ARTICLE
Classroom Activities: Simple Strategies to Incorporate Student-Centered Activities within Undergraduate Science Lectures

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The traditional science lecture, where an instructor delivers a carefully crafted monolog to a large audience of students who passively receive the information, has been a popular mode of instruction for centuries. Recent evidence on the science of teaching and learning indicates that learner-centered, active teaching strategies can be more effective learning tools than traditional lectures. Yet most colleges and universities retain lectures as their central instructional method. This article highlights several simple collaborative teaching techniques that can be readily deployed within traditional lecture frameworks to promote active learning. Specifically, this article briefly introduces the techniques of: reader's theatre, think-pair-share, roundtable, jigsaw, in-class quizzes, and minute papers. Each technique is broadly applicable well beyond neuroscience courses and easily modifiable to serve an instructor's specific pedagogical goals. The benefits of each technique are described along with specific examples of how each technique might be deployed within a traditional lecture to create more active learning experiences.

Key words: student-centered learning; active learning; lectures

A well-worn quip attributed to Mark Twain summarizes a lecture as the transfer of information from the professor's lecture notes to the student's notes without passing through the minds of either. Similarly, WH Auden and Camus have each been credited with defining a lecturer as a person who talks in someone else's sleep. Despite such popular and discouraging sentiments about lectures and lecturers, they remain the most common instructional modes in contemporary undergraduate education. The familiar practice of a professor delivering knowledge to room full of students passively absorbing that information has not fundamentally changed for centuries.

Traditional Lectures: Legacy or Liability?

Lectures originated as a necessary component of the oral tradition. Even when the printing press made it possible to collect information within bound volumes, these books were rare, precious, and expensive items well beyond the access of most students. When printing and copying techniques became more accessible and affordable in the 20th century, information rapidly became more accessible to students, yet was rarely sufficient without an instructor's guidance. The deployment of the internet in the late 20th century dramatically expanded both the amount and types of information readily accessible to both students and faculty, effectively reducing the information divide between teacher and student.

Even with this evolution of information access, instructors continue to be necessary components of the learning process by organizing, explaining, and contextualizing relevant information. Technology has also undoubtedly increased a lecturer's delivery options to make images, animations, and videos common in today's lectures (though the pros and cons of PowerPoint lectures in contemporary classrooms are hotly debated (Craig and Amernic, 2006; Tufte, 2003). At some institutions lectures are routinely recorded and then subsequently made available as podcasts and/or videos so that students (and professors) have the opportunity to review the lecture (Owston et al., 2011; Vajoczki et al., 2011). Consequently, experiences that were traditionally ephemeral can now be recorded and stored in perpetuity. Not only has technology made information more available, but it also makes people more available. Now students in a lecture hall can interact with guests via videoconferencing, Skype, and other technologies (Barresi, 2012). Inviting an expert to class, interviewing a scholar, or collaborating with students at another institution, greatly expanding the walls of modern classrooms in exciting new ways.

For centuries, professors appropriately taught through traditional lectures because students could not practically obtain full access to content central to the course. Today information is rarely the limiting factor in a student's education. Thus, modern pedagogy is gradually shifting the professor's role from "sage on the stage" to "guide on the side" where helping students manage their information is critical to learning (King, 1993; Saulnier, 2009).

In addition to the evolution in information access and delivery, in recent years numerous studies have demonstrated that traditional lectures that rely on passive learning are not as effective as active, student-centered learning strategies (Tanner, 2009). With pedagogical evidence discouraging traditional lectures, a rapidly evolving technological landscape, and the trendiness of lecture bashing, then why do lectures persist at nearly all colleges and universities? One obvious explanation is that most faculty members teach the way they were taught. Most of us learned science through lectures, and consequently we teach that way. An alternative explanation is that lectures are not all bad. They can be particularly effective for setting contexts, disseminating common material, synthesizing information from multiple sources, clarifying complex concepts, and modeling professional practices (Bligh, 2000, Charlton, 2006;

