Conceptual Academy

Handbook of Class Activities

Version 1.0

Dear Instructor,

Thank you for your interest in Conceptual Academy. As further support for your teaching efforts we have collated this handbook of class activities.

We begin with a six point overview of our thoughts on the best use of the time we spend with our students in the classroom. This is followed by ideas on how to organize students by teams as well as by nations. For the main show, you'll find detailed descriptions of our favorite class activities that you might adapt to your course as you see fit.

Thank you for sharing this handbook with others and for letting us know of any additional activities you would like to share for subsequent versions. You can write to John@ConceptualAcademy.com.

Good science to you,

-- The Conceptual Team


Leslie Hewit


John Suchocki


Paul Hewit


Suzanne Lyons


Jennifer Yeh

Conceptual Academy

Online Instructor Support:
ConceptualAcademy.Gallery.Video

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Six Points to Optimizing Class Time

1. Learning From Sports

An effective athletic coach provides instruction on how to work the game or how to execute a particular play. But this coach also nurtures a team spirit—a sense of community through which the athletes respond by willingly exerting themselves to the best of their abilities. In nurturing this community, the coach understands our social nature. We love being involved, playing a role, contributing to the team, and celebrating victory together in a shared meaningful experience.

If this is possible within athletics, it should also be possible within academics where the parameters are much the same: a body of students gathering regularly under the expert guidance of an experienced adult. A main difference is that the challenges faced within academics are more mental than physical. Yet another difference is expectations. While an athlete arrives to each session expecting both instruction and practice, the typical student arrives to each class expecting only instruction. An athletic coach who followed a formula of "instruction together and practice on your own" would be held liable for a losing season. There is much to learn from the sports model.

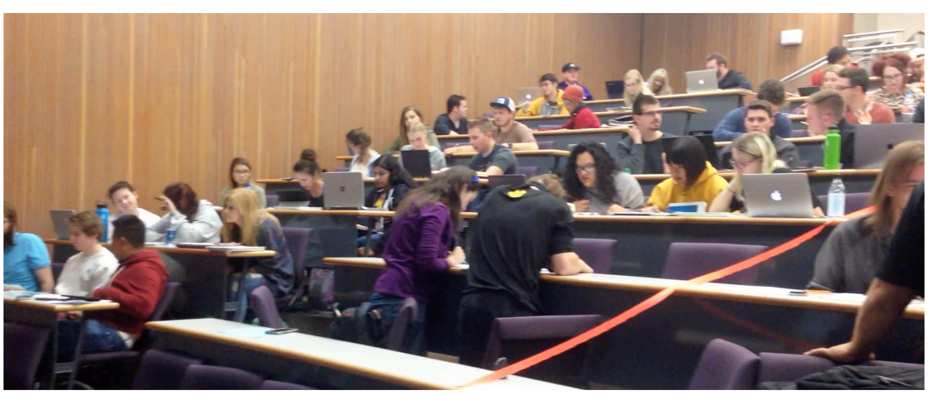
2. A Culture of Learning

Within a **culture of learning**, students work as a community supporting each other in their learning tasks. They do so under the expert guidance of the course instructor, who provides not only the structure for each meeting but also an atmosphere where students feel safe and relaxed. The instructor pushes the envelope academically. Mistakes are encouraged as are common courtesy and team work. Students arrive to class having already studied the material. During class students then have the opportunity to articulate what they think they understand. Corrections are provided by peers as well as the instructor. A culture of learning is as enjoyable as it is rewarding. In a culture of learning, everyone benefits.

A culture of learning supports our deepest wishes for our students. On the academic side, we wish for our students to gain a deeper understanding of how the world works and what difference this makes to our everyday lives. Through this, students strengthen their analytical and critical thinking skills. On the social side, we want our students to grow into knowledgeable, articulate, confident, well-adjusted, and happy individuals who are able to support themselves and a family while also contributing to society at large.

3. Initiating a Culture of Learning

A culture of learning can be developed regardless of student abilities and also regardless of class size. How long it takes for that culture to develop for a particular class depends upon many variables. In all cases, the development should begin on day one with clear explanations for why a culture of learning is being created and explicit guidelines for how it will be implemented. Students who are unfamiliar with this approach may resist, especially millennials who prefer texting over face-to-face interactions. However, mid-way through the semester these students will begin to realize the benefits, which include improved social skills, more enthusiasm, as well as better exam scores. By the end of the semester, the students are embracing the format, as is evidenced by course evaluations.



4. A Typical Class

Students work on their reading, video, and homework assignments before coming to class. Ideally, there is a point system that provides students credit for doing so. These may be points students earn before coming to class, such as through Conceptual Academy. They may also be points that students collect from a quiz at the start of class. To be on target, about 70% of students should be showing up to class having already studied the material. This is quite possible to achieve, but it requires constant pressure, especially within the beginning weeks. The pressure comes in the form of points, but also in the form implementing class activities that truly take advantage of their having come to class prepared.

With this in place, the following schedule scaled to a 75 minute class period becomes possible:

0:00 – 0:05 Announcements
0:05 – 0:25 Lecture Review
0:25 – 1:10 Class Activities
1:10 – 1:15 Expectations for next class

A schedule such as this should be published within the course syllabus so that students know what to expect. They should also understand that the schedule may vary from class to class depending upon the instructor's judgment of what will be the best use of class time for any particular subject.

5. Lecture Review

Students will show up to class having already studied the material. But by no means have they yet to master that material. Further, what they studied the previous evening is hardly on the tip of their tongues. This is where a review of the content given by the instructor is greatly appreciated and valued. This review can take many forms, including a traditional lecture. It should be emphasized to students that the presentation is only a review of what the students have already studied. Nuances and details may be left out and the focus is primarily on the more challenging concepts.

For the instructor, there can remain an urge to present all the material in lecture format. Repeating what has already been presented to the students through the textbook and online videos has benefits. A live presentation is always better than what can be provided through a textbook or video. Students will thus want the review to extend for as long as possible. The instructor may want this too and should proceed as deemed appropriate. However, this should be weighed against an understanding that with consistently longer lecture reviews, students will be less inclined to come to class having already studied. Further, there is less time available for the equally and sometimes more valuable class activities.

6. Class Activities

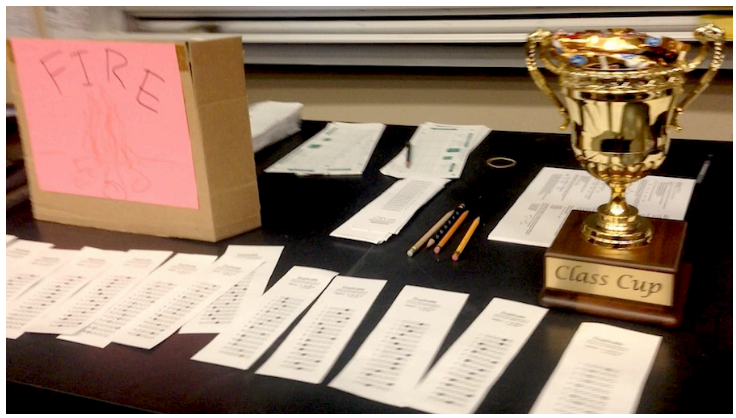
Just because we describe some new concept to our students does not mean the students now understand that new concept. At best, any description we provide is but an introduction. However, when that introduction is given *before* class, we are then free to take that introduction to a deeper level of understanding. This is realized when students are provided the opportunity to articulate the new concept themselves through their own words, written or aloud, or through solving problems. Providing that opportunity within an encouraging community setting is the underlying goal of any class activity.

Class activities come in many forms. Some are quick and easy to implement. Others are more complicated. Some are more appropriate for a small class. Others work well regardless of the class size, and some are specific to an online format. In general, the most effective activities are those that rely on students working together in teams. For all activities, there needs to be sufficient time allotted for a follow-up presentation of correct answers or explanations to questions given within that activity. This is key for addressing student misconceptions.

The development of a culture of learning occurs primarily during the "class activity" segment of each class period. Within this, time for practice is provided as a complement to instruction. Instruction also occurs during this time as needed, but the focus remains on practice. Over the full class period, key is finding an optimal balance between the two. Just as there is missed opportunity in a classroom focused 100% on lecture, there is also missed opportunity in a classroom focused 100% on activities. How much is done on one or the

other will vary significantly based upon the content as well as the instructor's available time and energy for planning such activities. If within course evaluations, students rate class time as anywhere from 30% to 70% lecture, then they will likely also be rating the course as a valuable experience. Let's be clear: athletes as well as students require both instruction and practice. Further, instruction and practice are best accomplished under the expert guidance of the course instructor within an empowering culture of learning.

There is a wealth of class activities that can be implemented for any particular subject. You may already have your own favorite activities, but are looking for some new ideas to adapt for your particular situation. This handbook is a compendium of ideas we conceptual authors have found work well. Of course, you'll find even more ideas through regional and national conferences. We also provide some references for print and online resources. You'll also want to tap your colleagues at your campus. A culture of learning among students is greatly supported when there is also a culture of teaching among instructors.



Again for emphasis: A culture of learning supports our deepest wishes for our students. On the academic side, it helps our students in gaining a deeper understanding of how the world works and what difference this makes to our everyday lives. Through this, students strengthen their analytical and critical thinking skills. On the social side, it helps our students grow into knowledgeable, articulate, confident, well-adjusted, and happy individuals who are able to support themselves and a family while also contributing to society at large.

We are hopeful you will find the resources within this handbook to be of great benefit to your teaching efforts. Please let us know how we might be of any further assistance.

--The Conceptual Team

Organizing Students

Forming Teams

Cooperative learning works well when students are grouped together in teams consisting of either 3 or 4 students each. For a team of 5 students, frequently the fifth student takes a back seat. For a team of 2 students, there is an insufficient diversity of ideas and attitudes.

Ideally, each team is well-balanced in terms of academic abilities and gender. Students sorting themselves into teams tends to go against this ideal. That's why it's helpful for the instructor to control team formations. On the first day of class, however, sorting students by academic abilities is not possible. Fortunately, at that time most students don't yet know each other, which means it works well enough to form teams simply based on where students randomly sit. Further, it can be helpful to encourage students to fill all empty seats up front. This may require roping off or removing seats in the back. Such re-seating is best done as students are first walking in before the official start of class. For a small class with movable furniture, you may wish to create islands where each island seats four students.

The first task is for students to introduce themselves to each other and to come up with a team name. Elements of the periodic table work well for team names. For a small class, you may wish to visit each team to introduce yourself and to write down student and team names on a class map. For a larger class, you might pre-designate team names using placards placed throughout the classroom before students arrive.

To maintain optimal team compositions and to encourage students to meet and work with many classmates, we recommend forming new teams after each mid-term exam. A common practice is to mix students into teams based on the results of the first exam. Student exam scores are sorted within a spreadsheet. Teams are then created by putting a high and a low scoring student together with two mid-scoring students while also paying attention to a balance of gender. As the semester progresses, your sorting may also include personality types. Students should also know they are welcome to make teammate requests with you in private. Importantly, this should include requests for not being on the same team as another particular student.

