2023 NTC Presentation

Using Problem-Oriented Discussion Cases to Develop Neuroscience Students’ Thinking & Learning Skills

Presented By:

A. Daniel (Dan) Johnson, Teaching Professor, Dept. Biology @ Wake Forest University

[johnsoad@wfu.edu](mailto:johnsoad@wfu.edu) (feel free to contact me with questions or to chat)

I am a teaching professor and former Core Curriculum Coordinator for Biology at Wake Forest University. I wrote and published my first formal teaching case in 2005. Since then I have written or co-written >35 cases for non-majors general biology, majors from first years to seniors, a federally mandated research ethics course, and graduate TA training programs. I also have been an invited reviewer for others’ published cases.

Overview

STEM courses serve increasing numbers of students who lack strong self-regulated learning skills, who need additional time to process information, or are neurodiverse in other ways. Instructors face the dual challenge of providing these learners with appropriate learning opportunities while also keeping higher-performing students engaged. This is particularly true in high-enrollment courses, where active learning opportunities are likely to be add-ons to a traditional didactive lecture format. These embedded activities may not give developing students enough opportunities to engage in deeper thinking. At the same time, the course moves too slowly to keep advanced students engaged.

Discussion cases are a reliable way of engaging students who have a wide range of skills simultaneously. Well-designed cases can be adjusted on demand to meet differing student needs. They can simultaneously reinforce prior knowledge or introduce new concepts, and let students practice both problem-solving and self-regulated learning. Students must deal with ambiguity and complexity, something that students at all stages find difficult. Their shared discomfort helps students at different learning stages work together more equitably.

Cases are not a panacea; like any teaching tool they have benefits and drawbacks. Case-oriented courses require considerable development work behind the scenes. Instructors give up their role as expert and become a learning coach instead. They must be ready to think quickly and adapt to evolving discussions in real time. Instructors also must be able to guide students past their need to know “the right answer.”

Before the Session (*optional*)

Attendees may want to read the backgrounders, “What Are Cases?” (**Supplement A**) and “Writing Cases” **(Supplement B),** and the demonstration case, “Gene Regulation in Autism” (**Supplement C**).

During the Session

The presentation will focus on:

1. How discussion cases are organized and implemented. I will **outline** how I use discussion cases (including the sample case provided to participants in Supplement B) in a multi-section course in cell and molecular biology.
2. For the remaining time, participants will brainstorm:
   1. what case topics are most appropriate to learning goals within existing neuroscience courses;
   2. appropriate general goals when using cases; and
   3. which case formats are most widely useful.
3. As time allows, participants will explore resources available for case writing on the [associated web site](https://adanieljohnson.github.io/NTC2023/index.html).

Intended Goals

1. Participants will leave with a better understanding of how to select cases for specific learning goals beyond concept and content knowledge.
2. Participants can use the co-developed topics list and shared tools to create their own neuroscience teaching cases. Alternatively they may want to collaborate with like-minded colleagues to develop shared cases.
3. Participants will have access to the presenter’s curated set of resources for developing new cases and for converting existing cases to other formats. Additional design and implementation resources that I wrote or collected while teaching with cases are available in the resources repository as well.

Part I. Why & How I Use Discussion Cases Currently

**BIO265: Cellular and Molecular Biology** is a multi-section course taken by most pre-health professions students. It also is a prerequisite for many 300-level biology courses. When we retired the previous version of this course in Spring 2020, I had the dubious distinction of developing and launching a new iteration during the pandemic. This turned out to be an opportunity to reimagine the course.

CMB is content-intensive, so many students try to memorize their way through it. As part of the redesign, I wanted to de-emphasize excessive details and **help students learn how we think about this topic: what kinds of questions do we ask, and how do we answer them?** For me, having students work on several cases in stable teams has been the best way to do that.

The course is arranged into 11 topic modules. For the first 10 weeks, we explore one topic each week. In the last 4 weeks, we spend 2 weeks per topic module. The course meets 3 days a week and is in flipped format. Students have both individual assignments, and activities they complete in teams of 4-5. The weekly workflow is outlined in Table 1.

***Table 1. Weekly Workflow in BIO265.*** *Case-related activities are highlighted.*

|  |  |
| --- | --- |
| **Day** | **Class Activities** |
| Wed., 5 pm of preceding week | Course materials for the following week are posted: textbook readings, topic guide questions, & pre-class readings for both case days. |
| Mon., 8 am | Students submit individual muddiest points for current topic, and 2 integration, synthesis, & application (ISA) open response questions. |
| 10 am-12 noon | I compile the most common muddy points and explain them in class. |
| Tues. 12 noon | Teams choose, refine, & submit 5 ISAs from their individual submissions. |
| Before class Wed. | Students complete pre-class reading for Case Day 1. |
| Wed. 10 am-12 noon | Teams read, discuss, complete Topic Case Day 1 handout. |
| By Wed. noon | I send each team’s ISAs to another team; the receiving team has 3 days to write an answer key for the first team’s questions. |
| Between Wed., Fri. | Students complete pre-class reading for Case Day 2 |
| Fri. 10 am-12 noon | Teams read, discuss, complete Topic Case Day 2 handout  Teams have 24 hours to complete case summary questions (grade shared by team) |
| Sat., 12 noon | Teams submit:   * Case summary questions (or equivalent team product) * Key for another teams integrated topic questions   Individuals submit a response to 1+ muddy points posted on discussion board. |
| Wednesday of following week | Teams receive graded keys with feedback. I encourage teams to share their commented keys with others to prepare for exams. Teams get comments back on case summary questions. When needed, I post a shared debrief document for the case. |

**Students must learn basic factual content on their own.** Reading guide questions, muddy points assignments, and ISAs ensure students master essential information. We spend 1 day (of 3) each week clarifying the most common muddy points, then students must work together via online discussion boards to understand the rest.