Woodring and Woodring, 2007; Adsit, 2012). A third explanation is that lectures remain economically effective delivery mechanisms. For the price of a single faculty member's salary (and perhaps some graduate teaching assistants) institutions can enroll as many students in one lecture class as they have seats in a lecture hall. In a tight economic climate where tuition increases rapidly outpace inflation, colleges and universities simply cannot afford to reduce class sizes, even in the face of compelling evidence. Fourth, most colleges and universities are literally constructed on the foundation of the lecture. Because lectures have such a long tradition in the academy, campus buildings and weekly class schedules presume lectures as the primary educational activity. Reconfiguring classrooms or calendars to accommodate active, student-centered courses requires cultural and facility changes that are difficult, slow, and expensive. Thus, faculty members who chose to avoid or minimize traditional lectures for other pedagogies are often still limited to teaching in spaces designed for monologues rather than conversation. As well, most college faculty must teach in prescribed time blocks of two 75-minute or three 50-minute periods each week. These time periods are longer than most effective listening attention spans, yet too short for many alternative teaching methods where students take the helm of their learning.

Student-Centered and Active Learning Strategies

Many creative instructors have transcended the limitations of traditional lecture hall architectures and time periods; they have designed smart (and often simple) ways to target "pops" of activity within their lectures much like a designer strategically places colorful pillows into an otherwise neutral decor. Some professors use their experience and intuition of what works in the classroom to guide their choices and others have designed educational research strategies to test the efficacy of active learning methods. Thus, there is a very large literature describing how faculty members can effectively deploy student-centered and active learning approaches within lecture courses (Bonwell, 1996; Mazur, 1996; McKeachie, 1999; Uno, 1999; Knight and Wood, 2005, Handelsman et al., 2007; Felder and Brent, 2009; Nilson, 2010). Active learning advocates contend that when students *do* something they learn it better than if they hear about it. Thus, the best way to learn about active teaching is by spending time in a classroom experiencing those techniques. For instructors who do not have local peers willing to let them sit in, many useful demonstrations of specific active learning strategies can be found online simply by searching the name of the technique and selecting the videos from the search engine's results.

This article is by no means an exhaustive or original description of active learning in undergraduate lectures. Instead, its goal is to illustrate a few examples of active learning strategies that can be readily incorporated into traditional lectures with minimal needs for changes in technology, time, and/or architecture. The thoughtful incorporation of a few simple active learning strategies can go a remarkably long way to making the traditional lecture more engaging for students, more rewarding for instructors, and more effective to all.

Ignorance and Frustration are Important Pedagogical Perspectives

It is also important to note that none of the active learning techniques described here are in any way specific to neuroscience. These strategies can be applied to lecture courses in all disciplines. In fact, one of the best ways to examine new teaching strategies is to visit the classrooms of colleagues outside your discipline or look for situations where you are not an expert. To this point I offer a personal example of how an experience far outside my discipline became a powerfully simple catalyst for transforming my own teaching and helping me think more about my lectures from student perspectives. Several years ago I attended a reading by the famous writer Joyce Carol Oates, who is also a professor of literature. Not equipped with literary analysis skills, I was uncertain how to learn from her guest lecture. She quickly put me at ease by briefly describing each poem before she read it. Her preview of a poem as, "four lines long," prepared me for a short, intense period of attention akin to a 100-yard dash. I knew almost nothing about poetry, but I did know that in a poem that short, every word was essential. She told us that the next poem was longer, so I knew to listen with a more sustainable pace, akin to a 5K. Finally, one poem she told us was on the page in the shape of a kite, and while I could not see the words on the page, recreating shape in my mind was an exciting challenge that augmented my listening to the poem. On the surface, Ms. Oates gave a traditional monologue lecture in a large performance hall, yet these small strategic cues helped me engage powerfully with material in which I had limited experience or interest. The next day in my Developmental Biology course I showed videos of various embryos. I had viewed these sequences many times before, often just saying "here is the zebrafish" or "let's look at *C. elegans* now." I found myself setting up the time-lapse videos with similar cues such as, "the sea urchin moves quickly, so don't blink" or "the time scale on the tadpole is slower, so settle in for a few minutes here." I use this example to argue that seemingly negligible cues by a lecturer can create significant engagement and learning gains for students. Moreover, I also use this example to make the important point that inspiration for improving lectures can come from unexpected places, often when the instructor is well outside her/his discipline and has little expertise in the subject. I recall a teaching advice column that suggested all faculty members should make an effort to learn something new or attempt something well out of our comfort zones every year or two because we ask our students to learn very new things in which they might not be naturally good. When I take a painting class or sign up for a triathlon, it is not because I imagine a career in art or a podium finish. Similarly, many of my students will never become developmental neuroscientists, but they have other reasons for taking my course. I may never be able to use a paintbrush effectively, I might not perform up to my abilities on a given day, and I will never set an athletic