For the class after an exam, students initially sit with their old teammates. They are asked to thank each other for their past support, before picking up their bags and moving to their new teams. For a small class, the new team rosters can be read aloud. For a large class, new team assignments can be posted alphabetically on the overhead or posted online. Students happy with the team they are leaving will grumble. This will be complemented by students who have been silently grumbling about the team they are now leaving.

The new teams after the last mid-term exam will be the teams that meet together on up to the final exam and potentially for the final exam if you do team-based examinations (see page 34). By this time, students have had plenty of opportunities to get to know each other and it may work well to allow for students to self-select their own teams by just sitting wherever they want. It's important to frame this as something students have earned by strong participation throughout the semester. If you also sort students by nation, you'll discover a built-in flexibility to allowing students to self-select their teams.

Nation Building

For a class of more than 30 students and certainly for a class of more than 60 students, it works well to sort students not only by teams, but also by nations, where a nation is a group of teams. A class of 80 students, for example, might be divided into four nations named: Air, Fire, Water, and Earth. Within each nation are seven teams of 3 to 4 students each. The layout of the room can help determine the nation locations. An aisle would a natural barrier between two nations. Bright colored marking tape might also be used. Within an auditorium setting, you might name any first row team "hydrogen", a second row team as "helium" and so forth using elements of the periodic table. A team would thus identify itself as, for example, Air nation Team Lithium, or Air-Li.

Many college students of the millennial generation will readily identify with a popular anime series called "Avatar: The Last Air Bender". These students will know by heart the following introduction to the series (edited for brevity): "*Long ago, the four nations lived together in harmony. Then Fire Nation attacked. Only the Avatar, master of all four elements, could stop them. But when the world needed him most, he vanished. A hundred years later my brother and I discovered the new Avatar, an airbender named Aang, and although his airbending skills are great, he still has a lot to learn. But I believe*

Aang can save the world." If you were to recite or read this introduction, you may find your millennial students cheering, which is a great kick-start to a strong culture of learning. Even more so when you pull out a trophy and describe how nations will be competing for this "class cup" through various team-based tasks. There are no grading points associated with winning the class cup—only honor plus any candy with which you fill the trophy.

How a nation earns credit toward winning the trophy can be anything that comes to mind. Consider another millennial institution, Harry Potter, wherein Dumbledore assigns points to houses for deserving behavior. Examples might include: best attendance, best improvement between a practice exam and actual exam, greatest number of average points collected at Conceptual Academy, or the greatest number of "golden tickets" (see page 41). The winner of the class cup can be announced, to great applause, after a practice exam, the actual exam or just prior to the formation of new teams and nations. With three mid-terms there will be three winning nations.

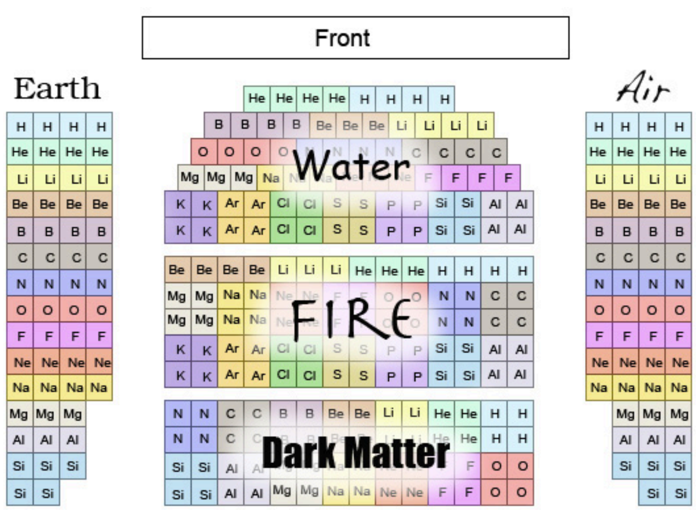
Tracking nation points on up to a mid-term exam involves sorting student scores by nation within a spreadsheet. But because no grading points are involved, you can also at times eye-ball a winning nation. For example, Learning Catalytics (see page 28) provides a color-coded seat map of correct responses—the nation showing the most "green" you declare to be the winner. To keep it simple, you might also use just a single event to determine the cup winner, such as a class activity or attendance for a particularly important day.

Mostly, the nation format allows a single large class to be parsed into multiple smaller ones, which can be easier to manage. For example, you can appoint a nation president as well as a nation vice-president to assist in various tasks, such as distributing handouts, collecting papers, or for totaling a nation average in a competition for the class cup.

Further, a number of class activities described in this handbook make use of the nation structure. For example, there are times you can have different teams working together, but only teams within the same nation. A student not happy with the responses of immediate teammates thus has the opportunity to solicit input from other "nation mates". This is the built-in flexibility for situations where a team of students is less than optimal. Lastly, the nation structure provides a short-cut to forming new teams after an exam. Have current team members distinguish themselves as marshmallow, chocolate, graham cracker, or campfire. You then direct all marshmallow to move to an air nation seat, all chocolate to a water nation seat, and so forth. Though you lose fine control of who sits with whom, this guarantees that each student will have new teammates.

With good structure comes many possibilities. This is an idea borrowed not from sports but from the military. While a class of 300 individual students may be cumbersome, a class of 5 nations with 15 teams each is much easier to direct, especially in the absence of any departmental TAs. For that fifth nation in the back of the auditorium, we recommend the title "dark matter". You might grant any dark matter member the power to permeate throughout the classroom and to occupy any vacant seat they wish. This solves two problems: 1) There will be DM students who would much rather sit up front. 2) You'll have vacant seats up front due to absences. For any nation, you can also assign ambassadors whom you direct to join neighboring teams that are short on members.

There are many possibilities. But with so many possibilities, it's important to aim toward the simplest and most comfortable ideas, especially for the first semester trying this nation approach. It may take several semesters of trial and error to get to where you feel it works well. Even then, you can expect continual refinements as you adapt it to your teaching style and the needs of your students. Let your students know you're having fun experimenting and thank them for their willingess to serve as guinea pigs. Afterall, this is a science course. Experimentation is to be expected.



Classroom Activities

Written

The following activities involve students articulating their understandings using a written format within teams or as individuals.

Implementation of each activity is rated as

Easy ★ Moderate ★★ Involved ★★★

The value of each activity is rated as

Good ★ Notable ★★ Significant ★★★

Classroom Activity: Practice Page Worksheets

Type: Written
Implementation: Easy ★
Value: Significant ★★★
Class size: Any

Description:

An important supplement to our conceptual textbooks are the Practice Pages, which are a set of minds-on, pencil pushing concept review worksheets. The Practice Pages are designed as a study aid that students can work on outside of class. They are far more effective, however, when students work on them together as a team under the supervision of the course instructor, who travels from team to team to assist students as necessary. A well-timed worksheet provides much value with much ease.

It is common that a Practice Page will prompt a question from a student that, in turn, prompts the instructor to give a short lecture presentation to the team. In such instances, neighboring teams can be encouraged to eavesdrop. When different teams start asking the same question, the instructor can switch gears and give a mini-presentation to the whole class. This is "targeted teaching", which is impromptu and in response to immediate student need.

All of our Practice Page worksheets are provided within the Doc Shares of Conceptual Academy sorted by subject. For example, under the chapter section on buoyant force, students will find our worksheet on buoyant force. (Answer keys are also provided).

It works well to print multiple copies of a select Practice Pages for students to tackle while in class with their teammates. This can be an enjoyable learning experience. Plus, it introduces the whole class to the value of these worksheets, prompting them to do more on their own.

Students who make use of these worksheets on their own are doing so typically right before the exam. So when you print a select worksheet for the entire class, you'll find the worksheet to be a fresh experience for just about everyone. Being quick and easy to implement with much return, worksheets are our "go to" class activity.

Examples:

All of our Practice Page worksheets are posted at Conceptual Academy within the Doc Shares of the FYI pages. You might consider mass producing ahead of time those that catch your eye for a particular class. It works well to post the answer key on a classroom wall. When ready, teams of students will migrate to the key to check their answers.

Classroom Activity: Focused Listing

Type: Written
Implementation: Easy ★
Value: Good ★
Class size: Any

Description:

This activity is from Thomas A. Angelo and K. Patricia Cross's classic: *Classroom Assessment Techniques, A Handbook for College Teachers, 2nd ed.*, Jossey-Bass, 1993. On a blank sheet of paper, students write down a list of 4 or 5 terms or phrases that help to portray the content of a particular section of the textbook or of some reading assignment. This activity assesses what key concepts have stuck with the student as well as the extent to which the student has studied the material. A related activity described by Angelo and Cross is called "The Muddiest Point" whereby students write down what concepts from a chapter were most unclear.

For a small class, the instructor collects these sheets of paper and quickly reviews them to get a sense of where students are at (or not at) relative to the content. For a large class, students can write online, such as through Learning Catalytics. The instructor then uses this information to launch a class discussion of the ideas listed by the students: Which are overarching concepts? Which are only minor details? How are they related to each other? What story do they weave?

This may evolve into a segue for a traditional lecture in which the students now feel invested. Alternatively, it's an entertaining exercise to slide into a class discussion where you, the instructor, are only allowed to respond to students via a question—a bit of pure Socratic method for as long as you can maintain it.

Examples:

From a chapter on chemical bonding, the students might respond:

Focused Listing
- There are three types of bonds: ionic, metallic, and covalent
- You can't see through a metal.
- Lone pairs are important
- I have no idea
- Polar molecules are sticky
- Electron pairs don't like each other

Muddiest Points
- Geometry and shape?
- Polarity
- Double bonds
- Electronegati-something
- I had no time to study last night
- Polarness

Classroom Activity: Most Important Concepts

Type: Written
Implementation: Easy ★
Value: Notable ★★
Class size: Any

Description:

This activity is a variation on Focused Listing, page 15. At the start of class have each student write down (on a note card or scrap piece of paper) what they think are the three most important concepts from their studies for today's class. Students need not include their names. If three concepts are too many for a student to recall, then encourage the student to include at least one.

Students who haven't studied will be caught off-guard. So you tell the class that for those of you who weren't able to study before class, to please write down a question instead, no matter how silly, but ideally related to today's class. Again, the student's name is not to be included.

On your mark, one of two things happens: 1) A student with a list of most important concepts gives that list to the team for all to inspect. 2) A student with a question holds their written question up for collection. For a small class, you can collect those questions yourself. For a large class, you can have nation presidents collect those questions. As this happens, students who weren't able to study beforehand are then subtly identified as the piece of paper is collected from them.

Word of caution: A student who didn't study beforehand isn't necessarily lazy. Life happens. You may find the most common reason a student didn't study beforehand was that they had to work the previous day in order to afford the price of college tuition. It's important to apply pressure to encourage students to come to class prepared. But it's also important to do so with a positive attitude assuming that, yes, every student is doing the best they can under the unique circumstances they face. It's a delicate balance.

After students have passed their cards or papers along, the next phase is for teammates to come to an agreement on the most important concepts, potentially writing a new list. While they do this, you can take the opportunity to review questions, if any, collected from students.

Conclude the activity by moderating the class to come to an agreement on the most important and key concepts. List these for the class at large. Tweak as you see fit. Then, use the anonymous student questions (if any) as a launching point for further discussions.