We spend the other 2, 45-minute class periods each week working through interrupted cases focused on more difficult threshold concepts and on developing thinking skills. There is a 1-day training case the first week of class, then 8 major cases for the course (see examples of cases and data they provide in Table 2). The final case is longer, requiring 4 days. Students do not work on cases during exam weeks. Instead, they have an in-class review session, a day for the exam, and a workshop day when they can work with their teams on final course projects.

***Table 2.******Cases that BIO265 students complete prior to Exam 1****. Case Goals lists the content (C), thinking skills (T) or process skills (P) goals, and opportunities to collect metadata (M) on student knowledge, skills, or affect.*

|  |  |
| --- | --- |
| **Case Topic** | **Case Goals** |
| 0: How are cells organized? | * How cases work **P** * Establish rules for teams **P** * Survey students’ prior knowledge of cell structure, functions **M** |
| 1: Transcription control: promoter mapping (in Supplement) | * 3D structure of promoter sites **C** * Reporter assays **C** * Introduce BHMA-9 CV system as repeating topic models **T** |
| 2: Translation control: blocking cancer | * Order of assembly of ribosome **C** * How molecular inhibitors work **C** * Inferring functions from indirect evidence **T** |
| 3: Gene regulation in autism | * Levels, mechanisms of epigenetic regulation **C** * Master genes, polygenic traits **C** * Locating, assembling reliable data from external sources **T** |

### **Grading Case Work**

In keeping with the goal of de-emphasizing details, I use a bins-based model (also called specifications grading.) All graded items are scored on a 5-point scale based on overall quality:

5 = complete, accurate, acceptable (equivalent to an A, or 95 in course grades)

4 = minor errors but essentially correct (B, or 85)

3 = significant errors in logic, reasoning, or interpretation (C or 75)

2 = seriously flawed, but submitted (D or 65)

0 = not submitted (F or 0)

Most of my grading time is spent giving written feedback to the teams to let them know whether they have met my expectations, and how to do better next time. Teams are welcome to meet with me to discuss gaps in their knowledge or thinking. Since there are no points to argue for, we have much more productive conversations than if I scored them on a points-based rubric.

This is the general strategy I use now for most coursework beyond my 100-level courses. In courses where students are resistant to a fully bins-based metric, I create rubrics for assigning points that align with my holistic scoring strategy. These rubrics provide students with points they can track but do not fundamentally alter how I allocate my grading time and effort.

I have run several analyses comparing students’ overall grades using a bins model versus strict points-based scoring, and consistently find most students earn similar scores. Bins scores tend to be slightly higher, but my overall impression is that is because students focus on larger learning issues instead of point harvesting.

Part II. Brainstorming Case Topics For Neuroscience Courses

We want to develop cases that give students opportunities to practice a range of thinking and learning skills. To that end, take a few minutes to:

1. **Choose 1-2 neuroscience courses** in which you are interested in using cases. Alternatively, think about a 100-level course in your discipline.
2. **Choose 2-3 thinking and learning skil**ls which you want students to develop but are either lacking or insufficiently developed in students taking the courses you picked for Item #1.
3. **Choose 2-3 topics or scenarios** that you think might be used to build engaging cases. As you choose topics, remember the goal is to develop learning and thinking skills. Teaching specific content knowledge is not the main goal currently.
4. As time allows, think about **what questions you have about case implementation generally?** They can be related to how my course operates, or to implementation challenges you foresee in your own courses.

*Please do not share any confidential information about your students during our debrief; I hope to summarize and publicly share comments from the group after the workshop.*

Part III. Framework for Picking & Designing Discussion Cases

Whether you are looking to adopt an existing case or write your own, a planning framework can help you think through the process systematically. The one I suggest below helps you identify the essential key elements while still leaving plenty of room for creativity.

**1. Goals and Topic:**

What 1-2 **learning goals** do you want this case to achieve? Be **specific**. Use action verbs to state the goals.

What **topic** do you want to make your case about? **Why** use that topic?

What **core question** do you want to make your case about? HOW will students to practice the thinking skills or reach the learning goals you set as they answer the core question?

**2. Scenario:**

The scenario puts the core question into context and gives it relevance. How complex it needs to be depends on how interested students are in the core question.

If the core question that students must answer is enough to keep them engaged and interested in solving the puzzle:

* What is the **minimum** amount of supporting information they need?
* How much information would overwhelm them or remove their opportunity to think through the problem?
* How can you provide the information so it encourages discussion?

If the core question is not sufficient on its own to keep students engaged:

* What **story or situation** **that is relevant or familiar to students** would capture their attention?
* How will the situation make the core question more relevant?
* Can you break the story up into segments with separate goals?
* Can you organize the scenario so it contains an **“and-but-so”** conflict or problem?
* What visuals or artifacts could help bring the story to life for students?

**3. Guide Questions and Supports:**

What initial questions can you ask students about this scenario that will require them to use a particular thinking strategy or apply a particular set of skills? If they do not have those skills yet, what questions would you ask to lead them through that process? Ideally your questions:

* Are open-ended (no clear single best answer)
* Can be discussed, explored in a small group of 2-6 students
* Require higher order thinking skills (no simple answers)
* Get students to think or act in ways that fit the learning goals

What follow-up questions can you ask that require students to apply or extend what they have learned in the discussion? Ideally these questions:

* Require using or building on the initial information surfaced by the first set of questions
* At least partly “close the loop”
* Get students to think or act in ways that fit the learning goals

**4. Logistics**

Sometimes the specifics of how you will run a case will already be in place, either from other cases or your overall class design. If you are just starting out:

* How will you introduce the case?
* What size discussion groups will you have? Self-selected or assigned?
* How long do you want the case to take?
* How will you close out the scenario, and move to the next topic?

What is your Plan B for **WHEN** things go astray?

* How can you shorten the case if time runs out?
* What technology do you need that could fail?
* What if students don’t “get it”? What additional information can you keep in reserve to help them along?

How are you going to ask students to provide responses to questions or feedback?

* Show of hands
* Group reporter
* Color cards
* Electronic poll
* Clickers

What will be your students’ deliverables that you will grade?