record, but I will want to be as good as I can be and I will get frustrated somewhere in the process. Again, most of my students will not be naturals and will experience frustrations in learning neuroscience that I may not have experienced. Being a learner means struggling with new knowledge when guided by an expert who likely found the topic more accessible and interesting. Thus, any opportunity for an instructor to understand a learner's perspective is helpful. Such empathy for the challenges of learning combined with strategic classroom activities that focus on the learner can transform a traditional lecture into a more effective learning experience for students without sacrificing time or content.

ACTIVE LEARNING STRATEGIES IN LECTURES

1. Reader's Theater

Explanation:

The instructor selects text relevant to the day's topic and assigns students in the class to read the text out loud. The text may be a short story, a passage, or a collection of statements. Depending on the length of the selected text and the size of the class all students may be assigned reading responsibilities or only a small fraction of the students may read out loud. If appropriate, the student readers may be encouraged to add drama, flair, or humor to their readings. This technique is particularly helpful for starting discussions, introducing new topics, or shifting gears during a long class period.

Background:

The Reader's Theatre technique is frequently used in elementary schools as an activity that encourages new readers to improve reading confidence, fluency, and comprehension (Martinez et al., 1998). This flexible teaching technique is also used in high schools to develop performance skills and enhance literary studies (Coger and White, 1973).

Benefits:

In an undergraduate science lecture, Reader's Theatre is an efficient way to get many students voices in the classroom and shift speaking responsibilities from the professor to the students. The technique can be useful for getting a variety of viewpoints onto the floor for discussion in a safe and/or efficient manner. For some topics a traditional discussion of volunteers might be difficult to cultivate and/or not reveal the full spectrum of viewpoints because of limited student experiences, lack of knowledge in the field, the controversial nature of the topic, and/or homogeneous demographics. Reader's Theater is efficient because the professor can construct a script with statements that illustrate the full spectrum of viewpoints, without requiring the class to spend the time to identify the spectrum. Similarly, for controversial topics Reader's Theater can be a particularly safe method because it is obvious that the reader was assigned the task and is therefore not personally advocating or representing a controversial viewpoint.

It is also important to note that Reader's Theatre is an effective method for encouraging participation, particularly from quiet students who may be shy and/or lack confidence in their own knowledge. Reading a short segment or statement is a relatively low-stakes activity where a quiet student's voice can be heard and/or a student who lacks confidence can make a valuable contribution to the class.

Reader's Theatre has benefits for its readers, but also promotes active listening by the non-readers. The instructor might preface the reading by giving specific instructions that require the non-readers to take notes, identify a stronger/weaker argument, identify an inaccuracy, categorize statements, etc. Given the many distractions inherent in today's classrooms where students are easily lured away from learning by text messages and social media, Reader's Theatre is a small way to encourage and demonstrate why focusing, note taking, and/or careful listening are critical skills for success.

Examples & Variations:

Reader's Theater can be a particularly effective technique on the first day of class to demonstrate the expectation that most of the talking will be done by students. The statements selected might model suitable contributions as questions, evidence-based statements, etc. Alternately, the statements read during Reader's Theater could exemplify a variety of strong and weak discussion contributions and students could then analyze which types of statements facilitated class discussion, which statements were less helpful, and/or how weak statements might be improved with the addition of logic, evidence, etc.

The instructor might also choose to shift responsibility for selecting the material read toward the students. For example, in a course focusing on clinical neuroscience, the instructor could assign some or all students to find a quote (or video) from a patient with a specific clinical condition that describes the symptoms from the patient's perspective. The students who find the quotes might even ask their classmates to do the reading out loud at the next class.

2. Think-Pair-Share

Explanation:

The instructor poses a question or prompt to the whole class with the explicit instruction that all students are expected to think independently about their answer(s) in silence (and possibly jot notes for themselves). After a minute or so (the duration will depend on the complexity of the prompt), the instructor directs the students to pair up with a nearby or assigned student. In pairs (or trios) the students compare their thoughts. Depending on the prompt, the instructor may guide the pairs to reach a consensus, pick the most convincing response, generate many responses, etc. After the students have talked in pairs the professor gets everyone's attention and asks pairs to share their responses with the full class. The instructor may select pairs by cold calling, asking for volunteers, requesting diverse responses, going around the room, etc. The instructor may also assign students to record the responses.

