# How do I help students engage productively in active learning classrooms?

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If you incorporate active-learning strategies into your teaching, you may find that students don't automatically embrace this new learning approach. Students may just sit back and listen, waiting for their peers to answer. They may engage enthusiastically at first, but that exuberance wanes in the face of a busy semester. Students may even openly resist and complain (though this is somewhat rare).

As instructors, we can be mindful about how we shape the class structure and culture to make engagement feel safe and worthwhile. You, as an educator, have the power to impact student behaviors and perspectives with what you say and do, thus actively affecting how students are engaging with the curriculum and the content.

**In this set of Expert Recommendations, you will find research-based recommendations for helping students to engage productively in active learning, along with concrete examples of how to incorporate these ideas in your classroom.**

**You can find all our articles online at PhysPort in our Expert Recommendation: How do I help students engage productively in active learning classrooms?**

**Or download all materials from this project here (zip).**

***About this project***

*The goals of this project is to identify and disseminate strategies that instructors use to engage students in active learning classrooms. This project arose from the Framing the Interactive Engagement Classroom project, led by Stephanie Chasteen (University of Colorado Boulder), with collaboration from Jon Gaffney (Eastern Kentucky University) and Andrew Boudreaux (Western Washington University). This work was generously supported by the University of Colorado Science Education Initiative and the University of Colorado Center for STEM Learning, via a Chancellor's Award.*

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# Introduction

## What is productive student engagement?

While many instructors talk about student "buy-in" (how much the students agree with the rationale for active learning), buy-in is only one component of what it means for a student to be actively engaged. You may have seen worksheet activities in which students were deeply engaged, due to the high cognitive demand of the task, but they don't *like* the activity ("it's like eating my spinach"). And while many students say they love clickers, you have likely observed students off-task during clicker questions, just waiting for the instructor to give them the answers. Thus, it is useful to think about engagement as having several dimensions, as outlined below (Engle and Conant, 2002; Fredericks, Blumenfeld and Paris, 2004; Chapman 2003; Demonbrun et al, in press):

- **Behavioral engagement:** Do students participate in the activity? Do they discuss with peers; are they attentive and persistent? Or are they off-task and distracted?
- **Emotional engagement:** Do students feel good about the activity? Is it fun, fulfilling, interesting? Or do they lack confidence, or feel anxious or bored?
- **Cognitive-emotional engagement:** Do students value the activity; do they feel the time used on the activity is beneficial? Or would they rather listen to a lecture? Do they recognize that the activities could beneficial for their major or career?

Take a moment to think about what might be missing in your class (see Chapter 5: Assessing Engagement for ideas.) In this series of chapters, we consider **"productive student engagement"** as the goal for our classes. Productive engagement includes behavioral, emotional, and cognitive engagement. How can we support students so they participate in active-learning activities, and feel that the activities are both worthwhile and fulfilling?

## How common is student resistance?

Active resistance, especially during class time, happens much less often than instructors anticipate – several studies have found that students respond positively to active learning strategies (Nguyen et al., in press; Nguyen et al., 2016). However, resistance can happen (Seidel and Tanner, 2013; Ellis, 2015). There may be "implementation dips", where student evaluations decline during first implementation of an active learning strategy, and then recover over time (Allen, Wedman and Folk, 2001). Students may resist active learning if they feel that it is more work: For example, in implementation of an active learning environment called SCALE-UP, students resisted the change, believing that they could have achieved the same grade with less work in a lecture class (Beichner, 2007). Students may also resist when they feel that the class design is unfairly imposed upon them, that expectations are unclear, or that the course is poorly

taught. Such was the case in a well-known example of student resistance in the TEAL initiative at MIT (see Breslow, 2010). Often, such initial pushback can decrease over time, as students accept the class structure as the "new normal", and initial difficulties are addressed (e.g. Breslow 2010, Koretsky and Brooks, 2012). See also Chapter 9: Student Complaints for discussion of student evaluations.

The most common form of resistance may be passive, non-verbal resistance, or partial compliance (Shekhar et al, 2015; Demonbrun et al, in press). Thus, I recommend that it is more productive to think about *engaging* your students productively (pulling them into the active learning) rather than *avoiding resistance* (which can inadvertently set up an adversarial relationship).

## What can I do?

Negative feedback from students can sometimes cause an instructor to prematurely give up on the idea of using active learning strategies, saying that students "didn't like it." Usually, the problem isn't so much that students truly don't like active learning, but that it isn't quite what they expected. Students, like anybody else, need help in figuring out how to work well and succeed in a new environment.

Luckily, there is much we can do to help our students. Student engagement is actually much more strongly connected to what an instructor does and says than the type of activity, students' expected grades, or students' prior experiences with active learning. (Nguyen et al., in press). You might look at some advice from instructors we have compiled, to learn from the collective wisdom of master teachers, and start thinking about your own preferred approaches!

One crucial aspect of student engagement is how *motivated* students feel to participate. Students feel motivated when they feel competent, connected to others, a sense of ownership over their learning, a connection to their own personal interests and goals, and believe that they can succeed (Pintrich, 2003). However, just because a student is *motivated* to engage doesn't mean that they *will* engage. Some students may be easier to engage than others. For example, younger students, those with prior experience with active learning, and/or a higher tolerance for ambiguity and risk, may be easier to engage (Ellis, 2013). Thus, there is no single "magic bullet" for increasing engagement, but using a constellation of approaches – such as creating a respectful atmosphere, setting appropriate expectations for students, and helping students take ownership of their learning – can have positive impacts on student engagement.

While the easiest approach may be to explain to students why you're using these instructional techniques, we have heard from several instructors that this approach has limited success (or may even have had negative consequences), so we suggest a much broader approach. Below are some general principles for improving engagement.

## General philosophies for improving student engagement

1. **Address engagement early and often.**
   Address issues of engagement from the first day, but don't leave it there. Revisit these issues periodically through the course. Student perceptions and class norms shift over time (e.g. Breslow 2010, Koretsky and Brooks, 2012), and different messages are salient at different times (Ellis, 2013). Students will become fatigued over the semester, and feel pressure from other courses (Ertmer, Newby and MacDougal, 1996).
2. **Show (rather than just telling) students why interactive engagement is helpful for their learning.**
   While explanations about the benefits of active learning have their place, this didactic approach is not sufficient. First, we learn best through experience, so experiencing the benefits of active learning, rather than hearing about them, is likely to have more impact. Second, explaining why you're using such teaching techniques might frame active learning as something controversial that students should resist by default. Third, you as the instructor may be seen as inflexible, ignoring students' learning styles and 'knowing what is best for them.'
3. **Address engagement interactively**.
   Rather than just explaining why you are using active learning, practice what you preach when it comes to engagement. Use active-learning activities such as direct experience and discussion to help students reflect on their learning, think about the class structure, and become self-directed learners who decide to engage.
4. **Adopt the perspective of your students.**
   Be student-centered in your reflection on student engagement. Think about how they experience the course, their own identity with respect to the subject, their experience of group dynamics, etc. Looking at their experience from the other side of the podium may often inspire new approaches to supporting their engagement.
5. **Promote engagement, rather than suppressing resistance.**
   Anticipating negative responses can be self-fulfilling, and can inadvertently lead to an adversarial stance among some students. Promote engagement instead, and *draw* your students in to active learning. Remember, active resistance seems to be quite rare. (Nguyen et al., in press; Nguyen et al., 2016), so don't expect resistance or automatically take a defensive position.
6. **Be consistent.**
   It's important to build trust by being consistent in the messages you send students. For example, don't talk about the importance of progress and effort, but then grade sharply on a curve. Grading on a curve is inconsistent with a non-competitive, collaborative classroom. Be consistent in the goals, instruction, and assessment of student learning, so that students feel that the activities are aligned. Adopting a backwards design framework is an effective way to achieve such an alignment.

## What approaches can I use to frame my classroom for productive engagement?

The main work of this project has been to collect specific approaches to promote engagement. What follows is a list of general factors – social, emotional, structural and cultural -- which promote student engagement. Each factor represents a distinct but interrelated issue, and affects how deeply students engage in the learning activities. Each chapter summarizes the research related to these factors and provides recommended strategies for helping students engage, supported with relevant examples. The chapters can be read in any order. You might focus on factors that seem particularly relevant for your course. Or you might try one strategy from within each factor. We also have a suite of example activities, linked within these chapters.

- **Chapter 1: Expectations**. How can I set clear expectations in active learning classrooms, so students know what they need to do to succeed? *(link to chapter)*
- **Chapter 2: Metacognition and Mastery.** How can I help students become more expert learners, so that they engage in and benefit from active learning? *(link to chapter)*
- **Chapter 3: Motivation:** How can I help students feel intrinsically and extrinsically motivated to engage in active learning activities? *(link to chapter)*
- **Chapter 4: Class community**. How can I create a positive community in an active classroom, so that students feel respected and encouraged to engage? *(link to chapter)*
- **Chapter 5: Assessing Engagement.** How can I assess the level of student engagement in my class? *(link to chapter)*

## How do I apply these ideas in specific situations?

Below are recommendations for specific, common situations or problem areas.

- **Chapter 6: First day of class.** What are some of these strategies that are best suited for setting the stage in the first days of class? (*link to chapter)*
- **Chapter 7: Group work.** How can I support student learning in cooperative groups, using appropriate group structures and tasks? *(link to chapter)*
- **Chapter 8: Class discussions.** What can I do if students don't speak up in discussions with peers, or with the whole class? *(link to chapter)*
- **Chapter 9: Student complaints.** What if I get low student evaluations, or hear complaints about active learning? *(link to chapter)*

## Appendices

- **All references**
- **All class activities**

## Further reading on this topic

Full references appear in the References section.


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# Chapter 1: Expectations

*How can I set clear expectations in active learning classrooms, so students will know what they need to do to succeed?*

When students encounter an active learning classroom, they may be unsure of what is expected of them. They may fear they won't be evaluated fairly, or won't see a clear path towards success. This anxiety and uncertainty can cause them to withdraw from interactive learning activities.

This chapter focuses on helping students engage productively in active learning classrooms through creating clear expectations for student engagement and learning.

## How do expectations affect student engagement?

***Keywords**: Expectations, expectancy violation, outcome expectancy*

When students don't know how to be successful in your course, including what will be expected of them in an active learning context, they may be anxious or resistant. Students often feel that active learning requires more of their time and effort (Ellis, 2013) and may not aware of the advantages of this teaching approach (Seidel and Tanner, 2013). They may feel anxious in this unfamiliar environment (Slezak, 2014; Jackson and Trees, 2003) and fear that their grades will suffer (Ellis, 2013). Such anxiety has a negative impact on student performance (Moreno, 2009), as well as student engagement in any given activity (Nguyen et al., in press). In one study, when instructors explained the purpose of active learning activities, students placed higher value on those activities, reacted to them more positively, and evaluated the course more favorably (Nguyen et al., in press). So, to get off on the right foot, explaining the value of active learning can go a long way towards promoting student engagement (Fredericks, Blumenfield and Paris, 2004). Below are several other elements to be taken into consideration.

**Student expectations need to be calibrated early.** Students may enter the classroom with a range of expectations based on prior experiences. Making it clear what this course will be like, what participation will be expected (preferably by jumping into active investigations), and how students will be evaluated, will help to set clear norms for engagement (Gaffney, Housley Gaffney and Beichner, 2010; Gaffney and Whitaker, 2015).

**Students need to feel that they will be evaluated fairly.** Students want to know how grades will be calculated, and that their grade will reflect their own work (rather that of their classmates; Ellis, 2013). Thus, communicating clearly how students will be evaluated is critical. Students also need to have a certain amount of faith that you are fair and honest; this kind of credibility

can be built over time by being open to questions, building rapport with students, responding to their concerns, and transparently discussing your decisions (Witt & Kerssen-Griep, 2011; Gaffney and Whitaker, 2015).

**Students need to know how to succeed in the course.** Students are more likely to work hard on something if they feel that it will lead to success ("outcome expectancy"; Moreno, 2009; Boekaerts, 2010). Students must believe that engagement in active learning will directly improve their performance in the course, as well as have accurate expectations about how to earn good grades. Additionally, clarity of instructions is important in active learning classrooms: What is the purpose of the task? Why will students be working together? Without this clarity of intention, students may feel bewildered and a lack of direction (Patton, 2010). Lastly, students can be overconfident in their abilities, leading them to minimize the benefit they can get from active learning. Often, overconfidence is strongest among weaker students (Karatjas, 2013); this lack of ability to see one's own flaws is called the Kruger-Dunning effect (Kruger and Dunning, 1999). Regular, clear feedback on student performance (using some low-stakes assessments) is thus critical for students to develop clear expectations and avoid overconfidence (Pintrich, 2003).

## Strategies for Setting Clear Expectations

It's important to calibrate student expectations, from the first day (Gaffney and Whitaker, 2015), but don't stop there. Student expectations are malleable, and can shift over the duration of the course (Gaffney, 2010). Below we describe early approaches, as well as strategies that can be used throughout the term. By attending to a few of these strategies, you will be able to foster a classroom where students are less anxious about their grades and recognize the benefit of engaging in active learning for their academic success.

### First Day: Be explicit about your pedagogical choices

Let your students know why you're using the approaches that you're using, and help them see the value in them, but try to avoid lecturing about how active learning is good for them. This "eat your vegetables" approach has sometimes been associated with student resistance (e.g., Smith, 2008), likely because students feel that they are being told what to do that they don't have ownership of their own educational process (Reeve, 2009). (See Chapter 3: Motivation for more about the importance of student ownership). Below are some ways to be explicit about your pedagogical choices.

**Explain to students why you have chosen to teach this way.**

You might explain the rationale for your use of active learning, and how this pedagogy aligns with research. Hear from several seasoned instructors in this 5-minute video on laying out the course approach. Here are Sample Slides Explaining Active Learning (PPT), and a video of an instructor discussing his use of clickers with the class, and a Tutorial and Clicker FAQs handout from CU Boulder. However, I have heard instructors report that such a didactic approach can backfire, and so it may be best to partner such explanatory approaches with active learning (e.g., see our Clicker Questions – How Do You Learn? (PPT), or as a reflection after the activity, to avoid students feeling lectured to. Invite discussion about the course approach. Invite discussion after you have described the course approach. E.g., "What are your thoughts about the approach described? How does this match your own approaches to learning? What questions do you have? What will you/I need to do for this to

work?" Return to these ideas later in the course; student may not necessarily remember this introduction (Tosh et. al, 2005). Note too that you will want to have a clear rationale in *your* mind for using active learning in order to be able to clearly communicate that rationale to your students!

### Highlight the shortcomings of traditional lecture.

One particular strategy is to use humor to show that learning is typically limited with traditional lecture, and hold a reflective discussion about how unsatisfying this traditional course structure can be, and what you and the students can do to avoid such an outcome. For example, you can do a parody of traditional lecture, and show a video of an instructor teaching a dance class via lecture (see the activity Traxoline and Dancealot), leading to a frank and collaborative discussion of the course approach and how it can best support students' learning.

### Solicit student ideas about the course.

Ask students what they expect in the course, and respond honestly and respectfully to any concerns. For example, solicit rumors about the course or pre-existing ideas about the content or fears of math or science (see the activity Rumors). This strategy creates positive expectations and establishes your credibility. However, set realistic expectations about how much say students really have in the course structure (Slezak, 2014), and trust in your curriculum – especially on the first day.

### Ask students to reflect on their learning strategies and goals.

Ask students about how they can best achieve their personal goals for the course, steering the discussion towards the utility of engaging in higher-level learning activities in class. In the First Day Questions activity, we give examples of how instructors ask students about their study strategies and personal goals – and how best to achieve them.

### Use a syllabus quiz

Include information about teaching strategies in the syllabus. However, we don't recommend reading the syllabus on the first day; instead, consider using an interactive Syllabus Quiz, where students read and discuss questions related to the syllabus, including often neglected issues such as ethics and cheating. Also, hear from several seasoned instructors in this 2-minute video on dealing productively with administrative issues on the first day.

## First Day: Introduce students to active learning, actively

Beginning the semester with active learning strategies from the very first day sets clear classroom norms and aligns your first day activities with the actual structure of the course (Gaffney and Whitaker, 2015). The challenge can be to find an activity in which students can engage, which does not require content knowledge. Below are some suggestions.

### Discuss the course approach or goals.

As described above, you can use an active learning approach to discussing the course structure and purpose, through activities such as Traxoline and Dancealot. You can also discuss why the course is relevant for student lives and careers – see several examples in the Why Study [Your Course] activity. Such activities serve the dual purpose of discussing the reason and rationale for the course, and setting accurate norms for engagement. Hear from several seasoned instructors in this 5-minute video on establishing expectations for participation.

### Open the floor for questions.

Invite students to ask questions and spend the first day answering any question, even crazy questions, about your subject (see example activity Ask Me Anything). This establishes your credibility and creates rapport with students.

### Engage students in accessible course content.

There are several ways to jump into course content without requiring prior knowledge. You might ask students to solve an estimation problem in a group (see example activity Fermi Questions), or use an activity on the nature of science (examples: Nature of Science activities, Make a Paper Airplane, or several geoscience examples that could be adapted for other disciplines).

## Make sure students know how to do well in the course

It is also critical that students know how to do well, because they will feel that they are in charge of their own learning (see Chapter 3: Motivation for more about the importance of ownership). As stated earlier in this chapter, student resistance often stems from anxiety about grades. Below are some strategies for ensuring that students know how to be successful.

### Share success strategies from past students.

It can be very useful to discuss the types of student behaviors that typically lead to success (Moore and Jensen, 2007). One approach is to show common student responses about strategies for success, such as preparing for class and interacting with other students. See Advice to Future Students for an example. If you use Learning Assistants, those LAs can also provide such advice as undergraduate peers.

### Clearly communicate expectations for student work

Show your learning goals for students at the beginning of the course, and at the start of each lecture. Align your assessments to these goals, and make sure students understand how assessments will be graded. To communicate expectations on a particular task, use a simple grading rubric. To help them better internalize your expectations, you might give students examples of good and bad academic work, and then ask them to grade the examples based on that same rubric. Make these rubrics public before the activity that they will be used to evaluate. You can gradually wean students from such rubrics over time, once these expectations are established (Seidel and Tanner, 2013).

### Use early, low-stakes assessments.

Within the first few weeks, give an assessment that counts very little towards the final grade. This assessment can improve student confidence, and clarity on course expectations, without significant risk to their grades (Ellis, 2013). It will also demonstrate how future work will be assessed. For example, use the first homework or a mini-quiz to demonstrate how assignments will be graded, or how a rubric will be used.

### Give regular, clear feedback.

Clear, individual feedback is one of the most essential ingredients to student learning (Pintrich, 2003, Moreno 2009). This feedback should be clear and accurate, to help students develop a clear sense of how well they are mastering the material. Feedback should also include recommendations on how to improve in the future. This can be done on individual work, or in feedback to the class as a whole. You

may also want to show students grade distributions (from the current and past courses), to allow students to properly manage their grade expectations. (Moore and Jensen, 2007). However, be careful of inappropriately setting students up for competition with one another, and realize that many students will (incorrectly) place themselves in the top part of the distribution.

**Mitigate overconfidence.**

Consider metacognitive strategies (see Chapter 2: Metacognition) to help students reflect accurately on their own performance. You may want to avoid open-book exams, which may falsely inflate students' confidence (Moore and Jensen, 2007; Jensen and Moore, 2008).

## Help students navigate group work

Students may feel anxious when presented with group learning opportunities, as the familiar routine of traditional lecture has been disrupted. Help ease the transition with a few of the following strategies to set clear expectations for working in groups.

**Establish a routine.**

With a clear, consistent routine, students will know what is expected of them and feel more comfortable (Slezak, 2014). For example, you might start each day with a clicker question related to the last class, go over student comments to the pre-class preparation activity, lecture for a short time, and then begin an active learning exercise. Or, you could begin with a group problem or other active learning exercise.

**Structure the groups for success.**

Use an early, engaging activity that requires students to work together, such as an easy Nature of Science activity. This builds successful collaboration early in the course, and helps to avoid isolated students who aren't part of a group. Also see our Group Skill Building activity for suggestions on forming the first groups, and Chapter 7: Group Work for more suggestions on structuring group work and tasks for engagement.

**Provide clear goals and instructions for tasks.**

Give clear instructions about the purpose of the task and what they will be doing, to mitigate any sense of aimlessness (Patton, 2010); the purpose of learning tasks is often clearer to the instructor than the students! Make sure your instructions on the task itself (e.g., written directions on the worksheet) are clear – again, this is an area where we, as educators, can often improve.

## Summary and Action Items

When students encounter an active learning classroom, they may be unsure of what is expected of them. They may fear they won't be evaluated fairly, or won't see a clear path towards success. This anxiety and uncertainty can cause them to withdraw from interactive learning activities. So, to get off on the right foot, explaining the value of active learning can go a long way towards promoting student engagement.

| General approaches | Specific strategies |
|---|---|
| **First Day: Be explicit about your pedagogical choices**<br>Let your students know why you're using the approaches that you're using, and help them see the value in them, but try to avoid lecturing about how active learning is good for them. | ☐ Explain to students why you have chosen to teach this way.<br>☐ Highlight the shortcomings of traditional lecture.<br>☐ Solicit student ideas about the course.<br>☐ Ask students to reflect on their learning strategies and goals.<br>☐ Use a syllabus quiz |
| **First Day: Introduce students to active learning, actively**<br>Beginning the semester with active learning strategies from the very first day sets clear classroom norms and aligns your first day activities with the actual structure of the course. The challenge can be to find an activity in which students can engage, which does not require content knowledge. | ☐ Discuss the course approach or goals.<br>☐ Open the floor for questions.<br>☐ Engage students in accessible course content. |
| **Make sure students know how to do well in the course**<br>It is also critical that students know how to do well, because they will feel that they are in charge of their own learning. Student resistance often stems from anxiety about grades. | ☐ Share success strategies from past students.<br>☐ Clearly communicate expectations for student work<br>☐ Use early, low-stakes assessments.<br>☐ Give regular, clear feedback.<br>☐ Mitigate overconfidence. |
| **Help students navigate group work**<br>Students may feel anxious when presented with group learning opportunities, as the familiar routine of traditional lecture has been disrupted. | ☐ Establish a routine.<br>☐ Structure the groups for success.<br>☐ Provide clear goals and instructions for tasks. |

## Further reading on this topic

Full references appear in the References section.


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# Chapter 2: Metacognition and Mastery

How can I help students become more expert learners, so they engage in and benefit from active learning?

Students may approach coursework from a fairly mechanistic stance: If the instructor gives me information, I will memorize it, and get a good grade. This approach to learning doesn't lend itself well to an active classroom, which requires students to wrestle with difficult ideas in order to lead to deeper conceptual learning. This chapter focuses on helping students engage productively in active learning classrooms by teaching students reflect on their learning and develop productive mindsets towards learning.

## How do attitudes towards learning affect student engagement?

*Keywords: Epistemology, self-efficacy, persistence, mindset, mastery, performance, achievement, self-regulation, metacognition, goal orientation*

Students' approaches to learning, and their ability to reflect on their learning, can affect both (1) their *willingness* to engage in active learning, and (2) their ability to *be successful* (e.g., learn effectively and get a good grade) in active learning classrooms (Ertmer and Newby, 1996). Thus, students' ability to think about their own learning (called "metacognition") is critical to the success of an active learning classroom. Let's spend a little time unpacking why this is the case.

**Student beliefs about learning affect their approach to coursework.**
Students have ideas and beliefs about what it means to learn a subject ("epistemology"), which can help or hinder their learning. A student who believes that she learns best by listening to a clear explanation may not readily engage in active learning strategies, thinking that this time is wasted and inefficient (Yadav, Lundeberg, Subedi and Bunting, 2001; Lake 2001). Similarly, a student who believes that physics is a collection of facts and equations (rather than a coherent set of concepts) may tune out during a conceptual question, not realizing that the point is to help him better understand the meaning behind equations. Some instructors explicitly embed epistemological discussions into their courses (see for example Brewe et al., 2009 and Redish and Hammer, 2009), such as discussing the assumptions that go into creating a physical model, seeking coherence in physical ideas, and how these ideas form the foundation of science. A clear focus on epistemology may help students develop productive attitudes towards learning (Brewe et al., 2013; Ding and Mollohan, 2015): Indeed, one of the few types of interactive instruction to result in positive shifts in attitudes towards learning physics (Modeling; Brewe et al., 2009) has a clear focus on epistemology.

**Students with a goal of content "mastery" are more likely to engage and persist**.
Students' goals for learning content affect their engagement (their "goal orientation"). Are students trying deeply understand the material ("mastery" orientation)? Or are they focused only on getting a good grade in the class ("performance" orientation)? Those with a performance orientation are more likely to focus on getting the right answers and earning a grade, defer to the instructor's authority, turn away from challenges and effort, and are less likely to engage in alternative instruction. Those with a mastery orientation are more open to challenges, tend to see learning as a process, see effort as necessary for learning, value the shared expertise in the room, and persist in the face of setbacks (Ertmer, Newby and MacDougal, 1996; Smith, Lewis, Hawthorne and Hodges, 2013; Dweck 2007; Good, Rattan and Dweck, 2012; Anderman and Dawson, 2010; Dweck and Leggett, 1988; Ames 1992; Blackwell, Trzesniewski and Dweck, 2007). See below for an outline of the difference between mastery and performance goal orientations (which is closely related to "growth" vs. "fixed" mindsets towards learning; see Smith, Lewis, Hawthorne and Hodges, 2013). Note that teams (not just individual students) can also show mastery or performance goal orientations (Linder et al., 2010)!

Students (or teams) with mastery vs. performance goals (adapted from Moreno, 2009).

| **Students with performance goals….** | **Students with mastery goals….** |
|---|---|
| See intelligence as innate ("fixed") | See intelligence as malleable ("growth") |
| Avoid challenges | Seek out challenges |
| Are motivated by easy tasks | Are unmotivated by easy tasks |
| Are more extrinsically motivated | Are more intrinsically motivated |
| Seek flattering feedback on their performance | Seek feedback on their learning |
| Attribute success and failure to ability | Attribute success and failure to effort |
| Are less likely to regulate their learning | Are more likely to regulate their learning |
| See errors as a sign of failure | See errors as an opportunity to learn |
| Are satisfied if they get a good grade or outcompete other students | Are satisfied if they try hard and make progress |

**Goal orientation is particularly important for underrepresented students.**
For example, women in the natural sciences often feel they are putting in more effort than the men in the course, and that they lack natural talent for the subject and thus do not belong in the discipline (Smith, Lewis, Hawthorne and Hodges, 2013). Black students, stereotypically, have not been well represented in the sciences, and so often encounter "stereotype threat" – the expectation that they will not do well due to their race. In both of these situations, focusing on the more productive "growth" mindset towards learning (e.g., that effort is a normal part of learning) has been shown to mitigate stereotype threat and increase a sense of belonging (Aronson et al., 2002; Good et al., 2003; Smith, Lewis, Hawthorne and Hodges, 2013).

**Students learn better when they are able to monitor and plan their own learning.**
"Self-regulation", or the ability to monitor and plan your own learning, and adjust accordingly, is a key ingredient in learning (Bransford, Brown and Cocking, 2000; Moreno, 2009). For example, a student might review questions to self-evaluate their progress; if he does not do well, then he goes back and reviews again (Moreno, 2009). Students with high levels of self-regulation have been found to maintain positive responses to interactive class techniques over time, but those with lower self-regulation lose their motivation and confidence by the end of the semester as

pressures from other courses mounted (Ertmer, Newby and MacDougal, 1996). You might enhance students' ability to self-regulate by providing many opportunities for them to reflect on their own learning ("metacognition") – such as writing down what they are confused about after a lecture -- so that they can see whether they are mastering the material or not.

**Instructors can affect student ideas about learning.**
Luckily, students' goals for learning are very malleable and context-dependent, which means that you *can* influence how students frame their goals for your course (Pintrich, 2003). First, you might want to reflect, what are your own ideas about learning? Your own implicit ideas can have a big impact on how you teach (Good, Rattan and Dweck, 2012). Do you implicitly have performance goals for your students – and yourself -- and a "fixed" mindset about intelligence? Think about the messages that you send students. Do you show your students that you want to be corrected during class, that you own up to your own errors, and learn from them? Or do you present yourself as a flawless lecturer who cannot be questioned? Do you praise students for their effort, or their grades? Consider intentionally framing your classroom for mastery: You can emphasize that learning science takes effort and that anyone can improve if they work hard (Dweck 2007; Good, Rattan and Dweck 2012; Anderman and Dawson, 2010). You can create opportunities for students to reflect on the process of their own learning so they become more self-directed learning (Elby 2001; Redish and Hammer, 2009; Bransford, Brown and Cocking, 2000). Helping students reflect on their own learning, or "think about thinking" is termed "metacognition." Metacognition is a learned skill that is unfortunately not directly addressed in many college courses.

## Strategies for helping students become more expert learners

Below we provide strategies for promoting student metacognition, productive ideas about learning science, and effective goals for learning. By using a few of these strategies, you can make ample progress towards helping students understand and experience the benefit of active learning. Many of these strategies will be most effective if used heavily in the first month of the course, particularly within assessments. For example, you might assess students' beliefs about learning early in the semester and then embed reflection questions into homework and clicker questions throughout the semester. After the first exam, provide them with an opportunity to reflect on their performance with an Exam Self-Reflection and discuss Bloom's Taxonomy. Pull out a few of these strategies throughout the semester, especially as students become stressed and fatigued later in the semester and may revert to old habits.