* Team items
* Individual items

### Tip #1: Look at Similar Cases Before Writing Yours

There are many ways to organize cases. Look at others’ cases for ideas on how to structure yours. You may find an existing case that will serve your needs as well as one you write yourself.

### Tip #2: Get Feedback on Your Case Idea Sooner, Not Later

Once you have a skeleton of an idea and a rough outline of the flow, describe them to 1-2 colleagues and 1-2 students to see what they think. If you still like your idea after you have explained it a few times, and your students seem interested in the concept, you have a working starting point.

### Tip #3: Write for Flexibility

Write the case so you can adjust it later. Inevitably you will need to revise or adjust a case. A case that only works one way is more likely to be dropped after a couple uses than a case with options to go in different directions.

Supplement A: What Do Teaching Cases Look Like?

What ARE Cases?

Cases are not new. Case-based teaching has been common in medicine, allied health, law, and business for several decades. Cases written specifically for basic STEM fields first emerged in the early 1990s; while not as widely used, they are well-established active teaching and learning tools.

All cases have a scenario or story that introduces a question or problem. The scenario is what draws students in and makes the exploration authentic. Cases can be categorized by their point of view, workflow, endpoint, length, and delivery method.

##### Point of View

**Historical cases** lay out a story of a past event with known outcomes. Business schools use these regularly. Even if the students are familiar with the general outcomes of historical cases, they can learn a great deal by analyzing data that were not known at the time or considering facts that are not common knowledge. **Discovery or narrative cases** lay out an unfolding story. The scenario can be entirely true, based in part on actual events, or completely fictional.

##### Workflow

A case can be either continuous or interrupted. For a **continuous case**, students receive all case materials at one time. They can work at their own pace, and usually there is one final debriefing or discussion at the end. Continuous cases are more common in business schools. In an **interrupted case** the instructor gives students the case piece by piece. Group work or facilitated discussions takes place before each new piece is revealed. The process guides students to intermediate points that will help them reach the end goals. Interrupted cases are more common in STEM, and standard for the problem-based learning cases used in the health professions.

##### Endpoint

**Closed-ended cases** have specific content knowledge or skills goals. For example, a case that trains students to read a logistic population growth curve has a specific goal would be an example. A case that leads them to classify poems according to criteria that the group has developed would be a closed-ended case. **Open-ended cases** do not have a specific knowledge goal, but instead emphasize general thinking processes. An open-ended case might ask students to evaluate data on groundwater contamination and decide whether to close a local tourist attraction. Bioethics cases often are open-ended. In practice, the distinction between open and closed is not critical, and a longer case can have both open and closed endpoints. I include these categories primarily to help with case development.

##### Length

**Single session cases** can be completed in a single class meeting. I include 2-day cases in this group (i.e., students work through the case one class session, then report back the next class meeting), because the planning and logistics for a 1- and 2-day case are similar. **Multi-session cases** require 2 or more class meetings to complete. Multi-session cases tend to have multiple learning and outcomes goals and require more outside research by the students. Some “flavors” of case teaching (explained below) use multi-session cases exclusively. Teaching an entire course entirely with multi-session cases IS possible but requires considerable planning and development.

Cases do not have to take an entire class session. **Mini cases** can be completed in part of a class session. I have seen references to **micro cases**, but personally I do not see a clear distinction from a class think-pair-share activity. If the activity has pre-written guide questions connected to it, I treat it as a mini-case. If students are discussing a question informally and debriefing, it is a think-pair-share activity.

##### Delivery Method

Case teachers toss around names for different case teaching strategies. Naming cases for the delivery method helps instructors find the type of case they need, but it can discourage them from exploring cases they might find useful. In practice, many cases can be modified for other delivery methods.

The classic delivery method is to give students printed handouts that they read and discuss face to face. This works well in classes up to 40 students but is hard to do in a larger group.

For larger classes, cases using embedded clicker questions are one solution. In a clicker case, most or all student response questions have been written to use clickers. Students discuss questions with their classmates, then respond as a team to the questions.

Video cases present the scenario and background via pre-made video rather than text. Related to these are flipped cases, where students watch videos or do exercises beforehand to learn basic concepts. In class, students work on single or multi-session cases where they must apply what they have learned.

Shared Features of Cases

Besides the story, most cases have pre-written guide questions that direct students’ learning and group discussion, plus keep students and teachers on task and less likely to wander off topic.

Most cases have one or more deliverables. These are assignments that the students must complete and bring back to class for follow-up activities. Researching a topic outside of class and bringing the results back for discussion would be an example of this type of deliverable. Other deliverables get turned in for credit. Many instructors default to written work but deliverables can be virtually anything.

When creating the deliverables for a case, it is a good practice to have at least one item that students complete and turn in individually. Otherwise, social loafers can take advantage of their group to avoid working. There also are evaluation strategies to discourage social loafers.

Teaching cases from a repository usually have separate supplemental notes for the instructor. Good supplemental notes describe:

* The intended audience and prior knowledge needed;
* The learning goals and process skills students will use;
* How the case flows from point to point;
* Logistics the instructor needs to manage when have in using the case; and
* Reasonable responses to the guide questions.

**I strongly encourage case writers to create supplemental notes for ALL of their own cases.** They do not need to be complicated, but in my experience when you pull a case out again after 6-12 months, you will not remember many of the details of the case. Supplemental notes help you pick up an old case and refresh your memory quickly. They also make sharing a case with other instructors easier.

Where to Find Cases

You have three options: use an existing case from a repository, use a case written by a colleague, or write your own. **Regardless of the source of your cases, decide what your learning outcome goals are FIRST**. If you do not know where you want your students to be at the end, it is extremely easy to pick a case that goes in a direction you did not intend.

### Using a Published Case

Most instructors start out using cases written by someone else. The advantage of a published case is it has supporting materials and guidelines for using it. The drawback is that a published case almost always needs editing and revision to match what you want to do. If a published case needs to be revised to fit your needs, go right ahead. So long as you do not re-publish the case and only use it for educational purposes in your own institution, revisions do not violate any copyright laws.