Background:
The Think-Pair-Share method is frequently attributed to Frank Lyman (1981). It is a tried and true strategy for group learning that has been used very effectively and very widely in postsecondary education (Nilson, 2010).

Benefits:
Think-Pair-Share offers multiple benefits. First, the moment set aside to think quietly communicates that *all* students are expected to think about the issue posed. It thereby reduces the chances that when an instructor poses a question to the class that most students will skip thinking an answer, counting on an eager or attention-seeking classmate to save the day. Similarly, dedicating time to think quietly also allows students who need just an extra moment to organize their thoughts (or gather their courage) a chance of contributing to the discussion. Not only does Think-Pair-Share encourage all students to think, it allows all students to talk. Thus, students experience the advantages of explaining their responses to a peer, vetting their thoughts, and revising. This one-on-one conversation is often much more comfortable for students than if the same question had been posed to the class and a single volunteer response elicited. With every student talking, the "pair" phase inevitably brings a burst of activity to the classroom – this phase alone can provide a quick and important change of pace to a lecture where energy and/or engagement are lagging. Students who might never talk in front of the full class are actively articulating their thoughts to a peer. Finally, in the "share" phase of this activity the instructor randomly calls on student pairs to report out. This "cold calling" sets the important tone that during Think-Pair-Share all students are expected to think and to talk, while minimizing the stress of cold calling an individual student. All pairs have vetted their points before they are raised to the full group, etc.

Examples & Variations:
There are numerous variations of Think-Pair-Share. It may be shortened to become Think-Pair, Pair-Share, or Think-Share. Similarly, students may be asked to share with more than one peer (say first on one side and then on the other), expanding the activity to Think-Pair-Pair-Share. This activity can be readily combined with voting mechanisms (clickers, show of hands, etc.) to make it Think-Pair-Vote. A small variation, Think-Vote-Pair, is particularly effective when the majority of a class has trouble identifying the correct answer to a question in a quiz. Asking the students to discuss their response with a neighbor and then re-enter their response to the question is a remarkably effective way to help the students refine their thinking. Finally, in the undergraduate science classroom, Think-Pair-Share can work particularly well with analyzing data, understanding experiments, and considering interpretations and conclusions.

3. Roundtable
Explanation:
The instructor asks students to collaborate in small groups on a specific prompt that can generate multiple responses. Students share a single piece of paper that gets passed around their circle rapidly. The goal is to generate as many responses as possible from all members of the group in a defined period of time. A small prize (candy, extra credit point, etc.) may be offered to increase the stakes if desired. Roundtables are often followed by a reporting mechanism in which the professor calls on groups to share their responses. The report-out instructions might ask for no repeated answers, the most predictable answer, the most creative answer, etc. Finally, the instructor may choose to collect the Roundtable papers after the exercise to get a full record of all the small group conversations.

Benefits:
Like many other active learning strategies Roundtable ensures that every student in the classroom is generating knowledge and contributing to a discussion simultaneously. Roundtables are particularly well suited to brainstorming exercises, but can easily be adapted to other situations where there are multiple responses. Roundtables can quickly transform the energy within a lecture hall because multiple groups are simultaneously engaged in animated conversations or contests.

Examples & Variations:
The Roundtable technique is best suited to brainstorming applications or problems that have multiple reasonable responses, such as experimental results that can have multiple interpretations. This technique can also be used as a way to help students rapidly generate a variety of diverse ideas as potential starting places for assignments or term paper topics. The Roundtable can also be an effective tool for test preparation by prompting the students to list as many key words or concepts that think they should understand to do well on an upcoming exam, etc.

4. Jigsaw
Explanation:
A class is divided into multiple teams of students. The instructor gives each team a slightly different but well-defined task with clear instructions that each member of the team will do to represent the group at the end of the work. Each team then collaborates on the task, developing expertise in the designated area. The instructor is available for questions and guidance as the groups work to learn their material. Then the instructor rearranges the groups to create new groups that are composed of one member from each of the original groups. Within the new groups each student has designated expertise and is responsible for teaching the information learned in the original group as well as learning the information from the other groups.