Examples:

From a chapter on Newton's second law:

Most Important Concepts
- Acceleration gets bigger as force gets bigger
- Acceleration gets smaller as mass gets bigger
- Air resistance makes it complicated
- The force must be the net force

Classroom Activity: Cartooning

Type: Written
Implementation: Easy ★
Value: Notable ★★
Class size: Any

Description:

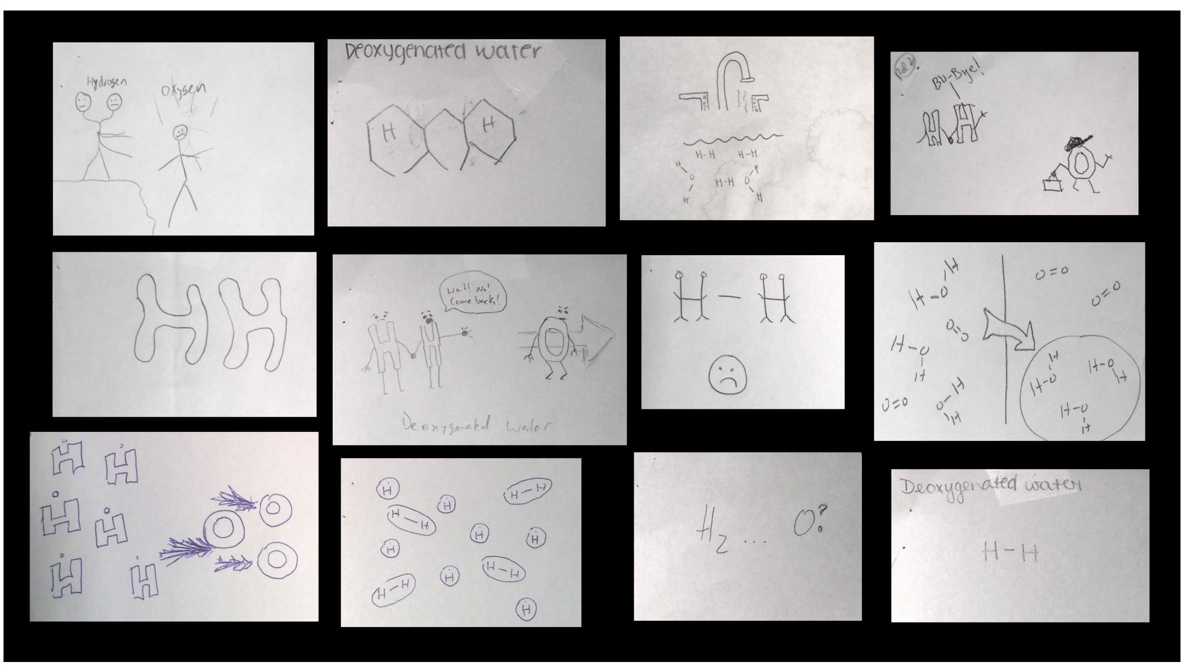
A picture is worth a thousand words. You ask students to draw a cartoon of a concept, process, or interaction. They do this on their own. They then share and discuss their artwork within teams. You will likely hear some enjoyable laughter.

For a small to medium sized class, it works well to have students draw their cartoon on a standard size, such as with a small note card. For a large class, students can draw their cartoons online. Learning Catalytics has such a drawing feature.

After teams have discussed their own drawings, you can solicit one cartoon per team with the team re-drawing their cartoon as desired. These select cartoons can then be displayed on the document camera and appropriately discussed. What works? What doesn't work? What's accurate? What's inaccurate? Which cartoon is the most representative?

Examples:

Students were asked to draw a cartoon of deoxygenated water:



Classroom Activity: Advice Column

Type:	Written
Implementation:	Easy ★
Value:	Notable ★★
Class size:	Any

Description:

Reflection is a key element of the learning process. This is where the student steps back to ponder the bigger picture: Why am I doing this? What have I done that works? What should I be doing? The student is likely thinking these thoughts on occasion, but there's nothing like putting those thoughts down into words, which can evolve into a kind of contract the student makes with him or herself. The "advice column" activity is exactly that, and it comes in at least three flavors, each delivered at a different time through the semester:

- What's Working For Me
- What I'm Doing Differently
- Dear Next Semester

Anonymously, the student writes a few sentences to a paragraph in response to one of the above prompts. This can be written on a note card that gets collected or online via a response system, such as Learning Catalytics.

A week or two into the semester, you can have students respond to "What's Working For Me". The first exam has yet to happen so their claim has yet to be verified and many students still really won't know for sure "what is working for them". Their statement, however, becomes a record of their initial attitude toward the class. The student also appreciates being heard. Further, this provides important feedback for the instructor. But keep in mind that early in the semester you'll still have students resisting an interactive format. You might get the comment: "This class is ridiculous. The instructor is making me learn on my own. I wish there were just lectures." If you have the time and energy, you can repeat this reflection at the end of the semester and compare responses.

Many students will not be pleased with the results of their first exam. So, a few weeks after that first exam you can ask students: "What are you doing differently this time around?" We recommend you collate these responses and print them up for the whole class to read. Students are thus sharing their advice with each other.

Toward the end of the semester, students are now experts at navigating through your course and ripe with advice for your next semester students. Anonymously, let them provide that advice. Collate this advice and give it to your students in the subsequent semester. Your own advice to students then becomes all the more believable. After a couple years, you'll find the student to student advice is much the same. At that point, it's still valuable to provide students the opportunity to provide advice.

Examples:

- Dear Next Semester, to succeed in this course it really, really is important that you study before coming to class. This course is challenging, but you're really going to love it and get so much from it. More than you think. Have fun!

Classroom Activities

Verbal

The following activities involve students articulating their understandings aloud within teams.

Implementation of each activity is rated as

Easy ★ Moderate ★★ Involved ★★★

The value of each activity is rated as

Good ★ Notable ★★ Significant ★★★

Classroom Activity: Any Questions

Type:	Verbal
Implementation:	Easy ★
Value:	Good ★
Class size:	Small (3 – 30 students)

Description:

This activity is similar to the snowball activity (page 21) except it works best for small classes. Print out a series of key questions and then cut out each question into a tiny strip of paper. Before students arrive, tape a question under each desk or seat. Begin class asking if there are any questions. After you field those questions, if any, use body language to get a student to look under their desk. After the student finds the question, ask the class once again: "Do you have any questions?". The student with the question you wrote will respond. Before answering that question comment that: "Why, that's a very good question. Before I provide an answer, why don't we all see if we have any teammates who might have an idea."

After the class discussion, you can provide your own response followed by: "Do you have any other questions?" Other students will then realize that they too have a question. At that point, you can have students entertain these questions within their teams as you migrate from team to team listening and supporting their discussions.

In creating these questions, you might want to have the same set of questions for each team. A more ambitious approach is to have a different question for each student. After team discussions, you can have each team share their thoughts on their favorite questions with the rest of the class in a team presentation. It's possible that the entire class period can be spent doing nothing more than working on these questions.

Examples:

Each question should require an explanation rather than simple facts. You might pull questions from the back of each chapter within the textbook or make up your own questions covering key concepts, such as:

- How is apparent brightness different from luminosity?
- Why does the pH of soda water rise when the bottle is opened?
- Why isn't white within the electromagnetic spectrum?
- Why does ice float?

Classroom Activity: Snowball

Type: Verbal
Implementation: Easy ★
Value: Good ★
Class size: Any

Description:

Write a key question on half a sheet of paper and then crumple it into a ball. Create about 12 of these question-bearing crumpled balls and place them in a bag or in the class cup trophy. Begin class asking if there are any questions. After you field those questions, if any, start throwing the "snowballs" into the classroom. Ask again if there are any questions. Students will quickly catch on that there is a hidden question within each snowball. Start fielding those questions, but before answering each question comment that: "Why, that's a very good question. Before I provide an answer, why don't we all see if we have any teammates who might have an idea."

At that point, it works to post a duplicate of the question on the Doc Camera or the overhead for all to see. You might be able to roam the classroom to participate in the discussions and to get a sense of how students are doing. Because you created these questions, you might have a routine you use to answer each one, such as a demo or artwork that you draw on the chalkboard or Doc Camera. Ideally, each question begets further class conversations. It's possible that the entire class period can be spent doing nothing more than answering these questions.

A variation is to have the students write out questions instead. Each student pulls out a scratch sheet of paper and writes down a question, preferably about the content. They crumple their question into a snowball. Upon your direction, all students throw their snowballs randomly into the air. Students then scoop up the snowballs from the floor and proceed to answer the questions within their teams or upon your asking the class if they "have any questions." At that point, only students who have received a quality question tend to ask that question. As a back up, you might throw your own questions into the mix using colored paper.

Examples:

Each question should require an explanation rather than simple facts. You might pull questions from the back of each chapter within the textbook or make up your own questions covering key concepts, such as:

- Why is a water molecule bent?
- Does a heavy rock weigh less when underwater? Please explain.
- Why is the sky blue?
- Why can't we hear radio waves?

Classroom Activity: Storytelling

Type: Verbal
Implementation: Easy ★
Value: Notable ★★
Class size: Any

Description:

Some content lends itself to a story. For example, there is the story of how a polypeptide is created from DNA or how a star moves away from the main sequence within the H-R diagram. Such material tends to be laden with many terms and intricacies but lends itself well to this particular type of class activity.

With a key graphic posted on the overhead, you spend about 5 minutes telling the first segment of the story off the top of your head. Students know it will be their turn to re-articulate what you just said but only one student at a time within each team. Once you stop, this self-designated student re-tell what they heard to teammates. If there are 20 teams, there will be 20 students re-telling to team mates. Within 3 minutes, you'll hear things quieting down, which is your cue to provide an even quicker summary yourself along with a title. You might say: "That which you just explained to your teammates goes under the title of *Replication*".

You then proceed to the next segment of the story using yet another key graphic. A laser pointer can be helpful. Upon stopping you say "Your turn". At that point, the next student within the team does the re-telling. Once all students in a team have had a turn, they start over again with the first student. You continue this pattern until you are able to finish the story. If you're running out of time, it can be humorous to keep going, smoothly transitioning through multiple segments. The on-task student will start to worry about having to repeat such a long segment. As the class time wraps up and you apologize that there won't be a subsequent "Your turn", you'll hear sighs of relief. But the main point is that you held their honest attention.

This activity helps to keep students on their toes. Knowing they will soon be on task to re-tell the story to teammates helps to turn on their listening skills. Further, as the student re-tells the story, this helps to cement the story in their minds and/or raise specific questions about what exactly is happening and when and why. Also, you'll find that as students are re-telling the story segment to each other, this gives you a chance to think carefully about what you'll be presenting next. Clearly, students who have studied the material before class have an advantage.