To find suitable cases of your own:

1. **Decide your learning goals for the topic you want to teach using a case.**
2. Pick a repository to search (some are listed in **Resources**) or use Google.
3. Choose key words from your learning goals and enter them as your search terms in the repository index. Cases in the repository that match those terms should be displayed.
4. Scan the learning goals and abstracts to see if the case fits your criteria. Personally, what I look for in declining order of importance is:
   1. Topic of the scenario. Is the story one that your students will find interesting? Is the topic one where you would feel comfortable?
   2. Student level. A case for advanced majors will take a lot of editing to revise for non-majors, and vice versa.
   3. Time needed. You can cut parts out of a multi-session case to make it fit into one session, but that takes time.
   4. How closely the goals of the case fit ALL of my teaching goals for the topic. The more our two goals overlap, the less time I will need to spend revising the case.

My suggestions for how to revise and refine an existing case are:

1. Revise the guide questions and deliverables FIRST so they match your learning goals. If your questions and activities are aligned to your goals, it is **much** easier to revise the narrative to fit.
2. When in doubt, shorten the case. In my experience, most published cases are too long.
3. Imagine how long the case will take your students, then double that estimate. Students need processing time to get to the same thinking state you are in as you read the case.
4. Make notes about how the case went as soon as possible after the session. Your memory will fade very quickly once the adrenaline wears off.
5. The first couple of times you use a new case, reserve some class time for debriefing it. Ask students **specifically**:
   1. What were the learning goals of this case? If the students cannot identify the goals **by the end**, then you might need to revise the narrative or introduction.
   2. What did they find to be interesting? What could be removed? What more do they need? Make appropriate adjustments for the next iteration.

Supplement B: Writing Your Own Cases

At some point you will have a topic for which there simply is no good case. Or you will find all available cases require more time to revise than it would take to write one from scratch. Writing your own cases lets you control every aspect of the story and make it exactly what you need. The downside is *de novo* cases require more time and effort. That said, **do not be afraid of writing your own cases**. You can easily create clicker mini-cases for large enrollment classes in a couple of hours, which is good practice for creating longer ones.

### Getting Inspiration

Kip Herreid, the founder of the National Clearinghouse for Case Studies Teaching in Science (NCCSTS), always says, “to write a case, start with a story.” You may have a specific story in mind that you want to build a case around. If not, these three exercises can get you started.

**Applied Thinking - Daily News:**

As professionals we read and process news differently than our students. Pick a story published in the **last 24 hours** that is relevant to an open question in your field or to a topic that you think students should understand better but do not currently. That story is the starting point for writing your case.

**Making Connections - Trigger Points:**

Pick a major event or change in your discipline. Now pick a seemingly minor event, development, or other factor that CONTRIBUTED to the bigger event. How the earlier event contributed to the latter one is the starting point for writing your case.

**Teaching Challenge - Specific Skill:**

Pick a teaching challenge you run into regularly. It can be a skill you want students to develop more fully, or a recurring problem (citing sources, for example). Addressing that skills gap is your starting point for your case.

### Getting Started

How I write a case is not the only way to do it. Every case author has their own approach. I’ve tried following other authors’ recommended workflows, but they do not work for me. Even so I encourage new case authors to look at how other case authors suggest doing it, and experiment until you find a comfortable workflow.

Personally, I prefer to start with my learning goals.

*“What do students need to know conceptually? What should they be able to DO?”*

Next I ask:

*“What situation, problem, or scenario will get students thinking about these concepts, and exercising these skills?*

Then I ask:

*“What AUTHENTIC deliverable can I ask for?*

Finally, I jot down a couple ideas for the storyline, and guide questions I could ask students. These rough notes are **very** brief; usually I can fit them on a 4x6 index card.

If I still like my rough idea, I take it for a walk. I pitch it to other teachers who use cases, and some students whose opinion I trust. Usually by the third or fourth time I’ve explained my idea, it has solidified into a draft that I can build out, morphed into something new but still useful, or fallen apart.

Once I have a solid idea, I start writing in earnest.

* For single- and multi-session cases I write a first draft of the scenario, questions, and deliverables, then flip between them several times while making revisions. For these longer cases, I want to be certain that the deliverables align with the learning goals, and that the questions guide students towards those goals.
* When I write a mini-case, I usually write a complete story, then insert guide questions that connect the story to my learning goals. I usually use mini-cases as part of general class activities, so my mini-cases do not have a final deliverable.

##### How Long Does Writing a Case Take?

It varies. Personally, I try to start writing mini-cases at least a week in advance of when I need them. I give myself 1-2 hours to write the draft, then 2, 20–30-minute blocks of time over the week for revisions. A couple times I have written mini-cases on the spot for class, but that is something I **do NOT recommend** doing routinely (unless you like having gray hair!)

Multi-session cases take longer; how long depends on their complexity and length, the background research needed, and what kind of visuals are available. For my cell and molecular biology course, each two-session, closed-ended case had both content knowledge and thinking skills goals, and required a significant amount of background research. I estimate each case required ~30 hours to develop. This might seem unsustainable, but I **always** write cases assuming I will reuse them. Out of the 8 cases I developed for BIO265, I have only dropped 1 case for a different topic. Of the remaining 7, 4 have required less than 2 hours of revision in 3 subsequent semesters, and 2 have required 4-5 hours of revision over 3 subsequent semesters. Only 1 case has required more extensive revision (and to be fair, it is the most challenging topic for students to understand.)

The most time I personally have ever spent was for a two-session video case (“What Happened to Beau?”) I created as part of a grant-funded workshop for the National Clearinghouse for Case Studies Teaching in Science. Writing the text and storyboard took approximately 25 hours. Creating the two associated videos and supporting quizzes and documentation took another 50 hours.

##### Common Mistakes When Writing Cases

I cannot speak for every case writer, but I can say what my experiences have been.