Background:
Jigsaw classrooms have long been used as a cooperative and collaborative learning strategy in all levels of education. Originally developed by Aronson for reducing racial conflict and promoting positive relationships across ethnic boundaries (Aronson and Patnoe, 2011), jigsaws have also been adapted as short exercises within

undergraduate science lectures and labs (Smith et al., 1991; Perkins and Saris, 2001; Doymus, 2008; Davis-McGibony, 2010).

Benefits:
In a Jigsaw exercise the teacher is responsible for structuring the activity with thoughtful prompts and perhaps providing appropriate resources, but students take responsibility for obtaining and conveying new knowledge. The Jigsaw format necessarily requires each student to be both a teacher and a careful listener during the exercise, yet no one student is required to do the front lines digging on all the topics. This exercise also naturally gets every student in the classroom talking and interacting with peers. The rearrangement inherent in the Jigsaw method also promotes interactions with classmates a student might not otherwise encounter as well as provides a burst of physical activity that can help maintain attention.

Examples & Variations:
Jigsaw's process of first developing expertise then sharing it with peers who have different but related expertise can fit into a class period, but may take up the full class time depending on the complexity of the knowledge and depth of the task. For example, instead of a professor giving a lecture describing various neurodegenerative diseases, a class could do a jigsaw exercise to accomplish the same goal. The instructor splits the class into initial groups by disease where the students learn, clarify, or review the causes and symptoms of one particular clinical condition. After an appropriate amount of time the instructor reconfigures the groups so that each new group had a student representing each disease. Individuals in the new groups then use their expertise to teach each other about the important characteristics of their assigned disease and learn about the other diseases. The instructor might then assign the reconfigured groups the more complicated cognitive task of collaborating to create a visual highlighting the common themes and important distinctions between all the diseases considered. If class time does not permit this synthesis, then this final activity could be assigned as collaborative or individual homework.

Jigsaws are also commonly used in science courses as ways to make primary research articles more approachable. Initial groups may first focus on specific sections (or figures) in a paper, then reconfigure so that each group has at least one member with expertise on each portion of the article. Jigsaws also work well for helping students write scientific manuscripts for the laboratory portion of a course. Initial groups focus on key components of each paper section (introduction, methods, results, discussion, etc.) and then rearrange to collaborate on the writing of a full report.

Jigsaw exercises may also fit well with learning activities outside of class. For example, in advance of a Jigsaw activity, an instructor might assign different readings to subsets of students. In this way the first phase of the Jigsaw is independent acquisition of expertise, which allows class time to focus on the collaborative teaching phase of the exercise.

5. Short Quizzes in Class
Explanation:
The instructor puts a question with a single correct answer out to the whole class and expects all students to respond. Quizzes are typically exercises completed by students working independently, but can readily be adapted into team activities (such as Think-Pair-Share).

Background:
Quizzing during class can accomplish several goals. First, quiz questions can stimulate thought during a lecture, cueing the students to think actively about the material at hand by pulling students out of passive, receptive modes into more engaged and contemplative modes. Quizzes on assigned readings and/or concepts from previous lectures are also useful mechanisms for ensuring students prepare for class by doing their reading and/or reviewing their notes. Finally, quizzes also test comprehension during a lecture, providing real-time feedback to both the student and instructor. The instructor can use the quiz results to spend more time on a topic not well understood or to move on to new material. Similarly, students can use the quiz results to gauge their own understanding in comparison to instructor expectations and peer performance.

Benefits:
Typically when an instructor tosses a question out in a lecture hall, it is answered verbally by a single student who shoots a hand into the air. Most other students quickly figure out that these eager classmates will reliably relieve them of thinking or responding responsibilities in future such situations. Even if the instructor ignores volunteers and asks a specific student to respond, a student's chance of being selected remains unlikely. Consequently, most students do not view an instructor's oral question as an opportunity to engage or reflect, but rather as a moment to wait out. Moreover, when an instructor hears only a single volunteer response, this feedback reflects how one confident student is thinking. The bulk of the class might have a very different understanding that is not obvious to the instructor. In contrast, when a question is reconfigured as a quiz, two important benefits emerge. All students are cued to think about the material and the instructor quickly gets a complete view of where the class's knowledge stands.

