add. As shown in Table 1, instructors perceive that Student Talk: 1) enriches the individual student learning experience; 2) transforms the nature of the large lecture class; 3) provides instructors with insight into students' thinking; and 4) promotes a collaborative, rather than competitive, culture in undergraduate science classes.

Table 1. Perceived outcomes of promoting Student Talk in undergraduate classrooms

Perceived outcomes of Student Talk	. . . which more specifically results in . . .
Transforms the nature of the large lecture class by . . .	Fostering meaningful learning during class time. Making large lecture classes more like small discussion sections and supplemental courses. Allowing students the opportunity to verbally rehearse their questions with peers and increasing the number of students actively involved in class discussions.
Enriches the individual student learning experience by . . .	Increasing student engagement and interest in coming to class. Providing opportunities for students with diverse learning styles to engage in the classroom beyond listening and more kinesthetically, interpersonally, and linguistically. Promoting student thinking about what they understand and what they don't understand, and so promoting meta-cognition.
Provides instructors insight into students thinking by . . .	Allowing instructors to listen to students' understandings and misconceptions. Allowing instructors opportunities to listen to students' use of language, key terms, and new vocabulary.
Promotes a collaborative, rather than competitive, culture in undergraduate science classes by . . .	Reducing students' feelings of isolation in large lecture classrooms. Engaging students in peer teaching and learning that may foster study groups outside of class time.

WHAT EVIDENCE IS THERE THAT STUDENT TALKING LEADS TO LEARNING?

The assertion that talking is an important facet of learning occurs frequently in the literature of developmental and cognitive psychology (Webb, 1989; Chi et al., 1994; Bielaczyc *et al*., 1995; Coleman *et al*., 1997; Lee and McKendree, 1998). In an analysis of numerous studies, Webb found that increased achievement after learning in small groups was associated with those students giving explanations and not associated with those receiving explanations (Webb, 1989). More recently, Chi *et al*. (1994) have elaborated on the role of talking in learning by postulating that a cognitive process underlying talk, termed self-explanation, facilitates the integration of new knowledge into existing knowledge. In the specific domain of biology learning, Coleman *et al*. (1997) demonstrated that students who were engaged in teaching others through explaining experienced the strongest effect on their learning, compared with students engaged in teaching others through summarizing. In addition, those students who only listened to other students (who were either explaining or summarizing) showed the smallest effect on learning). Although the mechanisms by which learning is facilitated by talking, explaining, or self-explaining are still unclear, one recent publication that focused on the role of talking in the undergraduate biology classroom merits further discussion.

Student Talk Itself, Not Just Knowledgeable Peers Sharing Answers, Is Key to Learning

In their recent article entitled, Why Peer Discussion Improves Student Performance on In-class Concept Questions, Smith *et al*. (2009) address a persistent question about the value of Student Talk. Situated in the context of university biology classrooms, these researchers set out to distinguish whether Student Talk in conjunction with clicker questions improves performance because understanding increases or because pressure from peers perceived to be knowledgeable influences other students to choose the correct answers.

The recent rise of Student Talk in large university lecture classrooms has been driven, in part, by instructors' use of clicker systems (Wood, 2004; Caldwell, 2007). This classroom technology allows every student to electronically register a response to a multiple-choice question anonymously. Clicker systems allow instructors to see an immediate summary distribution of all students' responses. Clickers are not necessarily linked to Student Talk, but they do provide instructors with an efficient mechanism for collecting data on student responses. Smith and colleagues exploited this advantage of clickers to collect data to investigate whether talking just gets students answers from peers or whether a deeper understanding emerges from the act of engaging in talk itself.

In this study, students first registered their initial answers to a conceptual question via clickers. Second, students engaged in Student Talk about the question with their lecture neighbors. Third, students registered their postdiscussion answers. Finally, students were given a second question related to same concept but in a different context. These questions were referred to by the authors as "isomorphic" and defined as "questions that have different cover stories, but require application of the same principles or concepts for solution" (Smith *et al*., 2009). All student responses were recorded via clickers, so that the researchers could track the profile of an individual student's responses over the process. Importantly, they did not show the students a summary of their responses, have a whole class discussion, or provide any instructor input into the conversation (all of which often occur in conjunction with Student Talk in classrooms) during data collection.