Examples:

Here are potential 5-minute segments in the story of DNA:

- DNA is housed in the nucleus
- Problem: cells divide, but does that dilute the DNA?)
- Nucleotides (chemical structures)
- Complementary Strands
- Replication
- Transcription (Part 1, Making the mRNA)
- Transcription (Part 2, mRNA to the Ribosome)
- Translation
- The Genetic Code

Classroom Activity: Think-Pair-Share

Type: Verbal
Implementation: Moderate ★★
Value: Good ★
Class size: Any

Description:

This technique was made popular by Eric Mazur of Harvard University in his book *Peer Instruction: A User's Manual*. A multiple-choice question is presented to the class. Students contemplate the question on their own and then commit to an answer via flash cards or online so that the instructor can quickly gauge student performance. Students then discuss their reasoning with adjacent students (teams). After student-to-student discussions, a second survey of answers is taken. If the responses prove satisfactory, the instructor can move on to the next concept. If students are struggling, then the instructor may decide to spend more time clearing up misconceptions.

This is the basis for the "instructor-led" module within Learning Catalytics (see page 28). For this activity, the quality of the question is very important. It's also valuable to include a graphic with the question to provide some context. For Conceptual Chemistry, you'll find a bank of higher quality questions posted at Learning Catalytics. These questions are tagged by chapter section number. For example, CC0601 will pull up the questions for Conceptual Chemistry, Chapter 6, Section 1.

Examples:

Question

What is the predominant gas found within a bubble of boiling water?

A. Air

B. Oxygen

C. Hydrogen

D. Water

E. Chlorine

F. Nothing

50 students, 20% correct

A. 4%
B. 32%
C. 30%
D. 20%
E. 10%
F. 4%

Classroom Activity: Please Describe

Type:	Verbal
Implementation:	Moderate ★★
Value:	Good ★
Class size:	Any

Description:

This activity requires you create a set of "please describe" questions. See examples shown below. It works best with an even number of teams within the class or within a nation. There should be a unique "please describe" question for each team. Hand out one question to each team along with a whiteboard and dry-erase pens. For the whiteboard you can use a plastic sleeve with white paper inserted into it along with a Kleenex tissue to erase pen marks. A roll of meat packing paper also works well. The following assumes an auditorium setting:

Step 1: Students within a team take 3 – 5 minutes to prepare a presentation based on their "please describe" question. One student is the presenter and the other students are the support.

Step 2: A team with an odd-numbered question turns to the team behind them and presents using the whiteboard as needed. As a follow up to that presentation, the even numbered team explains back what they heard.

Step 3: The even-numbered team then turns 180° to explain their question to the team behind them. The even-numbered team in the back migrates to the front of the class to explain it to the front row team.

Step 4: Each team then passes their question away from themselves so that the question migrates two teams distant. A team starting with an odd-numbered question will receive yet another odd-numbered question. Go to Step 1 but rotate who within the team presents.

Examples:

1. Please describe how you would make a 2.0 M solution of sugar water.
2. Please describe how you would make a saturated solution of sugar water.
3. Please describe the relationship between the mole and the periodic table.
4. Please describe how ethanol is infinitely soluble in water.
5. Please describe why the solubility of sugar in water increases with temperature.
6. Please describe why the solubility of air in water decreases with increasing temperature.
7. Please describe how soap works.
8. Please describe how water can be purified by reverse osmosis.

Classroom Activity: Talk to the Wall

Type:	Verbal
Implementation:	Easy ★
Value:	Good ★
Class size:	Small (3 – 30 students)

Description:

Students hate this activity. But that's okay because you're their academic coach, not their friend. You'll only want to have students do this once during the semester. However, later you can speak of it punitively but with a touch of humor. . ."You wouldn't want another 'talk to the wall' session, would you? Good. Thank you for coming to class prepared."

A series of short-answer questions are posted around the classroom. There are as many posted questions are there are students, which means this works only for relatively small classes. Beneath each question is a grid that allows the student to rate on a scale of 1 to 5. To begin, each student is placed in front of a question. At the sound of a bell, all students vocalize their explanation or answer. They tend to speak softly at first, but the instructor keeps insisting for them to speak louder. Ideally, the classroom becomes quite noisy. Students must continue to articulate, no pauses allowed until the bell rings once again. At that point, they rate on the grid how well they think they did. The whole class then rotates in the same direction so that everyone stands in front of a new question. This continues for as long as the instructor thinks is appropriate. When finished, the instructor runs around the room grabbing all the questions. Ones in which students gave themselves low marks are the ones that become the focus of subsequent class discussions.

The main point to emphasize with students through this activity is that there is a vast difference between thinking you know something and articulating that which you think you know. A true test for understanding is whether or not the student is able to explain their understanding verbally. So when one student explains a concept to another, who benefits the most? The sender or the receiver? Likewise, who is getting the best learning experience: the young professor refining his or her lecture presentation, or the students listening to this lecture presentation? It can't be emphasized enough that, if a student wants to really learn something, a good way to start is by moving the mouth, whether to a friend or a brick wall, it doesn't matter. It is not comfortable. But that's okay. Learning isn't always meant to be comfortable. The best ice skaters are the ones who have fallen down the most.

Examples:

- Please explain the Cathode Ray Tube.
- Please explain the Millikan experiment.
- Please explain the Gold Foil Experiment.
- Please explain why atomic masses are not whole numbers.
- Please explain how nucleons stick together.

Classroom Activity: Student Presentations

Type:	Verbal
Implementation:	Easy ★
Value:	Notable ★★
Class size:	Any

Description:

This activity works well for topics of current social interest, such as climate change, but is also useful for basic concepts, such as properties of water. It provides some lucky student the opportunity to present the thoughts of their teammates to the entire class.

Post a question on the overhead. Within each team, students agree upon a presenter who speaks on their behalf. Together they prepare a mini-presentation. It works well for the presenter to practice with the team providing suggestions. Soon the class will quiet down indicating it's time for the first presentation. Roll dice or draw from a hat to randomly select a nation. Then do the same to randomly select a team. The presenter of the winning nation-team stands to present to the entire class turning to the teammates for support as needed. A typical presentation won't go for more than 60 seconds. The class is encouraged to applaud. The presenter is then encouraged to ask if there are any questions. Typically there will be none from fellow students. That's when you can raise your hand waiting to be called upon by the presenter. You can then lead the presenter and the team through a series of questions off the top of your head. Your questioning can be used to clear up any misconception that were presented. You can also coach the students telling them that a very reasonable response to a difficult question can be: "That's a very good question. Perhaps someone else in this room might be able to answer it." Welcome any discussion that ensues as moderated by this presenter. Applause after the question phase of their presentation is also appropriate.

Once that first question has been squeezed dry, you can post subsequent questions and repeat the same procedure of selecting another team at random.

Examples:

1. What is the Keeling curve and what does it tell us?
2. Why is the Keeling curve wavy?
3. How can isotopes be used to determine past temperatures?
4. What is the Greenhouse Effect and why is it good?
5. Why won't current global temperatures be dropping anytime soon?
6. Use a bathtub analogy to explain your answer.
7. Describe an example of an environmental feedback loop.
8. How is a negative feedback loop different from a positive feedback loop?
9. Explain a mechanism for how the pH of the oceans have decreased by 0.1 pH units within the past century. Use the term "solubility" in your explanation.
10. What is solar singularity?
11. In 20 years, what percentage of cars in the U.S. will be fully electric?

Classroom Assessment Techniques (CATs)

The following class activities involve points students earn potentially toward their grade, but not necessarily. Earning points merely for practice is also a valuable experience. You'll find these "CATs" to be a combination of both individual effort and group effort.

For a large enrollment or online class, these CATs can be implemented through your campus learning management system (LMS) such as Canvas, or through a dedicated online response system, such as Learning Catalytics, which we describe first.

Implementation of each CAT is rated as

Easy ★ Moderate ★★ Involved ★★★

The value of each CAT is rated as

Good ★ Notable ★★ Significant ★★★

Learning Catalytics

A Quick Review

Learning Catalytics (LC) is a cloud-based student response system useful for managing an interactive classroom, online or F2F, with an emphasis on formative assessment in real time and rich with data analytics. In short, it's like the old "clickers" on steroids. Upon logging into their LC accounts, students access a set of questions produced by the instructor for that particular class period.

The system accommodates many different question types, such as matching, drawing, short answer, and numerical. Of these, we feel the multiple choice question type remains the most effective, provided you have access to a bank of high-quality multiple choice questions. For Conceptual Chemistry, search: Introductory Chemistry. All questions related to chapter 2 section 4 can be found using the tag: CC0204. For all chapter 2 questions, use the tag: CC02. And so forth. The Conceptual Physics and Conceptual Science question banks have yet to be organized as such.

A set of questions collated for students is housed within a "module". The instructor publishes this module for student access. This can be published on demand or at a pre-determined date and time, which is a valuable feature. There are four module types: Instructor-Led, Self-Paced, Self-Test, and Team-Based. The most effective and easiest to implement of these is the Instructor-Led module type, which presents students one question at a time. Students work on this question individually, then as teams, then as the entire class. The instructor can follow student responses in real time, which is helpful toward guiding class discussions.

While there are many wonderful aspects to Learning Catalytics, this software is still in a clunky phase of development. This is evident with the Team-Based module, which is fraught with difficulties when scaled to a large enrollment class. Our attention has thus been focused primarily on the Instructor-Led, Self-Paced, and Self-Test modules, which themselves have peculiarities, but work well for a large class.

We find ourselves using the "Self Paced" for quizzes and the "Self Test" for practice exams. Importantly, you'll find a set of two check boxes within the set up of each of these module types. The language accompanying these check boxes we find difficult to decipher and have resorted to trial and error to see what checking a box actually does. For the following CATs where we specify the potential use of Learning Catalytics, you'll see we provide for you the necessary configuration of these check boxes. Pay careful attention to those settings. For example, getting them wrong may mean the students suddenly have access to the answers before they should.

For all its oddities, we see much potential in the Learning Catalytics system and look forward to future updates. That the program comes free with Mastering or only $12 per student as a stand-alone is a big plus. If you are running a large enrollment or online class, we highly recommend you look into Learning Catalytics.

Classroom Activity: Minute Quiz

Type: CAT
Implementation: Moderate ★★
Value: Notable ★★
Class size: Any

Description:

At the beginning of class, it is valuable to give students a single-question quiz that assesses whether or not they have come prepared. Such a quiz might be designed to test for a familiarity with the material about to be covered rather than a deep understanding of this material. Note that these quizzes needn't take much time. They may be called "minute quizzes" because the students have only one minute to answer it.

For a small class, after the alotted time, students can opt to put their answered quiz (printed on a narrow strip of paper) into a blue box that gets passed around the class. As labeled on the box, a right answer is worth 25 points while a wrong answer is worth 10 points. If a student opts not to put their quiz into the box, they may hold onto their quiz until the word is given that they are allowed to open their notes, their textbooks, and talk with their neighbors about the possible answer. After another one minute period, they place the quiz into a second box labeled 20 points for a correct answer but 15 points for a wrong answer.

Students soon figure out their desired strategy. With this system, the prepared students are preferentially rewarded. By the end of the semester, all of the quiz scores may add up to a significant portion of the course grade. This is added incentive for students to come to class prepared. However, our experience is that students grow weary after about five of these quizzes. So be mindful of that transition point from where the minute quizzes help to where they nag. Beyond that point, you'll want to consider alternate quiz formats, such as the Redemption Quiz (page 30).