Examples & Variations:
Quizzes can be implemented in a wide variety of ways from high-tech classroom response systems (a.k.a clickers) to low-tech shows of hands. Clicker systems offer the benefit of rapidly collecting, recording, and displaying responses without individual attribution. Thus students selecting the wrong answer are not "outed," yet still know where they stand in comparison to their classmates. Moreover, clickers allow a variety of question formats such as true/false, multiple choice, and numeric responses. Clicker software can sometimes be clunky and the hardware expensive, but they have been used to good

effect in many courses (Wood, 2004; Keller et al., 2007; Crossgrove and Curran, 2008; Bruff, 2009) and new options that allow students to use their cell phones as the responding devices are emerging. Moreover, performance on clicker quizzes can be used to record attendance and/or count toward a student's course grade, providing incentive to attend and participate in class.

A lecturer does not need a classroom response system to reap the benefits of quizzing in class. Raised hands, mini whiteboards, a folded sheet of paper with A, B, C, D options, or colored index cards can accomplish the same pedagogical goals quite well without the expense or risk of failure inherent to technology (Lasry, 2008; Fallon and Forrest, 2011; Whitney, 2011). These low-tech alternatives retain the advantage of providing the instructor with quick feedback from the full class, but without the automatic record individual grades, potentially reducing incentives for students to perform well. In addition, these low-tech response systems do not provide the inherent confidentiality of clickers that reduce the fear of everyone knowing which students selected the wrong answers. Instructors can, however, enforce simple rules with the low-tech alternatives to reduce this anxiety considerably. For example, asking students to close their eyes before raising their hands, requiring that students hold their cards or whiteboards under their chins, and chastising wandering eyes all readily allow the instructor to scan the responses quickly and then report the outcome without students knowing how specific peers responded.

Finally, in-class quizzes do not need to be oral. They can also be very short (often timed) written exercises that come at the beginning or end of a lecture period. Written quizzes can also be placed in the middle of a lecture as a change of pace or signal closure to a topic. Written quizzes offer the advantages of engaging students in a confidential way with a record of individual performance. Such quizzes do not provide instant feedback and require grading after class.

6. Minute Papers

Explanation:

In a few minutes of class the instructor asks the students to write a quick response to a question regarding the day's lecture. This exercise is typically done at the end of class and turned in as students exit. Minute Papers prompt students to review the day's lesson before they leave the room. Questions for Minute Papers might include, "what was the take-home message?", "what was the most confusing concept?", "what question could you ask about today's material?", "what will (or will not) stick in your brain from today's class?", or "what points do you want to make sure you retain for the next exam?".

Background:

This technique has been widely used in large and small lecture courses (Harwood, 1996; McKeachie, 1999; Bressoud, 1999; Stead, 2005). As a short writing exercise, Minute Papers provide both the teacher and the students with a quick summary of what was learned in class. Minute Papers also serve as a way to identify points of confusion that might not be immediately obvious.

Benefits:

This technique prompts students to assess the day's lecture before they leave the room. It encourages them to identify key points and questions as a regular exercise. In addition to the well-known benefits of repeating, summarizing, and reviewing information as effective components of learning, minute papers can also decrease the impersonal, unidirectional nature of traditional lecture courses. Through Minute Papers, all students have an accessible opportunity to raise questions or a safe way to admit confusion.

Minute Papers also provide the instructor with a valuable glimpse into how students experienced the lecture, revealing that concepts the instructor intended as clear or important might have been regarded as confusing or trivial by the students in the room. Thus, an instructor can use feedback from Minute Papers to assess the effectiveness of the lecture as well as to identify areas that need additional clarification in the next class period (Angelo and Cross, 1993). When an instructor acknowledges feedback from Minute Papers in subsequent classes, this action not only improves lecture efficacy but can also enhance relationships between the student and professor even with large enrollments. A professor acknowledging that Minute Paper information was used in the design and delivery of subsequent lectures sends a powerful message that student learning is valued, even in very large lecture halls.

Examples & Variations:

Minute Papers can be varied in frequency or timing. Some instructors use Minute Papers in every lecture where they also serve as a means of taking attendance. Other instructors employ Minute Papers frequently, but not daily. Writing for a minute or two most often functions as a "cool-down" exercise to close out a lecture, but Minute Papers can certainly be used in the middle of a class period to change pace or signal a topic shift. As well, Minute Papers can be useful for students at the start of a class period as well as a "warm-up" activity (Nilson, 2010). For example, short periods of expressive writing about their anxiety before an exam have been shown to improve exam scores (Ramirez and Beilock, 2011).