* **Fixating on one idea**. I get several bad ideas that I have to discard for each good case idea I can build out. If your idea is not coming together into a good story, put it aside (I have a folder full of half-baked cases on my computer) and try a different one.
* **Forgetting to make the case relevant TO STUDENTS**. You might love the story, but if it does not engage the students’ curiosity or get them to invest emotionally, it is no different than lecture.
* **Trying to do too much in the time you have**. This is something I really struggle with. A rule of thumb when starting out is that a mini-case with one paragraph of reading, 1-2 guide questions for group discussion, and 1 follow-up question will take around 30 minutes of class time. You can adjust that once you know how your own students will respond to your cases.
* **Over-polishing a case**. A good case should be realistic, so it needs to be a **little** messy. If you remove every rough spot, students will not have to engage in any meaningful struggle to understand and interpret the case scenario.
* **Over-simplifying a case**. If the case is not quite right, be willing to revise it, but do so slowly. If students complain about a case being too hard, revise just the worst, most confusing step, and leave the rest alone until you put it front of students again and get more feedback.
* **Thinking that a case is “done**.” Cases change and evolve, just like students. You will constantly tweak and revise a case until eventually you grow tired of it, or it ages out and needs to be replaced with something that is more relevant or meaningful.

Classroom Logistics

A well-written case scenario POINTS student towards the desired learning outcomes, but how the case gets implemented determines whether students REACH them. Logistics can be divided into three parts.

##### 1. Guide Questions and Supporting Information

What initial questions will you ask students about this scenario that will require them to use a particular thinking strategy or apply a particular set of skills? If they do not know how yet, what questions would you ask to lead them through that process?

Generally, good guide questions:

* Are open-ended (no clear single best answer, and no simple answer).
* Can be discussed sufficiently by a group of 3-7 students in 10-20 minutes.
* Get students to think or act in ways that fit the learning goals.

You always should have some follow-up questions that can you ask that require students to apply or extend what they have learned in the discussion. Use these to challenge groups that finish early, or use them to extend the case discussion if it is running short. Good follow-up questions will:

* Build on the initial information surfaced by the first set of questions.
* Push the students to find the limits of the conclusions they just reached or make them find other example of principles they have learned.

##### *My Suggestions*

* Edit your physical handouts ruthlessly. Keep them as short and to the point as possible.
* Use clean, sharp, easy-to-read images without extraneous details.
* While writing a case you will likely collect a lot of ancillary materials. Do not throw that out after the case is written. When students start discussing the case, you may find that you did not provide enough supporting information. You should have some additional resources that you can provide in the event students get bogged down.
  + For example, if your case is about protein structure, you might assume your students know the structures of the component amino acids. If they do not, having a link handy for a web page showing amino acid structures can keep the case from falling apart.
  + Personally, I put links to online resources and names of supporting documents on a 1-page notes document that I can reference quickly. It is part of my facilitator notes.

##### 2. Student Products

How are you going to ask students to provide responses to questions or feedback? Keep in mind that student teams work at different speeds. You may find that a show of hands or clicker poll does not let you get feedback in a timely manner. If that happens, be ready with another response option.

A technique that helps keep groups moving is to put a summary table on the board, and have teams complete the table as they finish their discussion. Faster groups will take more time to fill out their row of the table. The slower groups need only fill in cells where their answers are significantly different.

When students are turning in responses for a grade, what format should they use? Where should they be submitted? Do you want one submission per team (what I recommend) or per person? Make sure students know this information and keep repeating it.

##### *My Suggestions*

* You will have a lot of submissions to grade, so keep them simple and focused. Try to find ways for students to demonstrate what they have learned that take less time to evaluate. For instance, ask students to draw a summary of a process rather than write a description of it.
* Have teams submit one group summary rather than individual assignments. If you want to ensure individual accountability:
  + Rotate who is responsible for submitting the final group summary for each case.
  + Have the team keep a log of who contributed which parts of a larger assignment.
  + Include 1 reflection question that each student must answer separately.

##### 3. Practical Challenges

* How will you introduce the case?
* What size groups will you have? Will they be self-selected or assigned?

Inevitably things go wrong when you use cases. What will you do **WHEN** things go astray?

* The most common problem I run into is that the case takes longer than I planned. How could you shorten the case if time runs out?
* What technology do you need that could fail? What will you do if that happens?
* What is your Plan B if students don’t “get it”? What can you do to help them reach the learning goals you planned for?

##### *My Suggestions*

* **Don’t rely on any hardware or software that you do not trust 100% to be reliable.** I have seen case presentations that were choreographed marvels which failed because just one thing was not working.
* **Don’t let students self-assemble in groups.** Spend time to created balanced teams and keep them together for multiple cases.
* **Have backups for EVERYTHING.** I store all of my case materials online in multiple locations, so I do not have to worry about computer failures.

Evaluating Student Case Work

##### Dan’s Personal Two Cents

I think we put too much energy into trying to quantify student performance when we use cases. The fact is that any number we assign is nowhere near as valuable as the descriptive feedback we give students. That feedback is how students know whether they have met our expectations, and how to do better next time.

*The remainder of this section is excerpted with revisions from an essay posted on the NCCSTS website****:*** [***http://sciencecases.lib.buffalo.edu/cs/teaching/assessment/student-case-work.asp***](http://sciencecases.lib.buffalo.edu/cs/teaching/assessment/student-case-work.asp)*.*

*(Begin abridged excerpt)*

How do you grade students in classes with case teaching? There are a host of possibilities. Here we deal with only a couple. Let's start with the toughest.

### Evaluating Class Discussion

Business school case teachers do it all the time. It’s not uncommon for them to base the final course grade on 50% class participation. And this with 50-70 students in a class! This sends shudders up the spines of most science teachers. Yet, what's so tough about the concept? We are constantly making judgments about the verbal statements of our colleagues, politicians, and even administrators. Why can't we do it for classroom contributions?