Through Learning Catalytics, the minute quiz can take the form of two "self-paced" modules (Round 1 and Round 2) with the following settings:

Round 1 (Closed book, closed neighbor)
- Participation Weight: 60% correct + 40% Participation
- Check Boxes: unchecked followed by checked
- Single Multiple-Choice Question: 25 pts

Round 2 (Open book, open neighbor)
- Participation Weight: 25% correct + 75% Participation
- Check Boxes: unchecked followed by checked
- Single Multiple-Choice Question: 20 pts

Advise student that any round 2 score will not count if they entered an answer for round 1. In other words: "Hands off round 1 if you're not sure about your answer because in round 2 you'll get to talk it out with your neighbor."

You'll later need to export the LC scores from these two rounds and manage the data accordingly within a spreadsheet.

Invariably, a student's cell phone or computer will run out of power or you'll have students who just don't sign up for LC. These students can write their answer on a strip of paper, which they must place into a cup before you call the end to the first round or a second cup before you call the end to the second round. For students who come in late, you might have a backup question that they answer after class using these cups.

Classroom Activity: Redemption Quiz

Type: CAT
Implementation: Moderate ★★
Value: Notable ★★
Class size: Any

Description:

The redemption quiz is a variation of the minute quiz and much preferred by students. It's nicely introduced after the students tire of the minute quiz. It spreads the risk over more than a single question and is more forgiving of a wrong answer in the first round.

All students are directed to take the first round where each question is worth 10 points for a correct answer and 4 points for each less correct answer. With two questions, students will earn either 20, 14, or 8 points. After all students have turned in the first round, teams of students are encouraged to discuss and research the answers. Students are then given the choice of taking the second round (same questions) where a correct answer is 8 points and a wrong answer is 6 points so that students will earn 16, 14, or 12 points. Doing so nullifies their first-round results, but allows students the opportunity to "redeem" themselves from a potentially poor first round performance. The only way to score a 20/20 is through the first round, which means coming to class prepared. But all students have a fair opportunity to earn 16/20 in the second round.

Through Learning Catalytics, the redemption quiz can take the form of two "self-paced" modules (Round 1 and Round 2) with the following settings:

Round 1 (Closed book, closed neighbor)
- Participation Weight: 60% correct + 40% Participation
- Check Boxes: unchecked followed by checked
- Multiple Multiple-Choice Questions: 10 pts each

Round 2 (Open book, open neighbor)
- Participation Weight: 25% correct + 75% Participation
- Check Boxes: unchecked followed by checked
- Multiple Multiple-Choice Questions: 10 pts each

Advise student that any round 1 score will not count if they entered an answer for round 2, which is the opposite of the minute quiz. In other words: "Hands off round 2 if you're pretty sure you got full credit on round 1."

You'll later need to export the LC scores from these two rounds and manage the data accordingly within a spreadsheet.

Invariably, a student's cell phone or computer will run out of power or you'll have students who just don't sign up for LC. These students can write their answer on a strip of paper, which they must place into a first round cup before you call the end to the first round or a second round cup before you call the end to the second round. For students who arrive late, you might have a backup question that they answer after class using these cups.

Classroom Activity: RAT-a-CAT

Type: CAT
Implementation: Moderate ★★
Value: Good ★
Class size: Any

Description:

This is a one-two punch of a RAT (Readiness Assurance Test) for practice combined with a CAT given for points. It flips the idea of individual work followed by teamwork, putting teamwork first. It is clearly the student's favorite quiz format, perceived as the fair. Another distinction is this: The minute quiz and redemption quiz formats serve the roll of making sure students come to class prepared. The RAT-a-CAT quiz format mainly serves to make sure students come to class. So, although students prefer the RAT-a-CAT format, its implementation needs to be balanced with the other quiz formats.

It begins when students are given a quiz and are permitted to work on the quiz together as a team. A five question quiz works well. You can distribute one quiz per team. Students might work together on one question at a time. Or they each might select one question and then discuss their answers with teammates. You can set a time limit or feel it out. The main point is that students are actively studying together, which is a good thing. You can also roam the class to provide subtle hints as you see fit. If you're using a nation format, you might also allow teams within a nation to consult with one another. A key concept is that the score on this initial team-based round doesn't count.

Through Learning Catalytics a team will be able to see their number correct in the first round. Nicely, they won't see which questions they got wrong, if any. But knowing how many are correct is useful information for them. Here are the LC settings:

Round 1 (team-based, Self-Paced module)
- Participation Weight: 100% correct + 0% Participation
- Check Boxes: unchecked followed by unchecked
- Five Multiple-Choice Questions: 1 point each

Very important: To see their results, students must still be logged into the session as you close that session.

After this first round, you provide the same quiz to every student. You might decide to rearrange the questions and/or answers for this second round, but students will appreciate knowing this beforehand. You'll also need to decide whether you will allow students to use notes. Your call. But consider that many teams will not have gotten a 5/5 in the first round. We recommend each correct answer worth 4 points and each incorrect answer worth 2 points. Here are the LC settings:

Round 2 (individual effort, Self-Paced module)
- Participation Weight: 50% correct + 50% Participation
- Check Boxes: unchecked followed by unchecked
- Five Multiple-Choice Questions: 4 points each

See previous quiz descriptions regarding students who can't access LC.

Classroom Activity: Attendance Quiz

Type: CAT
Implementation: Easy ★
Value: Notable ★★
Class size: Any

Description:

The previously described quiz formats all provide credit based on student performance as well as attendance. We find that a quiz graded solely upon attendance works well in keeping up a class morale along with supporting good attendance.

Ask whatever question you like. All students in attendance will receive full credit for merely attempting to answer. You might also have a policy whereby a student can still receive full credit if they contact you regarding a known upcoming absence or if they contact you after the fact with an acceptable excuse for their absence.

In addition to content questions, you can also ask survey questions, including the "Advice Column" questions described on page 18, or Focus Listing on page 15.

The points you offer for an attendance quiz can reflect the importance of a particular day. For example, if you know next Monday to be a pivotal class, you can let students know beforehand by telling them there will be a "Mega Monday", which means 100 points just for showing up. Jaws will drop. Attendance will spike.

As another idea, you can also start throwing in Conceptual Academy points. The points students earn for attending are added not to their in-class quizzes, but to their Conceptual Academy point total. You would need to keep track of these added points in a separate spreadsheet.

Toward the end of the semester, you can do an extreme move by announcing a "Terrific Tuesday". All students who show up next Tuesday will be granted half the points needed to reach the Conceptual Academy threshold. For example, if you set the threshold to 400 points, a student with 200 points would be granted 100 points. (400 – 200)/2. You would download the current point totals (export .csv) from the Conceptual Academy grade book and use a spreadsheet to do those calculations for all students. Again these bonus CA points would need to be tracked in a separate spreadsheet, but it guarantees strong attendance for the following Tuesday.

As described earlier, you may find the most common reason student don't come to class is because of conflicting work obligations. Crazy, but true. They need to work to afford college. It's important to apply pressure to encourage students to come to class. But it's also important to do so with a positive attitude assuming that, yes, every student is doing the best they can under the unique circumstances they face. It's a delicate balance.

Classroom Activity: Race for the Chocolate

Type: CAT
Implementation: Moderate ★★
Value: Significant ★★★
Class size: Any

Description:

For the small class, a set of eight not-so-easy multiple choice questions are posted around the room. Students work in teams to answer these questions. The first team to get all answers correct wins the prize, preferably something made of chocolate. Strategies are important. Some teams will decide to split up. Others will stay huddled as they migrate from one question to the next. Also, if a team submits answers but gets at least one wrong, they are not allowed to submit answers again until either all the other teams have had a chance or after a specified amount of time. Furthermore, the instructor does not tell teams which questions they got wrong, only the number they got wrong. This is certainly a fun learning activity and highly recommended.

Some mechanics regarding the above small classroom "analog" approach: you'll want to create an "answer strip" in which students bubble in their answer to each question. Hold their strip up to your own, which you've made into a punched-out answer key for a quick assessment. Reveal to the students only how many they missed, not which ones they missed. You should also color mark their sheet to indicate that they've made a submission so that you know not to grade them again until all other teams have had a go. With a class of 30 students, it usually takes about 3 rounds before a team earns an 8/8 and therefore the prize. Other students will groan because they don't want to stop. At this, you pull out some less favorable candy and declare we still await second place winners. After another round or two, the energy fizzles out, which means it's a good time to stop action and turn to a review and discussion each of the questions so that everyone leaves class understanding the answers to all eight questions.

For a medium to large class, this activity needs to be run through a system such as Learning Catalytics. Using a self-paced module, here are the parameters:

Race for the Chocolate (team-based, Self-Paced module)

Participation Weight: 100% correct + 0% Participation

Check Boxes: unchecked followed by unchecked

Eight Multiple-Choice Questions: 1 point each

You post the module and allow students to work on the questions within teams for an appropriate duration. Upon closing the session, students will see their score, such as 5 out of 8. They won't know which ones they missed. You'll know immediately if any team got 8/8 by the screams. Be aware that with a super large class, a team might have gotten 8/8 by dumb luck. Nonetheless, they earn the prize. In cases of multiple wins you can run a "shoot out". Have a member of each winning team explain one of the answers to the quiz. You select the question. The class applauds each explanation. The team with the loudest applause wins.

But other teams will still want to continue toward the perfect score. So you post another round. This time, however, you direct the winning students to act as TA's roaming the class to coach fellow students without giving away direct answers. The second or third place winners of a subsequent round can do the same, such that you'll end up with 8 to 12 students roaming the classroom helping others. When the energy fizzles out, it's time to review each of the questions with the class at large. Two races per semester works well. As a purely formative assessment, no points toward a students grade are provided.

Classroom Activity: Pyramid Exam (analog)

Type: CAT
Implementation: Involved ★★★
Value: Beyond Significant ★★★★★
Class size: Small (4 – 40 students)

Description:

The most significant activity we have to offer within this handbook is also the most complicated. But semester after semester, students consistently rate this activity as the most valuable—by far. So this is something for you to consider. We'll first describe how the Pyramid Exam format is run with a small class using only Scantrons. Then we'll describe how the Pyramid Exam can be implemented within a large enrollment class taking advantage of a nation structure with some digital assist.

The exam is run in three phases: Individual, Team, and Class. As a "pyramid" exam, possible points per question decreases with each phase: Individual (10 pts), Team (6 pts), Class (2 pts). The individual phase is like a regular exam. Students work alone, but you might allow an 8.5 x 11 cheat sheet. While taking the individual phase, the student fills in two scantrons: One bearing their name and another merely as an anonymous duplicate. Upon completion, they turn in both. You can also designate another classroom or even the "deep thought hallway" where students can have more time for the individual phase upon your starting the team phase. It's important to actively encourage students to use the deep thought hallway, but no cell phones or computers allowed.

Students then work in teams for the second phase of the exam. Each team has but one scantron bearing the names of all present team members. They can send a scout to review all the anonymous Scantron duplicates that you have displayed on a table. If possible, during the team phase you race to wherever you need to go to get the Scantrons scored. Upon returning you can post the class average on the board. It's imperative that students know that the exam questions are tough. They should know that a score above 60% is pretty darn good. Encourage them to applaud as you post the score.