A lecturer using Minute Papers has additional choices in how this technique fits best with the pedagogical goals of a specific lecture. Minute Papers may or may not be anonymous. Some students will be more likely to admit confusions, questions, or misunderstandings when the task is anonymous, yet other students may not take the exercise as seriously under this condition. Also, an instructor can choose that Minute Papers be graded or ungraded. Some instructors assign a token amount of the course's participation or attendance grade to Minute Paper assignments to discourage students from skipping class or sandbagging the exercise. Finally, returning the Minute Papers is another instructor choice. Some instructors read Minute Papers but do not return them to their students, while others return Minute Papers so students have their

own summaries and questions for their studying. A few instructors even use the Minute Papers to write short comments before returning them as an additional way to build relationships and start conversations with students as individuals.

Stating Goals as Part of Active Learning Strategies

Regardless of the specific active leaning strategy used, stating the goal of the exercise is a critical component of successful implementation of any active classroom strategy. To enhance student buy-in and engagement, revealing an activity's purpose is essential, particularly for new activities. Students are generally more receptive to a new method when they have insight into why they are doing it. While the purpose of an activity may seem obvious to the instructor, students are frequently unable to discern an activity's purpose on their own. Thus, a simple statement of the learning goal can go a long way to establish trust, value, and participation. I often think of this need for transparency as similar to a coach telling athletes, "we are going to warm up our legs with these stretches so we have more stamina when we run up hills today in practice." For example, an instructor might explain, "we are starting with a reader's theatre today so that we can get a spectrum of important perspectives on this issue out on the table rapidly and focus our discussion time more effectively" or "we will be seeing graphs like these all semester, so if you can explain an I/V curve to your neighbor, you will be more likely to know how to interpret an I/V curve on a test."

Establishing the goal of an activity demonstrates to the students that the instructor is explictly thinking about their learning and putting their needs first. This revelation also importantly establishes students and teacher on same team with a common goal. Some students are confused by the inherent paradox of a college professor who must play roles both as coach (lecturer) and as referee (grader). Showing students that the coach wins when the team wins can help some students see their professor as a facilitator of their learning rather than a judge of their performance.

There is no limit to when, where, and how learning goals can be revealed to students. Goals fit easily and quickly into classroom activities as well in many other places such as course syllabus, assignment instructions, comments on graded work, etc. Similarly, there is no prescription for precisely how or when an instructor should reveal an activity's goals. The statement of the goals will depend on the activity. Some goals can be stated up front. For example, "we are going to do a quick quiz now to make sure the concepts we just reviewed have sunk in" is an obvious situation where the goal can precede the activity. Similarly, a statement such as, "if our understanding of the ionic basis of the action potential is unclear, then the pharmacological actions of some toxins will not make much sense next week." While revealing the goal up front is often very effective, putting the goal first is by no means a requirement of effectively implementing classroom activities. Some goals are best revealed after the students have engaged in the activity. For example, after a brainstorming activity an instructor might say, "Now that you have some good ideas on paper for lab projects, you should prioritize those ideas on how well you will be able to test each hypothesis with the instruments we have in lab."

Finally, the responsibility to state the goal does not always need to fall to the instructor. Asking the students to clarify the goal works particularly well at the end of an activity. For example an instructor might ask, "why do you think that we just spent so much time discussing how Cajal and Golgi viewed the nervous system differently?" or "why do you think we read this research article for class today?". Encouraging students to look for the reasons behind their activities and assignments can help them take ownership of their own learning.

Practice Matters

Just as students use repetition and refinement in their learning processes, faculty members should not expect that an active learning strategy will work flawlessly the first time out. It takes time to develop expertise in front of a classroom with new techniques. The specificity of the prompts, in particular, often requires refining that is only possible by repeated attempts. Few instructors expect their students to understand a difficult concept on the first pass, yet hold themselves to perfection on the first attempt at an active learning strategy. Many active learning advocates advise instructors to start small with a goal of implementing one strategy or revising one lecture, rather than completely overhauling a course. As an instructor gains comfort and experience with techniques such as the ones highlighted in this article, lectures will likely become more active and useful experiences for the students.

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