What the authors found was striking. First, analysis of data pooled from 16 question pairs asked of >300 students showed that the average percentage of students who answered correctly on the second isomorphic question was significantly higher than the percentage who answered the initial question correctly AND significantly higher than the percentage of students who answered that same question correctly after discussion. Second, students whose answers to the first question were incorrect initially but correct after discussion were 77% correct on the second isomorphic question, whereas those who were incorrect initially and again incorrect after discussion were only 44% correct on the second isomorphic question. This suggests that the former students (and probably also some of the latter) did indeed increase their understanding during discussion enough that they could generalize this understanding to a new question. Third, the authors analyzed the statistical likelihood that knowledgeable students could have been present in each small discussion group (of approximately three students) to simply transmit correct information. At least for the most difficult questions, for which <20% of the students answered the initial question correctly, fewer than half of the discussion groups would have included a student who could answer the initial question correctly. This led the authors to their strongest conclusion, "that peer discussion enhances understanding, even when none of the students in a discussion group initially knows the correct answer."

PERCEIVED BARRIERS TO MAKING STUDENT TALK A COMMON EXPERIENCE IN (LARGE) UNDERGRADUATE BIOLOGY CLASSES

Even with research evidence to support the importance of Student Talk in learning, and widespread agreement among instructors as to its value, Student Talk in undergraduate science classrooms often just isn't happening. What are the impediments that keep instructors from engaging every single student in talking about their ideas every time they enter a biology class, regardless of class size? Student Talk seems to occur more often in university social science and humanities classrooms, so why not in university science classrooms? Table 2 lists some possible reasons that suggest why we're not making Student Talk happen in our undergraduate biology courses. These perceived barriers suggest that many instructors need support in addressing three key issues: 1) how to choreograph the mechanics of getting all students talking at once for a brief time, 2) how to cultivate a classroom culture that values talk as part of learning, and 3) what to do while students are talking.

OVERCOMING THE PERCEIVED BARRIERS: STRATEGIES FOR GETTING ALL STUDENTS TALKING IN UNDERGRADUATE BIOLOGY CLASSROOMS

To provide some practical strategies and guidance on promoting Student Talk, each of the perceived barriers that are common among instructors is addressed below. Although each instructor has his or her own individualized teaching style and although there are no doubt nuances and quirks to every classroom situation, the strategies below are highlighted because they should be applicable to biology classes of any size, on any topic, with any population of students.

On Choreographing the Mechanics of Getting All Students Talking at Once for a Brief Time . . .

Barrier. It is just not physically possible to give every student in a 600-person lecture hall a chance to talk.

Not only is it physically possible, it's pretty simple. One example is the THINK-PAIR-SHARE teaching strategy (Lyman, 1981; reviewed in Tanner and Allen, 2002). In three easy steps (Table 3), every student in a class of any size can be engaged in Student Talk.

After posing a question, give the class a few minutes to THINK and jot down their thoughts. This THINK time is key because different students have different cognitive processing times—our brains all work differently—and giving students time to just THINK has been shown to dramatically increase the quality of Student Talk and the number of students willing to talk about the ideas at hand (Rowe, 1987; Tobin, 1987).