### Help students think about their approach to learning

One way to help students reflect upon and realize the benefit of active learning is to help students think about their own ideas about teaching and learning, and how your teaching approaches align with those internal beliefs. Students benefit from reflecting on their personal learning strategies, empowering them to make adjustments for the future. This can be done by modeling reflective behavior, and then prompting students to engage in it. This cognitive support can be directly written into activities and gradually "faded out" as students become habituated to this approach. In a one-semester course, however, routine practice may be needed during the entire course to start seeing shifts in their ability to reflect on their learning. Below are some example approaches.

**Probe student beliefs about learning.**

There are several validated assessments about student beliefs about learning (such as the Chemistry Self-Concept Inventory or the Maryland Physics Expectations Survey). You might give one of these assessments early in the course for participation-only credit (e.g., on the first homework), and ask students to reflect on their responses. Giving the same assessment again at the end of the course will let *you* assess if the course had any impact. For example, ask students to reflect on the first day of class, and again after the first exam, "What is the most effective study strategy? The least effective?"

**Be explicit about your learning goals and teaching strategies.**

In order for students to effectively reflect on their learning, they need to know what it is they're supposed to learn and the best ways to learn it. Set clear learning goals for student work and communicate them. Describe the rationale for the activities you're assigning (see our Slides explaining active learning (PPT), or clicker questions-how people learn (PPT)).

**Model self-reflection in class.**

During whole-class activities, and small group work, you can model self-reflection by thinking out loud through problem solving. Take time to discuss the rationale behind a problem solution, instead of just giving the answer, including why other answers or strategies are not correct. Prompt students to think about their own thinking. You can help groups identify where they are stuck, and help students formulate their questions about the material (rather than explaining answers; Moreno, 2009). For example, ask students some questions in the first or last few minutes of class, such as "Write down anything you already know about _____," or "One of the things that I would like to learn more about is ____," or "What is one thing you are struggling with most in this content?" You can do this as a one-minute paper which is collected by the instructor. In larger classes, you might send students a link to an online form which they can even complete during class on their phones or computers, allowing easier sorting of responses. You can also use one-minute papers for students to reflect on the group process after a group activity.

**Have students self-reflect on their exams and homework.**

Ask students to reflect on their progress on exams or homework, or complete a short checklist on their work (see Self-Assessment Worksheets for example checklists). Consider asking students to share a "weekly insight" about the course (the course content or their learning). Midway through the semester, ask students to complete a brief survey about what they can do to improve their learning (see Stop Go Change activity.) You can use homework questions (see Metacognitive Homework), or clicker questions (see Clicker Questions – metacognition (PPT)) that ask student to reflect on their learning. After the first exam, ask students to complete an Exam Self-Reflection where they reflect on how they prepared for the exam, their performance, and how they might change their strategies to prepare for the next exam. You can also give students an extra-credit assignment, where they can earn points by answering questions they got incorrect on the exam.

**Embed epistemology directly into the course.**

If a significant learning goal for your classroom is that students develop as expert learners through a process of developing self-awareness about their own learning, then integrate this idea directly within the course content. Provide lessons on learning, include self-reflection as a component in all course aspects, and highlight ideas of thinking and learning in the lecture. For example, you might give a mini lecture on Bloom's Taxonomy, along with an activity where students discuss how to best learn at

higher levels (see Bloom's Taxonomy activity). You might periodically ask students to complete a self-reflection rubric (see Self-Assessment Worksheets) where they assess their learning skills (such as persistence, organization, and resourcefulness), and discuss what they plan to improve. See Redish and Hammer (2009) for an explicit approach to epistemology within a physics curriculum (particularly in the supplementary appendix). Lastly, give students course credit for completing these metacognitive activities, as this places value on self-awareness as part of the goals of the course.

## Give students feedback so they can adjust their learning approach

The use of frequent assessment for purposes of feedback to students (i.e., "formative assessment") is valuable both for setting clear expectations for student learning, and for guiding students to continually gauge their progress towards mastery, without significant risk to their course grade (Ellis, 2013). Frequent assessment can also help mitigate the common problem of student over-confidence in their ability (Karatjas, 2013), and help students adjust their approach through the course. These assessments do not need to contribute to the formal grade; having them be completed for participation credit can help avoid the demotivating aspect of grades (Schinske and Tanner, 2014).

### Provide frequent, low-stakes assessments of learning

The first homework or mini-quiz can be used to give student feedback on their learning, counting for a smaller portion of their grade. Clicker questions, one-minute papers, group work, quick in-class sketches, and other classroom assessment techniques (CATs) also give students valuable feedback. To avoid spending excessive time grading such assessments, .

### Use group or two-stage exams.

In a group exam, students complete the exam individually, and then again as a group, which contributes to their scores. This has the benefit of leveraging student motivation post-exam, giving them immediate feedback on their understanding, and using assessment strategies that align with an interactive approach which focuses on improvement. See Group Exams for detail.

### Give students opportunities to assess their work (or that of their peers).

Self- and peer- assessment provides valuable practice in metacognition. For example, a simple rubric can ask students to rate their work, and perhaps compare that rating to that of a teacher or peers. You might give students examples of good and bad academic work, and then ask them to grade the examples based on a rubric. This can provide valuable practice for self-assessment, as well as helping students understand what the professor is looking for in an assignment. See Self-Assessment Worksheets for a simple self-assessment checklist and sample peer assessments. The online Student Assessment of Learning Gains (SALG) can be used to prompt students to reflect about their progress on your learning goals.

## Help students see learning as a process, which requires effort

This final aspect of supporting students to become expert learners focuses on supporting their "mastery" orientation towards learning (see introduction). These strategies all focus on helping students overcome obstacles to see that they can succeed with effort and practice, rather than natural talent. If students see learning as requiring effortful practice, then the benefit of active learning strategies becomes clearer.

### Communicate that it's normal for learning to take effort.

Celebrate the hard work that goes into learning science, and that students can improve if they work hard (Smith, Lewis, Hawthorne and Hodges, 2013). Frame challenge as fun and useful, easy tasks as boring and not as helpful for learning (Dweck, 2010). As Slezak (2014) suggests, "I tell each class now that the queasy feeling they have in their stomachs is what learning is all about."

### Give students opportunity to revise and resubmit work.

Give students copies of quiz, exam, or homework solutions, ask them to make corrections, and discuss how they will use this information to improve in the future. Students turn this corrected work in as a required assignment. This method improves students' metacognition and relieves some of their exam stress (Henderson and Harper, 2009; . Alternatively, you may assign a "re-engineering" assignment, requiring the student to re-write the original question to make their chosen answer correct. You can also use a "mastery" approach to homework in general, by providing the solution with the assignment, grading on effort, emphasizing explanations on homework (and test questions), and reflecting on results (see Elby, 2001 for detail and Metacognitive Homework). As a policy, you can replace poor homework or quiz grades if a student later demonstrates mastery of the concepts, or replace the first exam score with the relevant score on the final exam, if the student demonstrates later mastery.

### Have high standards and don't hastily encourage students.

While it may be tempting to praise students as a way to help them gain confidence, providing challenging tasks, having high standards, and encouraging students to meet them is more likely to promote a "growth" mindset towards learning (Dweck, 2007). Praise students for their efforts, rather than for being right. If students receive praise easily, they may take this as a cue that you don't think they are capable of performing at a higher level (Dweck, 2007). After the first weeks of the class, reserve your praise. And when you do use praise, be specific. Ask rigorous questions, and generally work to cue students that you believe they can perform at a high level (Boekaerts, 2010).

### Focus your feedback on learning and growth.

Avoid comparisons to other students, including grading on a curve, and focus on students' individual effort and success instead (Pintrich, 2003). Celebrate their progress, focusing on the "aha" moments, and pointing them out to the class as a whole (Slezak, 2014). Emphasize the purpose of active learning tasks as learning exercises, not means to achieving a final grade (Boekaerts, 2010). For example, with an upcoming assignment, "I just want to see you striving to perform better. Everything is a step in the right direction; you all have already improved tremendously" (Kerssen-Griep, 2001). "You gave it a good try, but it didn't work, do you have any idea why? Or, "Could you think of another way to do this next time?" (Boekaerts, 2010).

## Summary and Action Items

Students may approach coursework from a fairly mechanistic stance: If the instructor gives me information, I will memorize it, and get a good grade. This approach to learning doesn't lend itself well to an active classroom, which requires students to wrestle with difficult ideas in order to lead to deeper conceptual learning. Help students engage productively in active learning classrooms by teaching students reflect on their learning and develop productive mindsets towards learning.

| General approaches | Specific strategies |
|---|---|
| **Help students think about their approach to learning**<br>Students benefit from reflecting on their own ideas about teaching and learning, and how your teaching approaches align with their internal beliefs. Engagement in this reflection will empower them to make adjustments in their approach to learning in the future. | ☐ Probe student beliefs about learning.<br>☐ Be explicit about your learning goals and teaching strategies.<br>☐ Model self-reflection in class.<br>☐ Have students self-reflect on their exams and homework.<br>☐ Embed epistemology directly into the course. |
| **Give students feedback so they can adjust their learning approach**<br>The use of frequent assessment for purposes of feedback to students (i.e., "formative assessment") is valuable both for setting clear expectations for student learning, and for guiding students to continually gauge their progress towards mastery, without significant risk to their course grade. | ☐ Provide frequent, low-stakes assessments of learning.<br>☐ Use group or two-stage exams.<br>☐ Give students opportunities to assess their work (or that of their peers). |
| **Help students see learning as a process, which requires effort**<br>Support students' "mastery" orientation towards learning (see introduction) by helping them to see that they can succeed with effort and practice, rather than natural talent. If students see learning as requiring effortful practice, then the benefit of active learning strategies becomes clearer. | ☐ Communicate that it's normal for learning to take effort.<br>☐ Give students opportunity to revise and resubmit work.<br>☐ Have high standards and don't hastily encourage students.<br>☐ Focus your feedback on learning and growth. |

## Further reading on this topic

Full references appear in the References section.


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# Chapter 3: Motivation

*How can I help students feel intrinsically and extrinsically motivated to engage in active learning activities?*

If students don't want to engage in active learning, it's pretty hard to force them. You can't rely solely on grades to spark students to action. This chapter focuses on motivating students to engage productively in active learning classrooms through the use of various internal and external rewards.

## How does motivation affect student engagement?

*Keywords: Autonomy, persistence, constructivism, facework, face threat, identify management, self-determination theory, identity, Productive disciplinary engagement, outcome expectancy, positive interdependence, Self-efficacy, learned helplessness, identity management, face threat, self-regulation theory, internal locus of control*

Motivation is probably the most important ingredient of learning (Pintrich, 2003; Ambrose et al., 2010). Learning is hard work and a motivated student is more likely to engage deeply with the material and push past difficulties. Students have busy and complicated lives, and the demands of your course are competing with multiple obligations. Make sure it's worth their while to prepare for your class, and engage in the activities. Luckily, there are many things that an instructor can do to motivate students to engage.

Motivation is a complex construct, with several different elements. First, some vocabulary. "Extrinsic motivation" is driven by external factors, such as rewards or grades. "Intrinsic motivation," on the other hand, arises from within the individual. The major components of intrinsic motivation are interest, a sense of ownership, and confidence in one's ability. For a useful review of factors affecting intrinsic motivation to learn, see this short handout on Motivating Learning. Intrinsic motivation is more powerful than extrinsic motivation in empowering students to learn, but both have their role. Below is a brief review of intrinsic and extrinsic motivation for engagement in active learning.

### Extrinsic motivation

**Students are more motivated to work together if they are held accountable for doing so**. One of the most common failure points of cooperative group learning is a failure to include accountability for working together and learning well as a group (Moreno, 2009; Slavin, 2010) – such as working collaboratively towards a group goal, or complete an assessment of their group process (see Chapter 7: Group Work for more). Student engagement hinges on such accountability (Engle and Conant, 2002; Svoboda and Passmore, 2010; Fredericks et al., 2004;

Slavin, 1995; Moreno, 2009). The intrinsic motivation of social interaction is not sufficient to generate engagement. If students feel a sense of "positive interdependence," or a sense that the group cannot succeed unless all members of the group succeed, they are more likely to participate, work together, and take each others' learning seriously (Moreno 2009, Slavin 1995). Indeed, when there is no group accountability, cooperative learning may be no more effective than traditional instruction (Klein and Schackenberg, 2000). Students also need *individual accountability* (e.g., assessment of individual learning, such as a clicker question on the group activity content, or an individual test of learning), so that all students contribute.

**Grades can backfire as incentives**.
Don't rely on grades alone to incentivize students. Several studies have shown that grading acts as a negative motivator -- students are motivated to avoid bad grades, rather than to engage in learning. Grades dampen students' intrinsic motivation, make them more externally motivated, decrease their enjoyment of the learning process, increase their anxiety, and increase competitiveness between students; particularly for students who are struggling (Moreno, 2009; Fredericks et al., 2004; Ames 1991). And even if grades initially boost student engagement, once the grading incentive ends, student engagement tends to end (Moreno, 2009). Grading trumps feedback: Students are demotivated by grades even when they are accompanied by positive written feedback (Schinske and Tanner, 2014 and references within. See Chapter 2: Metacognition for more information on creating a classroom atmosphere that focuses on growth, or mastery, mindsets.

## Intrinsic motivation

**Students are more motivated if material feels personally relevant**.
Students must, on some level, *care* about the course content or activity if they are to be motivated (Kerssen-Griep, 2001; Pintrich, 2003). If the activity feels interesting and worthwhile, connected to everyday life or to students' professional goals, students will be more likely to genuinely engage in it. A related idea is that of student *identity* and belonging; if students feel "I don't belong here," they may feel less motivated to engage (Cohen et al., 1999) – a problem particularly common for underrepresented students (Murphy, Steele, and Gross, 2007; Walton and Cohen, 2007). See Chapter 4: Class Community for ideas on how to intentionally create an inclusive, respectful class community.

**Students feel more motivated when they have a sense of ownership and autonomy**.
Ellis (2013) found that students who resist active learning are often influenced by feeling forced to engage in a learning environment that they don't like. Thus, student ownership and control are critical ingredients for engagement. If students feel that they have control over their learning, are engaging for their own reasons, and they have a say in classroom decision-making, they are more likely to engage (Fredericks, Blumenfield and Paris, 2004; Ames 1991, Pintrich 2003; Moreno, 2009), enjoy learning (Hall and Webb, 2014) and to learn effectively (Piaget, 1954). Autonomy is critical; even if other aspects of intrinsic motivation (see below) are adequately attended to, students may not be motivated if they don't feel that they are in control of their educational outcomes (Lim and Bowers, 1991 Thus, teachers need to give students some control and choice in their learning (such as choice in assignment topics, voting on office hours, ability to choose group members, or opportunities to give feedback to the instructor), and minimize external

pressures (such as grades and deadlines). Of course, there are many places where you, the expert, should be making choices about how to proceed, but even modest amounts of student control or choice can make a large difference in motivation. Consider the following parable: "The zookeeper told the monkeys in the zoo that they would be given 5 nuts in the morning and 2 in the afternoon. The monkeys were very angry. So the zookeeper said, OK, you can have 3 nuts in the morning and 4 in the afternoon. The monkeys were overjoyed." Consider – where are decision-points equal for you as the instructor, but may make a large difference for students? Those are the places to give students control, once you can find them.

**Students are less motivated if they feel controlled – but it's difficult, as the instructor, to avoid controlling behaviors.**

Controlling behavior is quite common: Using external rewards (like points), using language that puts pressure on students, being impatient for students to come up with the right answer, and asserting power in the face of student complaints or disengagement (Reeve, 2009). You can become more aware of your own controlling behaviors if you ask yourself the following question: Do you focus on students' internal motivations, or do you try to get students to think, act and feel in a certain way? While it is healthy for teachers to productively recommend ways of thinking or behaving, those recommendations become controlling when he/she tries to overrun the student's perspective (Reeve, 2009). This occurs, for example, when a teacher interrupts a student to take control of a computer simulation that the student is using, takes the marker out of the student's hand, or the teacher tells a student that he/she has to do something without explaining why it will be beneficial. Unfortunately, our culture tends to value a controlling classroom structure, and our natural tendency in the face of a student who is disengaged is often to fall back on these controlling behaviors (Reeve, 2009; Ambrose et al., 2010).

**Students are more motivated to engage if they feel capable and competent.**

Students' sense of competence and confidence, or "self-efficacy," is key to their engagement and persistence (Boekaerts, 2010; Moreno, 2009; Pintrich, 2003; Bandura, 1997; Cervone and Peake, 1986). Women in male dominated fields typically have low self-efficacy (Betz and Haacket, 1981). While a student's beliefs about their ability might not seem to be something you can impact in a single class, peoples' reactions vary greatly in response to different tasks. Your challenge is to tap into students' internal confidence through what you say and do in the class. On the far end of the scale are struggling students who have developed a sense of "learned helplessness," where they believe that their actions don't affect their academic success (Moreno, 2009). Framing tasks as helping students improve, rather than to evaluate their performance, can increase engagement for such students (Ames, 1991).

**Students are less motivated to engage if they feel "dumb".**

Don't forget that students are social animals. When we find ourselves in an embarrassing situation, we struggle to "save face." Such embarrassing situations are said to be "face threatening" (Witt & Kerssen-Griep, 2011; Kerssen-Griep, 2001; Lim and Bowers, 1991; Gaffney and Housley Gaffney, 2016; Gaffney and Whitaker, 2015). In active learning classrooms, there are plenty of opportunities for such "face threats" to occur, when students will be in situations where they feel unsure about their abilities. Feedback in particular has great potential for lessening the negative effects of face threat (Witt and Kerssen-Griep, 2011). See also Chapter 4: Class Community to help mitigate face threat in your responses to student ideas.

**Students are more motivated if they feel that the class environment is favorable for learning**.
The classroom context sends a strong message to students about the degree to which their ideas will be respected. If students feel included and supported, they are dramatically more likely to take the necessary risks to engage in cooperative learning. See Chapter 4: Class Community.

## Strategies for enhancing student motivation

Because motivation is such a complex concept, let's summarize the above in a short table (adapted from Ames 1992; Reeve, 2009; Lim and Bowers, 1991; Stefanou et al., 2004).

| What motivates students to engage? | So instructors can… |
|---|---|
| 1. Accountability | - Use individual and group goals and rewards<br>- Give credit for participation<br>- Offer small incentives, but reduce them over time<br>- Focus on improvement and effort<br>- Encourage a mastery goal orientation (see Chapter 2: Metacognition and Mastery) |
| 2. Interest | - Provide stimulating, varied tasks<br>- Provide material that is personally relevant |
| 3. Autonomy | - Engage students in decision making<br>- Welcome and build on student ideas and input<br>- Explain the rationale behind activities<br>- Avoid controlling student behavior |
| 4. Competence | - Help students "save face"<br>- Express respectful interest in contributions<br>- Give opportunities to feel successful<br>- Offer reasonable challenge |
| 5. Social context | - Positive and inclusive norms in the class<br>- See Chapter 4: Class Community. |
| 6. Instructor credibility | - Instructor seen as trustworthy, competent, honest, fair and caring<br>- See Chapter 4: Class Community. |

Below are specific examples of how to accomplish this. By attending to a few of these strategies, you will be able to foster a classroom where students are intrinsically motivated to engage in active learning. See Chapter 7: Group work for suggestions on building interest and motivation directly into your activity design. To hear from several seasoned instructors watch this 5-minute video on how they tap into student motivation.

### The First Day: Connect to students' interest and identity

From the first day, and onward through the course, seek to learn about your students' interests and clearly connect the course to those interests and goals. This strategy is very powerful for engaging students' intrinsic motivations, as well as helping them to feel a sense of identity and belonging in the course.

**Find out about your students.**

It is difficult to target activities to student interests if you don't know what those interests are. What you find interesting may not be as fascinating to your students as you would expect. You can ask students to answer a few questions about themselves on the first homework assignment, use a brief survey, or ask them to write on an index card (name on one side, answers to a few questions on the other side). This index card can then be used for randomly calling students to respond to discussion questions (see below). For examples, see this discussion of first day surveys on SERC, and this .

**Make explicit connections between the course content and students' lives.**

You can discuss the relevance of the course to students' lives or careers, describe career opportunities related to your subject, or have students build their own lists of what scientists in your discipline do. See First Day Questions for examples of discussions about students' personal goals in your course, and Why Study [Your Course] for discussion activities related to course relevance.

## Use grading and praise effectively

As discussed earlier, grading can be a poor motivator for students to engage. A good compromise can be to offer small external incentives that show the value you place on engagement, and that are directly linked to the behavior (like participation points for speaking up in class). You may be able to reduce grade-based incentives over time, as students become habituated to classroom expectations and more comfortable with speaking up (Dallimore, Hertenstein and Platt, 2012). In addition to points, you can use other types of external rewards, such as a built-in need to consult with other groups in an activity, or limited and specific praise on performance. In general, extrinsic rewards are more useful if they give students information about their learning, support effort and improvement, and are not perceived as trying to control or bribe student behavior (Anderman and Dawson, 2010; Ames, 1991). Below are examples of how to use grading in such a productive way to encourage engagement.

**Avoid curving or competitive grading.**

Grading on a curve sets students up against each other. Instead, use curving that focuses on individual performance and growth. If an exam question was confusing, eliminate it from analysis instead of curving it. See Chapter 2 (Metacognition and Mastery) for suggestions on using feedback to motivate students, and allowing students to revise and resubmit work.

**Grade for participation and effort.**

Give students opportunity to earn credit by doing the work and engaging with the material by providing credit for participation on in-class assignments (such as clicker questions or one-minute papers), for completeness on out-of-class assignments, or for having a quiz score exceed an earlier performance. Assign a portion of the overall course grade to effort and participation. Try using "Sticky Participation Points" to reward participation: When students speak up in class, give them a token that can be exchanged for participation points.

**Use praise as a reward.**

Informational feedback that praises the effort of a student is motivating (e.g., "excellent job," or "you planned your work well"). But, if you give praise for every behavior, students can interpret this to mean that you don't think they can perform at a high level. Specific praise, used sparingly, is most effective (Moreno, 2009).

**Provide both group and individual accountability.**

When working in a group, students must be striving for both group and personal achievement. See Chapter 7: Group Work for suggestions on how to support this in your classroom.

**Call on students at random to share their ideas.**

If you want students to participate in class discussions, students need to feel a responsibility for doing so. "Random call" is one way to generate this accountability, and increases students' comfort with participating in class discussions (Dallimore, Hertenstein and Platt, 2012), including participation by female students (Eddy, Brownell and Wenderoth, 2014). Random call after a group activity can also increase student participation in the group activity itself: Shekhar and Borrego (2016) found that cold-calling on students at the end of an activity increased group participation from one activity to the next. Conversely, when the instructor announced that she wouldn't call on students after the activity, the percent of students actively engaged in the activity dropped from 90% to 10%. Warm students up to the idea of random-call by telling students in in the first class that you will be doing this, but that you will give students a chance to reflect and prepare their answers in advance. You can use a randomized class list, dice, a deck of cards with student names on them, or phone applications such as Names in a Hat.

**Hold students accountable for pre-class preparation.**

In many active learning classrooms, instructors require pre-class preparation so that students arrive to class ready to engage. The best strategy is probably to require students to complete an assignment for a small number of points (which count towards their final grade), and to make sure *not* to cover the material from the preparation task in class. That way, the preparation feels more necessary and important. See Just in Time Teaching for more ideas about pre-class preparation.

**Use group or two-stage exams.**

In a group exam, students complete the exam individually, and then again as a group, which contributes to their scores. Such an exam style supports student motivation by including both individual and group levels of accountability, using the exam situation to provide immediate feedback on learning, and focusing assessment on understanding and collaboration. See Group Exams for detail.

## Support students' ownership over their learning

To support students' autonomy, teachers need to cede control of learning to the students, allowing students' own interests to drive the process of learning. As the instructor, you can let students make choices regarding their learning, ask for student input, and act on student suggestions and ideas (Moreno, 2009). The importance of autonomy also reveals why well-meaning attempts to explain why you're using active learning may backfire, since "selling" active learning may make students feel that ideas are being imposed upon them (Gaffney and

Whitaker, 2015). It can be hard to avoid acting in a controlling way in the classroom, resorting to providing punishments and rewards for student behaviors, especially if students are not engaging productively. See below for some suggestions.

**Set clear expectations for student behavior and work.**

Since students need to feel in control of their outcomes (particularly grades), make sure you have made it abundantly clear to them how they can succeed in the course. See Chapter 1: Expectations for ideas on setting clear expectations. If you try too much to convince your students that this approach is good for them, they may push back. You can also share success strategies from former students (see Advice to Future Students activity); if suggestions for course strategies and success come from their peers, rather than the instructor, students may be more receptive.

**Give students choices in their learning.**

There are many ways to give students a chance to decide how they want to achieve their educational outcomes. You may allow students to choose their group members, seating assignments, paper or assignment topics, the form of the final project, or develop their own homework problems (Kerssen-Griep, 2001; Ames, 1991; Ferlazzo, 2015; Stefanou et al., 2004). Have students diagnose their own learning needs, assemble their own learning resources, or evaluate their own learning (e.g., with a self-assessment checklist; Felder and Brent, 2016). It can be helpful to build in some flexibility, so students can vote on some aspects of the course such as optional topics, or the formatting of assignments. Deeper types of choices (such as how to solve a problem) can promote deeper engagement than more superficial choices (such as seating arrangements; Stefanou et al., 2004), but both are valuable.

**Welcome student voice.**

Ask for student input and suggestions, and respond to their ideas. This practice is deeply empowering for students, and is likely to have a high impact on student engagement. You can use Just in Time Teaching (where student answers to pre-class preparation activities are used to drive the following lecture. You can also ask students for their input on activities, projects, and assignments – and incorporate these suggestions if they align with their objectives. Provide them clear mechanisms for voicing their opinions, and let them know how their opinions have guided your practice (Moreno, 2009). You can ask for student input through a midterm evaluation (e.g., Stop Go Change), post-activity clicker questions, minute papers, or online reflection questions (Seidel and Tanner, 2013). With such mechanisms for students to voice concerns, you can respond to them before resistance swells (Seidel and Tanner, 2013). Listen to students' concerns and acknowledge their discomfort – but only make adjustments if they do not threaten the integrity of the course (Slezak, 2014). Trust your curriculum; set realistic expectations about how much say students really have, but respond respectfully and positively to requests.

**Give students enough time.**

Be patient as students work on active learning activities. Give them the opportunity to work at their own pace. Take the time to listen, give encouragement, offer hints, praise their progress, and don't rush them through. This supports their autonomy as self-directed learners (Reeve, 2009). You might use challenge questions within activities for students who finish early, to keep them engaged.

**Use language that supports ownership.**

You might use the phrase "our" class, and when responding to students give them hints, provide

encouragement, and respond to questions. Try to avoid telling students what to do (Reeve, 2009). Invite students to discuss the issues, while keeping control of learning objectives. For example, "We only have ten minutes left, how about we spend that time working in small groups on our project?" versus "We have only ten minutes left, I want to see everyone working on their project." Or, "You will now work on some practice problems, you can choose to do the odd or the even ones" instead of "You need to get through these problems." (Moreno 2009) Having a colleague observe your class can be helpful so you can become aware of controlling language you may be using unintentionally.

## Support students' sense of competence and capability

Help students to feel capable by giving reasonable challenges, and opportunities to feel successful. Framing tasks as helping students improve, rather than to evaluate their performance, can increase student engagement, particularly for those who are struggling (Ames, 1991). Be tactful with criticism, and praise student ideas.

### Ramp up the difficulty.

One way to build student confidence is to give them several early opportunities to feel successful, and then gradually increase the difficulty level of their activities. Don't use a task that is too challenging, especially at the start of the course, as it can reinforce student fears of incompetence (Gaffney and Whitaker, 2015). For example, give early short assignments worth less of their grade. Within an activity, ramp up the difficulty through the course of the activity, so that all students can easily complete the first questions. Scaffold activities so that students get decreasing amounts of guidance, and are able to do more on their own (Moreno, 2009).

### Let students know you believe they can be successful.

Set high expectations, show you're confident that students can achieve these expectations if they work hard, and give them accurate and realistic feedback about their progress (see Chapter 2: Metacognition and Mastery).

### Praise student success and focus on improvement.

This gives students a chance to feel successful and proud. Point out student "aha" moments in class and give positive feedback during class discussions (Slezak, 2014; Lim and Bowers, 1991). Pay particular attention when it seems like students are feeling uncertain, and try not to leave students feeling incompetent. Early in the semester, you might praise all ideas even if they're incorrect, so students are reassured that they can succeed and that it's normal to be wrong sometimes (e.g., Gaffney and Whitaker, 2015). Later, use praise sparingly. Focus on improvement. For example, for an upcoming assignment, tell students "I just want to see you striving to perform better. Everything is a step in the right direction. You have all already improved tremendously." (Kerssen-Griep, 2001).