By this time, teams are turning in their Scantrons. If you need more time, you can briefly look to a particular question that you know they likely missed with words such as: "Hmm, you might want to think more critically about number 4". Alternatively, it's good to have popular science magazines for students or teams who finish early.

Once you have all the team Scantrons you can begin the final class phase where your role is simply to record the class answer—majority wins. You call out the team answers from their Scantrons keeping a mental tally. Before you announce the correct answer you can ask for any arguments. Your goal is to moderate spirited and respectful debate lending voice to quiet students who know the correct answer. In the interest of time, you'll find yourself giving students credit for the now "easy" questions jumping straight to the more challenging questions.

When class is over, the students will have taken the exam three times and will know exactly how they did. It's a remarkable "formative" assessment plus community experience. The overall class average is the sum of all phases and tends to come to about 75%.

You can also provide "Explanation Sheets" that allow students to appeal missed answers from the individual phase for full, partial, or no credit. For each question, the students indicates the answer that they gave and then explains their own logic for the answer they gave. These sheets must be turned in before they leave.

The number of questions within the exam is critical. For a 110 minute class you can have up to 25 questions. For a 75 minute class, 15 questions works well. For a 50 minute class, you'll need to start with only 10 questions. All of these questions should be relatively difficult. Ideally, the class average for the first phase will hover around 55%. If possible, you'll want to consider running the exam during a lab period: 25 questions over a relaxed 150 minute lab period allows this format to really shine.

We recommend you run a Pyramid Practice Exam, also known as a RAT (Readiness Assurance Test), on the class before the actual exam date. Aside from allowing students to become familiar with the format, this provides students a solid sense of what they still need to do before the actual exam. For a RAT, it's typical that the individual phase average runs between 40% to 50%. If students' heads are drooped upon leaving a RAT, then it's mission accomplished. After much hard work, they'll be cheering when they see an actual exam individual phase average of 55%.

So then why is this format so popular with students? Because it's 1) directly related to their grade, 2) a true learning experience, and 3) community based with a strong element of sports—students working together toward the same goal of winning.

If you have three mid-terms with three RATs, that's a total of six class periods over the semester dedicated to this activity. Students will want a RAT for the final exam. You can tell them that all six previous exams were themselves RATs for the final. They'll ask if the final is also in this pyramid format. Our recommendation is: YES!

Further, if a final letter grade is to reflect a student's level of understanding, then it's simply not fair to the student who starts slow but ends strong—they are forever weighed down by an early poor exam score. One technique is to "drop the lowest exam score". That helps with the math, but it's no opportunity for the student to prove him or herself. Toward this, you might consider that for the final exam, you'll replace a student's earlier individual phase exam scores with that student's final exam individual phase score, provided it's higher. How many is up to you. We've found that with three mid-terms, replacing only the two lowest works well.

Just knowing of this possibility is enough to cheer most every student along to the finish line. As a coach, you're doing all you can to squeeze performance out of your students to the glorious end.

Students during the team phase of a pyramid formatted final exam.

Classroom Activity: Pyramid Exam (digital assist)

Type: CAT
Implementation: Involved ★★★
Value: Beyond Significant ★★★★★
Class size: Large (40 to 400 students)

Description:

To understand the nature of a pyramid exam format, please read the previous entry. Here we describe some mechanics for applying this format to a large-enrollment class.

With up to 200 students and a 75 minute class period, it can still work to have all three phase in one session, especially when students are divided into nations as well as teams. With only a 50 minute class period or when there are over 200 students, the first concession to make is to move the individual phase to an event that occurs before class. For example, using your LMS, a dedicated online examination system at your college, or a system such as Learning Catalytics, students can be required to take the individual phase within a specific time period. This is an out-of-class digital assist. Upon arriving to class, all students are ready to start on the team phase, which takes on the feel of a class review of the exam, except for that it counts for points, so long as it's not a practice run (RAT).

To include all three phases in class requires an in-class digital assist, which can look like the following. While taking the individual phase, students record answers in triplicate: 1) On a Scantron bearing their name, 2) On an anonymous Scantron that is a duplicate, and 3) Online within a system such as Learning Catalytics. The Scantron bearing the student's name is the important paper trail. The score on that Scantron is the only one that truly counts. The duplicate Scantrons are displayed up front for review during the team phase. Consider printing up some homemade duplicate sheets to avoid wasting too many actual Scantrons. The scores that show up online are unofficial, but very useful for monitoring. You'll want to use online data from the individual phase to mark questions with which students are having the most difficulty. It's these questions that will be your focus in the final phase. Further, once you close the individual phase session, students will then be able to see their score, provided they haven't logged out of the session.

Having a nation structure is particularly useful during the team phase, which you can divvy into both team points and nation points. In such a situation, it's still 6 points per question for the "team" phase. But 3 points come from the team Scantron. Another 3 points is the average of all team Scantrons within that nation. In this setting, a team might ace all the questions, but they'll be pull downward if all the other teams don't also ace all the questions. Thus, it is in their interest to migrate within their nation to see how the other teams are fairing. Look at the photograph on the previous page. You'll see Earth-Nitrogen has migrated down to Earth-Helium for consultation.

It's interesting to note that teams are slow to pick up on this strategy. Migrating within the nation is not the most comfortable thing to do. They'd rather stay where they are, especially in the beginning weeks. But with continued prodding, over the semester they eventually become more confident. They'll see others within their nation struggling and now have a means to help. The points may be the catalyst—they may be the "permission" for students to reach outward to fellow nation-mates. But under all that, students truly enjoy helping each other. The nation format leverages this valuable human trait.

It should also be mentioned that the nation format helps to alleviate situations where students within a team are not optimally matched. For many team-based activities, each student knows they can also consult a fellow nation-mates.

Key to successful implementation of the pyramid format is having all students finishing up the individual phase at the same time. You can thank students who are waiting patiently and even pass out popular science magazines. With Learning Catalytics, however, you can see in real time exactly where student are at, for example, showing that 78% of students have answered the last question. You can also just blatantly ask: "How many students need another 4 minutes? Show of hands." You'll need to judge when its time to begin the team phase. Provide a countdown so students can finish bubbling in answers. You'll then direct all students who need more time to the "deep thought hallway" (DTH) where they can have a few more minutes. No electronic devices allowed in the DTH.

Nation presidents can be used to help collect all the Scantrons. It works to make sure Scantrons don't mix between nations. Have a table or area at the front of the class designated for each Nation with a placard. When Scantrons are turned in and placed on these tables, you can close the LC session. Students still signed into the session will see their score pop up. You may hear emotional outbursts as this happens. For some students, the score won't appear. If you have the bandwidth, you can download the results from LC to share with these students at an opportune time.

If your duplicates are homemade then there's a huge benefit. From a stack of nation Scantrons and smaller homemade duplicates mixed together, pinch one corner tightly and shake. The smaller duplicates will fall out over the nation's table. Spread these out for team scouts to review during the team/nation phase. Meanwhile, keep an eye out for students returning from the DTH.

During the team/nation phase, each team has a single Scantron bearing the names of each team member. It works well to pre-label these Scantrons with the nation identity. For example, "W" for water nation. Just before starting the final "world" phase, collect all these team Scantrons, again being careful not to mix between nations.

The final "world" phase requires no Scantrons. Instead, it can be run using the instructor-led module on Learning Catalytics. Go through each question revealing the answer. You'll provide an automatic 2 points for the easy questions. You'll slow down only on the questions students found difficult. For such a question, get students to vote for the answer via LC. If over 50% of students are voting correctly, then they are awarded the 2 points.

For a small class, it's reasonable to allow students to appeal any or all of the question via the "explanation sheet" described earlier. Not so for a large enrollment class. So you might not even mention the idea. Alternatively, you might allow each student to appeal just one question. On this explanation sheet, the student identifies the question they want to appeal, the answer they put, and explains their logic. You'll then assign partial, full, or no credit as you deem fit.

If this all sounds like a lot of work, it is. The bulk of the work, however, is uploading the questions to the testing management system and then creating the multiple modules. BTW, for the team modules, you need to have LC automatically turn those on and off because it takes too long to do so manually during class. Fortunately, for Conceptual Chemistry, you'll also find a large bank of exam questions already posted for you. Use the tags provided earlier (format: CC0302) as well as these: CCExam2, CCExam3, CCExam4, CCFE, and CCFEWSU. Please note: How the questions appear at LC must be identical to how they appear on the printed exam. Enjoy!

Further Classroom Ideas

The following pages are dedicated to some ideas for you to consider for further class activities as well as managing and inspiring your students.

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Concepts Inventory

A Concepts Inventory is a short test taken by students at the beginning and end of the semester to measure increased understanding of basic concepts. Inventory questions should reflect concepts the instructor hopes the ideal student will learn by taking the course. A good inventory will also include questions addressing common misconceptions. At the end of the semester, the same concepts inventory is given or the same questions can be snuck into the final exam. With a concepts inventory, you can collect evidence that learning has taken place and to what degree.

Of course, student misconceptions can be well entrenched. To change these long-held misconceptions over a matter of weeks is no small task. We can't just tell our students that there is gravity in outer space and expect them to believe this hence forth. This is where an active classroom can help. It switches the roles. Students are put in a position where they have to defend new views against old views. This, in turn, helps them to own those new views. Does this help with learning? Does this help with retention of new ideas? For quantitative data, we can turn to the Concepts Inventory.

As described at the beginning of this handbook, there's more to learning than understanding new ideas. When learning effectively, students also discover within themselves new attitudes. For this reason, the inventory should include questions such as: "How much do you expect to value this class?" followed by "How much did you value this class?" It's through these sorts of meta questions we have a handle on assessing our lasting impact.

We would encourage you to work with your colleagues to develop meaningful concepts inventories. We've included a reference to a chemistry concepts inventory at the back of this handbook.

How to Learn—Best Practices

If our goal is to help our students learn, say, chemistry or physics, then it's worth a bit of effort at the beginning of the semester to coach our students through some basic learning strategies.

Ideally, every student will have already studied popular books such as "Make It Stick" by Peter Brown, et. al (See page 52). This particular book offers techniques for becoming more productive learners and cautions against study habits and practice routines that turn out to be counterproductive. We highly recommend this book. The ideas in this book are foundational. They are also inspirational, showing how all healthy humans have a powerful capacity to learn.

The reality is that most students have never learned how to learn effectively. For this they struggle. Thus, borrowing from the pages of "Make It Stick" we developed a much briefer article specifically for our students. This article is posted in the Doc Share of the first FYI page of every course offered through Conceptual Academy. The article is entitled: "Study Effectively". We encourage you to review this article and further to recommend it to your students.

Perhaps, it might be the basis for the lecture you provide to your students on "How to Study Effectively". At the heart of this presentation, you'll want to address the seven techniques delineated by the mnemonic: RIMEGReC. Then throughout the semester, you underscore when a particular technique is being used.