Table 2. Perceived barriers to promoting Student Talk in undergraduate biology classrooms

Perceived barriers	Point toward need to support instructors in addressing
It is just not physically possible to give every student in a 600-person lecture hall a chance to talk. It takes too much class time away from lecture to have students talk. Getting students talking requires using clickers and that's just too complicated, too expensive, etc. When the whole class is asked questions no one volunteers to answer or it's always the same two to three students who talk.	. . . how to choreograph the mechanics of getting all students talking at once for a brief time
Since most of the questions asked in class require only a single-word answer, what would students need to talk about? Students are too worried about being wrong or looking stupid. If students are given time to talk in groups, that time will be wasted.	. . . how to cultivate a classroom culture that values talk as part of learning
What is the instructor supposed to be doing while the students all sit around and talk? It's impossible to get around to all the small groups that are talking to make sure they're getting the idea right. There's no way to have enough time to hear from everyone. What is the instructor supposed to do with all the information gathered from listening to students while they're talking?	. . . how instructors should spend their time while students are talking

Table 3. Three steps of THINK-PAIR-SHARE

Step	What students are doing	Approximate time
1	Give all students a chance to THINK by having them jot down their ideas on a piece of paper.	One to 3 min (depending on complexity of question)
2	Give all students a chance to TALK by having them share their answer/response and ideas with a neighbor in a PAIR or a small group.	Two to 5 min (depending on complexity of question)
3	Give a few students a chance to SHARE with the whole class by asking for five students to share what was discussed (as opposed to the correct answer) in their pair/group.	Five to 10 min (depending on complexity of question)

Note: Many times a THINK-PAIR (with no SHARE) is all you have time for and all you need.

Then, provide a few minutes for each student to enunciate their ideas to another student in the class. For the majority of students who do not have the confidence to ask or answer questions in front of the whole class, this PAIR time may be the first time they have uttered a word in an undergraduate science classroom. PAIR time allows students to articulate their ideas in the presence of another person, compare their ideas with that of their peer, and identify points of agreement, disagreement, or confusion.

Finally, ask some students to SHARE their discussion. This step is familiar to most instructors because it is just as if they had asked the original question to the whole group. However, the difference is that the response to an instructor's question has been preceded by having all students engage in thinking about the question and discussing their ideas. All that is needed to try this technique is a question for students to think about and discuss, and a willingness to experiment with this approach.

Barrier. It takes too much class time away from lecture to have students talk.

Using the THINK-PAIR-SHARE technique, any instructor teaching a class of any size can engage every student in talking out loud about their ideas by using as little as 5 min of class time (Table 3). Many instructors already have questions that they ask of the whole class but that elicit responses from only a few students. The above-mentioned strategy engages every student in thinking and talking about these same questions, using about the same amount of time.

Certainly, discussion in response to a complex question could go on for longer, but more time is usually not necessary. In a recent article on training science graduate students in innovative teaching methods, Miller *et al*. (2008) highlighted how implementation of active-learning strategies such as this is not at odds with either the typical 50-min lecture period or with lecturing itself. Using multiple THINK-PAIR-SHARES—at the beginning, middle, and end of a class period—is a quick and easy way to engage students in the day's topic (beginning), check for understanding mid-lecture (middle), and quickly assess the status of students' conceptions at the end of class (end). Student attention will begin to flag after ~20 min of lecture, and a THINK-PAIR question can refocus attention. If time is an issue, the SHARING activity can be minimized or omitted entirely—the THINK-PAIR is where student talking really happens.

Barrier. Getting students talking requires using clickers and that's just too complicated, too expensive, etc.

Getting students to talk does NOT require clickers. Clickers can be a useful technological tool, giving the instructor an instant summary of student responses to a multiple-choice question. But with practice, listening to students talk with their peers during the PAIRing time can provide qualitatively similar insight.

More importantly, questions that are most effective at challenging students' ideas and promoting rich discussions are not always multiple-choice, in which case clickers become less useful. Instead of clickers, some undergraduate instructors require students to purchase a 100-pack of index cards as part of their course materials. Students are told that during each of their class meetings over the course of the semester, they will be asked to write down their ideas on these index cards, one to two times per class. Sometimes, the instructor will collect these cards; other times he or she will not. In all cases, these index cards are a good record for students of their thoughts about the concepts being discussed in the course.

Finally, clickers are often used to assign points for student participation. Although integrating grading with Student Talk is common, it is not necessary if you are explicit with students about the role of talking and learning, nor is it always desirable. Not all class activities need to be graded.