Most of our discomfort comes from the subjective nature of the act, something that we scientists work hard to avoid in our work-a-day world. It may be that we are even predisposed to become scientists because we are looking for a structured and quantifiable world. Flowing from this subjective quandary is the fact that we feel we must be able to justify our grades to the students. We are decidedly uncomfortable if we can't show them the numbers. This is one of the reasons that multiple-choice questions have such appeal for some faculty.

But let’s take a look at how the business school people evaluate case discussion. Some of them try to do it in the classroom, making written notes even as the discussion unfolds, using a seating chart, and calling on perhaps 25 students in a period. As you might expect, this usually interferes with running an effective discussion. Other instructors tape-record the discussion and listen to it later in thoughtful contemplation. Most folks, however, sit down shortly after their classes with seating chart in hand and reflect on the discussion. They rank student contributions into categories of excellent, good, or bad, or they may use numbers to evaluate the students from 1 to 4 with 4 being excellent. They may give negative evaluations to people who weren’t prepared or were absent. These numbers are tallied up at the end of the semester to calculate the grade. And that’s as quantified as it gets.

I especially like mathematician/philosopher Blaise Pascal's view of evaluation: “We first distinguish grapes from among fruits, then Muscat grapes, then those from Condrieu, then from Desargues, then the particular graft. Is that all? Has a vine ever produced two bunches alike, and has any bunch produced two grapes alike?” “I have never judged anything in exactly the same way,” Pascal continues. “I cannot judge a work while doing it. I must do as painters do and stand back, but not too far. How far then? Guess ....”

### Assignments

The simplest solution to case work evaluation is to forget classroom participation and grade everything on the basis of familiar criteria, say papers or presentations. This puts professors back in familiar territory. Even business and law school professors use this strategy as part of their grades. I’m all for this. In fact, I always ask for some written analysis in the form of journals, papers, and reports. Along with an exam, these are my sole bases for grades. I don’t lose sleep over evaluating class participation.

### Exams

You can give any sort of exam in a case-based course, including multiple-choice, but doesn’t it make more sense to have at least part of the exam a case? If you have used cases all semester and trained students in case analysis, surely you should consider a case-based test. Too often we test on different things than we have taught.

### Peer Evaluation

Some of the best case studies involve small group work and group projects. In fact, I strongly believe teaching cases this way is the most user-friendly for science faculty and the most rewarding for students. Nonetheless, even some aficionados of group work don’t like group projects. They say, how do you know who’s doing the work? Even if they ask for a group project, they argue against grading it. They rely strictly on individual marks for a final grade determination. I’m on the other side of the fence. I believe that great projects can come from teams, and if you don't grade the work, what is the incentive for participating? Moreover, employers report that most people are fired because they can’t get along with other people. Not all of us are naturally team players. Practice helps. So, I’m all for group work including teamwork during quizzes where groups almost invariably perform better than the best individuals. But we have to build in safeguards like peer evaluation.

“Social loafers” and “compulsive workhorses” exist in every class. When you form groups such as those in Problem-Based Learning (PBL) and Team Learning (the best ways to teach cases, in my judgment), you must set up a system to monitor the situation. In PBL it is common to have tutors who can make evaluations. Still, I believe it is essential to use peer evaluations. I use a method that I picked up from Larry Michaelsen in the School of Management at the University of Oklahoma.

At the beginning of every course I explain the use of these anonymous peer evaluations. I show students the form that they will fill out at the end of the semester. Then they will be asked to name their teammates and give each one the number of points that reflects their contributions to group projects throughout the course. Say the group has five team members then each person would have 40 points to give to the other four members of his team. If a student feels that everyone has contributed equally to the group projects, then he should give each teammate 10 points. Obviously, if everyone in the team feels the same way about everyone else, they all will get an average score of 10 points. Persons with an average of 10 points will receive 100% of the group score for any group project.

But suppose that things aren’t going well. Maybe John has not pulled his weight in the group projects and ends up with an average score of 8, and Sarah has done more than her share and receives a 12. What then? Well, John gets only 80% of any group grade and Sarah receives 120%.

There are some additional rules that I use. One is that a student cannot give anyone more than 15 points. This is to stop a student from saving his friend John by giving him 40 points. Another is that any student receiving an average of seven or less will fail my course. This is designed to stop a student from doing nothing in the group because he is simply trying to slip by with a barely passing grade and is willing to undermine the group effort.

### Observations

Here are some observations after many years of using peer evaluations:

* Most students are reasonable. Although they are inclined to be generous, most give scores between 8 and 12.
* Occasionally, I receive a set of scores where one isn’t consistent with the others. For example, a student may get a 10, 10, 11, and a 5. Obviously, something is amiss here. When this happens, I set the odd number aside and use the other scores for the average.
* About one group in five initially will have problems because one or two people are not participating adequately or are habitually late or absent. These problems can be corrected.
* It is essential that you give a practice peer evaluation about one-third or one-half of the way through the semester. The students fill these out and you tally them and give the students their average scores.
  + You must carefully remind everyone what these numbers mean, and if they don't like the results, they must do something to improve their scores. I tell them that it is no use blaming their group members for their perceptions. They must fix things, perhaps by talking to the group and asking how to compensate for their previous weakness.
  + Also, I will always speak privately to any student who is in danger. These practice evaluations almost always significantly improve the group performance. Tardiness virtually stops and attendance is at least 95%.

*(End abridged excerpt)*

Where to Learn More

The National Clearinghouse for Case Studies Teaching in Science should be your first stop. Founded by Dr. Kip Herreid at the University of Buffalo, NCCSTS has > 900 STEM teaching cases, plus resources for writing, implementing, and evaluating cases. NCCSTS was adopted by the National Science Teachers’ Association (NSTA) after Dr. Herreid’s retirement. The current URL is:

<https://www.nsta.org/case-studies>

Two good print resources written by Dr. Herreid are:

1. *Science Stories: Using Case Studies to Teach Critical Thinking*, edited by Clyde Freeman Herreid, Nancy A. Schiller, and Ky F. Herreid, NSTA Press, 2012. A compilation of case studies with questions and teaching notes that can be used to help develop STEM students' critical thinking skills.
2. *Start with a Story: The Case Study Method of Teaching College Science*, edited by Clyde Freeman Herreid. Originally published in 2006 and reprinted in 2013, these 40+ essays examine every aspect of the case study method. Includes examples of case studies as well as strategies, tips, examples, ideas, and resources for applying the case method to the science classroom.