## Summary and Action Items

If students don't want to engage in active learning, it's pretty hard to force them. You can't rely solely on grades to spark students to action. Motivate students to engage productively in active learning classrooms through the use of various internal and external rewards.

| General approaches | Specific strategies |
|---|---|
| **The First Day: Connect to students' interest and identity**<br>Seek to learn about your students' interests and clearly connect the course to those interests and goals. | ☐ Find out about your students.<br>☐ Make explicit connections between the course content and students' lives. |
| **Use grading and praise effectively**<br>Grading can be a poor motivator for students to engage; instead, you can choose to offer small external incentives that show the value you place on engagement, and that are directly linked to the behavior. | ☐ Avoid curving or competitive grading.<br>☐ Grade for participation and effort.<br>☐ Use praise as a reward.<br>☐ Provide both group and individual accountability.<br>☐ Call on students at random to share their ideas.<br>☐ Hold students accountable for pre-class preparation.<br>☐ Use group or two-stage exams. |
| **Support students' ownership over their learning**<br>Teachers need to cede control of learning to the students, allowing students' own interests to drive the process of learning. Let students make choices regarding their learning, ask for student input, and act on student suggestions and ideas. | ☐ Set clear expectations for student behavior and work.<br>☐ Give students choices in their learning.<br>☐ Welcome student voice.<br>☐ Give students enough time.<br>☐ Use language that supports ownership. |
| **Support students' sense of competence and capability**<br>Help students to feel capable by giving reasonable challenges, and opportunities to feel successful. Framing tasks as helping students improve, rather than to evaluate their performance, can increase student engagement, particularly for those who are struggling. | ☐ Ramp up the difficulty.<br>☐ Let students know you believe they can be successful.<br>☐ Praise student success and focus on improvement. |

## Further reading on this topic

Full references appear in the References section.


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# Chapter 4: Class Community

*How can I create a positive community in an active classroom, so that students feel respected and encouraged to engage?*

It is challenging for instructors to create and maintain a classroom environment where students are comfortable engaging with each other and sharing their results with the class. This difficulty increases with class size. This chapter focuses on helping students to engage productively in active learning classrooms, through creating a supportive and respectful classroom community that welcomes engagement.

## How does classroom community affect student engagement?

While the interactivity inherent in active learning techniques can be motivating in itself, many studies have demonstrated the importance of a respectful, supportive atmosphere, with clear norms for participation (Fredericks et al., 2004). Thus, we suggest creating a "community of learners", in which the classroom is intentionally built with communication styles and structures that enable constructive discussion (Moreno, 2009). This doesn't mean you should have a "fluffy" course, with low expectations and nothing but team building exercises: You can, and should, still have high expectations for your students and how your class time is spent. But attending to the student experience through intentional framing of the classroom culture is crucial to making active learning work in the long term (Moreno, 2009). In smaller courses, you can use personal communication to achieve this; in a larger course, you will need to rely on more general cues to students. Below are general ideas to keep in mind regarding student needs in a community of learners. *Keywords: Sociocultural theory, social constructivism, belonging, identity, psychological needs, autonomy, competence, discourse, community of learners, democratic instruction, identity management theory, self-regulation theory, self-determination theory*

**Students need to know the norms for participation**.
Some student pushback to active learning could be interpreted in a cultural light: when the patterns and norms of interaction change, students may be uncomfortable having to readjust their expectations (Penuel, Roschelle and Abrahamson, 2006). Setting clear norms for participation, and setting them early, helps calibrate student expectations. See Chapter 1: Expectations.

**Student learning is influenced by social factors.**
Learning does not happen only within an individual student; there is a strong interaction between the student and the social environment in which she finds herself (Vygotsky, 1978; Boekaerts, 2010; Lemke, 2001; Ferlazzo, 2015). The importance of social factors in learning is the essence of sociocultural theories of education that focus on the importance of social interaction for student learning and behavior (Moreno, 2009). Additionally, many theories of motivation

highlight that students need to feel related to others (i.e., respected, valued, and included) in order to be motivated to engage (Moreno, 2009; Deci, Ryan and Williams, 1996). Negative attitudes towards active learning could be an indication that this psychological need is not being met.

**Your classroom has a culture.**
The way you communicate and the structures you create form a set of norms and expectations that define a class culture. Is the instructor primarily in a position of power, or are they working alongside students? What is the general attitude towards learning in the course? What is the stance towards collaboration? How are student ideas responded to? One of the few classroom techniques that has been shown to improve students' attitudes towards learning physics (as measured by the CLASS instrument) is Modeling Instruction (Brewe et al., 2009; Brewe et al., 2013). One of the notable features of Modeling is that it uses a particular type of classroom discourse structure that is geared towards creating a culture in which all feel safe and valued in their contribution. A concrete discussion of Modeling Discourse Management can be found in Desbien (2002) and forms the basis of some of the recommendations in this chapter, and a new study of "instructor talk" provides insight into the type of language instructors use which promote a positive class culture (Seidel et al., 2015).

**Students can feel anxious in front of their peers.**
To engage in active learning, students need to feel comfortable taking risks in the classroom and then have those risks rewarded (Penuel, Roschelle and Abrahamson, 2006). There is very real possibility that anxiety will be generated in an active classroom as students put their ideas forward into a public forum. In this situation, there are many opportunities for both students and the instructor to "lose face," or our ability to be seen positively by others. When that public identity is threatened, this is called "face threat". There are many strategies that an instructor can use to mitigate face threat (called "facework"), and studies are indicating that attending to facework seems to be connected to instructor's credibility in the students' eyes and their formal instructor evaluations (Witt & Kerssen-Griep, 2011; Gaffney and Whitaker, 2015). For example, you can learn student names, respond positively to student ideas, praise success, be tactful when critiquing work, and help students feel that "we're all in this together" (Lim and Bowers, 1991; Kerssen-Griep, 2001). All of these practices help to create a safe climate for risk taking and protect students from losing face. Conversely, acting impatient, condescending, annoyed, or accusatory has negative impacts on class climate (see for example Scherr, Close and McKagan, 2011).

## Strategies for creating a positive class community

Below I provide a variety of recommendations for creating a respectful, positive class culture where students feel safe in risking their ideas. By using just a few of these strategies you will be able to cultivate a productive atmosphere for learning and collaboration.

### The First Day: Set appropriate norms for collaboration

From the first day, you can communicate norms for collaboration, and have students engage in the types of interaction that you will be expecting during the rest of the semester. To hear from several seasoned instructors, watch this 5-minute video on establishing a comfortable classroom climate.

### Decide on your norms and goals and assert them.

What are your goals for collaboration? Some common norms for group work include (Tanner, 2013): "Everyone here has something to learn."; "Everyone here is expected to support their colleagues in identifying and clarifying their confusions about biology."; "All ideas shared during class will be treated respectfully." For an overview of different philosophies and approaches that can be used on the first day, watch this 2-minute video of instructors' goals on the first day and this 5-minute video of how their approaches have changed over time, and as a result of the type of class that they teach. Many instructors simply verbally assert the expectations, often on the first day of class. See our sample slides (slides-explaining active learning (PPT)) for some examples.

### Break the ice.

You might start class with practice clicker questions to generate a sense of community (such as, "How did you arrive to school today?" "How many of you hate math?") Use this opportunity to demonstrate productive discussion styles. Use early icebreakers for students to become acquainted. For example, ask them to introduce themselves to their neighbor, and then introduce their neighbor to two other students. You can use the "whip around", where each student is asked to give a 30-second response to a question (such as "what is your favorite memory of learning biology?"). In large classes, you might do a whip-around by row or by group (Tanner, 2013). For more icebreaker ideas,. By focusing an icebreaker on emotional content, you create a respectful, personal atmosphere from the outset. If you feel that there are issues with students not feeling that they belong in your course (e.g., a minority of women), consider a Social Belonging Intervention.

### Jump into active learning.

Actions speak louder than words. You can directly *demonstrate* your expectations by having students engage in group behavior, from the first day. Examples that are appropriate for the first day of class include Fermi Questions, Make a Paper Airplane, and Nature of Science Activities. See our Group Skill Building activity for suggestions on forming the first groups and supporting discussion about group roles. Here are some other examples of first day activities to create class climate and to practice science skills.

### Create a class contract.

The most democratic approach to norm-setting is to allow students to define their own rules of engagement or social norms for the class, which can include expectations for the use of technology, engagement in class discussions, off-task behavior during class, and more. This activity can serve as an excellent first-day activity, helping students to coalesce as a community, as well as establish productive, respectful social norms. For an example of this approach, see Sieber, 2001.

## Show respectful interest in student ideas

The way that you respond to student ideas and contributions sends a powerful message about the classroom norms and your expectations. Model the behavior that you want to cultivate in students, and send explicit messages about respect and inclusion. Communicate a personal enthusiasm for debate and productive conflict, where students are encouraged to address each other's viewpoints (Barron and Darling-Hammond, 2010). Below are some ways to promote such a respectful culture.

### Validate and build on student ideas.

Doing so consistently creates a culture where everyone's ideas are valued. For example, be responsive to student ideas that are brought up in large group discussions of clicker questions, so that it's clear that if students take the risk to speak up, they will be rewarded by having their ideas addressed. You can model how to productively listen to multiple ideas by asking the entire class to brainstorm ideas while you write them on the board, listing pros and cons of each idea. This provides a good model for groups to follow when listening to each other's ideas (Moreno 2009). Be careful of unintentional negative messages: For example, the word "just" (e.g., "It's just conservation of energy,") implies that the solution is trivial. See Gavrin, 2015 for more unintended negative messages we tend to send.

### Hear from multiple students.

If you want broader participation from students, set those expectations clearly. For example, Tanner (2013) suggests saying: "I'm going to pose a question, and I'd like to see at least three hands of colleagues here who would share their ideas. I won't hear from anyone until I've got those three volunteers". Stick to your rule, or students will quickly learn that they can outwait you. If you still see no hands, maybe they need help processing the question; ask them to turn and talk to their neighbor in a "think pair share" style. Be wary of the "rapid reward," where you respond affirmatively as soon as you hear the correct answer, as this discourages other students from adding their ideas. Additionally, call on students who are not necessarily perceived as high achievers, to frame the goal of questioning as hearing from all students (not just getting the right answer), and to probe student responses (rather than just explaining why a wrong answer is wrong.) See Chapter 8: Student Discussions for more ideas on getting students to participate in whole-class discussions.

### Do not judge responses.

Acknowledge student responses neutrally. That doesn't mean that you have to give weight to an inaccurate idea. Stating, "I'd like to hear from a number of us about our thinking on this, and then we can sort out what we are sure of and what we are confused about," lets students know that you will not be evaluating the merit of ideas. You can also say, "I hear you saying X, is that righ?" or "thanks for sharing your ideas" after a student responds to create a positive respectful culture in the class. This can increase the number of students willing to share their ideas (Tanner, 2013). If you get an unexpected question or answer, try to work with that idea instead of shutting it down. Here is an excellent example of a teacher dealing with unexpected questions in a middle school classroom.

## Create a respectful, safe atmosphere for active learning

Through your facilitation of conversation and discussion you can create an atmosphere where students feel that they can contribute – and that they are not at risk of looking stupid. Below are some ideas for encouraging such productive discourse, from Desbien (2004; p. 49-64). For ideas on how to assess students in a way that promotes a culture of growth and learning, see Chapter 3: Motivation.

### Collaboratively decide on the meaning of vocabulary.

Scientific language can feel alienating and foreign to students. You might create a rule that no term can be used in class discussions until its' definition has been agreed on. This gives students a sense of ownership, and democracy.

### Use communication tools to facilitate discussion.

Communication tools can be important elements of your classroom. You can use small whiteboards (where students write and share their ideas) or clickers (where the whole class can contribute to a discussion), or just pieces of paper. Out-of-class communication tools, such as discussion boards, are also valuable ways to create community and collaboration.

**Seed questions and ideas.**

As groups work on a problem, the instructor can seed their discussion with a question or hint. This gives students a chance to work through the idea and gain ownership. A good seeding question is direct, and helps the group to move forward. Don't wait until the end of their discussion to ask a seeding question, or the group may not have time to work through it. Seeding can be a way of bringing an idea to the class as a whole, so that it comes from students, rather than the instructor. If a group is reluctant to talk in the whole-class discussions, you can seed a simple idea that's easy for them to introduce, or a question that they can ask the whole class. One challenge with seeding is that, when the students come up with ideas that you haven't intended, you must determine whether the tangential discussion is worthwhile.

**Frame yourself as the guide, but not the leader of discussions.**

This requires students to take ownership of the direction of their conversations, both in small groups and in large class discussions. It can be difficult to resist explaining ideas that are not understood, but this is a time during which the instructor can pay careful attention and use that information to guide the class. Here is an example of students productively working in small groups, with productive guidance from the teacher in a middle school physics classroom.

**Correct errors in a way that is not embarrassing.**

Help students avoid losing face in front of their peers if their ideas are off-target by focusing on their strengths, not weaknesses. When students use hedging language such as "I don't know," or responding nervously when criticized, they may be indicating that they feel threatened. If you quickly respond in such situations to mitigate face threat, it can build trust and confidence, enhancing student motivation (Gaffney and Whitaker, 2015). You can do this by focusing on the strengths of the idea (find something that is correct about the idea, or validate in the assumptions that they are making) and through nonverbal cues (stand near the student, meet their gaze, gesture, and use warmth in your voice; Kerssen-Griep, 2001).

**Intentionally fail to provide closure.**

In the whole class discussion, you do not necessarily need to weigh in on unresolved issues -- keeping these issues alive will result in students continuing to wrestle with the ideas after the end of class, and return with new ideas. Lack of closure is a valuable tool for keeping students engaged as well as increasing office hour attendance. Be sure to return to those unresolved questions, however, or students may feel frustrated.

**Personally reflect on the discussion.**

Are you pleased with your own management of the discussion? Questions you might reflect on are: Did I intervene too much during discussion? Did I let the discussion progress too far? Not far enough? Was more time needed for the activity? What ideas surfaced that I was not prepared for?

**Train instructional assistants to use productive discourse.**

In a large course, you may have several Teaching or Learning Assistants who can circulate during group activities and facilitate student discussion. Many of these staff, particularly graduate students, may see their job as correcting student errors and knowing the answer. This can be counterproductive to creating a collaborative atmosphere focused on reasoning through the answer. Don't skimp on preparing these staff to work well with students. Some resources for training instructional staff include Periscope, this video on running weekly preparation sessions, and this article describing interactions during tutorial sessions (Scherr, Close and McKagan, 2012).

## Create a positive relationship with your students

To create trust and a "side by side" relationship with students, you can use a variety of verbal and non-verbal techniques such as humor, body language, vulnerability, learning student names, and more. These create a sense of social immediacy that increases students' participation (Seidel and Tanner, 2013). While more challenging in a larger class, there are still some strategies you can use, below.

### Use positive body language.

To increase trust and confidence, use techniques such as humor, less formal language, compliments, smiling, open body position, come out front behind the desk, make eye contact, gesture, and talk to them like a colleague. These behaviors can help students feel that you're on their side (Witt and Kerssen-Griep, 2011; Kerssen-Griep, 2001).

### Be vulnerable and take risks.

Being somewhat vulnerable can help to build your credibility by showing that you are willing to take risks too. This can be particularly valuable on the first day of the course. You might give a brief biography on the first day of class, or open the floor to any and all questions, no matter how silly, and reveal personal information along the way (see the Ask Me Anything activity.) I know one instructor who makes sure to do something ridiculous on the first day of class (like standing on a desk) to demonstrate to students that she won't ask them to do anything she's not willing to do as well.

### Learn student names.

This is easier said than done, especially in a large class. However, even if you learn just a few names, it sends a powerful message. On the first day, you can ask students to write their names and a few pieces of information on an index card. Carry these around, perhaps adding a photo of the student, and use them to call on students during class discussions. Another idea is to use Table Tents for students to introduce themselves to classmates, and keep their name visible for you. Both of these items (index cards or table tents) can be sorted to create small groups (Tanner, 2013).

### Listen to student feedback and complaints.

If students complain that things are boring or too hard, acknowledge their complaints. Ignoring the complaint and focusing on the work to be done sends the message that the work is more important than the individual and their emotions. Responding to and acknowledging negative emotions indicates that the teacher understands the student's position – and provides a productive opportunity for changing the activity at hand, or suggesting an alternative perspective to the student (Reeve, 2009). Other ideas include soliciting Rumors about the course on the first day, or using a midterm Stop Go Change evaluation to solicit student ideas.

## Summary and Action Items

It is challenging for instructors to create and maintain a classroom environment where students are comfortable engaging with each other and sharing their results with the class. This difficulty increases with class size. Help students to engage productively in active learning classrooms, through creating a supportive and respectful classroom community that welcomes engagement.

| General approaches | Specific strategies |
|---|---|
| **The First Day: Set appropriate norms for collaboration**<br>From the first day, you can communicate norms for collaboration, and have students engage in the types of interaction that you will be expecting during the rest of the semester. | ☐ Decide on your norms and goals and assert them.<br>☐ Break the ice.<br>☐ Jump into active learning.<br>☐ Create a class contract. |
| **Show respectful interest in student ideas**<br>The way that you respond to student ideas and contributions sends a powerful message about the classroom norms and your expectations. | ☐ Validate and build on student ideas.<br>☐ Hear from multiple students.<br>☐ Do not judge responses. |
| **Create a respectful, safe atmosphere for active learning**<br>Through your facilitation of conversation and discussion you can create an atmosphere where students feel that they can contribute – and that they are not at risk of looking stupid. | ☐ Collaboratively decide on the meaning of vocabulary.<br>☐ Use communication tools to facilitate discussion.<br>☐ Seed questions and ideas.<br>☐ Frame yourself as the guide, but not the leader of discussions.<br>☐ Correct errors in a way that is not embarrassing.<br>☐ Intentionally fail to provide closure.<br>☐ Personally reflect on the discussion.<br>☐ Train instructional assistants to use productive discourse. |
| **Create a positive relationship with your students**<br>To create trust and a "side by side" relationship with students, you can use a variety of verbal and non-verbal techniques such as humor, learning student names, body language, and vulnerability. All of these techniques are likely to create a sense of social immediacy and increase student participation. | ☐ Use positive body language.<br>☐ Be vulnerable and take risks.<br>☐ Learn student names.<br>☐ Listen to student feedback and complaints. |

## Further reading on this topic

Full references appear in the References section.


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# Chapter 5: Assessing Student Engagement

Instructors who are attempting active learning are often concerned that students won't like it, or will resist. It can be hard, even in the middle of a course, to gauge how well-engaged students are. This chapter focuses on ways to assess student engagement, both formally and informally.

## Midterm surveys

Use a mid-semester survey to find out mid-stream what students don't like about the course, and try to address it. Even a simple feedback form such as Stop-Go-Change can provide useful information. Or, you could hold a focus group with students (or have your teaching and learning center to do for you) to hear about how students would like to learn, and then sharing this information with the class as a whole. Listening to your students, and addressing problems early can increase students' sense of autonomy (see Chapter 3: Motivation.), and their trust in your good will (see Chapter 4: Class Community).

Below are several validated assessments that you can use to more systematically measure engagement in your course.

## Assessing student engagement or resistance

Student Response to Instructional Practices (StRIP). Survey which measures student response to instruction, and instructional strategies for influencing such engagement.

Classroom Observation Protocol of Student Resistance. A structured observation protocol to assess the level of student resistance in active learning classes.

Behavioral Engagement Related to Instruction (BERI). A structured observation protocol to assess the level of on-task behavior in the classroom.

## Assessing student expectations about the course

Maryland Physics Expectations Survey (MPEX). Probes aspects of students' expectations in physics courses.

Pedagogical Expectancy Violation Assessment (PEVA). An instrument to gauge the disconnect between student expectations and the actual course structure.

## Assessing students' learning attitudes and habits

*There are several additional assessments of student attitudes towards learning on PhysPort's Assessments Page.*

Colorado Learning Attitudes about Science Survey (CLASS). Measures students' self-reported beliefs about physics and physics courses. Also developed for biology, chemistry, and experimental physics.

Maryland Physics Expectations Survey (MPEX). Probes aspects of students' expectations in physics courses.

Epistemological Beliefs Assessment for Physical Science (EBAPS). Probes epistemological stances (beliefs about learning) of students in physics, chemistry, and physical science.

Effective Learning Strategies Survey (ELSS). Assesses student habits and strategies that tend to promote learning.

## Assessing student motivation and goals for learning

Physics Goal Orientation Survey (PGOS). Assesses students' motivation and goal orientation in university-level physics.

Sources of Self-Efficacy in Science Courses – Physics (SOSEC-P). Assesses students' beliefs that they can succeed in their physics courses.

Colorado Learning Attitudes about Science Survey (CLASS). Measures students' self-reported beliefs about physics and physics courses. Also developed for biology, chemistry, and experimental physics.

Sense of Belonging to Math scale. Measures students' sense of membership, acceptance, and trust in math.

## Assessing students perceptions of the course and instructor

*One of the best ways to assess student perceptions is through a mid-semester evaluation, such as Stop Go Change or another informal survey. You can also ask a colleague to hold a discussion with your students in a mid-course assessment (details here). Below are several validated assessments.*

Classroom Climate scale. A short survey to examine student perceptions of the supportiveness of classmates, the instructor, and the instructor's responsivity.

. Measures student perceptions of instructor credibility (competence, goodwill, and trustworthiness).

Facework scale. Students reflect upon instructors' attending to facework (mitigating potential threats to a student's image in social situations).

# Chapter 6: The First Day – And Beyond

*How can I set the stage for student engagement in an active learning classroom, from the first day?*

When students come into your class, they may not be expecting the energy and risk that an active classroom demands. The first day (or really, the first week) is particularly important for framing the norms, expectations, and rationale for your class approach, tapping into students' internal motivations and creating a supportive class community. This chapter focuses on activities that can be done in an active learning classroom in the first week of class, to increase student engagement throughout the semester.

## Why is the first day of class important for creating student engagement?

The first day is particularly important in any class, but particularly in a class that will be centered on active learning. Students may need to be oriented to their role in the classroom, and you can seed productive structures and patterns of interaction. Here are some things students may be wondering as they enter your class.

1. **How does this class work?** Students may enter the classroom with a range of expectations based on prior experiences. Making it clear what this course will be like (preferably by jumping into active investigations), and explaining how students will be evaluated, helps to set clear norms for engagement (Gaffney and Whitaker, 2015).
2. **How do I get a good grade?** When students don't know how to be successful in your course they may be anxious or resistant. Students often fear that their grades will suffer in an active class because they aren't sure how to succeed (Ellis, 2013).
3. **How does this style of instruction help me?** Students often feel that active learning requires more of their time and effort (Ellis, 2013), without providing them clear learning advantages (Seidel and Tanner, 2013). In one study, when instructors explained the purpose of active learning activities, students placed higher value on those activities, reacted to them more positively, and evaluated the course more favorably (Nguyen et al., in press).
4. **Will my contributions be valued?** In a traditional class, this would be a non-question, so you may need to work especially hard to set the standard for a classroom in which all feel safe and valued in their contribution, and students *want* to participate – because it's the norm, and it helps them learn.

Many of these questions are directly addressed by the topics in the rest of the series of chapters on student engagement, and I recommend that you peruse them for a broader perspective.

## Strategies for the first day of class

Below are several strategies to consider for the first day. For an overview of different philosophies and approaches, watch this 2-minute video of instructors' goals on the first day and this 5-minute video of how their approaches have changed over time, and by the type of class they teach.

### Frame the entire course

Make sure that students know how class will be conducted, the goals of the course, and why you are teaching this way. This helps to establish clear expectations. Hear from several seasoned instructors in this 5-minute video on laying out the course approach, and this . Rather than reading from the syllabus (relegate that to a Syllabus Quiz), try some more engaging strategies for framing the course.

#### Discuss the course approach or goals.

As described above, you can use an active learning approach to discussing the course structure and purpose, through activities such as Traxoline and Dancealot. You can also discuss why the course is relevant for student lives and careers – see several examples in the Why Study [Your Course] activity. Such activities serve the dual purpose of discussing the reason and rationale for the course, and setting accurate norms for engagement. Hear from several seasoned instructors in this 5-minute video on establishing expectations for participation.

#### Explain to students why you have chosen to teach this way.

You might explain the rationale for your use of active learning, and how this pedagogy aligns with research. Hear from several seasoned instructors in this 5-minute video on laying out the course approach. Here are Sample Slides Explaining Active Learning (PPT), and a video of an instructor discussing his use of clickers with the class, and a Tutorial and Clicker FAQs handout from CU Boulder. However, I have heard instructors report that such a didactic approach can backfire, and so it may be best to partner such explanatory approaches with active learning (e.g., see our Clicker Questions – How Do You Learn? (PPT)), or as a reflection after the activity, to avoid students feeling lectured to. Invite discussion about the course approach. Invite discussion after you have described the course approach. E.g., "What are your thoughts about the approach described? How does this match your own approaches to learning? What questions do you have? What will you/I need to do for this to work?" Return to these ideas later in the course; student may not necessarily remember this introduction (Tosh et. al, 2005). Note too that you will want to have a clear rationale in *your* mind for using active learning in order to be able to clearly communicate that rationale to your students!

#### Highlight the shortcomings of traditional lecture.

One particular strategy is to use humor to show that learning is typically limited with traditional lecture, and hold a reflective discussion about how unsatisfying this traditional course structure can be, and what you and the students can do to avoid such an outcome. For example, you can do a parody of

traditional lecture, and show a video of an instructor teaching a dance class via lecture (see the activity Traxoline and Dancealot), leading to a frank and collaborative discussion of the course approach and how it can best support students' learning.

**Share success strategies from past students.**

It can be very useful to discuss the types of student behaviors that typically lead to success (Moore and Jensen, 2007). One approach is to show common student responses about strategies for success, such as preparing for class and interacting with other students. See Advice to Future Students for an example. If you use Learning Assistants, those LAs can also provide such advice as undergraduate peers.

**Solicit student ideas about the course.**

Ask students what they expect in the course, and respond honestly and respectfully to any concerns. For example, solicit rumors about the course or pre-existing ideas about the content or fears of math or science (see the activity Rumors). This strategy creates positive expectations and establishes your credibility. However, set realistic expectations about how much say students really have in the course structure (Slezak, 2014), and trust in your curriculum – especially on the first day.

**Ask students to reflect on their learning.**

Ask students about how they can best achieve their personal goals for the course, steering the discussion towards the utility of engaging in higher-level learning activities in class. In the First Day Questions activity, we give examples of how instructors ask students about their study strategies and personal goals – and how best to achieve them.

## Use active learning

Beginning the semester with active learning strategies sets clear classroom norms for interactivity. Hear from several seasoned instructors in this 5-minute video on establishing expectations for participation. Below are several approaches for introductory active learning strategies which set the stage appropriately for an active classroom.

**Open the floor for questions.**

Invite students to ask questions and spend the first day answering any question, even crazy questions, about your subject (see example activity Ask Me Anything). This establishes your credibility and creates rapport with students.

**Engage students in accessible course content.**

There are several ways to jump into course content without requiring prior knowledge. You might ask students to solve an estimation problem in a group (see example activity Fermi Questions), or use an activity on the nature of science (examples: Nature of Science activities, Make a Paper Airplane, or several geoscience examples that could be adapted for other disciplines).

**Structure groups for success.**

See our Group Skill Building activity for suggestions on forming the first groups, and Chapter 7: Group Work for more suggestions on structuring group work and tasks for engagement.

## Create a positive classroom environment

Student engagement is heavily influenced by the culture and norms of the classroom. Think about how to set those norms, and begin to generate an environment that feels welcoming to all students, and establish yourself as a trustworthy instructor who will listen to students. To hear from several seasoned instructors, watch this 5-minute video on establishing a comfortable classroom climate.

### Break the ice.

You might ask, "I want everyone in this class to know each other by their first name. I need ideas of how to accomplish this." Then, use the strategies that students suggest. You might start class with practice clicker questions to generate a sense of community (such as, "How did you arrive to school today?" "How many of you hate math?") Use this opportunity to demonstrate productive discussion styles. Use early icebreakers for students to become acquainted. For example, ask them to introduce themselves to their neighbor, and then introduce their neighbor to two other students. You can use the "whip around", where each student is asked to give a 30-second response to a question (such as "what is your favorite memory of learning biology?"). In large classes, you might do a whip-around by row or by group (Tanner, 2013). For more icebreaker ideas,. By focusing an icebreaker on emotional content, you create a respectful, personal atmosphere from the outset. If you feel that there are issues with students not feeling that they belong in your course (e.g., a minority of women), consider a Social Belonging Intervention.

### Learn student names.

This is easier said than done, especially in a large class. However, even if you learn just a few names and show that you are always *trying* to learn names, it sends a powerful message. On the first day, you can ask students to write their names and a few pieces of information on an index card. Carry these around, perhaps adding a photo of the student, and use them to call on students during class discussions. Another idea is to use Table Tents for students to introduce themselves to classmates, and keep their name visible for you and other students. Both of these items (index cards or table tents) can be sorted to create small groups (Tanner, 2013).

### Call on students at random to share their ideas.

If you want students to participate in class discussions, students need to feel a responsibility for doing so. "Random call" is one way to generate this accountability, and increases students' comfort with participating in class discussions (Dallimore, Hertenstein and Platt, 2012), including participation by female students (Eddy, Brownell and Wenderoth, 2014). Random call after a group activity can also increase student participation in the group activity itself: Shekhar and Borrego (2016) found that cold-calling on students at the end of an activity increased group participation from one activity to the next. Conversely, when the instructor announced that she wouldn't call on students after the activity, the percent of students actively engaged in the activity dropped from 90% to 10%. Warm students up to the idea of random-call by telling students in in the first class that you will be doing this, but that you will give students a chance to reflect and prepare their answers in advance. You can use a randomized class list, dice, a deck of cards with student names on them, or phone applications such as Names in a Hat.