Barrier. When the whole class is asked questions, no one volunteers to answer or it's always the same two or three students who talk.

In encouraging students to attempt answers to instructor questions in class, the THINK-PAIR part of the above-mentioned strategy is critical. This technique simply inserts the THINK-PAIR activities before asking a question of the whole class. While using as little as 3 min of time, two things probably occur. First, as a result of the PAIR discussion, questions often emerge from differences in their explanations that students genuinely want to know the answer to, questions that they would not have come upon just by listening to the lecture. In addition, the process of talking in a PAIR and having another student agree that your question is important can give some students the confidence that they may have lacked to ask the instructor their question in front of the whole class. Anecdotally, in my own classroom setting, I regularly have twice as many students willing to ask me a question in front of the whole class after using a THINK-PAIR strategy as the preamble.

On Cultivating a Classroom Culture That Values Talk as Part of Learning . . .

Barrier. Since most of the questions asked in class require only a single-word answer, what would students need to talk about?

Questions that are closed ended—those that require only a "yes/no" or single-word response—are usually not questions that will drive deep understanding and meaningful learning (Bloom *et al.*, 1956; Allen and Tanner, 2002). Promoting Student Talk allows instructors to ask more complex questions, which are generally prepared before coming to class. Often, questions posed to students during a THINK-PAIR-SHARE may not look like questions per se. Instructors may ask students to solve a genetics problem, to provide an opinion about the scientific correctness of a particular statement (e.g., Evolution is the improvement of an organism over time, which is a misconception), or to articulate the connections between two or more terms or ideas (e.g., Describe the relationship among mutations, proto-oncogenes, and cancer).

Barrier. Students are too worried about being wrong or looking stupid.

A key part of getting students to talk in class is developing a classroom culture that is not focused on correct answers, but rather on understanding. By the time they reach undergraduate studies, many students are convinced that responding to questions posed by a teacher in a classroom is all about getting the right answer. This is reinforced if instructors ask simple questions or ignore or ridicule students who reveal alternative explanations or confusions in answering questions in class. It is not surprising that students are highly reluctant to share their ideas in whole class situations, given the experiences many have had previously.

Students are often worried about being wrong or seeming stupid precisely because they have been presented with a relatively simple profile for learning, namely, that instructors provide information that students are then supposed to know. Research on learning does not support this model, and students would be well served if more instructors acknowledged that learning in science is often based on a struggle to reconcile ideas and observations and is not as simple as memorizing "facts." It is important to make it clear that whether an idea is right or wrong is not its only value. The classroom and lab should be safe places where students can offer ideas, even if based on misconceptions, without fear of ridicule. Being explicit in explaining that talking out ideas is part of learning and that you expect all students in your class to talk is a key part of developing a classroom culture of discussion. If a Student Talk culture is set up during the first few classes of a new term, and students figure out that they are expected to talk in class, then they will talk in class.

Learning, changing your mind about something, and integrating new ideas into your conceptual framework is messy (Posner *et al.*, 1982). Students are used to hiding this messiness in their thinking inside classrooms and revealing it only in environments well outside their instructor's view, perhaps in study groups with peers or in other safe havens. As such, instructors must share with students that talking is essential in figuring out their own confusions and that this process is a valued part of learning in the class at hand. Practically, this means that we must value student comments and voices as a useful part of class time, even if this sometimes takes us in unexpected directions.

Barrier. If students are given time to talk in groups, that time will be wasted.

There are three common reasons why students may be off-task when given the opportunity to talk with their neighbor or in small groups. First, the question posed may not have been challenging, relevant, and accessible. When students feel they are done, they will take up a new topic and that conversation may or may not be related to class. Listening in to Student Talk, discussed in more detail below, is the quickest and easiest way to detect whether a question just doesn't work. Even a carefully prepared question may fail to engage students in the ideas the instructor anticipated. In this case, the best thing to do is to end the talking and move on.