**Other Resources**

Pedagogy in Action - SERC Portal for Educators: Teaching With Cases

<https://serc.carleton.edu/sp/library/cases/index.html>

A general introduction to case teaching.

UIUC Center for Innovation in Teaching and Learning: Problem-Based Learning

<https://citl.illinois.edu/citl-101/teaching-learning/resources/teaching-strategies/problem-based-learning-(pbl)>

Problem-base learning (PBL) is a case-based teaching method popularized by McMasters University School of Medicine and used worldwide. It differs from project-based learning (also going by PBL), which has a different instructional focus.

Lundeberg, MA. 2008. Case Pedagogy in Undergraduate STEM: Research We Have; Research We Need

<http://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_072622.pdf>

This white paper from a National Academies workshop provides a high-level overview of the origin of cases for STEM teaching.

Farhoomand, A. 2003. Writing Teaching Cases: A Quick Reference Guide. *Communications of the Association for Information Systems* (12)103-107.

The World Association for Case Method Research & Application (<http://wacra.org/>) has resources on case methods for a variety of subjects. One of the most interesting I want to explore more is SWIF (student-written, instructor-facilitated) cases; go to <http://www.wacra.org/student%20case%20writing%20guide%20-%20swif%20manual.pdf> to learn more.

Supplement C: Example of an Interrupted Case

Gene Regulation in Autism

*NTC 2023 Workshop Notes:*

* *The Background section is pre-class reading that is posted 5 days in advance on the course LMS site. All of the information up to “Why Do We CARE” is a recap of general concepts covered on the first day of this topic module or earlier in the semester.*
* *“Our Model System” introduces ASD and explains the connection to gene regulation.*
* *Details have been generalized and simplified to make this case a manageable length and difficulty. If students want to know more, I have pre-selected review articles.*

**Background**

We have seen in class how cells can regulate gene activity at multiple points. They include:

1. **Regulating chromatin structure and accessibility.**   
   The structure of chromatin is based on histone acetylation and methylation, and DNA methylation. These modifications determine whether DNA is organized as euchromatin or heterochromatin.
   1. While DNA is in euchromatin form, it is available for use by the cell, but when the DNA in heterochromatin form, it is not available.
   2. DNA is not always one or the other; it can differ:
      1. Between cell types (for example, genes in euchromatin in liver cells may be in heterochromatin in neurons), and
      2. At different stages in the cell’s life such as before vs. after it has differentiated.
2. **Regulating promoters and transcription.**  
   Assuming DNA is available for transcription, cells regulate how often RNAs are transcribed by:
   1. controlling assembly of core promoter s(TBP/TF-IID and related proteins);
   2. controlling specific transcription factors that stimulate (enhancers) or inhibit (repressors) activity of the core promoter; and
   3. changing the rate at which RNA polymerase II moves along DNA by modifying its C-terminal domain.
3. **Modifying RNA structure to regulate its half-life, and the final protein products.**As RNAs are transcribed:
   1. Splicing machinery removes introns and creates alternatively spliced mRNAs.
   2. Length of the polyA tail is adjusted to control mRNA activity and stability.
   3. 5’ and 3’ UTRs bind proteins that control mRNA half-life.
4. **At the level of translation.**Cells frequently adjust the rate of translation by:
   1. Making miRNAs that block mRNA translation and tag it for destruction.
   2. Turning eIFs 1, 2, and 4 on/off by chemical modification.
   3. **Both processes** are regulated by signaling paths that tell the cell:
      1. if it has the resources it needs to make proteins, and
      2. if environmental conditions will let it make the proteins safely.
5. **Through post-translation modifications, compartmentalization, breakdown.**   
   In Topics 4 and 5 we will see other ways that cells regulate the functions of proteins **after** they have been translated and folded.

***Why Do We CARE About Where and How Genes Are Regulated?***

The first heritable diseases for which we worked out mechanisms are caused by a single well-defined gene mutation. Examples include sickle cell anemia (caused by a single base mutation in beta globin) or hemophilia (caused by a mutation in the coding region of the gene encoding one of the clotting factors). However **most diseases with an inheritable predisposition are not easily mapped to one gene.**

We know that genetics contribute to cardiovascular disease, cancer, Alzheimer’s, and many other diseases, but we do not have clear causality where Mutation A causes Error B that leads to Outcome C. Instead, these disease or conditions are the result of **a network of faulty interactions** caused by:

* Inherited DNA mutations,
* Faulty epigenetic regulation,
* Improper transcription and translation of functional proteins, **and**
* External environmental factors

We are going to explore how maladaptive processes **interact** with each other by looking at how they come together to disrupt normal brain development.

***Our Model System***

Autism spectrum disorders (ASD)are a family of neural developmental disorders defined by **four clinical features**:

1. Impaired ability to engage in social interactions or make social attachments.
2. Impaired speech and communication, especially in social situations.
3. Repetitive patterns of behavior or actions.
4. Restricted attention and interests.

There is considerable variation in the severity of these traits. This is partly why ASD is considered a family of related disorders. Current evidence suggests ASD is caused by a c**ombination** of inheritable DNA mutations, faulty epigenetic and transcription controls, defective functional proteins, and environmental factors. We are going to leave out the environmental factors for now and focus on the other elements that are occurring INSIDE of the neurons.

I selected 15 genes for which there is reliable evidence of a **link** to autism spectrum disorders. I will provide you with a table that lists the standardized Gene ID in the human genome, full name, and a **general description of its function**.