## Connect to students' motivation and goals

From the first day, and onward through the course, seek to learn about your students' interests

and clearly connect the course to those interests and goals. This strategy is very powerful for engaging students' intrinsic motivations, as well as helping them to feel a sense of identity and belonging in the course. To hear from several seasoned instructors watch this 5-minute video on how they tap into student motivation, and this .

**Find out about your students.**

It is difficult to target activities to student interests if you don't know what those interests are. What you find interesting may not be as fascinating to your students as you would expect. You can ask students to answer a few questions about themselves on the first homework assignment, use a brief survey, or ask them to write on an index card (name on one side, answers to a few questions on the other side). This index card can then be used for randomly calling students to respond to discussion questions (see below). For examples, see this discussion of first day surveys on SERC, and this .

**Make explicit connections between the course content and students' lives.**

You can discuss the relevance of the course to students' lives or careers, describe career opportunities related to your subject, or have students build their own lists of what scientists in your discipline do. See First Day Questions for examples of discussions about students' personal goals in your course, and Why Study [Your Course] for discussion activities related to course relevance.

## Strategies for Mid-Semester "pick me ups"

You will likely find that student engagement needs a few boosts throughout the semester, as fatigue sets in and students are distracted by other obligations. Here are a few ideas for mid-semester interventions to help boost morale.

### Solicit student feedback.

Use a mid-semester evaluation, such as Stop Go Change, after the first 3-4 weeks of the course. Use this evaluation to show responsiveness to student ideas, to address early issues, and to re-confirm the reasons that you are using active learning.

### Have students reflect on their learning

Help students to remember that active learning is useful for them. Consider asking students to complete a weekly insight or other self-reflection, such as a weekly insight or exam wrapper. Discuss the role of active learning, perhaps using the Bloom's Taxonomy activity. Periodically ask students to complete a self-reflection rubric (see Self-Assessment Worksheets), where they assess their learning skills. See Chapter 2: Metacognition for more ideas.

### Inject a highly motivating task

Do you have a task or topic that is highly motivating and engaging, or deeply relevant to students' lives? Pull it out mid-semester as an energy booster. See Chapter 7: Group Work for ideas on what types of activities can be highly motivating for students.

### Re-invigorate your use of other strategies.

Are you still using productive, supportive feedback? Are students still using their Table Tents?

Are you continuing to use language that supports a positive classroom culture? Do students need more support in working productively with their groups? Do you need to remind students of your reasons for using these teaching strategies (see for example "Sermons for Grumpy Campers.") Don't overwhelm yourself, but choose a few strategies to try.

## Summary and Action Items

When students come into your class, they may not be expecting the energy and risk that an active classroom demands. The first day (or really, the first week) is particularly important for framing the norms, expectations, and rationale for your class approach, tapping into students' internal motivations and creating a supportive class community. Here are some activities that can be done in an active learning classroom in the first week of class, to increase student engagement.

| General approaches | Specific strategies |
|---|---|
| **Frame the entire course**<br>Make sure that students know how class will be conducted, the goals of the course, and why you are teaching this way. This helps to establish clear expectations. | ☐ Discuss the course approach or goals.<br>☐ Explain to students why you have chosen to teach this way.<br>☐ Highlight the shortcomings of traditional lecture.<br>☐ Share success strategies from past students.<br>☐ Solicit student ideas about the course.<br>☐ Ask students to reflect on their learning. |
| **Use active learning**<br>Beginning the semester with active learning strategies sets clear classroom norms for interactivity. | ☐ Open the floor for questions.<br>☐ Engage students in accessible course content.<br>☐ Structure groups for success. |
| **Create a positive classroom environment**<br>Student engagement is heavily influenced by the culture and norms of the classroom. Think about how to set those norms, and begin to generate an environment that feels welcoming to all students, and establish yourself as a trustworthy instructor who will listen to students. | ☐ Break the ice.<br>☐ Learn student names.<br>☐ Call on students at random to share their ideas. |
| **Connect to students' motivation and goals**<br>Seek to learn about your students' interests and clearly connect the course to those interests and goals. This strategy is very powerful for engaging students' intrinsic motivations, as well as helping them to feel a sense of identity and belonging in the course. | ☐ Find out about your students.<br>☐ Make explicit connections between the course content and students' lives. |

## Further reading on this topic

Full references appear in the References section.


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# Chapter 7: Group work

*How can I help students have a positive learning experience when working in small groups, so they are more likely to engage?*

Most active learning techniques involve the creation of student groups, but groups do not always work productively, and not all tasks are suited to group work. Poor group dynamics, or ill-suited tasks, can reduce student engagement in active learning. This chapter focuses on helping students engage productively in active learning classrooms through the type of tasks that are used, and support of productive group dynamics.

## How do group structures and tasks affect student engagement?

*Keywords: Sociocultural theory, social constructivism, positive interdependence, accountability, cooperative learning*

As you might imagine, not all "cooperative groups" actually work cooperatively. That is, students may be in a group, but not be working collaboratively towards a common goal that improves their learning. Students can come in with poor attitudes towards group work (Gillespie et al., 2006), including having a fear of loafers. Or the structure of the groups may be at fault: Often, what we think are cooperative groups are really traditional classroom groups (where some students work hard and others do not), or pseudo learning groups (where students have no interest in working together) (Moreno, 2009; Nokes-Malach, Richey and Gadgil, 2015). These types of learning groups often do not actually improve student learning when compared to traditional instruction.

Students need to have a reason to work together (**"positive interdependence"),** be accountable as a team as well as individually for their learning, learn skills for working together productively, and have clear expectations for the outcome of group work (Slavin, 2010; Anderman and Dawson, 2010). Luckily, students typically find group work fun and motivating, and over time will typically have more productive learning experiences (Nguyen et al., in press; Bacon, Stewart and Silver, 1999)

Additionally, the benefits of cooperative learning are highly dependent on the task itself (Slavin, 1995). Students are motivated by **interest:** if a task feels stimulating, fun, relevant, authentic and novel, this will draw students in. Students are also attracted by the **value** of a task: A task that is useful, important, and challenging with high benefit and few costs will engage students (Pintrich, 2003; Boekarts, 2010; Engle and Conant, 2002; Moreno, 2009). Tasks that are less motivating are ones that can be completed using superficial memorization and without setting clear goals or involving any collaboration. A task may also be overly restrictive, offering little student latitude.

Design authentic, collaborative, and fun tasks with the goal of sparking pleasure, pride, and satisfaction in students. **Variety** in group tasks is very motivating and tends to keep students engaged (Shekhar et al., 2015). A commitment to variety also allows you to address different student interests (Boekaerts, 2010; Pintrich, 2003; Tanner, 2013), and keep student attention as the semester progresses (Ertmer, Newby and MacDougal, 1996). See Chapter 3: Motivation for more on what motivates students.

## Strategies for helping students work productively in groups

Below are some general strategies for helping to support productive group work. There are many books and chapters devotes to this topic. See Further Reading for many of my preferred sources. Below are some of the most salient strategies related to student engagement.

### Hold students individually accountable for group work

Students must have some accountability for their individual learning in order for groups to work effectively (Slavin, 1995).

**Follow up group work with individual assessments of learning.**

After students work together in a group, you might use a clicker question that addresses the objective of the group activity (which gives immediate feedback to students and the instructor as to the group's success). You can also use a one-minute paper to ask students what they have learned and what is still confusing to them, or you can give a single individual assessment question on the topic at hand.

**Use assessments of individual effort to adjust grades.**

On group projects, you can mitigate "hitchhiking" (students who let others do all the work) by only giving credit to active participants, or using peer ratings to adjust team project grades for individual contributions (Felder and Brent, 2016; see details of such peer rating here).

### Give groups a collaborative goal

It is also important to have the group working together to achieve a collaborative goal, and that the group's success is dependent on the individual learning of all members (Slavin, 1995).

**Give students goals as a group.**

Students might work on a single assignment as a group (such as an activity sheet), and hand it in as a group for a group score (Slavin, 2010). Or, they might work in groups of 3 on a set of challenge problems, and share their results with one another (Ames, 1991). "Mutual goals" are also useful, where each member of the group can be responsible for one part of the overall task, but it is the group's performance as a whole is evaluated (Slavin, 1999). Another option is for students to research different aspects of a topic, and teach them to one another (Moreno, 2009). Jigsaw activities (students complete parts of an assignment, and reorganize into different groups to build expertise) naturally include mutual goals.

**Use achievement rewards.**

Give each team a certificate or other reward for meeting a certain benchmark (Slavin, 2010), such as

when their average quiz scores reach a minimum threshold (Moreno, 2009). You could use a tournament structure, where each team might compete with members of other teams to win points for their team (Slavin, 2010). Some instructors use Jeopardy-style games for this purpose.

### Use group exams.

One strategy which explicitly draws in both group and individual accountability are group, or two-stage, exams; students first complete an exam individually, and then again as a group, with the group exam score potentially boosting their individual score. See Group Exams for details.

## Use productive group structures

The structure of groups is also important for success and engagement. The group size should be well suited to the task, and so that each student will be able to contribute. A group might benefit from having roles assigned to each student, especially early in the semester, to facilitate productive collaboration.

### Consider assigning roles to students.

You might assign roles to each student in the group, such as facilitator, scribe, reporter, data manager, materials manager, time manager, coach, encourager, question monitor, etc. (Moreno, 2009).

### Use appropriately sized groups.

Groups should include fewer than 8 people, and the best group size is 3-6. If the group is too small, there won't enough diversity of student perspective. If the group is too large, it will take longer to manage diverse tasks (Moreno, 2009). It is prudent to remember that with groups that are larger (or projects that are larger in scope), there are more opportunities for "social loafing," where students don't participate equally (Aggarwal and O'Brien, 2008). So, keep group sizes small, especially when you are first implementing active learning.

### Decide whether to let students choose their own groups or not.

The research is not clear on the best strategy for group selection. Below are some considerations for both approaches (Moreno, 2009; Anderman and Dawson, 2010; Slavin, 2010; Bacon, Stewart and Silver, 1999). Students tend to prefer staying with the same group during the semester, as they become used to one another and changes can be perceived as jarring (Gillepsie et al., 2006). However, you might consider switching groups a few times to reduce the risks of poorly functioning groups and connecting students with a broader social network. After the first such change, students will anticipate the group changes.

| | Instructor created groups | Student created groups |
|---|---|---|
| Pros | Can support greater group diversity. Reduces anxiety of non-native speakers, who are less likely to be excluded from groups. | Students, especially those with experience in groups, prefer this. Can be very motivating. |
| Cons | Students may not prefer this approach. | Social issues may impinge on the work (such as personal disputes, or students feeling like a "3rd |

| | | |
|---|---|---|
| | | wheel" in a group of friends) |
| **Tips** | Avoid having a single minority in the group. Aim for diversity in student achievement, gender, culture and ethnicity. Can use CATME's online team maker to form teams based on such criteria. | |
| **Techniques** | By test scores, random number generation, and then balance by race/gender. | By student choice (nearest neighbors, friends) or by characteristics (e.g., high school attended, mutual interests). |

## Help groups collaborate effectively and monitor their performance

Students are likely to need some help in working together well. Below are several strategies for helping students to start out on the right foot, and keep working together well. There are also several helpful suggestions for dealing with dysfunctional teams in Felder and Brent (2016).

### Use team-building exercises.

Especially when students will be working together in the same team for a long time, build in some time for them to get together as a group and socialize with each other. (Bacon, Stewart and Silver, 1999). Some of the icebreaker activities in Chapter 4: Class Community may be useful. CATME provides several online tools for teamwork training and effective meeting support. Additionally, see our Group Skill Building activity for suggestions on forming the first groups, and supporting discussion about group roles.

### Coach students and model effective behavior.

Monitor student discussions, especially at the end of the discussion to help them frame their ideas. For shy students, you might learn about their interests and use those interests as the basis for future learning activities to draw them in. You might also assign them a peer partner who is more outgoing (Moreno, 2009). If you notice a student who did a particularly good job of planning a project, assign him the role of leading his group during the next planning phase of the project (Moreno, 2009). Or, if you notice a group who did a particularly good job of a group task (such as answering a clicker question, or providing a project outline), call on them to share their thinking or outcome with the class. As an instructor you can also model effective processes, such as modeling group decision making by having the whole class brainstorm ideas, as you write them on the board, along with pros and cons of each idea. Then, you can coach the class through making a decision among the ideas as a group (Moreno, 2009). See also useful training and supports for productive team-work at CATME.org, including team member preparation documents, team charters and sample team agendas.

### Help teams develop productive goals.

You may consider a group "contract" with rules to be determined by the group on how to handle assignments or non-participation. Once again, see support documentation at CATME.org. Additionally, have students develop mastery goals for the team as a whole (see Chapter 2: Metacognition and Mastery) by asking them to individually identify their learning goals. Next have teams discuss how

they plan to address individual learning goals (Linder et al., 2010). Such a discussion could be framed in an assignment, for points, or as an informal check-in.

**Require groups to self-reflect.**

Use checkpoints during activities, or every few weeks, where students must stop and reflect on questions, such as "How are we doing as a group? What is working well? What is something we may need to change?" This can be done as an exit activity or a survey. See our assortment of Self-Assessment Worksheets for possible group evaluation worksheets. CATME also provides several tools for self- and peer evaluations.

## Build motivating tasks

Build "motivational embellishments" into your activities, leveraging students' psychology to draw them in naturally to the task and make them want to engage due to intrinsic interest and value for the activity. Motivational embellishments include the insertion of specific challenges, material based on student interest, or giving students perceived control over the outcome of the task.

**Don't bite off more than you can chew.**

One common mistake made by teachers starting to use active learning is trying to implement too much at once. Reduce the number of tasks or activities, so that you can carefully design each one and consider the best facilitation techniques for a given situation. Good preparation helps you create an excellent learning task that is truly beneficial for student learning. Student confidence will increase when the tasks that you give feel well-developed (Slezak, 2014).

**Vary group learning methods.**

Try techniques such as jigsaws, role-play, clickers, group investigations, and worksheets. Examples of several instructional techniques can be found on PhysPort and at this succinct list from U. Minnesota, and in Tanner, 2013.

**Give clear, written instruction.**

The way that you frame the task has important implications for student engagement. Do students understand what they need to do? Are all questions clear? Do students understand the purpose of the exercise? Clarity will help teams to work productively and know what is expected of them (Bacon, Stewart and Silver, 1999), even if the task itself is complex. Additionally, using language focused on effort and improvement can orient students towards more mastery rather than performance-based goals (see Chapter 2: Metacognition).

**Focus on authentic, real world scenarios.**

Relate subject matter to potential student careers, and motivate the problem at hand before introducing the formalism. Make sure students know why someone would care about the answer to this problem. For example, a group objective might be to create an engineering project that addresses a particular need of the local community. One strategy for including interest and relevance is to use case-based instruction (Ertmer, Newby and MacDougal, 1996). See PhysPort's collection of productive questions for clickers and peer instruction, guidance on designing good group activities and activities for small group discussions..

### Allow for fun.

It's too easy to forget about fun! Making tasks connected to real-life or about interesting real-life scenarios can inject true pleasure and pride into tasks. For example, ask students to identify all the forces acting on their feet as they walk backwards. If it feels appropriate, you may inject some silly or quirky aspects into your activities. You might get students up out of their seats to act something out, or allow them to create their own activity. Feel free to get creative.

### Give tasks that are just above student ability.

It is very motivating for students to feel challenged, but then be able to successfully complete a task, and see how much they have learned (Pintrich, 2003; Ames, 1991). It can be hard to pitch a task at the right level of difficulty, so that students feel challenged (see Chapter 2: Metacognition and Mastery), but not overwhelmed by feeling incapable of completing it (see Chapter 3: Motivation). Diagnostics or other assessments can also help you determine the ability level of your students. You can also structure your task so that students can be successful, by starting with easier items and then ramping up the difficulty, including "bonus challenges" at the end for those who finish early.

### Give students choice and autonomy.

Perceived control is an important aspect of task interest, whether that control is related to how to students will accomplish something, or which topic they choose to explore (Ames, 1991). You might choose tasks with multiple pathways to the solution. Another factor in autonomy is time: Don't rush students through an activity. Give them a chance to work at their own pace and feel in control of their learning (Redish and Hammer, 2009; Reeve, 2009).

## Summary and Action Items

Most active learning techniques involve the creation of student groups, but groups do not always work productively, and not all tasks are suited to group work. Poor group dynamics, or ill-suited tasks, can reduce student engagement in active learning. This chapter focuses on helping students engage productively in active learning classrooms through the type of tasks that are used, and support of productive group dynamics.

| General approaches | Specific strategies |
|---|---|
| **Hold students individually accountable for group work**<br>Students must have some accountability for their individual learning in order for groups to work effectively. | ☐ Follow up group work with individual assessments of learning.<br>☐ Use assessments of individual effort to adjust grades. |
| **Give groups a collaborative goal**<br>It is important to have the group working together to achieve a collaborative goal, and that the group's success is dependent on the individual learning of all members. | ☐ Give students goals as a group.<br>☐ Use achievement rewards.<br>☐ Use group exams. |
| **Use productive group structures**<br>The structure of groups is important for success and engagement. The group size should be well suited to the task, and so that each student will be able to contribute. | ☐ Use team-building exercises.<br>☐ Coach students and model effective behavior.<br>☐ Help teams develop productive goals.<br>☐ Require groups to self-reflect. |
| **Help groups collaborate effectively and monitor their performance**<br>Students are likely to need some help in working together well. | ☐ Use team-building exercises.<br>☐ Coach students and model effective behavior.<br>☐ Help teams develop productive goals.<br>☐ Require groups to self-reflect. |
| **Build motivating tasks**<br>Build "motivational embellishments" into your activities, leveraging students' psychology to draw them in naturally to the task and make them want to engage due to intrinsic interest and value for the activity. Motivational embellishments include the insertion of specific challenges, material based on student interest, or giving students perceived control over the outcome of the task. | ☐ Don't bite off more than you can chew. Vary group learning methods.<br>☐ Give clear, written instruction.<br>☐ Focus on authentic, real world scenarios.<br>☐ Allow for fun.<br>☐ Give tasks that are just above student ability.<br>☐ Give students choice and autonomy. |

## Further reading on this topic

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# Chapter 8: Student Discussions

*What can I do if students don't speak up in discussions with peers, or with the whole class?*

Many active learning techniques require students to discuss their ideas either in small groups or in a large class discussion, but, as you know, students don't always erupt into productive conversation. This chapter focuses on helping students engage productively in discussions in active learning classrooms.

## How do I get students to discuss in small groups?

Students can experience very real anxiety when asked to discuss their ideas with their peers, especially if they did not anticipate that they would be required to interact in this way. See Chapter 4: Class Community for a discussion of the importance of helping students feel safe sharing their ideas and creating a collaborative class culture. Below are a few specific strategies for promoting student discussion that promote student motivation and accountability for engagement. See also PhysPort's recommendations for how to get students to engage in productive discussion of clicker questions.

**Circulate and listen in.**

Be involved in the activity by approaching passive student groups, and gently encouraging them to participate. This has been shown to result in increased engagement (Shekhar et al., 2015). You can also listen to their conversations, "shopping" for ideas and difficulties to bring up in the large class discussion.

**Use questions that students want to discuss.**

Use challenging, complex problems that students need each other to solve, and that are inherently interesting and motivating. Shekhar and Borrego (2016) found that when presented with a complex problem, students who had originally resisted sitting near their peers moved to a nearby group so they could discuss. A problem that requires group effort can thus lessen student resistance.

**Hold students accountable for small group discussions.**

For example, you might use clickers to have students respond to questions at the end of group activities. See other ideas in Chapter 7: Group work.

**Use "random call" during whole class discussions.**

Another form of accountability is an expectation that students will speak up in the whole class discussion. "Random call" provides this accountability, as well as increasing students' comfort participating in class discussions (Dallimore, Hertenstein and Platt, 2012; Knight, Wise and Sieke, 2016) and increasing participation of female students (Eddy, Brownell and Wenderoth, 2014). Shekhar and Borrego (2016) found that cold-calling on students at the end of an activity increased group

participation from one activity to the next. Conversely, when the instructor announced that she wouldn't call on students, participation dropped from 90% to 10%. Warm students up to the idea of random-call by using it in your first class, but giving students a chance to reflect and prepare their answer in advance. You can use a randomized class list, dice, a deck of cards with student names on them, or phone applications such as Names in a Hat.

**Use cluster seating.**

If possible, seating students in groups has been shown to facilitate discussion (Shekhar and Borrego, 2016).

**Promote a culture where expressing ideas is safe and normal.**

See strategies in Chapter 4: Class Community.

## How do I get students to speak up in whole class discussions?

Many active learning techniques require students to speak up in a whole class discussion. Even more so than in a small group, it is quite intimidating for students to speak up in front of a large group. If you get an uncomfortable silence when you ask students to share their answers with the whole class, you're not alone. Here are some strategies for motivating students to take the risk.

**Use student response systems ("clickers").**

An alternative way of hearing student ideas, though often limited to ABCDE, is to use electronic response systems to motivate students to participate (Shekhar and Borrego, 2016).

**Use "random call" during whole class discussions.**

See discussion of "random call" in the section above. This has the added benefit of increasing student comfort with sharing their ideas over time (Dallimore, Hertenstein and Platt, 2012).

**Give points or rewards for speaking up.**

Some instructors toss out candy or give gold-star stickers to students who speak up in class (best if done a little tongue-in-cheek). Another great idea is to use Sticky Participation Points, where each participating student is given a post-it note that serves as extra credit or participation credit. Either way, the action rewards students explicitly for their effort, and sends the message that you value student contributions.

**Increase your "wait time."**

To increase verbal participation and give students a chance to process, wait at least 3-5 seconds for a student response after asking a question. It's best to actively count up those seconds, as it usually feels like a long time while you're standing quietly, not saying anything. But the wait will pay off; with additional wait time, more students volunteer answers, are willing to share when called on, and give more complete answers (Allen and Tanner, 2002).

**Use Think-Pair-Share to help them process the question.**

If after adequate wait time you still hear no responses, maybe students are lost. Have them think on their own for a specified amount of time (e.g., 30 seconds), and then signal them to turn to their

neighbor and discuss, and then be ready to share with the whole class.

**Have them write down their responses.**

You might explicitly ask students to write out their ideas quietly as in a minute paper (perhaps requiring students to purchase a pack of index cards for this purpose). When they pass these up to you, you can scan them for the main ideas, and maybe grade for participation (Tanner 2013). Some technologies such as PollEverywhere also allow students to input text responses for anonymous display.

**Assign a group reporter.**

Assigning a reporter ensures that those less likely to volunteer will have opportunities to practice sharing their ideas (Tanner, 2013). Ask groups to select the person with the darkest shirt, whose birthday is closest to today, or who has the longest hair (especially if you want to encourage female participation.) In smaller classes, you can put colored clips on students' Name Tents, or hand out colored index cards as students enter (Tanner, 2013).

**Use the "whip around."**

Particularly in smaller classes, require each student to share a response to the question in 30 seconds or less (Tanner, 2013). In a larger class, you could ask all students in a single row to share their response.

**Promote a culture where expressing ideas is safe and normal.**

This includes responding supportively to student ideas, and being tactful in the face of student mistakes. See strategies in Chapter 4: Class Community.

## Summary and Action Items

Many active learning techniques require students to discuss their ideas either in small groups or in a large class discussion, but, as you know, students don't always erupt into productive conversation. Here are some strategies to help students engage productively in discussions in active learning classrooms.

| General approaches | Specific strategies |
|---|---|
| **Help students participate in discussion in small groups**<br>Students can experience very real anxiety when asked to discuss their ideas with their peers, especially if they did not anticipate that they would be required to interact in this way. | ☐ Circulate and listen in.<br>☐ Use questions that students want to discuss.<br>☐ Hold students accountable for small group discussions.<br>☐ Use "random call" during whole class discussions.<br>☐ Use cluster seating.<br>☐ Promote a culture where expressing ideas is safe and normal. |
| **Help students speak up during class discussion**<br>Many active learning techniques require students to speak up in a whole class discussion. Even more so than in a small group, it is quite intimidating for students to speak up in front of a large group. | ☐ Use student response systems ("clickers").<br>☐ Use "random call" during whole class discussions.<br>☐ Give points or rewards for speaking up.<br>☐ Increase your "wait time."<br>☐ Use Think-Pair-Share to help them process the question.<br>☐ Have them write down their responses.<br>☐ Assign a group reporter.<br>☐ Use the "whip around."<br>☐ Promote a culture where expressing ideas is safe and normal. |

## Further reading on this topic

Full references appear in the References section.


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# Chapter 9: Student Complaints

*What if I get low student evaluations, or hear complaints about active learning?*

While active resistance among students is relatively rare (Nguyen et al., in press; Nguyen et al., 2016), sometimes students do complain about active learning techniques (Seidel and Tanner, 2013; Ellis 2015). This chapter focuses on addressing some common student complaints in active learning classrooms. While student complaints may be challenging or even hurtful to hear, they offer valuable opportunities for you to learn from your students, and possibly improve the overall engagement of the class.

## There are a few vocal students who don't like the class

You might hear a few vocal complaints from students. Some comment complaints include, "the professor isn't teaching anything," "We have to teach ourselves," "The class is too much work," "We're wasting time," or more personal attacks on the instructor. These complaints can be demoralizing, and seed doubt in the rest of the class. Such complaints may be specific to the student (what is their learning approach?), or the institution (how frequently is active learning used?) or the instructor (how experienced are you with active learning?). Often, such initial pushback can decrease over time, as the course structure becomes more normative, and initial difficulties are addressed (e.g. Breslow 2010, Koretsky and Brooks 2012). Here are some strategies for addressing such vocal complaints.

### Listen and respond constructively.

It can be useful just to listen to students the first time you hear complaints, and respond positively (e.g., "I hear you. It can be challenging to learn in new ways.") Resist the urge to preach to students. Listening can help you better understand the problem, as well as supporting a positive relationship with your students – where they may be more receptive to your recommendations. A common mistake in the face of complaints is to respond in a controlling, authoritative manner. This undermines the foundation of a cooperative class (Reeve, 2009). See Chapter 3: Motivation for discussion of how a controlling manner can backfire when trying to support students' internal motivation, and Chapter 4: Class Community for discussion of the importance of giving students a voice in order to generate a positive relationship with students. In general, be careful of telling students to "eat their vegetables" (i.e., engage with the active learning because it's good for them), as this undermines students sense of control.

### Try to identify the problem.

To find out how widespread the problem is, you might use clicker questions or an online survey to

solicit ideas from the class as a whole (also see some suggestions in Chapter 5: Assessing Engagement.) Listen and try to understand the problem from the student perspective. For example, if students complain that the questions are vague, maybe you need to clarify the prompts in your activities. If they complain that you're not teaching them anything, clearly identify the goals of the activity, and include reflective discussion about learning gains afterwards. If students complain that the course is too much work, make sure the learning benefit is clear (see Chapter 2: Metacognition). Use student input when appropriate, but stay the course and trust your curriculum; you should expect some bumps along the road as you try something new. See Richard Felder's article "Hang in There!" for some more ideas (and reassurance!)

**Let other students make the point for you.**

Find out how other students think about the class, and share those responses publicly. One instructor developed the midterm Stop Go Change evaluations in part due to complaints of students in a vocal minority. Now that she gives students a chance to voice their ideas, and demonstrate the diversity of opinion in the room, those dissatisfied students realize, for example, that "not everybody hates the labs."

**Set appropriate expectations for the course.**

On the first day, and throughout the course, make sure that students know what is expected of them, and the rationale for the activities. Pepper (2010) found that while the primary thing that students liked about problem-based learning was being an independent, self-directed learner, it was also the primary complaint. Many students felt that they were wasting time, or didn't understand the point of the activity. See Chapter 1: Expectations for suggestions about discussing the course rationale, and Chapter 2: Metacognition for suggestions on helping students reflect on why the course approach is useful, and Chapter 7: Group Work for giving clear instructions on the purpose of tasks. See also Richard Felder's "Sermons for Grumpy Campers.")

**Reassure students that learning is hard.**

If students are off-task during activities, it may be that they aren't willing to expend effort and risk failure (Boekaerts, 2010). Acknowledge that working on such tasks may seem unstructured and challenging (Patton, 2010). Clearly indicate the point of the activity and give students a clear sense of direction. Use non-threatening feedback, and help students develop a mastery orientation towards their work, seeing learning as a process (see Chapter 2: Metacognition).

## I get low student evaluations

Active resistance to interactive engagement is relatively rare (Nguyen et al., in press; Nguyen et al., 2016), but resistance and low evaluations can happen (Seidel and Tanner, 2013; Ellis 2015; Slezak, 2014; Pepper, 2010). You might experience "implementation dips", where student evaluations decline during first implementation, and then recover over time (Allen, Wedman and Folk, 2001). However, please remember that student evaluation results should be taken with a grain of salt, as they are not necessarily measures of student learning. Student learning has not been shown to be well correlated with student evaluations of teaching effectiveness (Uttl, White and Gonzalez, in press). Student evaluations tend to be higher in courses where they get higher grades, but not necessarily in those that promote deeper learning (Carrell and West, 2010). Also, student evaluations are known to be biased against female and minority instructors (Centra and

Gaubatz, 2009; Miller and Chamberlin, 2000; Potvin and Hazari, 2016).