R: Delayed **R**etrieval

I: **I**nterleaving

M: **M**nemonics

E: **E**laboration

G: **G**eneration

Re: **Re**flection

C: **C**alibration

With team-based learning, the following warrants attention: Friends don't necessarily make for good study buddies. Explain this directly to your class. Explain how learning necessarily requires effort—no one is exempt. Explain how learning is less about comfort and more being challenged. There are many obstacles. Facing those obstacles alone is not as effective as facing those same obstacles together as a team.

Golden Tickets

During class, it works well to carry some golden tickets in your pocket. These can be simple yellow-colored carnival tickets that you can pick up at a local stationery store, such as Staples.

When a student puts themselves forward, daring to ask a question, daring to share their reasoning for an answer, daring enough to say "I don't know", that's when you can hand them a golden ticket. Say nothing except perhaps: "Wow, that was wonderful. Here, have a golden ticket" as you hand out the ticket. For any type of merit you see as you interact with your students, honor that merit with a golden ticket.

After a few weeks, students will begin to ask: "What are these golden tickets good for?" You can explain that you have yet to decide but that you're open to suggestions. "But doesn't it feel good to receive a golden ticket?"

But don't overdo the Golden Tickets. They are there mostly as a heart-warming aside.

That said, golden tickets can also be a means of competing for the class cup. You might advise students to hold onto their golden tickets bringing them to each class. You might announce that the nation with the greatest number of golden tickets wins the class cup. On the big day, such as the day before a mid-term exam, each nation president roams the nation collecting all the tickets. The nation with the most golden tickets wins the trophy, which you have filled with desirable candy.

You might repeat golden tickets as the means of wining the class cup for the subsequent mid-term exam. We find, however, that mixing things up works well. The metric for the first mid-term might be the golden tickets. But for the second mid-term, your metric might be focused on class attendence for a series of days or even for a single day that you know to be particularly important.

Interactive Demos

A fun concept-illustrating demonstration is welcomed by everyone. Traditionally, demonstrations have been used to break up a long lecture bringing the rich content to life. They are just as effective when incorporated into a briefer lecture review. Taking it up a notch, you know well that pacing any demonstration with a series of "what if" questions can move the demo into more of an interactive class activity.

Here is an example borrowed from a chemistry course:

> What if 50.0 mL of ethanol were mixed with 50.0 mL of water? What would the total volume be? Ask students to discuss the possibilities and then ask for a show of hands: less than 100.0 mL, 100.0 mL, or more than 100.0 mL?
>
> Do the mixing on the document camera for everyone to see up close. As you're almost finished pouring the mixture back into the graduated cylinder, ask for further consultations and then another show of hands. Does anyone wish to change their mind?
>
> After students see that only 96.0 mL of a mixture is formed, prod them to come up with explanations. Make a discussion out of the possibilities while directing students to think of this demonstration from the point of view of particles, which might not all be the same size. As a clue, you can show them 50.0 mL of kidney beans alongside 50.0 mL of millet seeds.
>
> To conclude, add 500.0 mL of water to a couple tablespoons of sugar in a dry beaker. What then should be the total volume of the mixture? Ask students to discuss the possibilities before asking for another show of hands: less than 500.0 mL, 500.0 mL, or more than 500.0 mL. Ask them to please explain their line of thinking to each other. And so on.

The main point here is to leverage the power of a demonstration to get students thinking on their feet in the presence of others.

Hands-On Science

For a small classroom, there's much that can be done with hands-on activities, many of which you'll find within the conceptual textbooks. The idea here is to turn a bit of "lecture" class time into a mini-lab time. Of course, moving labs into a lecture is not possible when lecture time is 100% lecture. But when students have already been introduced to the content via the textbook and online videos, then that provides an opening. This is particularly important for a course that doesn't have a dedicated laboratory component.

Here are two examples from chemistry and physics:

Radial Paper Chromatography

Provide each student a concentrated dot of black water-soluble ink at the center of a piece of porous paper. Course filter paper works best, but napkins or paper towels also work. The student dips their finger into some water so that a drop of water hangs from the tip of their finger. Upon touching this drop of water to the dot of ink, the water gets absorbed by the paper. The moment it is all absorbed, the student adds another drop and then another allowing water to spread radially through the paper. The different color components of the ink will separate while the water travels through the paper.

Electromagnet

Provide each student or team a nail, insulated copper wire, and a small C-size battery along with some paperclips or loose staples. Ask them to build an electromagnet able to pick up the paperclips or loose staples.

Office Visits

The one-on-one time a student receives when working with the instructor during an office visit is immensely valuable. Why not replicate that value right during class time while students are pre-occupied with a class activity, such as worksheets? That's the idea behind "speed office visits"

Speed Office Visits

The instructor pulls individual students away to a corner of the classroom for a brief office visit. The instructor inquires about how things are going and whether the student has any general or specific questions or concerns. This is also a good time to show the student his or her present course grade and provide advice on how to do well in the course. Mostly, this activity serves as an important ice-breaker making students more inclined to take advantage of regular office hours.

If your offer for speed office visits is announced as an invitation to "anyone who might be interested", then you'll find it's typically the brighter students who come forward. Not bad. But if there are specific students you want to reach, such as those who are not doing too well, then it's a disservice to actively select and potentially embarrassing that one student in front of the rest of the class.

Poorer students, however, tend to sit in the back of the classroom. Thus you can announce your ambition of having a speed office visit with everyone, starting with the back of the class. It'll take at least 2 minutes for each speed visit and then 30 seconds for each transition. You'll be lucky to get to 20 students. Do you continue the next class period to reach all students? No need. From those 20 students, you'll have a meaningful cross-section of where students are at (or not at). The benefit goes both ways.

En-Masse Office Visits (EMOHs)

For a large enrollment class, regular office visits and even speed office visits have their limitations. There are only so many one-on-one interactions you can have over the course of a semester. When you've got 300 students? What then?? The answer was invented a long time ago. They're called recitations, which you can introduce to your students as an EMOH (pronounced: ee'-mo).

Survey your students as to when are good times for them to meet before or after class and on what days. It works well to offer EMOH's in doublets to maximize availability. For example, one on Tuesday afternoon and another on Wednesday afternoon. All students are welcome. They are advised to come with all their burning questions and worries. EMOH's are most popular the week prior to a mid-term exam. Run the EMOH primarily as a Q/A session, focusing on review, as directed by the students. From a large class, an attendance of 10 to 20 students makes for a great EMOH. The tone is informal. Welcome students to bring their lunches if appropriate.

Study Group Leaders

For a large-enrollment class where departmental TA's just aren't available, there's a remedy, which is to create your own TAs. Say, for example, you know that you'll be hitting these tough concepts in two weeks time. You can announce to the class that in two weeks time we'll be hitting some tough concepts and that you're concerned that many students will fair poorly, which is not your goal. Rather your goal is to see everyone through successfully.

Toward this, you clearly are going to need some help. And so you say: "Let's just admit that some of you students are, well, pretty darn motivated. Tell you what. How would you like to volunteer yourself to become a study group leader? What does this mean? It means that next week I'll be running a specialized training session on how best to learn these upcoming tough concepts. Then the following week when we hit those tough concepts, you can each organize a study group session. You'll post your name and the time and place for meeting, like in the library. If enough students sign up for your group, as determined by you, then it's a green light. They won't expect you to be an expert on the tough concepts, but at least you'll be there to help work it out together. Anybody here interested in helping us all out as a study group leader? Awesome. When's a good time for the SGL workshop?"

Within the "SGL" workshop, you emphasize that the best way to learn is to teach. Thus, these motivated students are not just helping others, they are also helping themselves. That's the context as you dig into the concepts with an emphasis on lecture.

Organizing Study Group Leaders makes for a nice complement to the EMOH, which is great for reaching out to the struggling students. Here, with the study group leaders, you've flipped the coin. Rather than reaching out to the struggling students, you're endearing the motivated students and training them to use their skills to inspire others. No one knows the perspective of a student better than a student. The support these motivated students can provide to fellow less-motivated students is of a different and potentially higher quality. Indeed, you may well be nurturing future educators.

> *"I am a student from your fall 2016 Chemistry 1305 class. I know it's been a while and it was certainly a big class, but when I was asked to include a description of a class that challenged me in the TTU scholarship application your class came to mind. It was my first semester at TTU and being able to succeed in your class with your guidance really built up my confidence in my academic abilities. You also chose me to be one of the study group leaders toward the end of the semester! I learned how to succeed in a college science class and of course some good chemistry because of you, so thank you again."*
>
> -Ashleigh Arredono

Entrance Exam

This entrance exam idea only works for a small class. The idea is this: You wait by the classroom door for students to arrive. As they arrive you hand them the "entrance exam" (see example below). That is, the student is not allowed to "enter" the classroom until they have completed the entrance exam, such as in the hallway. It shocks the students in a humorous kind of way as they open their backpacks searching for a pencil. You can even offer points in lieu of a minute quiz.

The entrance exam itself is merely a survey asking students what chapter sections they have already studied. You can use the results of the entrance exam to direct students to different tables (or "stations") you have set up in advance. For that day's class, teams are temporarily dissolved. Students sit where directed.

Each station can be marked relative to chapter sections of the textbook. One station, for example, might be marked Sections 14.1 – 14.2. Another as 14.3 – 14.4. And so forth. You can then move students into the "Student Presentations" activity (page 26) where they are to present a summary of each chapter section to the class at large.

For students who have yet to study, you have a special station where they'll find copies of the textbook chapter to start reading. Again, you are providing subtle but effective pressure for them to come to class prepared to learn.

Entrance Exam

Name: ______________________________ *(automatic 25 points for entering your honest answers)*

Please check the sections of this chapter that you have already studied

________ I have studied through just about the entire chapter

I have studied through the following section(s):
________ 14.1 Medicines Are Drugs That Benefit the Body
________ 14.2 The Lock-and-Key Model for Drug Design
________ 14.3 Chemotherapy Cures the Host by Killing the Disease
________ 14.4 The Nervous System Is a Network of Neurons
________ 14.5 Psychoactive Drugs Alter the Mind or Behavior
________ 14.6 Pain Relievers Inhibit the Transmission or Perception of Pain
________ 14.7 Medicines for the Heart

________ Sorry. Things came up. I have yet to study any of this chapter.

Reverse Quiz

In a stern voice, you can declare: "Pull out a piece of paper. We're going to have a quiz." Students nervously pull out a sheet of paper and writing utensil. You then explain how, gosh, you've been giving them so many quizzes but they have yet to give you any. How fair is that? That's the essence of the "Reverse Quiz". Here, the student gets to ask a question of you. Short answer. Long answer. Multiple choice. Any format will work. They then quickly realize that creating a quality question is no small task.

When time is up, you collect all the questions and sort through them. For a large enrollment class, students can write their question online via a class management system, such as Learning Catalytics.

You slide through the minutes answering select questions, some of which will launch you into the longest explanations.

After you finish answering a particular question, you can then pull on your students a "reverse reverse quiz question". If they understand your answer, if they really do, they should then be able to answer this. . . . (and here you ask them a follow-up question.)

Through all of this activity, you are also on the look-out for quality student questions that you might adapt to put on a subsequent exam.