NONE of these have a mutation that is sufficient by itself to be the single “cause” of autism. However, mutations or other changes in each of them have been shown to potentially CONTRIBUTE to autism. Your goal as a team is to identify the **smallest possible subset** of mutations or errors in these genes that, **acting together**, can produce the full set of abnormal behaviors and development changes we call ASD.

*(Note: It is not required to complete the case, but if you want more information about any gene, search for it in GeneCards (*[*https://www.genecards.org/*](https://www.genecards.org/)*) using the Gene ID. For more on a specific disease, search the MalaCards Disease Database (*[*https://www.malacards.org/*](https://www.malacards.org/)*).)*

**Your Team’s Specific Tasks**

On **Wednesday** you will:

* Identify which of the distinctive traits of autism **each** gene might be causing or promoting.
* Decide whether each gene is involved in:
  + Epigenetic regulation,
  + Transcription control,
  + Translation control,
  + Neuron or brain development, or
  + General neuronal cell function.
* Propose a model for how autism develops that uses the **smallest** number of genes possible.

On **Friday**, your team have 5-8 minutes in class to explain your initial model.

* Please use an illustration or diagram showing what your model looks like.
* Hand-drawn sketches are fine; the point is to have something the other teams and I can LOOK at as you explain your thinking.
* **Send me your sketch in advance of class so I can project it.** You will have a chance to revise your model before you submit it on Saturday.

On **Saturday** what you will turn in is:

1. A finalized list of which genes are linked to epigenetic control, to transcription control, to translation and expression, and to end functions in the cell.
2. A short (1-2 paragraphs at most) description of your proposed model for how a minimum number of genes causes autism, and your reasoning behind it. Include a figure or diagram showing how the genes interact. (Basically, a revised version of what you presented on Friday.)

**Topic 3 Case: Data Handout For Day 1**

|  |  |  |
| --- | --- | --- |
| **Clinical Features to Explain** |  | **Level of Control or Effect** |
| Impaired ability to engage in social interactions or make social attachments. |  | Epigenetic regulation |
| Impaired speech and communication, especially in social situations. |  | Transcription control |
| Repetitive patterns of behavior or actions. |  | Translation control |
| Restricted attention and interests. |  | Neuron or brain development |
|  |  | General neuronal cell function |

***Table 1: Genes Linked to Autism***

The genes are listed in alphabetical order by the Gene ID.

|  |  |  |
| --- | --- | --- |
| **Gene ID** | **Gene Product Name, Information** | **Probably Acts At Level of \_\_  & Why?** |
| ANKRD11 | Ankyrin repeat domain protein 11.   * Recruits histone deacetylases to chromatin, modifying histone acetylation and gene expression * Has a role in proliferation and development of cortical neuron precursors * Loss of this gene leads to intellectual disability. |  |
| ARID1B | AT-Rich Interaction Domain 1B.   * Part of SWI/SNF chromatin remodeling complex. * Regulates cell cycle activation, progression to mitosis. |  |
| CHD8 | Chromodomain Helicase DNA Binding Protein 8   * Unwinding of DNA in transcription, promotes cell proliferation, and regulates RNA synthesis. |  |
| FOXP2 | Forkhead box transcription factor P2.   * Binds directly to ~400 gene promoters. * Regulates a variety of genes. * Expressed in fetal and adult brain. * Mutation causes speech & language impairment, cognitive impairment, delayed motor development. |  |
| HIST1H1E | Histone 1.4.   * Binds to DNA between nucleosomes. * Mutants lack the lysines, arginines needed to hide negatively charged linker DNA, & for protein-protein interactions. |  |
| IMMP2L | Inner Mitochondrial Membrane Peptidase Subunit 2.   * Transports proteins into mitochondria. * Controls one path to apoptosis. |  |
| KCTD13 | K+ channel tetrameric domain 13 protein   * Part of E3 ubiquitin-protein ligase complex. * Sends RhoA to proteasome for destruction in synapse formation. * Essential for behavioral self-regulation. |  |
| KDM5C | Lysine demethylase 5C   * Involved in regulation of transcription, chromatin remodeling. * Mutations associated with X-linked cognitive disability. |  |
| MeCP2 | Methyl CpG binding protein 2   * Binds to DNA w/histone deacetylases (HDACs). * High concentrations in brain neurons. Associated w/ maturation of brain and forming new synapses. * Without MECP2, unrepaired DNA damage accumulates. * Mutation causes Rett syndrome (a type of ASD), with repetitive stereotyped behavior. * Children with non-Rett forms of ASD do not have MeCP2 mutations, but brain levels of MeCP2 are reduced. |  |
| OXTR | Oxytocin receptor   * Oxytocin/receptor are important in uterus during birth, & for forming parent-child attachment. * No alternative splice variants or sequence mutations in the coding region of this receptor have been found in ASD children. |  |
| RAY1/ST7 | * The gene is in a region on chromosome 7 known as ***autism-susceptibility locus***. * Sequencing of region in autistic children did not find any specific mutations. * There is RNA transcribed from the gene, but no known proteins are translated from the RNA. |  |
| RELN | Reelin   * Regulates neural cell migration in developing brains. * After birth it regulates synapse remodeling. |  |
| SHANK3 | Shank protein 3.   * Scaffold protein in dendrites links neurotransmitter receptors and ion channels to the cytoskeleton and holds them in place. * Needed for synapse formation on dendrites. |  |
| UBE3A | Ubiquitin protein ligase E3A.   * Breakdown of RhoA is required for synaptic transmission. * Ubiquitin ligase E3A is part of the complex that sends RhoA to the proteasome for destruction. * Mutation causes Angelman Syndrome: severe motor and intellectual retardation, muscle weakness, seizures, loss of speech, facial defects. |  |
| ZNF778 | Zinc Finger Protein 778.  (Zinc finger proteins form specific DNA binding sites.   * Required for normal development of cognitive skills. * Mutations cause cognitive impairment. |  |