**Use alternative measures of teaching effectiveness.**

To document your teaching effectiveness (especially for promotion or tenure), gather alternative data on student learning (see PhysPort's Assessment page for concept inventories, interactive teaching, and student attitude assessments). If you expect evaluations to drop in your course, you might ask your chair in advance not to consider the student evaluations for the term in your portfolio. Be proactive to make sure that your chair understands the risks associated with using active learning (especially for a junior faculty member). Invite your chair and/or a senior faculty member to visit your class and provide feedback. In this way, students will not be the sole source of course evaluation.

**Gather mid-semester feedback**

Use a mid-semester survey to find out mid-stream what students don't like about the course, and try to address it. Even a simple form such as Stop-Go-Change can provide useful information. Or, you could hold a focus group with students (or have your teaching and learning center to do for you) to hear about how students would like to learn, and then sharing this information with the class as a whole. Listening to your students, and addressing problems early can increase students' sense of autonomy (see Chapter 3: Motivation), and their trust in your good will (see Chapter 4: Class Community).

**Give students choices.**

While you likely don't want to stop your use of active learning due to poor student feedback (after all, you have good reasons for using these techniques, you might increase students' sense of autonomy (see Chapter 3: Motivation) by providing them some choices along the way. For example, let students choose among three topics to engage in through active learning. Or if they complain about exam grades, offer them an extra credit assignment.

**Find out where problems are and address them.**

Find out what students think about your course, either during the course or during exit interviews or surveys (see Chapter 5: Assessing Engagement). Get feedback from an instructor more experienced with active learning. Read through the other chapters in this series. Consider that you may not be attending adequately to the student learning experience (Allen, Wedman and Folk, 2001). Some research suggests that low evaluations can be related to instructor credibility (that is, trustworthiness, competence and goodwill; e.g. Witt, Wheeless and Allen, 2004; Witt and Kerssen-Griep, 2011) so consider this as a possible issue. If students feel that their social reputation is being threatened, consider how to mitigate this through tactful, and promoting solidarity with students ("face threat mitigation"; see Chapter 4: Class Community). Use this information to direct changes the next time you teach. See Richard Felder's article "Hang in There!" for some more ideas (and reassurance!)

**Don't do too much, and stay in touch with your teaching instincts.**

One common problem faced by instructors when first embracing active learning is trying to do too much at once. This can lead to negative student evaluations because you're scrambling to keep up, and students sense it. Such overwhelm reduces student confidence (Slezak, 2014) as well as limits the degree to which you can adequately plan each activity for success. Consider rolling out active learning in smaller pieces so that you can master each part, or piloting the course as a summer section, especially if low evaluations could have significant career implications.

## Summary and Action Items

While active resistance among students is relatively rare, sometimes students do complain about active learning techniques. Here are some ways to address some common student complaints in active learning classrooms. While student complaints may be challenging or even hurtful to hear, they offer valuable opportunities for you to learn from your students, and possibly improve the overall engagement of the class.

| General approaches | Specific strategies |
|---|---|
| **Addressing student complaints**<br>You might hear a few vocal complaints from students. Some comment complaints include, "the professor isn't teaching anything," "We have to teach ourselves," "The class is too much work," "We're wasting time," or more personal attacks on the instructor. Often, such initial pushback can decrease over time, as the course structure becomes more normative, and initial difficulties are addressed. | ☐ Listen and respond constructively.<br>☐ Try to identify the problem.<br>☐ Let other students make the point for you.<br>☐ Set appropriate expectations for the course.<br>☐ Reassure students that learning is hard. |
| **Responding to low student evaluations**<br>Active resistance to interactive engagement is relatively rare, but resistance and low evaluations can happen. Please remember that student evaluation results should be taken with a grain of salt, as they are not necessarily measures of student learning. | ☐ Use alternative measures of teaching effectiveness.<br>☐ Gather mid-semester feedback<br>☐ Use group exams.<br>☐ Give students choices.<br>☐ Find out where problems are and address them.<br>☐ Don't do too much, and stay in touch with your teaching instincts. |

## Further reading on this topic

Full references appear in the References section.


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# Appendix:  Example Activities

Below are specific activities and strategies that have been used by instructors to accomplish the recommendations in this set of articles.

# Advice from Instructors

**Authors: Beth Simon (UCSD), Ian Beatty (UNC Greensboro), Brian Katz (Augustana College), Doug Duncan (CU Boulder), DJ Wagner (Grove City College), Mark Maier (Glendale C.C.), Paul Camp (Spelman College), John Hubisz (North Carolina State U.)**

## Overview

In response to our call for materials to use in framing active learning classes, several instructors shared a description of their general approach rather than particular materials. We felt that these comments in their raw form represent some well-articulated pedagogical philosophies, and so we share them here so that other instructors can benefit from their insights.

### IAN BEATTY, UNC Greensboro (Physics)

*See Ian's clicker questions and meta-communication strategies in the "clicker" files.*

I try not to frame my course as "stuff that will help you on the exam" or otherwise cast the whole game as about exams and grades. Call me an idealist, but I stubbornly stick to the perspective (vocally, in my courses) that the point is to learn stuff that's both fascinating and long-term useful to their personal and career aspirations, and that exams and grades are annoying necessities that we should avoid getting too hung up about. (In my junior-level thermo course this fall, I actually refused to give any points, grades, or other codified evaluative feedback until the final course grade at the very end. All feedback on homework and exams was individualized commentary on strengths, weaknesses, and things to work on.)

That being said, I make a distinction between "explaining" clicker use (and other active-learning strategies I use, such as group whiteboarding and group exams) and "selling" it to the students. If students feel like I'm trying to sell the idea to them, they get suspicious, because I've stupidly communicated the idea that (a) clickers are something controversial that needs to be sold, and (b) they have some kind of valid opinion on the matter. I prefer to take the position that "this is just the way I teach, because overwhelming evidence and experience show that it's what works well, but I also want you to understand what I'm doing and why so that you can play your role with as much awareness as possible. The more we're on the same page, the better this whole thing works." See the difference? It's all about framing.

I meta-communicate a lot with my students, both at the beginning of the course and throughout. I occasionally interject bits about how the brain works, tidbits from learning research, etc. I habitually explain why I'm doing the things I'm doing in my teaching, and what I want them to be focused on. I also promise them that they're always free to ask me the justification for any element or aspect of the course.

I include clicker questions designed to support meta-communication, and also to (subtly or obviously) communicate a certain framing of clicker use. Features include obviously having multiple defensible choices (so it's about reasons rather than answers picked), latent ambiguities that students can discover, leading to discussions about the role of assumptions in learning and doing physics, etc.

I think not giving any form of points or credit for clicker questions, and keeping no track of which students even have which clickers, helps. I can, with great credibility, claim that clickers are merely one more tool to help us communicate, discuss, and generally make sense of this stuff.

Frankly, if a student isn't into this whole engaged-active-learning thing, they're going to have bigger problems with my class than just the clickers. They usually complain that I don't lecture much and "don't teach them anything", forcing them to learn everything by themselves outside of class.

Do all the students buy the approach? Definitely not. But typically, enough do to set a positive class climate, and the recalcitrant ones grudgingly go along. Even those usually change their tune by the end of the second semester in the sequence.
It also helps that I work like a flaming dog to teach as well as I can, and the student see me bleed for them (extra grading from "letting" them redo exams as take-home open-book collaborative tests, etc.). They may disagree with my methods, but very few doubt my sincere intentions. That goes a long way.

One of the meta-communication bits I repeat again and again is that "you need to talk to learn". I stress the importance of putting your own thoughts into words in order to figure out what you actually think and to improve your thoughts, and of confronting other people's thinking. For me, clickers (and group whiteboarding) are first and foremost a mechanism for provoking students into discussing with each other.

I think starting off a course with straightforward "right or wrong" content questions is a bad idea. I'd rather give them an immediate taste of an interesting, controversial, argumentative question that raises more questions than it resolves. Last time I taught Conceptual Physics, I started off with a 10-minute narrative about an accident on a roller-coaster at an amusement park where a teenager got seriously injured, (true story), and then pose a simple clicker question: "Was the designer of the Triple Hurricane [roller-coaster] at fault? 1. Yes; 2. No." That starts quite a debate, that begins with ideas of self-responsibility but gradually evolves (with some careful nudging from me) to ideas about banking curves and inertia. Boom: Newton's first law has now been motivated. :)

### WENDY ADAMS, Colorado State University (Physics)

Last year I described how the course would be taught and why on the first day with the syllabus. I immediately had pushback. A week later I showed a CU clicker video which really helped but I still had a sizable fraction (~30%) of the class that didn't like it at all.

This semester I skipped ALL mention of how I'm teaching the course and why it works. This year I have seen no sign of push back. Zero.

While this is anecdotal, it does suggest that it might be beneficial to skip the discussion of why you’re teaching the course the way that you are.

## BRIAN KATZ, Augustana College (Mathematics)

*See Brian's first day activity, "What do you need to know?" in the "activities" files.*

I should say that I've been burned by giving a mini-speech about how the course is going to function. It's been my experience that this frames the course activities as something that the students should find undesirable and should resist by default. Instead, I simply ask the students to stand and work at the board in small groups, as they will do every day in class. At the end, I say that this is what class will be like. I generally ask the students to read a syllabus that might contain a more detailed picture that night, AFTER they have this experience. I have also had positive results from including reflection assignments about the structure of the course that include reading some research about how learning works; for example, see Ch5 of Ken Bain's new book "What the Best College Students Do", which is about "messy problems".

## DJ WAGNER, Grove City College (Physics)

I talk about how the materials (McDermott Tutorials, labs based on Real-Time Physics, etc.) are based on substantive research into student difficulties and have proven to be more effective than traditional activities in helping students learn difficult concepts.

I discuss studies that have shown that making predictions help you learn and remember physics better. Sci Am even had an article (I think this summer) that showed that even truly random "predictions," to questions such as "what color will the next dot be?" with randomly-generated answers, improved memory of what the answers were.

I talk about how collaborative group-work skills is an ABET standard and thus important for the engineers to develop (for classes including engineers). I mention that in the work force you will be working with folk who have different backgrounds and different strengths than yourself and you'll need to describe your expertise and be able to press others to better explain theirs. I also mention an informal survey I conducted at our Career Fair, when I asked any employer who would talk to me (not just those seeking technical majors) what they looked for. Two themes emerged, across discipline: the ability to work collaboratively in a mixed-background group, and an out-of-classroom research/internship/etc. experience.

When using Clicker Questions, I relay a few anecdotes from Mazur's book.

The Hake study is always a good thing to cite too – professor experience/popularity doesn't affect normalized gain on conceptual evaluation, but the amount of active engagement in the classroom does.

## MARK MAIER, Glendale Community College (Economics)

Although it is beneficial to explain to students why collaboration is a worthwhile classroom pedagogy, I find it more effective to structure initial lessons so that students *experience* successful collaboration. In this way, students practice pair work and small group work in a scaffolded manner before being asked to do so on their own. In particular, students need

assistance with group formation, equal participation, individual accountability and positive interdependence (components advocated by Spencer Kagan as essential for effective classroom group work; see also "Cooperative Learning" at the Science Education Resource Center, http://serc.carleton.edu/introgeo/cooperative.)

The first small group activities are designed so that positive interdependence (students need input from one another in order to complete the task) occurs within the task itself. Such activities include students surveys that requiring data from each student and jigsaws that require answers from each group member. Looser structures often create a situation in which students inexperienced in working together can complete the activity better on their own. As result, students see no reason to collaborate. Activities that build in positive interdependence demonstrate to students the effectiveness of group learning more effectively than my exhortation about the importance of collaboration.

## PAUL CAMP, Grove City College (Physics)

In my experience, by the time students reach college they have learned how to operate school and violating their expectations carries risks. The first time I did it, my class rebelled and I got in serious trouble with my dean – serious enough that I had to leave that job.

Since that time, I've always spent the first day of all introductory classes giving a brief overview of some basic ideas of cognitive science and what they imply for effective learning environments. I tell them I give the best lecture on why lectures are bad that they'll ever hear (though lectures aren't always bad – you just have to be ready to hear information as opposed to me being ready to tell it to you – a need to know has to be there first).

This almost always gets me over the hump for a few weeks. However, it is not a permanent fix unless students perceive their skills to be improving as a result of the course. I have a variety of ways of accomplishing this, but they all form a cycle of feedback and reflection. I often use rubrics, similar to those used by Eugenia Etkina, but I use them in the following way.

1. A student receives their assignment and the grading rubric that will be used at the same time. When they complete their assignment, the self-assess using the rubric. I expect they mostly will score themselves high since they wouldn't deliberately hand in something substandard. The only low scores they give themselves are things they totally didn't know how to do.

2. I assess using the same rubric. My scores are generally very different from theirs. I give a short list on the rubric of the things I looked at to determine my scores.

3. They write a short reflection to figure out why my scores are different from theirs. If they did something wrong or incomplete, what was it that led them to think it was right? If they missed something, how should they have thought? They should also project forward to the next part of the class and explain what they will do differently and why.

This allows students a moment for metacognition. They get to assess the quality of their thinking rather than the product, identify shortcomings, and plan for improvement.

I do almost always see improvement, and I do tell them that grades will be based in part on the magnitude of their improvement and not just a straight average of all their grades. This adds practical value to improving in addition to the satisfaction of getting better at your skills.

I should note, however, that many of the things I assess are process skills rather than content – aspects of being a scientist that are distinct from the scientific concepts themselves.

### JOHN HUBISZ, North Carolina State (Physics)

From over 50 years of teaching, I learned long ago that physics students "know" how I am supposed to teach.

I have to set them up for interactive teaching. My first day, I ask for questions and get none. I wait 25 to 35 seconds and maybe get an older student to pose a lukewarm question. I then require each student to turn in a question on a quarter sheet of paper that had always wanted to ask, but never did. I collect the questions and start answering them, even the craziest of questions. They learn quickly that I am serious about asking their questions and should have no fear of asking questions in class. Within four weeks, I have no problem getting questions from students during my classes.

I also present a question for the students in groups of three to answer. They think that they need to go elsewhere to get information in order to answer the question. They don't. Members of the group have pieces of information that will help and at first they do not realize it. Last year I asked them to determine the number of people per square meter in the 48 states. In this question, you can see that there has to be a conversion of units. Someone will know how or someone can guess. As to the dimensions of the U.S. someone will have a rough guess usually in miles and when they get the required number, they are surprised that so many groups came up with roughly the same answer even though the guesses that they made were slightly different. There are lots of Fermi Question collections out there.

Each class day I have wide variety of activities that require the groups to report on one sheet of paper with their names on it. At first the write-ups are poorly written (incorrect grammar, bad spelling, etc.). When I turn those back in with comments, they improved quite quickly. The activities might be a 25 words or less description of what I have been talking about, a solution to a problem on the physics of the day, an answer to a question about a video clip or demonstration just done, etc.

### LESLIE BOWMAN—Online Instruction

*Excerpted from a discussion on a LinkedIn group.*

After trying many first-day activities and handing out a survey at the end of the class and again

three weeks later about the first class, I was not surprised to learn that students hate ice-breaker, introduction types of activities. They hate having the syllabus read to them. They are either there because they have to be or because they want to be. And nothing we do the first day changes their perception of the class. It's what we do the first few class meetings that reinforces or changes how they feel about the class.

To that end, I jump right in to the course content after introducing myself. So many students do not have the text in the first class session so I give a short introduction to some aspect of the content for the week and send them to the computer lab for 15 minutes to locate current events related to what I introduced. Then they come back, get in groups, discuss, then share with the class.

For the second hour, we repeat the process with more info that I give in a 5-min mini- lecture. And off they go again, this time in pairs or small groups. See, they're getting to know each other already.

Ditto the third hour. The final parting shot right before class ends is my take home syllabus quiz that is twice as long as the syllabus, a reading assignment with questions to prepare in writing for the following class discussions.

Bottom line -- they LOVE this. And by the next class meeting, they know the syllabus up one side and down the other and I've never said a word about it.

Why waste time with ice-breakers and introductions? As a student, I hated all that wasted time. And I'll wager that if you give a short survey to your students, you'll find they hate it too. Just one more boring first day.

Try something new and wake up, motivate, and interest your students in the content. Starting out with students working together to complete tasks related to content creates the beginning of a community of practice that grows exponentially through each class meeting (provided you continue with problem-solving, task-related activities).

## STEPHEN RANSON

*Excerpted from a discussion on a LinkedIn group.*

I have my students get to work right away, engaging in meaningful dialog and activity as much as possible. This includes using the service Socrative to collect interesting information about them and sharing it back with them instantaneously to drive conversation. Socrative is free, easy to use, and runs on all devices. So, my students use their phones to participate.
http://www.socrative.com

I also use some of the great ideas here with modification

http://www.facultyfocus.com/articles/teaching-professor-blog/first-day-of-class-activities- that-create-a-climate-for-learning/

Since I teach some classes in computer labs, I've done a modified version of this great Speed Dating activity that uses a shared Google Doc. Students create their own interesting profile on a shared Doc. Then, after skimming everyone else's profile, they find at least 2 others that they follow up with. http://www.facultyfocus.com/articles/effective-classroom- management/love-the-one-youre- with-creating- a-classroom- community/

## ANTON TOLMAN

*Excerpted from a discussion on a LinkedIn group.*

I do a quick ice breaker mostly asking students why they are taking the course; I don't usually accept "it is required" -- I ask them to give another reason. Then I lead a class discussion based on Gary Smith's "first day questions" from the National Teaching and Learning Forum (www.NTLF.com). Those questions basically ask students what they see as the purpose of their education and this course (acquiring information, learning to use that information, or developing lifelong learning skills). The students vote and then we have a discussion about that.

Depending on time, I either break the class into groups and have them review the sections of the syllabus that typically confuse students; each team has to come up with 3 questions they want clarification on and then we go round-robin to answer the questions. This not only builds community, it signals that this is not a lecture and go class. OR I have them vote, by teams, about the remaining chapters we will cover for the semester.

Prior to the first day of class, I post a "draft" syllabus that has blanks for the reading assignment for about half of the weeks. I pick about half of the chapters and the class picks the other half. This is partly modeled on Mano Singham's article "Death to the Syllabus". We have a discussion about why I picked the chapters I did, and I give my own feedback on the remaining chapters which they can listen to or disregard. The teams typically have vigorous discussion about which chapters they want covered, and then we vote, and I post a final version of the syllabus on our LMS. I generally try to do both of these things, but we often have to wait until the 2nd day for the syllabus vote -- students have a say in the class; their thoughts matter. For some classes, in the first two days, I will also use a KWL exercise because students come to my classes with lots of misconceptions and stereotypes.

## DANIEL ANDERSON

*Excerpted from a discussion on a LinkedIn group*

I start by passing around a strange little craft-object-thingy. I take it from student to student and ask each of them what their name and major is then I ask them to ask a question about the object. This can take a few minutes because they sometimes have to struggle to form a question. Then, if there is time, I pass it around again and make them do it over.

This does two things for me. First, I get to put names and faces together and they get to introduce themselves. Also, it offers me an opening to talk about question-based education, which is what I prefer. I really value student engagement and this little (sometimes frustrating) exercise helps me establish it at the outset of class. I also think that it makes the course seem a little less like a business and a little more about personal curiosity, which is better for student engagement in the

learning process.

## THOMAS CAREY

*Excerpted from a discussion on a LinkedIn group*

The activities you choose are determined by your Goals for the First Day of Class. For help in aligning your goals and activities for the First Day, check out the guides, video cases and worksheet in the open educational resources at http://elixr.merlot.org/case-stories/course-preparation--design/first-day-of-class

## DEE FINK

*Excerpted from a discussion on a LinkedIn group*

Being a faculty developer for 25 years, I learned that the first day of class is CRITICAL. If you doing anything unusual or innovative, you need to prepare students for that quickly; otherwise, they will resist and fight back the whole semester. And even if we aren't doing anything unusual, we need to help prepare students to do serious learning, if that is what we want.

One strategy for that are the "first day questions" that Anton Toman mentioned above. That activity guides students through re-thinking the questions of (a) what they see as important kinds of learning and (b) the kinds of learning activities that will help them learn that.

A second major strategy, created by Stephen Carroll at Santa Clara Univ., is to guide students through a re-thinking of who they are, why they are in college, why they are in this class, etc. Stephen has taken time to create a partially animated video of what he does, and put it on YouTube: http://www.youtube.com/watch?v=kM-DXWEns2Y (Part I)
and http://www.youtube.com/watch?v=W-2ZOkO_s6Y (Part II).

In his words, since he started doing this 6 years ago, his students do MUCH better work in every respect, than they did before. That is, this exercise really motivates and guides students to be better "self-directing learners"!
http://meta-learning.org

# Advice to Future Students

**Author: Jenny Knight**
**University of Colorado Boulder**

## Classroom Context

Various Biology Classrooms

## Time Requirement

10 minutes

## Objectives

To communicate beneficial study strategies in a way that does not feel autocratic – by letting students share ideas with the future class cohort.

## Activity

At the end of the semester, ask your students to respond to the following prompt on a piece of paper or online if you are already doing a survey: "If you were to give advice to a fellow student starting this course, what would you suggest they do to be successful?" You don't have to do this every semester, unless you've changed your course substantially, or are curious to see what students will say. The idea is to collect the responses and share them with your students at the beginning of the next time you teach this course.

I collect the responses and roughly categorize them. A lot of students say things like "keep up with the homework" "do all the practice problems" "go to office hours" – all things that I would encourage my students to do anyway. Some students say things like "pray" or "give up" which indicate they are frustrated, or sometimes funny things like "Dr. Knight is not too scary once you get to know her." Humorous responses like this are helpful to lighten the mood on the first day and create a warm atmosphere.

I share a few examples of all the different kinds of quotes with the students early on in the semester (within the first week, or first day). It is helpful to hear from other students rather than using my own words to encourage them. I think it's ok to show them that some people have great suggestions, but that others have given up or never figured out how to be successful, and that you want to help them figure out how NOT to be in that category.

## Effectiveness

It only takes a few minutes, usually gets the students talking and laughing, and allows you to communicate some strategies with them from the mouths of other students just like them.

# Ask Me Anything

**Author: John Hubisz**
**Physics Department, North Carolina State University Materials & Resources**

## Classroom Context

Various

## Time Requirement

Varies

## Objectives

To set the tone for interactive learning during the semester.

## Activities

My first day, I ask for questions and get none. I wait 25 to 35 seconds and maybe get an older student to pose a lukewarm question. I then require each student to turn in a question on a quarter sheet of paper that had always wanted to ask, but never did. I collect the questions and start answering them, even the craziest of questions. They learn quickly that I am serious about asking their questions and should have no fear of asking questions in class. Within four weeks, I have no problem getting questions from students during my classes.

I continue to give activities in each class day, requiring groups to report out on one sheet of paper with their names on it. The activities might be a 25 words or less description of what I have been talking about, a solution to a problem on the physics of the day, an answer to a question about a video clip or demonstration just done, etc.

## Effectiveness

I started this in college courses in 1995 and never had any reason to change. I have presented these techniques at various conferences, and teachers are always surprised at how well it works. Admittedly, one has to be a bit of a ham, but it is easy to become one as you build up a repertoire of answers and a few jokes.
Jon Gaffney (The Physics Teacher, Vol. 53, March 2015) notes that such an activity is likely to be effective because it takes risk on the part of the instructor, and by being willing to put him/herself in that situation, the instructor gains credibility and students learn that they will be taken seriously.

# Bloom's Taxonomy

**Author: Michael Braunstein**
**Physics Department, Central Washington University**

## Materials & Resources

Handout on Bloom's Taxonomy (below)

## Classroom Context

Freshman Seminar

## Time Requirement

15-25 minutes in class

## Objectives

To discuss the rationale for active learning and non-traditional modes of teaching, so that students are less likely to resist those methods

## Activities

I. **Assign reading** of the one page summary of Bloom's Taxonomy before class (the version of Bloom's Taxonomy in the handout has been prepared by D. R. Clark who has granted me permission to use it for teaching purposes in classes at CWU provided it includes appropriate citation). Do NOT include questions on back of the worksheet in the materials distributed for reading.

II. *(Optional)* A **class ticket question** about Bloom's Taxonomy or at beginning of class a brief reading quiz over Bloom's Taxonomy.

III. **Handout and mini-lecture** covering instructor determined key aspects of Bloom's Taxonomy and its role in understanding the types of cognitive domain tasks students will encounter in their progression through college coursework. Some suggested aspects of that lecture:

- Review the taxonomy
- Point out that the taxonomy is hierarchical in the sense that successive levels represent more sophisticated and challenging, but valuable, thinking and learning.
- Perhaps ask students to identify assignments they have had in previous courses that correspond with the different levels. Estimate the percent of their assigned work that correspond to the different levels (most will be in the knowledge category).
- A university education is a transition to thinking and learning at successively higher levels in the taxonomy, and so the types of instruction must change. While lecture can be an effective way to transmit knowledge we know from research that it is less and less effective at teaching and learning for the higher levels in the hierarchy. This means that they can expect that what their instructors do in class and expect of them will change –

that for tasks higher up in the hierarchy more and more engagement and responsibility of the student is required and the instructor becomes less a transmitter of knowledge and more a facilitator of learning.

- It is in their best interest to actively seek out opportunities to learn at higher levels of Bloom's Taxonomy

IV. **In-class exercise** with partner: assignment classification on back of worksheet. (Note that in our classroom context, #9,10,11 were assignments that these students would face, so presented an opportunity for discussing the rationale of such assignments as opposed to "sage on the stage" learning.

V. **Class discussion** of the assignment classification, along with instructor emphasis of the importance of recognizing and appreciating the different cognitive domain tasks and the different roles and responsibilities of students and faculty in the different cognitive domains. What I typically point out are the roles and responsibilities that they and their instructors will have in proposing and carrying out a quarter-long small group "research" project that is a key element of the curriculum. I also discuss that because these proposals and projects by design represent higher level thinking and learning in the taxonomy they can be quite challenging to students, can generate anxiety, and can look very different from the kind of learning that they have become comfortable with (based on instructor experience in this curriculum). The instructors understand this and will be a resource for the students to successfully complete their projects, but by the same token won't give students step-by-step instructions or provide all the answers. Finally, the taxonomy is evidence that in spite of the challenge this type of learning environment represents it is in their interest, and seriously investing themselves in it will serve them well for the remainder of their university career and beyond.

**Bloom's Taxonomy: Cognitive Domain**

| Category | Example and Key Words |
|---|---|
| **Knowledge**: Recall data or information. | **Examples**: Recite a policy. Quote prices from memory to a customer. Knows the safety rules.<br>**Key Words**: defines, describes, identifies, knows, labels, lists, matches, names, outlines, recalls, recognizes, reproduces, selects, states. |
| **Comprehension**: Understand the meaning, translation, interpolation, and interpretation of instructions and problems. State a problem in one's own words. | **Examples**: Rewrites the principles of test writing. Explain in one's own words the steps for performing a complex task. Translates an equation into a computer spreadsheet.<br>**Key Words**: comprehends, converts, defends, distinguishes, estimates, explains, extends, generalizes, gives Examples, infers, interprets, paraphrases, predicts, rewrites, summarizes, translates. |
| **Application**: Use a concept in a new situation or unprompted use of an abstraction. Applies what was learned in the classroom into novel situations in the work place. | **Examples**: Use a manual to calculate an employee's vacation time. Apply laws of statistics to evaluate the reliability of a written test.<br>**Key Words**: applies, changes, computes, constructs, demonstrates, discovers, manipulates, modifies, operates, predicts, prepares, produces, relates, shows, solves, uses. |
| **Analysis**: Separates material or concepts into component parts so that its organizational structure may be understood. Distinguishes between facts and inferences. | **Examples**: Troubleshoot a piece of equipment by using logical deduction. Recognize logical fallacies in reasoning. Gathers information from a department and selects the required tasks for training.<br>**Key Words**: analyzes, breaks down, compares, contrasts, diagrams, deconstructs, differentiates, discriminates, distinguishes, identifies, illustrates, infers, outlines, relates, selects, separates. |
| **Synthesis**: Builds a structure or pattern from diverse elements. Put parts together to form a whole, with emphasis on creating a new meaning or structure. | **Examples**: Write a company operations or process manual. Design a machine to perform a specific task. Integrates training from several sources to solve a problem. Revises and process to improve the outcome.<br>**Key Words**: categorizes, combines, compiles, composes, creates, devises, designs, explains, generates, modifies, organizes, plans, rearranges, reconstructs, relates, reorganizes, revises, rewrites, summarizes, tells, writes. |
| **Evaluation**: Make judgments about the value of ideas or materials. | **Examples**: Select the most effective solution. Hire the most qualified candidate. Explain and justify a new budget.<br>**Key Words**: appraises, compares, concludes, contrasts, criticizes, critiques, defends, describes, discriminates, evaluates, explains, interprets, justifies, relates, summarizes, supports. |

Clark, D. R. (2004), Bloom Taxonomy Cognitive Domain Categories Table. Retrieved November 3, 2009 from http://www.nwlink.com/~Donclark/hrd/bloom.html#revised

Seminal reference on Bloom's Taxonomy:

Bloom, Benjamin S. & David R. Krathwohl. (1956). Taxonomy of educational objectives: The classification of educational goals, by a committee of college and university examiners. Handbook 1: Cognitive domain. New York , Longmans.

For each of the following items, imagine the instructor in a course you are taking has assigned the item as a task, assignment, exercise, or project. Identify which category of Bloom's Taxonomy best describes the assignment.