Second, students may be off-task because the instructor gives too much time for talking. It only takes a few minutes for pairs of students to share their initial ideas about a question. Two indicators that it is time to end Student Talk and move from the PAIR phase to the whole class SHARE phase come from the noise level in the room and the content of student discussions. As a classroom transitions (at the behest of the instructor) from the THINK phase to the PAIR phase, the noise level should skyrocket. Instructors can actively listen for the characteristic decrease in the noise level of the room as students exhaust new ideas to share. Depending on the nature of the question posed, this dramatic drop in noise can happen quickly (for simple questions) or be more delayed (for very complex questions). At that point, instructors can bring PAIR discussions to a close before students move to talking off-task for lack of anything else to do.

Third, students will waste time if they do not think their instructor really values Student Talk. If we want students to value talking as a part of learning, we as instructors have to be explicit with them about why it is that we want them talking. Letting students in on what is motivating you to engage them in talking makes them partners in teaching and learning; most often this will earn an instructor both respect and buy-in.

On Understanding the Role of the Instructor While Students Are Talking . . .

Barrier. What is the instructor supposed to be doing while the students all sit around and talk?

During Student Talk, instructors should be doing nothing but listening. Although it may be tempting to go over lecture notes or strategize about course announcements, instructors will profit by investing their energy in attentive listening to what pairs of students are saying. Listening to students is a rich source of insight into student thinking, misconceptions, and confusions. I explicitly tell students to ignore me when

I come around and am listening to their conversations. I assure them that I will never attribute a comment that I've heard to any individual but that hearing their comments helps me understand how to best use our class time and how to best focus my lecture.

Barrier. It's impossible to get around to all the small groups that are talking to make sure they're getting the idea right.

During Student Talk, instructors should NOT move around the room giving mini-lectures to pairs or small groups. Thus, it is NOT critical that you visit every group in your class. The goal of Student Talk (as described in the research above) is not for every student to "get it right," but rather for every student to have a chance to articulate their ideas and to discover what they do not understand; and secondarily to give the instructor insight into at least a subset of students' ideas. Integrating Student Talk into lecture classes affords the opportunity for more students to realize that they aren't really understanding the material and for instructors to detect confusion, providing immediate insight into what might be most important to emphasize, clarify, or revisit during class time.

Barrier. There's no way to have enough time to hear from everyone.

You don't need to hear from everyone for talk to have an impact on learning. Often, we as instructors feel that we need to be an intimate part of each student's learning, when in fact it is more important that we construct opportunities for them to do the learning themselves.

Instructors will usually be able to listen to only a small fraction of Student Talk, whether the class size is 30 or 300. Thirty seconds of listening to a pair of students talking is often enough to get insight into the kinds of vocabulary they're using, the concepts that are arising in responding to the posed question, and misconceptions that are driving the discussion. Although at the beginning of a term instructors might randomly sample which student pairs they are listening to, with time they can more purposefully sample PAIR discussions to include a mixture of those who might be most, moderately, and least likely to be struggling with the material, providing insight into the thinking (and conceptual struggles) of the class as a whole.

Barrier. What is the instructor supposed to do with all the information gathered from listening to students while they're talking?

It is important not to forget that Student Talk has benefits in the absence of the instructor gaining insight to guide their teaching. Optimally, instructors would take the insight they gained from listening to student discussions and weave them into their teaching that day. You can use examples of struggles from student discussions to frame or introduce parts of the lecture, or change the relative amount of time spent on a concept if a very prevalent confusion or misconception is detected. Using THINK-PAIR-SHARE toward the end of class can provide information—whether it is on index cards, from clickers, or simply by listening—to craft the next class or lecture.

SUMMARY

Student Talk is key to student learning. In addition, the teaching strategies needed to promote student talk are highly accessible to all biology instructors and are applicable to classroom settings of any size. Whether your teaching philosophy is more aligned with a traditional lecture approach or a more active-learning approach, Student Talk is easily integrated into the classroom in as little as 5 min. Together, these ideas suggest that with relatively minimal effort, instructors can promote Student Talk as a regular and expected part of undergraduate biology learning and have a significant impact on student learning.

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