Salon de Science

This is yet another idea that works well for the small class. Bring in a stack of recent science journals, both popular and technical. Set the classroom up as though it were a coffee house—quiet background music, tea, donuts, etc. Students merely spend the class time reading through these journals and discussing science-related topics with their peers as well as the instructor. Strange but true, many if not most of your students may have never read through a science journal or magazine.

Salon de Science (pronounced See-ance) is also a good forum for the Contextual Chemistry essays found at the back of each chapter in Conceptual Chemistry. Assign each student his or her choice of Contextual Chemistry essay. Students use the class period to read their selected essay while you roam the class answering general and specific questions.

You can work student teams in one of two fashions 1) each student on a team reads the same essay, or 2) each student on a team reads a different essay. In the first case, students can discuss the questions at the end of the essay. In the second case, each student can be required to summarize the important points of their essay to the other students.

The Salon de Science is a good way to emphasize how science relates to issues of social concern. It may seem a bit extreme to "waste" an entire class period on such an activity. But when provided toward the end of the semester (when students are close to burning out), the Salon de Science is a good opportunity for students to find social applications to all the concepts they've been learning. The session will start fairly quiet as students simply read. But you can then later encourage discussion by directly asking students to start discussing what they've read with each other.

For a large class, you can offer hard copy magazines, while also posting on the overhead a list of web addresses to respectable and interesting online articles.

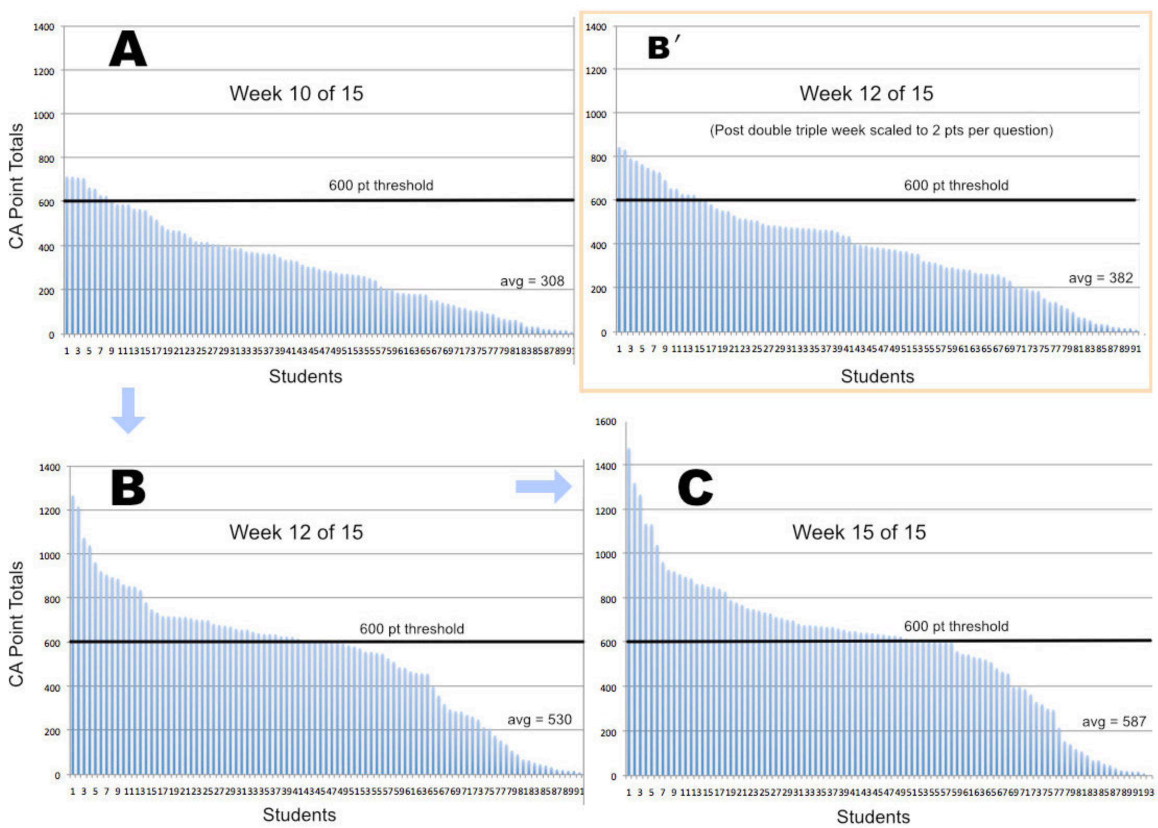
Triple Week

Students are assigned Conceptual Academy as a semester-long project through which they are required to earn a certain number of points. That number of points is determined by each instructor. All students who reach this point threshold receive 100% on their Conceptual Academy project, which may count for up to 20% of the overall course grade.

The histograms shown below are from one of our courses (Suchocki) with 91 students in a traditional F2F on-campus classroom. Students collected points at a rate of 2 points per correct question at Conceptual Academy. These point settings can be adjusted as desired by going to the "Quizzes" tab from your user profile page.

Starting week 10, students were offered a "triple week special", which meant each correct answer provided 2 x 3 = 6 points. Students responded well enough that the instructor "accidentally" forgot to turn the settings back to 2 points until two weeks had passed, which made this a "double triple week special". Histogram **B** shows the results as seen by the students. Histogram **B'** scales student scores to what they would have been had it remained 2 pts per question. Histogram **C** shows final scores at the end of the semester.

Most notable is that many students continue to collect points even after reaching the threshold. We see this across all campuses using Conceptual Academy with or without triple week. The effect of triple week is much like a limited time sale being offered by a department store. We see triple week as a valuable tool—one that can be used as needed. There are likely many variations on this theme. For example, rather than just giving it away, students might need to *earn* a triple week, which is offered only when the class average gets to a certain value or when class attendance for any particular day reaches, say, 90%.



Homework and Classwork

Homework is vital to student success. For an introductory science course geared toward non-science majors, however, there are special considerations. Foremost is to keep in mind our ultimate goals, which include helping the student learn content while also inspiring them to see the relevance to their everyday lives. Importantly, we want them to enjoy the process.

On one extreme, consider the homework regimen of a general chemistry course for chemistry majors. Consider the other extreme of absolutely no homework for fear it might promote a negative attitude. Clearly, neither of these extreme are appropriate. Instead, it's upon us to find some optimal balance where our homework assignments are challenging but manageable.

We authors equate "homework" with a set of questions or problems the student is required or encouraged to complete. These questions or problems may come from the end-of-chapter material within the textbook. They may also be provided through an online homework system, such as Mastering or Sapling.

The word "homework" has a distasteful connotation among students. That's why we prefer to use the word "study" when directing students to read a textbook chapter or to watch a Conceptual Academy video. The reading check and video check quizzes they find at Conceptual Academy are not "homework". Rather they are means for providing the student credit for having spent time studying.

The word "homework" includes the word "home". What do we call it when homework is actually done not at home but in class? How about "classwork"? Most all of the class activities described in this handbook are exactly that. You'll notice they have students working together on sets of questions or problems for credit that counts toward their grade. This is essentially "homework" done in class. But here's the real issue: class time is not very long. While a 20-minute class activity is a valuable experience, it is also insufficient.

Each course has its own flavor. You might be teaching a course for potential nursing students. It might be a course for elementary educations majors or a catch-all course for liberal arts majors. You'll know best the degree to which your students should be required to complete homework assignments that take any class activities to the next level.

You may find a robust schedule of class activities including multiple pyramid practice exams suffices (see page 34). You might be going more lightly on class activities, in which case weekly online homework assignments work well in preparing your students for the exams. There are plenty of opportunities to find a balance that is optimal not just for your students but for yourself.

Class Journal

Team-based learning is such fertile ground for educational innovation. As soon as possible after teaching a class, it's a good idea to open up your Class Journal and start recording what went well and what went wrong. Through this process, ideas for improvements and new ideas altogether arise. It works to document the details of each class session even if you don't think anything unusual occurred. There are likely ideas brewing within your subconscious. The process of writing in your journal, especially soon after class, is a great way to allow these ideas to bubble up to the surface where you can consider them in fuller detail.

Short and sweet entries or long and detailed. Either way, you are doing your future self a huge favor. In a subsequent semester, you'll be wondering what to do for the next day's class. A quick review of what you did in a previous semester is a huge head start. Further, it minimizes any mistakes made and brings back to mind new ideas you wanted to explore. This makes for powerful professional development.

For very good reasons, as scientists we record ever so carefully all that we do in our research labs. Why should our time in class be any different? Viewing each semester itself as a research experience guarantees we'll never get bored. A class journal is an important tool for keeping our love of teaching alive and growing.

Weber State University,
Chem 1010, Section 20219
Fall 2017
Class Journal

29 August 2017 (Tuesday)

I'm teaching a single section of Chem 1010 at Weber State University, Ogden, UT. This class has a max enrollment of 125. The system shows 105 students enrolled. The number of students showing up today was 89. It is an amphitheater setting, but the seats are on rollers and comfortable. I still need to enter the seat map in learning catalytics. But the arrangement is easily divided into four nations. Air nation on my left. Down the middle section I placed orange marking tape. To the left of the tape is water nation. To the right is fire nation. Earth nation is to my right.

At promptly 10:30 I begin the intro to "Avatar: The last air bender". Students knew what I was doing, but it was apparent not so many as at TTU. It nonetheless made a nice introduction to the various nations. At each seat I had placed a colored card with an embossed silver or gold sticker, with the letter A, W, F, E. I told students to keep these cards and to bring them to each class. I forgot to ask them to sign the back of the card. Be sure to do that on Thursday.

I introduced myself and the nature of the course. I emphasized that there is so much more than just learning chemistry at stake here. This is a time you get to focus on strengthening yourselves. Also a time of learning how to work with others. We'll certainly be digging into the chemistry. We'll certainly be learning how chemistry applies to our daily lives. But, in the end, the main game is the opportunity for personal growth.

I also discussed some of the mechanics of the course. The rationale for using class time as a glorified study time. The challenges of moving toward this approach. I went into Step 1/Step 2 learning without the Powerpoints. This felt appropriate. Then, when I went into the Powerpoints, it made for a more detailed review.

Some References

Team-based learning and other innovative techniques are thriving at many colleges and universities. Here are a select few references.

WebSites:

Carl Wieman Science Education Initiative
http://www.cwsei.ubc.ca/

Science Education Initiative
https://www.colorado.edu/sei/

Chemical Concepts Inventory
http://jchemed.chem.wisc.edu/JCEDLib/QBank/collection/CQandChP/CQs/ConceptsInventory/CCIIntro.html
or just type: "Chemical Concepts Inventory" into Google.

Collaborative learning activities
https://www.wcer.wisc.edu/news/detail/education-technologies-improve-collaborative-learning-in-undergrad-chemistr

Field-Tested Assessment Guide (CATs)
http://archive.wceruw.org/cl1/flag/default.asp

Just in Time Teaching
https://cft.vanderbilt.edu/guides-sub-pages/just-in-time-teaching-jitt/

Process Oriented Guided Inquiry Learning (POGIL)
www.POGIL.com

Classic Books:

Make It Stick: The Science of Successful Learning by Peter C. Brown, Henry L. Roediger III, and Mark A. McDaniel (Harvard University Press, 2014).

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