1. List the first three elements in the Periodic Table of Elements in order.

2. Compare and contrast the Theory of Evolution by Natural Selection and Intelligent Design, identify which one you think is more consistent with the scientific evidence and defend your position.

3. Solve Newton's Laws of motion for the acceleration of a solid ball rolling down a ramp inclined at 30° to the horizontal

4. Use the computer programming algorithm described in section 3.2 of your text to write a program that will find the roots of the quadratic equation.

5. Explain the process by which mitochondria produce ATP.

6. Use a voltmeter to troubleshoot the electronic circuit you've been assigned, and identify why it doesn't work.

7. Follow the instructions in the lab manual to titrate your solution.

8. Write a senior thesis concerning the research you performed last summer during the Science Honors Program.

9. Use the data you collected on bacterial colonies to graph population versus nutrient density in an Excel spreadsheet and interpret it.

10. Write a proposal to carry out a project related to the topic of energy.

11. Carry out an independent project related to the topic of energy with a group of students and write a final report on the project.

# Fermi Questions

**Author: John Hubisz**
**Physics Department, North Carolina State University**

## Materials and Resources

More Fermi questions:

U. Maryland: http://bit.ly/3E5890

The Physics Teacher: http://bit.ly/13QFqnu

Math Forum: http://bit.ly/5A3ktw

Prof. Meade Brooks (with annotated solns): http://bit.ly/W0TxFT

## Time Requirement

Varies

## Objectives

To set the tone for interactive learning during the semester in a course that requires quantitative reasoning, and to build student confidence.

## Activities

My first day, I present a Fermi Problem* for the students in groups of three to answer. For example:

- What is the number of people per square meter in the 48 states?
- How many piano tuners are there in Chicago?
- How long would it take to walk from the classroom to a different city?

They think that they need to go elsewhere to get information in order to answer the question. They don't. Members of the group have pieces of information that will help and at first they do not realize it. In the example above (the number of people per square meter) you see that there has to be a conversion of units. Someone will know how or someone can guess. As to the dimensions of the U.S. someone will have a rough guess usually in miles and when they get the required number, they are surprised that so many groups came up with roughly the same answer even though the guesses that they made were slightly different.
Jon Gaffney (The Physics Teacher, Vol. 53, March 2015) notes that in the third question (the time it would take to walk to a different city), students naturally begin by estimating distance and then proceed with a calculation for average velocity. Assumptions made by students leave much room for discussion.

## Effectiveness

I started this in college courses in 1995 and never had any reason to change. I have presented these techniques at various conferences, and teachers are always surprised at how well it works.

Admittedly, one has to be a bit of a ham, but it is easy to become one as you build up a repertoire of answers and a few jokes.

Jon Gaffney (The Physics Teacher, Vol. 53, March 2015) notes that students are able to get much better results working together with others than they do alone, and also realize that there is not one right answer to some questions. They also gain confidence in their ability to figure these things out – especially if the instructor is attentive to the possibly threatening nature of the activity, keeping students from feeling incompetent or isolated.

** A Fermi problem or Fermi question is an estimation problem aimed to teach skills in approximation, dimensional analysis, and the importance of identifying assumptions that go into an approximation. Named after physicist Enrico Fermi, known for his ability to perform such approximations to high accuracy.*

# First Day Questions

**Author: Scott Freeman**
**Biology, University of Washington, (as recalled by Sarah Wise, University of Colorado Boulder)**

## Materials & Resources

"First Day Questions," National Teaching and Learning Forum, 17(5), September 2008.

## Classroom Context

Large introductory science course

## Time Requirement

10 minutes

## Objectives

To set the stage for the fact that students will need to do certain kinds of tasks out of class, leaving in-class time for more interactive engagement. To do this in a way that doesn't feel coercive, telling students to engage in active learning because they should "eat their vegetables" (i.e, engage in active learning because it's good for them) but rather demonstrates his respect for his students and builds a positive rapport. This represents a departure from simply *telling* students why they should engage in active learning.

## Activities

Start with two questions, and write student responses on the board:

1. How do you plan on studying for a class like this?
2. What skills do you want to prepare you for your ideal job?

Then he asks:

1. Is there any overlap between these two lists?

2. What do you need to do to learn the skills you want to learn?

Another version of these types of questions comes from Gary Smith:

1. Thinking of what you want to get out of your college education, and this course, which of the following is most important to you? Acquiring information (facts, principles, concepts), learning how to use information and knowledge in new situations, or developing lifelong learning skills

2. All three of these goals are clearly important. Which of these three goals do you think you can make headway on outside of class, by doing your own reading and studying?

3. Which of these do you think would be best achieved in class working with your classmates and me?

That launches him into making the pitch for a different kind of class, one that is focused on active learning and collaboration and directly hits the skills they need for the future. He compliments them on their study skills list, and says: "You are now really good at finding out facts, memorizing terminology and the like. For that reason, I am going to let you do all that out of class (through pre-reading and pre-reading quizzes). You are going to do really well on those pre-reading assignments since you are already good at this kind of learning. That will leave us enough time to really practice the skills you need for your future jobs in class, and by practicing that in class you will be prepared to do well on the exam even though the exam questions are going to be different than you expect for a large lecture hall class like this. We are going to practice enough that if you are engaged in the out of class work and on the exam, you will do well. But you have to prepare yourself to work harder than you expected to when you walked in the door. My past students say it was more work each week than they expected, but they wouldn't have it any other way because they are actually learning something valuable."

## Effectiveness

The author indicates that his classroom environment and student evaluations changed dramatically by having this discussion. Jon Gaffney (The Physics Teacher, Vol. 53, March 2015) notes that this activity is likely to be beneficial because it acknowledges students' need to feel in control of their own learning, thus not threatening their sense of autonomy. This generates a more relaxed classroom atmosphere.

# Group Exams

## Authors: Various

## Materials & Resources

References at end of this article

Benefits of group exams

Two Stage exams

## Classroom Context

Various

## Time Requirement

20 minutes

## Objectives

To align assessment with instructional techniques in an active classroom, by assessing interactively. To increase the motivation to engage in group work by creating coherence in the course and leveraging students' high levels of interest and motivation post-exam and providing immediate feedback on learning. These suggestions are taken from several articles, see right.

## Activities

In a two-stage exam students first complete and turn in the exam individually, and then, working in small groups, answer the exam questions again. Students must come to consensus and use one answer sheet for the group portion. Grades are based on a combination of the individual and group score. See a video of this in action: excerpts with commentary, http://blogs.ubc.ca/wpvc/two-stage-exams/

Stage 1: Individual, between 2/3 and 3/4 of the examination time; a standard formal examination that students complete working alone. The majority of the exam score is typically given to the individual exam (85-90%).

Stage 2: After students turn in their individual exams, small groups solve similar or identical problems during the remainder of the examination time. This stage takes less time since students have already thought about the problems. The group score typically adds only 10-15% of the score, and cannot reduce a student's grade.

## Individual portion

1. Start the exam as normal. Make the exam about 2/3 as long as normal and make sure there is plenty of time for both the individual and group portion.

2. As students finish the individual portion we ask them to hold onto their exam sheets until time is up. It is much quicker to get students to hand the exam in all at once by passing

exams to the aisles. Also, when students still have their exams they are less inclined to whisper to their neighbors and disrupt others.

Have a well defined plan for the transition from individual to group. Give very clear instructions during the individual-to-group transition during the exam. For example, students should remain seated while their individual exams are collected. Remind and check that all names and student numbers are listed on the group exam. The switch can be done in less than 5 min; A short video showing logistics in a large class is at: http://blogs.ubc.ca/wpvc/two-stage-exams

## Group portion

1. After all individual exams are collected, tell students to get into groups of 3-4 then raise their hands.

2. Students who do not have full groups or who do not have a group are asked to come to the front where they can be placed in groups.

3. Give one exam sheet per group to those with raised hands. It is very important that each group gets only one exam sheet. They must come to consensus on their answers. If each student has their own sheet they give up on discussion too easily and don't correct their errors.

4. During the group exam try to identify students who are not participating. If you find students who are not participating, approach them, find out why, and see if you can help. We inform these groups that everyone's help is important and that groups of less than 4 underperform.

5. Do not worry about cheating in the group portion. The room will be very loud and lively. Scores do not improve much after more than 4 people per group and those who listen to other groups will still get the benefit.

You can use various approaches for the content of the group exam: 1. Repeat entire exam 2. Repeat subset of questions (e.g. the most challenging ones; conceptual questions work well) 3. Turn open-ended questions into multiple choice or ranking tasks 4. Add a more challenging question that wasn't on the individual part. Two-stage exams work well with any question type except for longer essay type questions and lengthy calculations. Most other types of questions are short enough or structured such that everyone can contribute.

## Grading

1. Marking two stage exams may be a little quicker than normal although for machine marked exams the time difference is negligible. A small amount of extra administrative effort may be needed to coordinate students' marks and combine individual and group scores. Well organized spreadsheets will make this more efficient.

2. Each student's grade will be a combination of their individual and group exam scores. Do not give the group portion of the exam too much weight. 85% /15% is enough to convince students to engage, but does not overly compensate people who are unprepared.

3. Do not penalize students who score higher than their groups, unless you have a good reason and spend lots of time explaining to students why you would do this. Our preference is to allow those few students who may beat their groups to keep 100% of their individual mark.

## Preparation

1. Prepare students to work in groups by using group activities during lecture. Tell students before the exam about the format, why you are doing it, and how it will work.

2. Use two exam sheets. Develop the individual exam as usual. Then make the second, group part of the exam, identical or perhaps add one or two very difficult questions.

3. The individual exam should be about half the length of a normal exam. If this is a concern, add another midterm to the course (to increase questions tested over the term), book an evening exam slot, or take solace in research that shows longer exams are not necessarily better or more reliable exams.

4. On the group portion include four lines for student names and numbers plus space for a group number. Use your photocopier's "count" functions to add unique numbers to each sheet, or do this manually.

5. If exams are marked electronically (i.e. Scantron) each group can enter their group number on the answer key under student ID. When collecting marks you need only enter which group each student was in and use the VLOOKUP function in MS Excel to find their marks.

6. Prior to the exam explain to students the rationale of the format, preferably more than once. Describe the exam early, put it on the course syllabus, and reinforce that it will only improve their mark (see Post Exam below). When preparing them for the exam, encourage students to sit near their group in the individual portion. Also consider giving students strategies for dealing with deadlocks during the group process (for example appealing to arguments from the class – NOT just "Trust me" or flipping a coin).

## Effectiveness

Used properly, two-stage exams can improve feedback, increase learning, and correct misconceptions. In the classic exam, students are intensely engaged with the material, but they

lose the opportunity for formative assessment, because the feedback is mainly right/wrong and comes a long time after the exam. By contrast, in a two-stage exam, students receive immediate, specific feedback and increase their mastery.

In our two-stage exams, students participated strongly in the discussions, and their reactions were overwhelmingly positive. Even those who found the discussions uncomfortable, because they saw where they had made mistakes, acknowledged that they learned what they needed to learn. During the second stage, the room is filled with spirited and effective debate with nearly every student participating.

We have found that students' response to the use of two-stage exams is overwhelmingly positive. In response to a survey, 87% of the students recommended continued use of two-stage midterm exams and only a few percent recommended against their use.2 Some student quotes indicate what they found useful about the exams: "I was able to instantly learn from my mistakes." "Interesting. All had different ways [of] approaching the question. Very helpful to understand everyone's response and why they thought their answer was correct."

**Overview of benefits:**

1. Students get immediate feedback on how they did on each question of the exam. Lower achieving students benefit from extra explanation at their level.
2. Higher achieving students benefit from explaining concepts to others
3. Being forced to come to consensus develops important group work skills
4. Many students report reduced exam anxiety
5. Fewer students drop courses with group exams
6. Student retention of information is increased
7. ALL students participate! A class doing a group exam is awesome to watch.

**What students say:**

*"Great idea! The group exams give you a chance to go over your answers to the exam while you still care about the questions."*
*"You actually learn what you got wrong right away from a student perspective"*
*"Discussion over tricky questions facilitate learning immediately and the answer/concept is stuck in your brain FOREVER!"*
*"You actually learn what you got wrong right away from a student perspective"*
*"They facilitate discussion amongst group members and people who know the material well can reason with others and improve everyone's understanding. For material everyone is only partly familiar with, discussion can help groups piece together the puzzle, so to speak."*

## References


1. B. Gilley & B. Clarkston, Collaborative Testing: Evidence of Learning in a Controlled In-Class Study of Undergraduate Students, J. College Science Teaching, 43(3), pp. 83-91 (2014), www.cwsei.ubc.ca/SEI_research/files/Gilley-Clarkston_2-Stage_Exam_Learning_JCST2014.pdf.

2. C. Wieman, G. Rieger, & C. Heiner, Physics Exams that Promote Collaborative Learning, The Physics Teacher, 52, pp. 51-53 (2014), www.cwsei.ubc.ca/SEI_research/files/Physics/Wieman-Rieger-Heiner_Two-Stage-Exam_PT2014.pdf;

3. G. Rieger & C. Heiner, Examinations That Support Collaborative Learning: The Students' Perspective, J. College Science Teaching, 43(4), pp. 41-47 (2014), www.cwsei.ubc.ca/SEI_research/files/Rieger-Heiner_2-stage-Exams_JCST2014.pdf.

# Group Skill Building

## Authors: Various

## Classroom Context

Various

## Time Requirement

Varies

## Objectives

To structure lessons and support group work skills so that students experience successful collaboration. In particular, students need assistance with group formation, equal participation, individual accountability, and positive interdependence (components advocated by Spencer Kagan as essential for effective group work).

## Forming the First Groups

Mark Maier, Glendale Community College. You can contact Mark with questions at mmaier@glendale.edu.

This activity allows students to practice pair work and small group work in a scaffolded manner before being asked to do so on their own.

**Group formation**: Pair work on first day: I make certain that the all students will be able to form pairs quickly by setting up the room with an even number of rows so that pairs can be formed by asking students in pairs of rows to work with the person sitting across from them. In observing otherwise cutting-edge, research-based physics education classrooms, I have noticed that when students are asked to "find a partner," some students are left alone, often precisely those students most in need of collaborative help. Thus, it is important to structure the room and the pairing instructions so that all students have a partner.

Once the semester is well underway, I move to instructor-formed base groups of four students that remain intact throughout the semester. (See Kagan on recommended group size of four) I form the groups so that friends are not working together and groups have a mix of skill levels and race, ethnic and gender diversity (while not isolating potential minorities; see literature for advice on doing so.)

**Equal participation and individual accountability**: In the initial pair work, the activity is structured so that each student has a specified time to speak. Also, one student is designated as the notetaker and the other student is asked to report out, with roles reversed in the next activity. In this way, students immediately begin to practice more equal participation and individual accountability. Later in the term, it is possible to relax these time constraints and role assignments. However, without practice with good group dynamics, domination by one student and free-riding by others will undercut effective group work.

**Positive interdependence**: The first small group activities are designed so that positive

interdependence (students need input from one another in order to complete the task) occurs within the task itself. Such activities include students surveys that requiring data from each student and jigsaws that require answers from each group member. Looser structures often create a situation in which students inexperienced in working together can complete the activity better on their own. As result, students see no reason to collaborate. Activities that build in positive interdependence demonstrate to students the effectiveness of group learning more effectively than my exhortation about the importance of collaboration.

### Activity: Constructive and Destructive Group Behaviors

On the following page is a worksheet that can be given to students to discuss different type of behaviors among group participants. This can be used for setting productive norms for group collaboration in the course.

### Effectiveness

Attention to the structure of small group work during its initial use frees the instructor to focus on the learning goals. Thus, rather than assisting isolated students who have no partner, or groups in which some students dominate, the instructor can highlight successful student work, pointing out that it occurred because of successful collaboration. Also, students learn the expectations for group work so that pair and group work can be implemented quickly in subsequent classes with appropriate group formation, participation and accountability.

### Further Reading

Mark Maier, KimMarie McGoldrick, Scott Simkins, Cooperative Learning and Disciple-Based Pedagogical Innovations: Taking Advantage of Complementarities, In Cooper, James. Ed. S*mall group learning in higher education: Research and practice*. Stillwater, OK: New Forums Press, 2011.

Kagan, S. (1994) *Cooperative learning*. San Juan Capistrano, CA: Resources for Teachers, Inc

Millis, B. J. (2010). *Cooperative learning in higher education: Across the disciplines, across the academy.* Sterling, VA: Stylus Press.

"Cooperative Learning" at the Science Education Resource Center: http://serc.carleton.edu/econ/cooperative

## Constructive and Destructive Group Behaviors

Each group will have its own feel and personality based on the people in the group. This exercise helps clarify, both to you and your participants, the strengths and weaknesses each member contributes to the group.

Activity (10 minutes): Each participant chooses his most constructive and destructive group behavior from the following lists. Each participant then shares the choice with the larger group and explains why she chose those behaviors. The facilitator may also wish to write down each participant's strengths and weaknesses so individual participants can be called on when a certain behavior is needed or needs to be curbed.

*Constructive Group Behaviors*

*Cooperating*: Expresses interest in the views and perspectives of other group members and is

| | |
|---|---|
| | willing to adapt for the good of the group. |
| *Clarifying*: | Makes issues clear for the group by listening, summarizing and focusing discussions. |
| *Inspiring*: | Enlivens the group, encourages participation and progress. |
| *Harmonizing*: | Encourages group cohesion and collaboration. For example, uses humor as a relief after a particularly difficult discussion. |
| *Risk Taking*: | Is willing to risk possible personal loss or embarrassment for the group or project success. |
| *Process Checking*: | Questions the group on process issues such as agenda, time frames, discussion topics, decision methods, use of information, etc. |

## *Destructive Group Behaviors*

| | |
|---|---|
| *Dominating*: | Takes much of meeting time expressing self views and opinions. Tries to take control by use of power, time, etc. |
| *Rushing*: | Encourages the group to move on before task is complete. Gets "tired" of listening to others and working as a group. |
| *Withdrawing*: | Removes self from discussions or decision-making. Refuses to participate. |
| *Discounting*: | Disregards or minimizes group or individual ideas or suggestions. Severe discounting behavior includes insults, which are often jokes. |
| *Digressing*: | Rambles, tells stories, and takes group away from primary purpose. |
| *Blocking*: | Impedes group progress by obstructing all ideas and suggestions. "That will never work because…" |

Adapted from Brunt (1993). Facilitation Skills for Quality Improvement. *Quality Enhancement Strategies*. 1008 Fish Hatchery Road, Madison, WI 53715

# Make a Paper Airplane


## Author: Dwain Desbien

Physics, Estrella Mountain Community College


## Materials & Resources

WeirdPaperAirplane.mp4
Handout (see below)
Desbien, D., 2002, "Modeling discourse management compared to other classroom management styles in university physics," Dissertation, Arizona State University.

## Classroom Context

Modeling classroom

## Time Requirement

Varies

## Objectives

To build community in an active learning classroom by asking students to work together to build a paper airplane. The purpose is to give students a chance to practice discussion without the pressure of "learning physics." This is part of a Modeling classroom, which focuses on how we create and interpret models in an intensely collaborative environment.

## Activity

Students create instructions on how to make a paper airplane.

1) Give each group of students 3 pieces of blank printer paper. Their instructions are to write directions (to be exchanged with another group) on how to create a paper airplane. 1 sheet of paper is for writing out the instructions, 1 sheet of paper is for practice, and 1 sheet will be used in the future to follow another group's instructions.
2) Collect instructions from groups
3) Distribute those instructions to other groups, and tell them to follow the instructions exactly. Where the instructions are unclear, they must interpret the best that they can.
4) Optional, you may slip in "Weird paper airplane" instructions (see end of document) to some groups.
5) Circulate while students make their airplanes.

While circulating:

1) Immediate questions often arise, such as "can we use pictures?" "Does the plane have to fly?" "Do we have to write it down? Answer all questions the same way, by repeating the charge to create instructors to make a paper airplane. Tell students to decide themselves what that means and act accordingly.
2) While students are working on creating/following instructions walk through the room suggesting the following to various groups:
    a. Suggest diagrams to some groups when creating instructions.
    b. Try following the instruction literally (e.g. what does "longways" mean?)
3) As students are making their instructions, ask various questions to students to get them to

think at a meta-level about what they're doing:

a. What characteristic define an airplane?
b. Why would we have you do this activity?
c. What is a model? (e.g. are these paper airplanes models of real planes? Why or why not?)

4) As students are following instructions to make an airplane, ask questions to help them identify their assumptions in their interpretations of instructions:
    a. If the instruction says "fold the paper lengthwise," what edge is the length and what edge is the width? Why? What if you print in landscape mode?

As students realize that instructions can be interpreted many different ways, they often create airplanes that in no way resemble what was intended.

## Follow-up Discussion

Discussion is best in groups of 20-30 students; for larger groups, consider breaking into multiple groups. Bring students into a circle, and explain that this will be the standard mode for class discussions (if indeed it is). The instructor remains outside the circle, occasionally joining the circle to interject a question but otherwise remaining outside the discussion. This way the instructor is seen as part of the circle, not the leader of the discussion. You may ask students to prepare presentation boards (e.g., 2x3 foot whiteboards) to answer the questions below.

1. What was difficult in making the paper airplanes?
   Instructor Note: encourage different presentations from a group that followed the instructions very literally; one group that was successful, but made assumptions; and one group that used diagrams.
   What was difficult in making the airplane? What terms were ambiguous? What assumptions did you need to make?

2. Why did I give you this activity?
   What is to be learned from this? What role does this activity play for the rest of the classroom discussions?
   Students typically comment that the class must define terms, that it's important to identify assumptions, that pictures are often better than words (i.e., the importance of multiple representations), and that participation and communication are key to all of these elements.

3. What makes a model a model?

You can use the "weird paper airplane" to focus the discussion. Is this a model? Why or why not? The model represents the physical reality but is not the same as the physical reality. For an airplane to be a successful model, it should fly, and have the characteristics of an airplane. This discussion is useful in classrooms in which modeling plays a key role.

## Results

Desbien (2004) states: The entire activity described above is completed on the first day of class to get the learning community started. The reader should note that several other modeling discourse management techniques were introduced, including seeding, creation of shared meaning, and inter-student discussion. A critical component of the modeling discourse

management style is to *lay the foundation of a learning community early and continue to build the community throughout the semester*. Students are reminded of basic rules throughout the semester. The most common reminders are that only one person should talk at a time and that evaluation of other student work must be done in a positive manner."

# Metacognition Homework

## Author: Andrew Elby

(2001). "Helping students learn how to learn," Am. J. Phys. 69, S54, http://scitation.aip.org/content/aapt/journal/ajp/69/S1/10.1119/1.1377283

## Materials & Resources

None, but see article above

## Classroom Context

High school, small to medium class size

## Time Requirement

10 minutes

## Objectives

To help students develop more sophisticated beliefs about teaching and learning ("epistemological beliefs"), because these beliefs can affect students' studying habits and learning outcomes. This activity is excerpted from the published article cited to the right.

## Activity

In the article, Dr. Elby describes several homework and in-class problems designed to foster reflection about learning. He bases grading on completeness, not content, of the answers. Example questions are shown below.

1. Think about the material you learned for last week's quiz.
   (a) What role did memorization play in your learning of the material?
   (b) What makes the material "hard"?
   (c) What advice about how to study would you give to a student taking this course next year?

2. On last week's circular motion lab, there were experiments, conceptual questions about those experiments, and "textbook-like" summaries. In each case, the summary came *after* you attempted to answer some questions about the material covered in the summary. But on other labs, I've put the summaries *before* the related questions.
   (a) When it comes to helping you learn the material, what are the advantages of putting the textbook-like summaries *before* the conceptual questions about that same material? Please go into as much detail as possible.
   (b) When it comes to helping you learn the material, what are the advantages of putting the textbook-like summaries *after* the conceptual questions about that same material? Please go into as much detail as possible.

3. In lab last week, most people seemed surprised to find an apparent contradiction between common sense and Newton's 2nd law ($F$net = $ma$), for a car cruising at constant velocity. But the night before the lab, you read a textbook section about Newton's 1st and 2nd laws. Why didn't you notice the apparent contradiction while doing the reading? I'm not "yelling" at you or

blaming you; I know you're careful, conscientious readers. That's why it's *interesting* to think about why the apparent contradiction went unnoticed. What could you and/or the textbook have done differently to help you discover—and possibly resolve—the apparent contradiction?

Along with these assignments, Dr. Elby used two non-traditional policies to help students view homework as an opportunity to learn the material: Grading was based on effort (not correct answers), and he handed out detailed solutions with the assignment (receiving no credit for copied work). A graded mini-quiz on the material provided additional accountability for learning, and penalized copying.

## Effectiveness

Elby indicates that student responses helped him to understand their views, which helped him to plan subsequent classes, and nudge individual students. Students who copied the homework tended to do poorly on tests, but those who wanted to learn the material tended to be able to focus more on learning the concepts instead of the right answer, due to his grading policies. Homework and test questions also emphasized explanation, providing additional accountability for deeper learning.

## Going Further: Metacognition labs

Dr. Elby wove metacognitive strategies throughout the course in this article, but one that may be of use to instructors using activities or labs in their course are the metacognitive activities developed for labs, problems, and class discussions. In the article, he describes two force labs designed to help students understand that learning physical laws involves refining one's intuition.

For example, in a Newton's 2nd law lab, he asks students to explain their intuition of what will happen (regarding the force on a moving car), complete some calculations, and then answer a question designed to help them identify their reasoning:

> **3.** Most people have—or can at least understand—the intuition that the forward force must "beat" the backward force, or else the car wouldn't move. But as we just saw, when the car cruises at steady velocity, Newton's 2nd law says that the forward force merely *equals* the backward force; *F*net = 0. Which of the following choices best expresses your sense about what's going on here?
> (a) *F*net = *ma* doesn't always apply, especially when there's *no* acceleration.
> (b) *F*net = *ma* applies here. Although common sense usually agrees with physics formulas, *F*net = *ma* is kind of an exception.
> (c) *F*net = *ma* applies here, and disagrees with common sense. But we shouldn't *expect* formulas to agree with common sense.
> (d) *F*net = *ma* applies here, and appears to disagree with common sense. But there's probably a way to reconcile that equation with intuitive thinking, though we haven't yet seen how.
> (e) *F*net = *ma* applies here. It agrees with common sense in some respects but not in other respects.

After leading them through some additional reasoning, he asks them:

> **7.** OK, here's the punch line. Most people have the intuition that, if an object is moving forward, there must be a (net) forward force. Explain in what sense that intuition is

helpful and correct, and in what sense that intuition might seem misleading. Post-lab discussions helped to bring home the epistemological point of the lab. An additional example is provided in the article.

# Misconceptions about Learning


## Author: Stephen Chew

Psychology Dept., Samford University


## Materials & Resources

Materials are included in the downloaded archive.

From article, “Improving classroom performance by challenging student misconceptions about learning,” S. L. Chew, APS Observer, 23(4), April 2010.

Online at http://bit.ly/oFEkRu.

See original article for citations mentioned within.

See also the author’s popular "How to Get the Most Out of Studying Video Series: http://bit.ly/nxKAuy

## Classroom Context

Phycology course, but broadly applicable

## Time Requirement

20 minutes

## Objectives

To persuade students that they have misconceptions about learning, and that they need to change the way that they study.

## Activity

The following is excerpted and paraphrased without permission from the article cited at right. Materials for running the activity are included in the archive.

**I pose the following question to the students:**

Which of the following is the MOST important ingredient for successful learning?

1. The intention and desire to learn
2. Paying close attention to the material as you study
3. Learning in a way that matches your personal learning style
4. The time you spend studying
5. What you think about while studying

*(Note that this could be used as a clicker question).* Usually most of the group is split among alternatives one through four, with relatively few people choosing five.

**Instead of telling the group the correct answer, I let them discover it through a**

**demonstration of levels of processing and learning**.*
Students listen to a list of words. For each word, they carry out an orienting task that creates either deep or shallow processing:

- One group rates the pleasantness of each word ("Is the word pleasant?"
- Another group checks each word for the presence of an E or G ("Does the word contain an E or G?").

The group that did pleasantness ratings, the deeper processing orienting task, virtually always remembers strikingly more words.

For large groups, say over 40, I use a 2 × 2 between groups factorial design with levels of processing (deep or shallow) as one variable and intent to learn (intentional or incidental) as the other. Before the presentation, I divide the room into quadrants and assign conditions to each one. Everyone in a quadrant gets the handout for the assigned condition. In addition to instructions, each handout has a grid with 24 rows of two columns, one column is headed "Yes" and the other "No." I then read the list of 24 words shown in Figure 1. For each word, everyone carries out their assigned orienting task by checking the "Yes" or "No" box after each word.

| | |
|---|---|
| Group 1:<br>Memorize + Rate Pleasantness | Group 2:<br>Memorize + Check for E, G |
| Group 3:<br>Don't Memorize + Rate Pleasantness | Group 4:<br>Don't Memorize + Check for E, G |

### Word list for demonstration:

| | |
|---|---|
| (1) Evening | (13) Cold |
| (2) Country | (14) Love |
| (3) Salt | (15) Bargain |
| (4) Easy | (16) War |
| (5) Peace | (17) Hate |
| (6) Morning | (18) Wet |
| (7) Pretty | (19) Rich |
| (8) Expensive | (20) Nurse |
| (9) Poor | (21) Pepper |
| (10) Doctor | (22) Hard |
| (11) City | (23) Ugly |
| (12) Dry | (24) Hot |

**After I present all the words, I ask everyone to recall as many words as they can**, which always elicits groans from the incidental learning groups not forewarned about the recall test. Lastly, I have students count the total number of words they recalled; I do not check for accuracy of scoring.

**Next, I explain levels of processing, orienting tasks, and the four conditions.** I then describe three hypotheses about how the results might turn out. First, if intent to learn is critical, then

those who were forewarned about the recall test (the two Intentional groups) should do better than those who were not (the incidental groups), regardless of level of processing. Second, if depth of processing is important, then those who rated the pleasantness of words (the two deep groups) should recall more than those who did E/G checking (the shallow groups), regardless of whether they knew about the recall test. Third, if both level of processing and intent to learn are important, then the group that did pleasantness ratings and was warned about the recall test (the deep/intentional group) should do better than the other three conditions. I survey the students to see which hypothesis they believe will be supported. Usually the vote is split, with a preference toward the joint effects of deep processing and intentional learning.

**Everyone is now eager to see the results.** For large groups, I have everyone stand. I instruct people to remain standing if they recalled at least three words and sit down if they did not. I then ask about six words and proceed upward by threes. People will start sitting down starting at nine, and it becomes obvious at about 12 to 15 that the shallow processing groups recalled very few words, regardless of whether they were warned or not. The majority of people standing did deep processing, and there should be equal numbers of people who were warned or not warned about the recall task. The results show that level of processing is much more important than intent to learn.

The intent to learn with shallow processing leads to poor performance, whereas deep processing without the intent to learn still leads to good recall. I ask if people noticed the words were in pairs. The deep processing groups invariably notice it and use it in recall. People in the shallow processing groups often do not notice it at all.

**After the demonstration, we return to the question regarding the most important ingredient for successful learning.** The levels of processing demonstration showed that the desire to learn, paying close attention, and the time spent studying may be necessary, but they are not sufficient for learning. The shallow and deep processing groups were matched on time and attention. The third alternative addresses learning styles because many students believe in them, such as being a visual or kinesthetic learner, but current formulations of learning styles have weak if any research support (Coffield, Moseley, Hall, & Ecclestone, 2004). That leaves alternative five, what a student thinks about while studying, as the correct answer. Time studying and intent to learn are only effective if they cause students to use deep processing during study. Students may spend a huge amount of time studying and be highly motivated, but if they use shallow study strategies, they will not learn. Many entering students have ineffective, shallow study strategies, such as rote memorization of isolated facts.

**In the Levels of Processing framework, memory is conceptualized as a continuum of levels going from shallow to deep (Craik, 2002). Depth of processing depends on how a learner encodes or rehearses information. Shallow levels involve encoding of meaningless physical characteristics such as spelling or font. Intermediate levels involve acoustic information such as rhymes. Deep levels involve distinctive semantic analysis. The deeper information is processed, the more likely it is to be recalled later. Although the Levels of Processing framework is no longer considered a viable model of memory, it still serves as a powerful heuristic for helping students to improve their study effectiveness.*

## Effectiveness

Uncertain, but developed by U.S. Professor of the Year in 2011. An instructor in economics (Bill Goffe) mentions that this did not have a large impact in his own class, and hypothesizes that it is important to draw the results of the experiment back to ideas about studying, spending more time on reflection. Nathaniel Lasry used this in a workshop with adult learners, and reports that it was incredibly effective. Stephanie Chasteen used this in a non-majors physics course, and students seemed to have difficulty understanding the point of the exercise – considering how to present and make sense of the results is important.

# Nature of Science Activities

## Authors

Various

## Materials & Resources

**Learnification blog** (Joss Ives)**:**http://bit.ly/13qz5hs

**Game of Science:**

http://bit.ly/13p7MFk (article)
http://bit.ly/qUrdW7 (sample materials)

**Cereal Boxes:**

http://bit.ly/X2jUWC (article)

## Classroom Context

Introductory science courses

## Time Requirement

20+ minutes

## Objectives

To provide (a) an introduction to the nature of science and thus frame the nature of the course, (b) an engaging activity in the style that students will experience throughout the course, and (c) a platform for a reflective conversation about why active learning strategies are effective.

## Activities

Following are a variety of activities that can be used to address the Nature of Science and draw on students' natural curiosity and ability to find patterns, with little pre-existing knowledge. Each should be followed by a reflective discussion/conversation about the activity; e.g., "Why did we spend our first class period doing this?"

**1. The Game of Science**

"Learning the Game of Formulating and Testing Hypotheses and Theories" (The Physics Teacher, Jan. 2010, Vol. 48, Issue 1, pp. 22).
Original article: http://tpt.aapt.org/resource/1/phteah/v48/i1/p22_s1
Sample materials: http://users.ipfw.edu/maloney/game_of_science.htm

As described by Joss Ives on his Learnification blog (http://bit.ly/10pDROF) :

You give each group in your class a "list of the moves made by two novice, but reasonably intelligent players" from when they played an abstract strategy boardgame (think games like checkers or go but way simpler in this case). The group plays out the moves of the two novice players and tries to deduce the rules of the game. The students are able to generate hypotheses (propose rules) which can be disproven by data (moves which break the rules). Further sets of rules can be given to test the students theories (the sets of rules which have survived the hypothesis testing). The links between what they are doing and hypothesis testing and theories is

discussed explicitly. This activity also leads to discussions of if it is possible to prove a hypothesis or theory and how a theory, once accepted by the classroom, is quite robust. If a future list of moves for a subsequent game ended up showing that one of the small rules was wrong, it wouldn't mean that the entire set of rules was incorrect, but instead would just mean that the set of deduced rules (the theory) would need to be slightly revised. You are also able to discuss ideas like scientific consensus, with all the groups in the room agreeing on the deduced rules and confidence in theories which withstand many tests (sets of moves lists).

## 2. Learning About Science from Cereal Boxes

"Learning About Science and Spectra from Cereal Boxes" (The Physics Teacher, Oct. 2009, Vol. 47, Issue 7, pp. 450

As described by Joss Ives on his Learnification blog (http://bit.ly/10pDROF) :

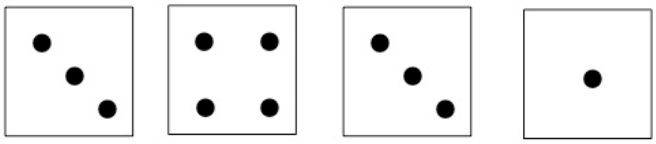
This is an activity that is very much in the same spirit as the Game of Science. They provided students with the barcodes (with UPC) for four boxes of cereal. The students then developed some hypotheses based on the UPC codes that they had. Due to the specific codes that they were supplied they were able to hypothesize that the first set of 5 numbers in the UPC represented the manufacturer. They also hypothesized that all the UPC codes started with a 0, but were able to later disprove this hypothesis when they discovered that their textbook had a UPC code which started with a 9, prompting them to revise their hypothesis to UPC codes for food start with a 0. This activity leads to the same types of discussions surrounding the process of scientific inquiry and the development of scientific knowledge that are highlighted in the above discussion of the Game of Science.

They also did further activities with matching the barcodes to the UPC codes. In the post-activity discussion several groups called the UPC/barcode the product's thumbprint and the instructors drew a parallel to spectra being unique identifiers for elements: "a way to recognize each using nothing but a set of lines in specific patterns." Although this activity can be used to teach about the nature of science, in the authors' implementation it also served to set up a unit on spectra.

## 3. The Farmer and The Seeds

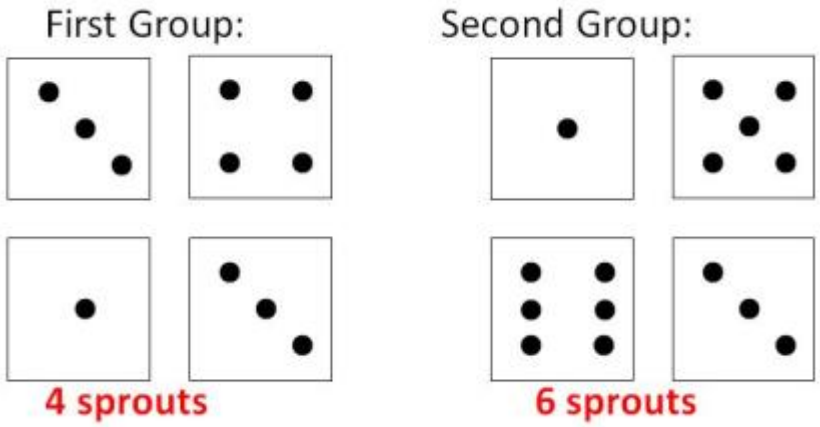
Author: Dewey Dykstra, "Piaget beyond 'Piaget' for physics learning" workshop, in American Association of Physics Teachers National Summer Meeting (2006). Some activity wording from Noah Finkelstein, Physics, University of Colorado Boulder.

A "seed" is defined as a square with some dots on it, as shown below.



**Four different kinds of seeds**

A farmer always plans 4 seeds in a group. He then observes the number of sprouts the group produces. The farmer would like to know the number of dots on the seeds affects the number of sprouts that it produces. That is, he would like to know the underlying structure of his seeds by examining the sprouts (an obvious connection to the nature of science).

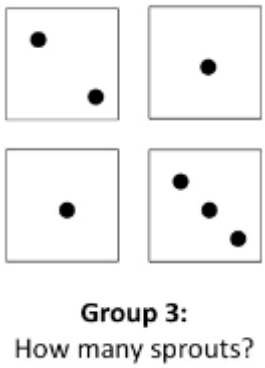



Have students work in groups to answer these questions:

**What is the pattern?** What do you think is the relationship between the number of dots on the four seeds, and the number of sprouts they produce? In your group, come up with as many "theories" as you can to explain the possible pattern.

**How would you know?** What evidence would you need to collect in order to determine if any of your theories were right?

Students will come up with a variety of creative hypotheses about how the number of sprouts relates to the number of dots, e.g., # sprouts = highest # of dots, total even # of dots, etc. Have them share their theories with the whole class.
Then, show them the following group of seeds and ask what their model would predict:




Tell them that this grouping produced **7 sprouts.** Discuss using the following questions:

- How should we make use of the comparison between each of these predictions and the outcome the farmer actually observed?

- Where did these schemes we have been discussing come from? (Note: This question is not about the elements of the schemes, but the decisions as to what elements to use and how to use them. They came from our heads.)

- How do we know if we have figured out all the possible schemes?
- If we have made many different tests of the seed groupings and have found a scheme that has worked on all of them so far, how do we know if will work on the next new test?

Summary:

- Scientists "make up" theories to explain the evidence they see.
- These theories are constrained by experiment.
- We can't always open up the seed and look inside. Have to make inferences from indirect evidence.
- A theory with a plausible mechanism is more convincing than a rote algorithm.
- The more different cases our theory works on, the more we believe it.
- But it could always be wrong…

# Participation Assessment

**Author: Denise Knight**
published in Faculty Focus (http://facultyfocus.com), September 14, 2008.

## Materials & Resources

Original article here.

## Classroom Context

Various

## Time Requirement

10 minutes

## Objectives

To explicitly address the common gap between students' perception of their participation, and the instructors' assessment of the participation – with the ultimate aim of enhancing the quantity and quality of student participation.

## Activities

From the article:
One tool that I have found particularly effective is to administer a brief questionnaire early in the semester (as soon as I have learned everyone's name), which asks students to assess their own participation to date.
Specifically, I ask that students do the following: "Please check the statement below that best corresponds to your honest assessment of your contribution to class discussion thus far:
_____ I contribute several times during every class discussion. (A) _____ I contribute at least once during virtually every class discussion. (B) _____ I often contribute to class discussion. (C) _____ I occasionally contribute to class discussion. (D) _____ I rarely contribute to class discussion. (E)"
I then provide a space on the form for the student to write a brief rationale for their grade, along with the option to write additional comments if they so choose. Finally, I include a section on the form for instructor response. I collect the forms, read them, offer a brief response, and return them at the next class meeting.

## Effectiveness

This informal self-assessment exercise does not take long, and it always provides intriguing results. More often than not, students will award themselves a higher participation grade than I would have. Their rationale often yields insight into why there is a disconnect between my perception and theirs. For example, a student may write, "I feel that I have earned a 'B' so far in class participation. I know that I'm quiet, but I haven't missed a class and I always do my reading." Using the "Instructor Response" space, I now have an opportunity to disabuse the student's notion that preparation, attendance, and participation are one and the same. I also offer concrete measures that the student can take to improve his or her participation.

When this exercise is done early in the semester, it can enhance both the amount and quality of participation. It helps to build confidence and reminds students that they have to hold themselves accountable for every part of their course grade, including participation.

# Self-Assessment Worksheets

**Authors: Various**

## Objectives

To allow students to reflect on their learning processes, both individually and groups. To encourage metacognition and expert learning strategies.

## Self-Assessment checklist

From Reinholz, D.L. Int. J. Res. Undergrad. Math. Ed. (2015) 1: 234. doi:10.1007/s40753-015-0005-y

**Completeness, Organization and Labeling**

Did you answer all questions asked, showing all steps, in the proper order? ___ yes ___ no

(If applicable) Did you label and explain all graphs, including units, etc.? ___ yes ___ no

**Explanations**

Did you explain why (and not just what)? ___ yes ___ no

**Use of language**

Did you avoid the use of pronouns (and other ambiguous language)? ___ yes ___ no

(If applicable) Did you consult definitions of mathematical terms you used? ___ yes ___ no

**Justification**

Did you justify your solutions in at least one of the following ways? ___ yes ___ no

- By checking if answers to different parts of the question are consistent?
- By explaining how you know your solutions is correct?
- In some other way?

## Self-Reflection Rubric

# Physics 98: Introduction to Modeling

## Self-Evaluation Rubric, Fall 2012

The self-evaluation rubrics are designed to help you in your process of self-reflection. Each skill in the rubric has questions to help you understand what the skill means and descriptions of what it means to be beginning, developing, and succeeding in each skill. The skills are divided into a primary set, which you should focus on first, and an advanced set, which you should move on to once you feel like you are succeeding in the primary set.

Once you pick the class in which you want to self-evaluate, use the rubrics to identify skills that you want to work on each week and write about your progress in those skills in your self-evaluations. Honest, thoughtful reflection is key here: there is no way to improve if you are not truthful with yourself about how you are doing.

Your self-evaluations are due by **midnight each Monday** in your **dropbox on bSpace** as **PDFs**, and should contain the following pieces of information:

- The name of the class you are evaluating.
- The skill(s) you are evaluating
- Whether you think you are beginning, developing, or succeeding in each skill. This should be accompanied by evidence to support your decision (for example, an anecdote).
- In what way you want to improve in each skill, and how you will do that. This will require you to **identify** the change you want to make, come up with a plan to **implement** that change, be **consistent** in your implementation, and **frequently reassess** how your change is working.

### Primary Skills

| Skill | Questions to ask yourself | Beginning | Developing | Succeeding |
|---|---|---|---|---|
| **Persistence** | ☐ What do you do when you're frustrated?<br>☐ Do you independently pursue understanding? | I tend to try one or two things. I give up more easily than I should. | I try to stick with things, but I sometimes feel unsuccessful. Sometimes I seek new approaches to help. | I look for new ways to think about the problem. I find a way to persist when appropriate. |
| **Organization** | ☐ Do you keep accurate, thorough, and consistent records of work?<br>☐ Do you submit materials in a timely manner?<br>☐ Do you refer to your records to support conclusions? | There are significant gaps in my records, and/or I consistently forget to complete assignments on time. | I don't complete all assignments on time or I have no record of some of my work/activities. When I neglect to do something, I forget about it because it's too late. | I am timely and thorough with work and record-keeping. When I've neglected something, I correct my oversight quickly. My records are a valuable resource. |
| **Connections** | ☐ Do you try to make connections with new people who might be able to help you in the future?<br>☐ Do you make use of your | I tend to go it alone. | I sometimes get help from other people, but only when I really need it. My network of supporters could | I have a strong network of people who I go to regularly for help and support. |

## Advanced Skills

| Skill | Questions to ask yourself | Beginning | Developing | Succeeding |
|---|---|---|---|---|
| **Courage** | □ How do you react to uncertainty?<br>□ What do you do when you feel overwhelmed?<br>□ Do you take intellectual risks? | I don't like to try things unless I'm reasonably certain what the outcome will be. | I take some risks, but I sometimes miss out on some good opportunities. | I make a decision to trust that I'll learn something from each experience, even if I'm unsure at times. |
| **Mental Resourcefulness** | □ Where do you turn for new ideas?<br>□ Do you look for connections between ideas?<br>□ Do you apply past experiences to new situations? | When something feels unfamiliar, I often assume it's not useful. | There have been times when I disregarded new ideas before considering them fully. I don't often see connections between what I'm doing and what I've done. | I always try to consider things, even if they seem odd or surprising at first. I often relate new ideas to old ones. |
| **Communication** | □ Can you clearly convey an idea to someone else using pictures, speech, or demonstrations?<br>□ Do you give examples that support your ideas?<br>□ Do you seek consistency in ideas? | It seems like others don't understand what I'm trying to say/convey most of the time. Once I try to communicate something, I move on to the next thing. | I can usually convey my ideas, but often others don't seem to understand what I'm trying to communicate. When the message doesn't get across, I might try one other way of communicating. | Communication is strength of mine. When I'm feeling misunderstood, I search for new ways to convey my point. I look back through my conclusions to make sure they're clear and consistent. |
| **Diligent Skepticism** | □ How do you evaluate the quality of procedures?<br>□ Do you scrutinize sources of information and search for ways to test ideas?<br>□ Can you identify problems with procedure that lead to erroneous or incomplete conclusions? | Much of what I believe came from someone else directly. When someone sounds convincing, I trust that they are right. | I should ask more questions about information that I receive, and steps that I'm taking. Sometimes I discover that I've been lead down a path that I could have avoided with more thought, testing, and questioning. | I ask plenty of questions (to myself and others) and head off problems before they start. |
| **Collaboration** | □ Are you respectful, supportive, and critical of peers?<br>□ Do you share your ideas with others?<br>□ Do you consider strategies employed by your peers for study, organization, and investigation? | Sometimes I either: don't participate; dominate the work, so that others might not feel like they have a role; or, distract others. | I'm great as either a leader or participant, but not both. I could be more mindful of the needs of others with whom I work. I try to learn from what others are doing. | I am an asset to any team. I know how to lead when appropriate, and how to support others when they take the lead. I think pretty much everyone has something to offer me. |
| **Reflection** | □ Do you consider past experiences when making choices?<br>□ Do you reference prior work?<br>□ Are your reflections thoughtful and substantive? | Once I complete something, I usually just move on to the next thing, without thinking about how it went. | I don't always reflect after each science experience. I don't review my notes during and after a topic of study. I'm not great about considering how things went. | I squeeze every bit of learning from everything that I do by evaluating what happened. My notes are excellent, and I use them often to check on my ideas. |

# Physics 98: Introduction to Modeling

Self-Evaluation Rubric, Fall 2012

The self-evaluation rubrics are designed to help you in your process of self-reflection. Each skill in the rubric has questions to help you understand what the skill means and descriptions of what it means to be beginning, developing, and succeeding in each skill. The skills are divided into a primary set, which you should focus on first, and an advanced set, which you should move on to once you feel like you are succeeding in the primary set.

Once you pick the class in which you want to self-evaluate, use the rubrics to identify skills that you want to work on each week and write about your progress in those skills in your self-evaluations. Honest, thoughtful reflection is key here: there is no way to improve if you are not truthful with yourself about how you are doing.

Your self-evaluations are due by **midnight each Monday** in your **dropbox on bSpace** as **PDFs**, and should contain the following pieces of information:

- The name of the class you are evaluating.
- The skill(s) you are evaluating
- Whether you think you are beginning, developing, or succeeding in each skill. This should be accompanied by evidence to support your decision (for example, an anecdote).
- In what way you want to improve in each skill, and how you will do that. This will require you to **identify** the change you want to make, come up with a plan to **implement** that change, be **consistent** in your implementation, and **frequently reassess** how your change is working.

## Primary Skills

| Skill | Questions to ask yourself | Beginning | Developing | Succeeding |
|---|---|---|---|---|
| **Persistence** | □ What do you do when you're frustrated?<br>□ Do you independently pursue understanding? | I tend to try one or two things. I give up more easily than I should. | I try to stick with things, but I sometimes feel unsuccessful. Sometimes I seek new approaches to help. | I look for new ways to think about the problem. I find a way to persist when appropriate. |
| **Organization** | □ Do you keep accurate, thorough, and consistent records of work?<br>□ Do you submit materials in a timely manner?<br>□ Do you refer to your records to support conclusions? | There are significant gaps in my records, and/or I consistently forget to complete assignments on time. | I don't complete all assignments on time or I have no record of some of my work/activities. When I neglect to do something, I forget about it because it's too late. | I am timely and thorough with work and record-keeping. When I've neglected something, I correct my oversight quickly. My records are a valuable resource. |
| **Connections** | □ Do you try to make connections with new people who might be able to help you in the future?<br>□ Do you make use of your connections when you need help? | I tend to go it alone. | I sometimes get help from other people, but only when I really need it. My network of supporters could be better developed. | I have a strong network of people who I go to regularly for help and support. |
| **Self-compassion** | □ When you're having difficulty with something, how do you feel about yourself?<br>□ Do you make productive use of failure? | I have trouble with feeling like a failure, and these feelings often make me feel like giving up. I'm my own worst critic. | I am sometimes overly critical of myself. I tend to ignore feelings of failure rather than using them to improve. | I acknowledge my difficulty, but I don't let it define how I feel about myself. I act kindly towards myself and view failure as an opportunity for self-improvement. |

## One-Minute Paper: Group Work

from Moreno R. (2009), *Educational Psychology*, John Wiley & Sons, Hoboken NJ.

1. How is your group making progress towards its' goal?

2. What does your group need to do to improve?

## Group Self-Reflection

From Felder, R. and Brent, R., *Teaching and Learning STEM: A Practical Guide*, Jossey-Bass, San Francisco, CA (2016).

Every 2-4 weeks have teams respond in writing to questions such as:

1. How well are we addressing the goals and expectations we agreed on?

2. What are we doing well?

3. What needs improvement?

4. What (if anything) will we do differently from now on?

## Group Assessment Worksheet

from Moreno R. (2009), *Educational Psychology*, John Wiley & Sons, Hoboken NJ.

Name:

Group Members:

Group Evaluation

*Rate how your group worked together today*

| | Strongly disagree | Disagree | Somewhat agree | Agree | Strongly agree |
|---|---|---|---|---|---|
| My group was on task | 1 | 2 | 3 | 4 | 5 |
| My group used reading strategies we learned in class | 1 | 2 | 3 | 4 | 5 |
| Everyone in my group helped complete the assignment | 1 | 2 | 3 | 4 | 5 |
| Everyone's opinion was respected | 1 | 2 | 3 | 4 | 5 |
| Everyone was given a chance to speak | 1 | 2 | 3 | 4 | 5 |

What do you think your group did well today?

What do you think your group needs to do differently next time?

## Peer Assisted Reflection

Reinholz, D.L. Int. J. Res. Undergrad. Math. Ed. (2015) 1: 234. doi:10.1007/s40753-015-0005-y

http://link.springer.com/article/10.1007/s40753-015-0005-y

In Peer Assisted Reflection (PAR), students do one homework problem in advance of its' due date; students complete a short self-reflection and discussed the problems in groups in class, prior to turning in the assignment. There is also a short "critical friend" training exercise to ensure that students give each other useful feedback.

**Student instructions**

**1 Overview of Peer-Assisted Reflection (PAR)**

Your recitation includes a special activity called Peer-Assisted Reflection (PAR). PAR promotes communi- cation, collaboration, and persistence, which are all essential to college success. Research on PAR at other universities has shown improved student passage rates in calculus by 13% (in the first study) and 23% (in the follow-up study). We are presently exploring opportunities to use PAR here at CU Boulder.

**1.1 Basic Procedure**

1. Students complete an initial solution to the PAR problem (working individually or with peers) as homework (outside of class). Students then complete the self-reflection sheet.
2. On Tuesday, students come to class and sit in a random seat (so that they work with a new partner each time).
3. When class starts, students trade work with a peer. They spend 5-7 minutes silently reading each other's work and providing written feedback. Afterwards, they trade packets and conference about their work for 5-7 minutes longer.
4. After conferencing, the whole class completes the CRAFT activity, designed to help students give critical, constructive feedback to one another. Students have about 5 minutes individually to write their analyses of the sample work, and then the class discusses the sample work as a whole for about 5 more minutes.
5. Students go home and revise their work based on their conferences.
6. On Wednesday, students turn in their "PAR packet" to their TA's mailbox. The packet includes: (1) original solution, (2) self-reflection form, (3) PAR form (filled out by your partner), and (4) revised solution based on feedback you received. To receive full credit all, 4 items must be turned in, but only the final solution is graded for correctness.

7. All PAR problems are available online at: http://www.colorado.edu/csl/par/calculus1/

### 1.2 Making the Most of PAR

1. You need to work with a new partner each week. This will allow you to get a variety of different perspectives and also meet new students in your class. As students enter class, they need to sit in a new, random seat.
2. Students need to provide feedback silently at first. It is crucial that students focus on each other's work, not just the problems themselves.
3. Providing feedback is not an option. Even the best solutions can be made better. Even students who did not complete the problem can still engage in conferences.

Use what you've learned from PAR to collaborate with your classmates outside of class. Building a strong community is one of the best ways to ensure that you are successful in college.

## Peer Reflection Sheet

## Peer Feedback Form (to be filled out by a partner)

**Hwk11 PAR Problem** Peer-Assister's Name: _____

**Instructions:** On Tuesday in class, trade your solution with a classmate **you didn't work with** to receive peer feedback.

**Communication:** Give at least one suggestion to improve the communication of the solution. (Focus on explanations, imprecise use of language, organization, labeling, etc. Be specific: don't say "it was hard to follow" or "part 2 was unclear;" say *why* it was hard to follow, *what* was unclear, and *how* to improve it.)

**Correctness:** Note any errors you found. (Focus on misunderstanding of concepts, misuse of mathematical language, calculational errors, incomplete answers, etc. Be specific: don't just say "part 2 is was wrong;" say exactly *what* is wrong, *why* it is wrong, and *how* to improve it.)

**(Optional:)** What other feedback do you have? How else could the solution be improved?

## Being a Critical Friend handout

Peer-Assisted Reflection (PAR) will help you improve your communication skills and

understanding of calculus. Writing solutions for someone who does not already understand your work is a skill that requires practice. We will improve our skills by acting as "critical friends" to each other. Critical friends take the time to fully understand each other's work, finding the flaws and weaknesses so that they can be improved. Critical friends don't just say "everything looks good" because it provides no room for growth.

**Reading Peer's Solutions**
Try to understand the solution based only on what is written (without thinking of your own solution). Note any gaps in logic you have to fill in yourself. Tell your partner; these need to be revised.

Was the solution justified? What evidence would you need to be sure the solution is correct? Note any calculational or procedural errors you find. Don't just gloss over calculations, but work them out in your head to see if your partner's work makes sense.

Finally, compare your partner's solution to your own. Did you get the same result? If you used different approaches, were they consistent or did your solutions contradict one another? The more you connect the two solutions the more you will deepen your understanding.

**Peer Conferencing**
A few simple guidelines will help you have more meaningful conversations with your partner.

1. Focus on the mathematical aspects of the solution to the problem and how they were communicated.

2. Ask questions. Encourage your partner to ask questions. Discussing ideas will help you learn.

3. Demand meaningful feedback. If your partner only says "everything looks good" you learn nothing.

4. Practice revisions to your explanations (verbally) before writing them. This is a unique opportunity to get instant feedback on your communication. Use it!

5. If both you and your partner are unsure about the solution, try to figure it out together. Talk through your reasoning, where it got you, and where it got you stuck.

**Meaningful Feedback**
Use the self-reflection questions as a guide for areas you might give feedback to your partner on.

7. Be specific. Saying "your explanation was unclear" is not nearly as useful as saying why it was unclear (e.g., "you used the term asymptote incorrectly.") If you say why you think something, your partner can evaluate your feedback, regardless of your confidence.

8. Be constructive. As much as possible, don't just say that something needs to be improved, but suggest how it could be improved (e.g., "asymptotes can be touched by the function; you know you have an asymptote because you have a certain limit").

9. Try to help your partner learn. If the solution seems to indicate misunderstanding of a concept, spend time talking about that concept until both you and your partner are clear on it. Explaining and discussing concepts with your partner will help you understand them better.

**Not Very Meaningful Feedback**

Here are a number of examples of feedback that are not very helpful for you partner (explanations why in italics). Please refrain from offering these types of feedback.

Communication:

- Everything looked good. (Even the best solutions can be improved. Put more effort into thinking how your partner could do so.)
- Your solution was explained well. (This feedback not only doesn't say what about it was explained well, but it also doesn't help your partner improve.)
- Your solution could use a little bit more explanation. (Tell your partner exactly what needs more explanation and try to suggest how they could improve their explanation. Remember, simply adding more isn't always better.)
- Your explanations were a little unclear. (You need to tell your partner what exactly was unclear, and try to suggest how they could improve it. Try focusing on what you couldn't understand or where you got lost.)
- Show a little bit more work. (Tell your partner exactly where you got confused. You need to be more specific with your feedback.)

Correctness:

- I found an error in part (e). (Tell your partner what the error was and why it was incorrect.) Your answer to part (a) needs improvement. (Tell your partner what was wrong and how to improve it.)
- I think your solution is wrong. (Tell your partner what the error was and why it was incorrect.)
- Be sure to finish the problem. (Your partner probably didn't finish the problem because they didn't know how to. Instead of telling them the obvious, try to help them figure it out.)
- Everything looks good. (What evidence do you have for saying this?)

**Strategies for Facilitating Peer-Conferences**

Sometimes it may feel like you don't know what to say or how to get better feedback from your peer conferences. If your partner simply says "it looks good" it does nothing to help you improve. PAR is a unique opportunity to get feedback and talk about the mathematics in a

problem, so make sure that you take advantage of it!
Here are some suggestions for things you might say or ask in order to have a more productive conversation. One key strategy is asking questions about specific aspects of your solution or your partner's solution. Here are some suggestions:

- I was struggling with how to communicate X, do you have any suggestions?
- Would it be all right if I practiced my explanation with you before I revise my solution?
- Did you check all of my calculations, and did you find any errors?
- I noticed that we did the problem differently. Can we look together and make sure our solutions are consistent?
- I was unsure about (concept X, or how to do X). Can we talk more about it?

In your solution I noticed that you did X. Can you explain why?

# Rumors


## Author: Robert Beichner

Physics, North Carolina State University


## Materials & Resources

Handout (below)

Colorado Learning About Science Survey (CLASS): http://colorado.edu/sei/class

## Classroom Context

More activities and information about SCALE-UP at http://scaleup.ncsu.edu/

## Time Requirement

One class period

## Objectives

Introduce students to the approach of the course, which has a reputation among some students.

## Activities

This activity is part of a suite of activities used to introduce students to the SCALE-UP class experience, which is a rather extensively transformed course structure. Students complete the CLASS survey, discuss why course material is important to learn, do this "rumors" activity, think about why they are here, talk about how this course is different from others.

In this activity, we ask students to collect rumors (about physics, instructor, curriculum, SCALE-UP) in small groups.

The person whose home is furthest from campus must record on big whiteboard for the entire table.

In the class wide discussion, the instructor can set a good precedent by responding honestly to concerns, dispelling inaccuracies, highlighting syllabus content, and negotiating certain aspects of the course. Discuss with humor and tact, in the spirit that "we're all in this together".

## Effectiveness

Jon Gaffney (The Physics Teacher, Vol. 53, March 2015) notes that the "rumors" disguise is intended to allow students to dissociate themselves from their concerns, while creating an atmosphere of openness and respect. Students are surprisingly honest in this activity.

# Social-belonging Interventions

## Author

From Walton, Logel, Peach, Spencer and Zanna (2015), "Two brief interventions to mitigate a 'chilly climate' transform women's experience, relationships, and achievement in engineering." J. Educational Psychology, 107 (2), 468-485.

## Materials & Resources

Sample quotes from students (last page)

## Classroom Context

Introductory Engineering

## Time Requirement

10 minutes

## Objectives

These two brief interventions build on research to help female students cope with the chilly climate of STEM. Female STEM students often express concerns about (1) being taken seriously and treated with respect, and (2) fitting into a male peer culture. These are issues of concern among both male and female students in many STEM disciplines, and commonly leading to students leaving the discipline. These interventions are designed to address psychological factors in threatening situations.

## Activities

Two different interventions were used:

**Social Belonging Intervention**

This activity gives students a narrative for interpreting negative events like feeling excluded or not being taken seriously, by showing that challenges and worries about belonging are normal and dissipate with time. Quotes shown from students highlighted that both men and women worry about being treated with respect in engineering, but that this improves over time.

**Affirmation training.** This activity encourages students to incorporate key self-identities and personal values, to remind them of their self-defining values and provide an important resource in times of stress or threat. Quotes shown from students emphasized a broad sense of identity, and managing stress and finding balance.

The structure of each intervention followed the same format?

1. **Cover story.** The study was represented as an opportunity for students to learn about students' experiences entering engineering and to share their experiences with future students to improve their transition.

2. **Survey of upper-year students.** Students read summary statistics and quotations from

senior engineering students describing their transition to engineering.

3. **"Saying is believing" exercise**. Students wrote a brief essay about "why people's experience in university develops in the way the senior students described" illustrating their essays "with examples from your own experience" and a personal letter to a future student describing "what you've experienced, and what you've learned." Students were encouraged to try to write a letter that would be meaningful for future students, and those letters were delivered to new first-year students.

4. **Keychain.** Students received either a keychain depicting University of Waterloo insignia (social-belonging), one comprising opaque plastic containing a slip of paper on which students wrote a word or phrase to remind them of an important value (affirmation-training). The physical object was intended to serve as a reminder cue of the intervention

## Effectiveness

Each intervention led to positive outcomes, including increasing women's grades to be on par with men's, helping women view adversities and stressors as manageable challenges, and reporting more confidence and positive experience in the field.

**Example Quotations from Upper-Year Engineering Students**

**Social-Belonging Condition**

When I first got to Waterloo, I worried that I was different from the other students. Everyone else seemed so certain it was the right place for them and were so happy to be here. But I wasn't sure I fit in – if I would make friends, if people would respect me. Sometime after my first year, I came to realize that almost everyone comes to Waterloo and feels uncertain at first about whether they fit in. It's something everyone goes through. Now it seems ironic – everybody feels different first year, when really we're all going through the same things.

- "Karen," 4A Electrical

I didn't go to a very good high school, and I worried that my high school courses had not prepared me well for university. Honestly, when I got here, I thought professors were scary. I thought they were critical and hard in their grading, and I worried about whether other students would respect me. I was nervous about speaking in class and I didn't want to ask people for help with assignments. After some time, I began to feel more comfortable – I made some close friends, and I started enjoying my classes more. I also became more comfortable asking for help when I had trouble with an assignment. And I saw that even when professors are critical or their grading harsh, it didn't mean they looked down on me. It was just their way of pushing us. Since I realized that, I have been quite happy at Waterloo. It took time, but now I really feel like I belong in the intellectual community here. And to be honest, I'm glad I have been challenged. It's made me a better engineer.

- "Tom," 3B Chemical

Initially my transition to university wasn't bad. I enjoyed most of my classes. But it took a while to get to know my classmates. I remember once in my first term having lunch with some other civil engineers. They spent 90% of the time talking about hockey, about which I know next to nothing. I felt like I didn't belong. It was discouraging. But over time I got to know my classmates better, individually and as a group. Once I remember talking about the TV show *Monster Machines*, which I have to admit I love. We had a great time sharing stories about the different episodes. Even though I don't share their love of hockey, I realized that we do have a lot in common – an interest in how things work – and that's why we're all engineers. My major has turned out to be a lot of fun. I have made good friends with a number of my classmates, and I feel like I really belong here at UW.

- "Fatima," 4A Civil

**Affirmation-Training Condition**

When I first got to Waterloo, I worried that I was different from the other engineers. Everyone else seemed so excited and happy to be here but I just felt stressed and overwhelmed. There were so many new people, my classes were harder, it was a totally new environment. Sometime after my first year, I realized that almost everyone feels overwhelmed at times in the transition to university. It's just a process that everyone goes through. It takes time to find your own way of keeping things in balance in a new place. Now it seems ironic – everyone feels different first year, when really we're all experiencing the same things.

- "Karen," 4A Electrical

Two Interventions Transform Women's Experience in Engineering 83
My first year was tough. I didn't know many people, and my classes were a ton of work. There was one particular stretch – I had a bunch of midterms and some nasty assignments, all at the same time. I was stressed. One night, I remember, I was trying to finish up an assignment and I had to study for a test later. It was going to be a long night. But I took a break and called home. I talked to my mom. It was just a 5-minute phone call, but when we hung up and I went back to studying I felt so much better. I understand now the value of taking a time-out. Sometimes when I'm about to take a test, I take a mental break – and think about getting together with friends later or talking to my parents. There is so much going on, sometimes you have to take time to chill out.

- "Mike," 4A Mechatronics

In first year I sometimes felt like I had tunnel vision – that I was just so completely caught up with life at Waterloo – with classes, with people I was meeting, the whole thing really – and I hardly thought of anything else and, it was hard at first and it was stressful. But then I realized that, well there are things outside of engineering that I do care about. I remembered that I had done volunteering in high school, and so I decided to get involved with an environmental group here on campus. And even though, objectively, I had less time with, volunteering on top of

schoolwork, I found I felt really refreshed and I could concentrate a lot better. I also met a lot of people while I was volunteering, and most of them shared similar interests as me, and we all became really good friends. I find that the longer I spend in Waterloo, the more I find things to do that are just broadening my life away from schoolwork and it's really good. It took me time to find those activities, but they've made a really big difference in my experience. And, I guess the one thing I had to learn was that it isn't the best thing for me to just study non-stop.

- "Mahesh," 3B Environmental

# Slides

See our online materials for Lecture Slides on:

- How do you learn?
- Metacognition
- Why study this?
- Explaining active learning

# Sticky Participation Points

**Authors: Douglas Duncan and Nick Schneider**
University of Colorado Boulder

## Materials & Resources

None

## Classroom Context

Introductory Astronomy; 160 students in stadium seating with a central aisle

## Time Requirement

Varies

## Objectives

To encourage student participation during class by indicating that the instructor values participation and by visibly rewarding that participation. To create a climate that invites participation.

## Activities

I carry a pad of colorful "post-it" notes. Anytime a student answers a question of mine or asks a particularly good question I hand them a "participation point." They write their name on the sticky and give it to me at the end of class. In my class it is worth one clicker question, and clickers represent 10% of their grade, so each participation point is worth maybe 1/10th of one percent of their grade. By the end of the semester they might raise their grade 1%, and the tangible effects are remarkable! They seem to get a lot of immediate gratification from being given a "point" for their contribution, and I've been handing out an average of 12 per class.

How these are graded: I say that the points are worth about 1 clicker question. I give participation points as extra credit (they are in a separate column in our LMS). The sticky points are worth 1/600 of the class grade, so I take the number of sticky points, divide by 600, and add this to their total score. A very participatory student might get 12 sticky points, increasing their grade by 2%.

Comments from Stephanie Chasteen: Another benefit of this technique is that it gets you out from behind the podium, giving a tangible reward directly to a student who contributes to class. It makes the class more dynamic, as well as visibly rewarding the behavior you are looking for. Another option for grading is to add the number of sticky points to the number of clicker questions that the student gets credit for, so that they are part of the required participation grade (10% in our class).

## Effectiveness

By the end of the term around 2/3 of the 160 students have spoken out in front of the large class. That is a lot of discussion for a big class. More than any of the ones I took as a student, that's for sure.

I'm not sure I could have managed conversation in a classroom of 160 when I came here 10 years ago. I can now. I do a lot of metacognitive discussion (how do you learn in this class? Is it as good to listen as it is to be the one talking (no!) and encourage participation and set up a good class climate.

Comments from Stephanie Chasteen: I also found this technique very effective at rewarding student participation.

# Stop-Go-Change: Midterm Evals


## Author: Eleanor Sayre

Kansas State University (You can contact Ellie with questions at le@zaposa.com)


## Materials & Resources

Handout (below)

## Classroom Context

## Introductory science course; upper-level science course

## Time Requirement

20-25 minutes

## Objectives

To communicate to students that I have expertise in pedagogy, and thus that these instructional techniques are purposeful. To communicate to students that they have agency in this class, and that I respect their ideas enough to elicit and implement them. And, finally, to improve end-of-term evaluations.

## Activities

The stop-go-change protocol (see below) is distributed at the beginning of class, or distributed online. Students are given 5-10 minutes to fill it out individually. While they are doing the activity, the instructor circulates to make note of themes (or if done online, the instructor collects responses). The instructor holds a 15-minute class discussion about the activity at the end of class or the next day:

- Reading some sample responses
- Explaining some of the common themes (which can be judiciously chosen to highlight the kinds of things you want to highlight)
- Emphasizing diversity of opinion (e.g., "some of you felt strongly that X, but many of you also explained that Y.") This can combat the "neighborhood effect" where students think that everyone feels the same as the 6 students near them.
- Taking a vote on some elements. If there are things that can be effectively done in different ways, you might take a vote among students to see if they want things done differently (e.g., do you want assignments more clustered, more

Usually, they are annoyed that I don't just tell them answers during the course of instruction. I ask, "why would I decide to teach like that?" They're smart people and we figure it out in discussion. They point out that the reason they're not doing well on exams is because they're not studying well; I praise them for being self-aware and remind them to study better (they laugh). They're also worried that in a discussion-based class, they don't know what notes to take. We talk about note-taking strategies and I promise to give a brief summary at the end of every class (done Socratically).

There are usually two or three other things that they are deeply split on (balance of simulations vs. experiments, how many hours the course is "supposed" to take, etc). In our discussion, I point out how different they are and we come to some kind of accord wherein the status quo doesn't change much. In other words, you can use your authority to make decisions in areas where they are split, which allows them to recognize the diversity in the class, feel that they have a voice, but you can still exercise your ability as instructor to make decisions.

### Effectiveness

This has really helped my end-of-semester evals from being all over the place -- students are much less likely to say "everyone hated the labs" when they've had a frank discussion in which not everyone hated them.

This mid-term evaluation will give me feedback on how the class is going. Your answers are entirely anonymous, but I will use them in aggregate to start a class discussion.

### Activity

STOP

What is something you don't like? It can be about the professor, the class format, the material, your fellow students, yourself, etc.

GO

What is something you like? It can be about the professor, the class format, the material, your fellow students, yourself, etc

CHANGE
Tell me something about your own learning. What could you be doing differently to help you succeed in this class?

**Sample student responses**

| Stop | Go | Change |
|---|---|---|
| I don't like how it takes a long time to find out if someone's statement is correct or not. We tend to elaborate more on each person's idea and sometimes get far from the answer. When doing this, it's hard to realize the truth behind each statement. | I love the review that we had today, it had the most insight and I feel like I got a lot of the facts that I need to prepare myself for the test. | Remind you at the end of the hour for a summary. |
| The class moves very slow on some topics that are easily understood, and when the hard concepts come up it seems like we speed through them and everybody gets a little lost. | I like the work with a group style of teaching. I like interacting with the people around me to see what they think; it helps me learn the material. | I need to take better notes during class, everything that is being written on the board and said I need to take a note of. That way I have something to study for when the test rolls around. |
| *There are no definite answers to problems *we discuss topics but are not told what is the correct belief | *The content of this class is very interesting | *More class periods that are structured like the class review days (where things are drawn on the board so we can take notes) |
| The expectations are not laid out very specifically | The class discussion builds on what we know/understand | I struggle with 'figuring it out on my own.' I could spend more time, and work with classmates to gain understanding from them. |
| The class format is frequently conversational, which I am okay with, but it can kind of trail off of a subject. A little bit more structure could be beneficial; I frequently leave class thinking, "What was the topic of the lecture that I just attended?" The freedom of choosing topics can sometimes be nice, but when it is chosen on the fly, we often lose track. | I like the fact that we are allowed to choose topics that interest us. The Piyd was a nice change from classes that dictate every detail. | Adding structure, maybe showing us your notes for the class everyday before lecture. I know you said you don't like to do that, but if you did we could maybe take notes based on your outline, and it would help us stay on track to the topics for the day, instead of getting distracted by other very interesting topics that simply aren't the task at hand. |
| I don't like how we cover such a wide range of information but we don't ever 'recap', and make sure we got all the important parts. I sometimes feel like I learned a lot, but not always the parts that matter... | I like how class is sometimes a discussion. I like an interactive class. I also like how everyone seems to be involved/interested in the class. | I am better with the interactive, hands on learning. Also if I have something to read later on the topic I retain more. |
| The class sometimes skips important flow steps. We jumped from a very classical model of an atom to a more contemporary model and I did not understand how the two related.<br>I also do not always understand the connections between lectures, as this is not a 3 day a week class, a small review of the key concepts from last time would be helpful. | I really like the opportunity to ask questions, thank you for being so willing to discuss them, and, also, for putting some aside until later. | Some practice homework with the wave functions as would be on the test would be helpful. From the board to the test page was a challenge, and I would really appreciate the help of working on it some on my own, besides the HW from the sim. |
| Sometimes I feel like things are left a little bit ambiguous where I'm not sure what the "right" answer to a question actually is. | I enjoy the highly interactive classroom environment. | I could spend more time investigating class topics outside of class. |

# Syllabus Quiz


## Author: Eleanor Sayre

Kansas State University (You can contact Ellie with questions at le@zaposa.com)


## Materials & Resources

Handout (below)

## Classroom Context

## Introductory science course; upper-level science course

## Time Requirement

10 minutes

## Objectives

To generate discussion about the course format, promote student behaviors that to lead to maximal learning, and ensure that students have read the syllabus. In particular, my goals are:

- Setting norms in the class about the importance of class discussion
- Establishing the dry particulars of the course
- Highlighting the way that your course is special and different from other courses they might have experienced

## Activities

Students are instructed to work together to complete the quiz (see below) for homework. One quiz is turned in (for points) per several students. Prior to collecting the quizzes, the instructor holds a whole-class discussion about the answers. I want them to develop as collaborative, agentic learners. Thus, I turn the discussion to make them decide about what is best behavior in the questions about cheating and student behavior, and I don't tell them what I think.

## Effectiveness

It's quite effective at generating discussion and ensuring that students read the syllabus. It's part of a larger program to promote productive epistemology of science and student agency for learning, and that program works quite well.

Students usually start physics classes unwilling to speak to each other. The structure of this quiz helps them feel like they have something to say and resources to look at that don't depend on their prior physics courses (great for classes with diverse preparation!). It sometimes takes a little prompting to get them to talk to each other while doing the quiz, but by the time we get to discussion they're much less reticent.

The questions about collaboration feed in to students' fears and covert behaviors about plagiarism and looking things up on the internet. Students are often shocked to learn that I encourage them to use outside resources, and somewhat uncomfortable with the fact that I know about (and permit use of) the published solution guides to the book problems. Our discussion about academic honesty is a lot more robust than the usual "don't plagiarize!" discussion, and I've never (yet!) had academic honesty problems in classes where I use this quiz.

The questions at the end about Stu and Dent doing poorly emphasize to students that they are

responsible for their own learning, and that there are a lot of institutional and course resources to help. I reinforce these ideas when students come to me with problems by asking who they work with and which online sources they're using.

## Activity

**Syllabus Quiz**

8. Where is Dr. Sayre's office?

9. When are office hours?

10. When is homework due?

11. Stu and Dent are working on their homework together. Is that ok?

12. Stu finds a similar problem, with solution, on the internet. Dent says, "Its ok to look at it, but we have to put it away when we write our homework." Stu says, "No, we can copy it and just cite it." Stu and Dent are both partly right and partly wrong. What should they do?

6. Stu and Dent do not have their homework done on time. On a piece of paper, Stu writes: "I forgot my homework in my dorm room. I would like to turn it in after class, before 3:30. Stu" Dent writes an email which arrives at 2pm:"Hi Dr Sayre, I have the flu and won't be in class. Can I have an extension on the homework? - Dent" Should Stu and/or Dent get extensions? Why or why not? What could they have done better? What did they do that was right?

7. It's March, and Stu feels really lost in this course. He missed a week of class, and he did really poorly on this week's homework. What can Stu do so that he does not fail the upcoming exam?

8. What can Stu do to bring up his grade?

9. Dent skipped class on Tuesday and didn't get the assignment. Where can Dent find out what the homework is? List at least three options.

# Table Name Tents

**Author: Jenny Knight**
University of Colorado Boulder, adapted from Diane Ebert-May, Michigan State University

## Materials & Resources

Paper or cardstock, sharpies

## Classroom Context

**Various biology classrooms**

## Time Requirement

10 minutes

## Objectives

To create a sense of community in a classroom from the first day. Essentially, this is an easy way to make the class feel more intimate since you can use the card as a tool to call on everyone by name and get to know people's names as well.

## Activity

On the first day of class, either pass out cardstock paper (you can choose a colored paper so it's easier for them to find in their notebooks) or just ask them to use a piece of notebook paper. If you have a large class, it's probably worth passing out the cardstock, along with lots of colored sharpies so that you'll be able to see what they write on the tent.

Ask students to fold the paper in three, so that it can stand up in a triangle or "tent" shape. Ask them to write just their first name (or the name they prefer to be called) large in the middle, large enough that you'll be able to see it from the front of the room.

Then, ask them to write in smaller font, anything you like in the four corners of the tent. Some suggestions: your home town, your major, your favorite food, your favorite activity/hobby, a word your best friend would use to describe you…etc.

You can then use these for two purposes. Immediately, you can use them as an icebreaker where students show their name cards to the people around them and introduce themselves. Depending on what you ask them to put on their cards, you could also use it as a mechanism to form groups or to discuss how different people will work together in groups (for example, if you ask them to write down a strength, you might have people who say they are leaders or good listeners or organized—all of these are good talking points for forming groups and being productive members of a group).

In addition, you can ask the students to keep their name tent in their class folder and bring it with them every day. If you have a small class, they can put their table tents on the desk or table in

front of them, and soon everyone will know everyone else's name. This might be more challenging in a large class just due to space, but they can still be put to excellent use in a large class. Every time someone has a question, insist they hold their name card up. If you like to randomly pick people from the audience, or if you call on pre-formed groups, have them hold up their name card when you call on them, so you can use their name.

### Effectiveness

This has been a valuable tool in my class!

# Traxoline and Dancealot


## Author: Jon Gaffney

Eastern Kentucky University, and Various
You may contact Jon with questions at <jon.teaches.physics@gmail.com>


## Materials & Resources

Faculty Focus, January 9, 2013: **http://bit.ly/ZUBVfO**

Montillation of Traxoline, in Slides-Intro or at **http://bit.ly/z3T9G**

Professor Dancealot video: **http://bit.ly/ut13S6**

## Classroom Context

## Introductory physics course (for pre-service teachers)

## Time Requirement

30 minutes

## Objectives

To directly address what students expect in the class, to engage in a collaborative discussion about classroom practices and norms, and to generate class community.

## Activities

Jon Gaffney (Physics and Astronomy, Eastern Kentucky University) shares this progression of activities:

First, he does a group active-learning activity. This can be any activity that works within the context of a particular course, but he uses the "Game of Science" (see "Nature of Science" Activity, elsewhere in this collection.) Next, he does a "Rumors" activity, (see SCALE-UP Introduction activities), where students report on what they have heard about this class (and maybe even the instructor), both positive and negative.

Then, he says, "OK, enough background. Now it's time to get down to work." He presents the slide on "Traxoline", which is a parody of traditional instruction aimed at memorization without understanding (see below, or see http://solar.physics.montana.edu/tslater/montillation_of_traxoline.html). Students tend to dutifully take notes and write down the lesson. After a few minutes, he admonishes them. "This is ridiculous! I don't want the class to be like this; I want us to be an authentic class where we can learn stuff. Otherwise, it will turn out like this…"

He then shows a YouTube video, "Professor Dancealot," http://www.youtube.com/watch?v=1k8aeDUC9XQ, which depicts a dance class in which the instructor lectures students about dance steps, with a final exam consisting of their ability to

dance. He then asks students, "What can I do to prevent the class from becoming like this?" "What can you do to prevent the class from becoming like this?" Students work in groups on whiteboards, which are then displayed during a group discussion.

## Effectiveness

Jon Gaffney says that he has played with the progression of these activities multiple times, and found that students showed more buy-in when this particular progression was followed. He conjectures that this progression leads students through a progression of strong emotions when they realize that the course structure violates their expectations: Denial ("every teacher says their class will be different"), Anger ("Tell me what negative stuff you've already heard about this class," Bargaining ("let's discuss how we will behave in class"), and finally Acceptance (see D. U. Silverthorne, Teaching and learning in the Interactive Classroom, *Advances in Physiology Education*, 30, 135-140 (2006)).

In recent years, Jon has noticed more students actually expecting an active-learning approach and visibly demonstrated *relief* upon completion of the Traxoline activity. Two things are particularly powerful: 1. He tell students that he will never show another powerpoint slide in class after Day One, and 2. He gives students the right to call "Traxoline" out any time they feel that jargon is being used without understanding. Students tend to appreciate the language and the agency to call the instructor out (although they rarely use it).

One student comment on course evaluations is suggestive of the impact of these activities:

"I have learned the most about science in this class than in any other science class I have taken. We learn about things that I can easily apply to the world around me and understand how it works.I like that I can explain how a light bulb and a compass work. It's just stuff that makes me feel smarter for knowing. It's also things I will remember. This class helped me by using hands on approaches. I loved it. Learning for yourself is much more interesting than learning from a power point slide. **As soon as we watched that 'dancealot' video the first day, I was excited for the class.**

**Slide for Traxoline activity (uses animations)**

# Traxoline

It is very important that you learn about traxoline.
Traxoline is a new form of zionter. It is monotilled in Ceristanna. The Ceristannians gristerlate large amounts of fervon and then bracter it to quasel traxoline.
Traxoline may well be one of our most lukised protofoms in the future because of our zionter lescelidge.

1. What is traxoline?
2. Where is traxoline monotilled?
3. How is traxoline quaselled?
4. Why is it important to know about traxoline?
5. How is traxoline similar/different from table salt?

**Don't fool yourself about when you really understand**

*Attreibuted to Judy Lanier*

# Why Study [your course]?


## Authors:

Course Minute Papers: Jean Hertzberg, Fluid Mechanics course, University of Colorado Boulder. You can contact Jean with questions at hertzber@colorado.edu.

Why are you here?: Steven Pollock, University of Colorado Boulder Introductory Physics course. You can contact Steve with questions at steven.pollock@colorado.edu

Messy Thinking: Brian Katz, Mathematics, Augustana College


## Materials & Resources

None

## Time Requirement

10 minutes

## Objectives

To generate discussion about the course format, create comfort with small group work, frame the purpose of the course, and generate motivation.

## Activity 1: Course Minute Papers

Students complete two "Minute Papers" where they answer the following questions on a piece of scrap paper, and sign it. (If TA resources allow, they will get credit for these Minute Papers at the end of the semester)

- What is Fluid Mechanics?
- Why study it? What applications do you know about or interest you?

The instructor scans the answers during a short break while students are encouraged to meet and exchange contact information with their neighbors. Then the content of the course is discussed, as well as the variety of applications of the course content.

These questions are asked for two reasons:

1. What is your starting point? What ideas do you come in with, what are you most interested in?
2. I want you to think about what you know now.

Leads into discussions of learning:

- Constructivist theory of learning is that you build on what you already know. Learning is not an assembly process that you carry out. The professor only provides some pieces, not all. You incorporate concepts, develop ideas, and store them in accessible ways.
- "Metacognition" is thinking about thinking. Watch yourself learn. What works for you? Be honest with yourself. Does reading what you highlighted in the text really help? Maybe try testing yourself with problems; it might be more efficient.

This is followed with a clicker question (see "clickers" files), "Does knowing fluid mechanics mean…. Getting the right answer or Understanding concepts." (Answered on a continuum from A to E). In discussion to this, she discusses the roles of engineers and how the value of getting the right answer has changed over time.

### Effectiveness

No formal studies of effectiveness have been made, but the stage is set for later metacognition activities, and the list of student interests is helpful later in the semester when designing real-world contexts for assignments. The short icebreaker activity seems to be very effective; the energy level in the room rises noticeably, and students willingly engage in pair-share activities for the rest of the semester.

### Activity 2: Why are you here?

This is done as the first "small group" activity of the semester. In groups of 3, students are asked to discuss this open-ended question.
The instructor discusses their own view: Physicists take "obvious" questions and dig deeper. So let's do that in this course!
After they've discussed, I tell them that I bet I know the superficial answer: "because I have to." But WHY do they have to? Why does someone in their own major feel this course is important to them? And, why ELSE besides being forced into it.
Students generate lots of nice thoughts here – relevance to real life, personal interest, it's fun, needed for MCATs, useful in science careers, … I also talk about "scientific method" as transferable, about quantitative understanding as being useful for everything from medical diagnosis to tax forms!

### Effectiveness

I have done this a few times and it always generates good discussion / noise level in the room. I get a reasonable number of "callouts", (i.e. students volunteering their ideas) in the all-class discussion period afterwards. I don't have data collected on this, but last term in a class of 200, I recall getting ~30-40 hands, and ultimately heard voices of maybe a half dozen students before I decided to move on. Indeed, part of what's happing in that callout session is to point out that I *want* to see more hands and hear their opinions, i.e. to make explicit what the classroom culture of "all-class discussion" should be like!

### Activity 3: Using messy thinking in a career

This is for a teacher prepration course. Many students expect the course to simply solidify high school level geometry content. This activity is intended to get students to recognize that there is more than that to the course, and for them to recognize that they need to be interactively engaged in the content (rather than the instructor imposing those goals and methods). Students in the course were resistant to getting information from an authority
I show the students a video of a high school course (I used the first 10 minutes of a high school geometry course at http://www.learner.org/resources/series34.html; #8 about parallelograms; click VoD twice). Note that this is a course for pre-service teachers, so the video was chosen for that audience. For other audiences, a video showing another career path using course content would be appropriate.

I then asked what knowledge, skills, and dispositions the teacher in that video needs in order to be able to teach that content to his/her students. The students in my course were clear that I could not prepare them to respond to the wide variety of thinking exhibited by these high school students, so it would be valuable to interact with the messy thinking of their fellow students, rather than listening to my polished thinking.

### Effectiveness

This exercise seemed to be a powerful tool to make sure that all were on the same page that conveying information was not the goal of instruction in the course.