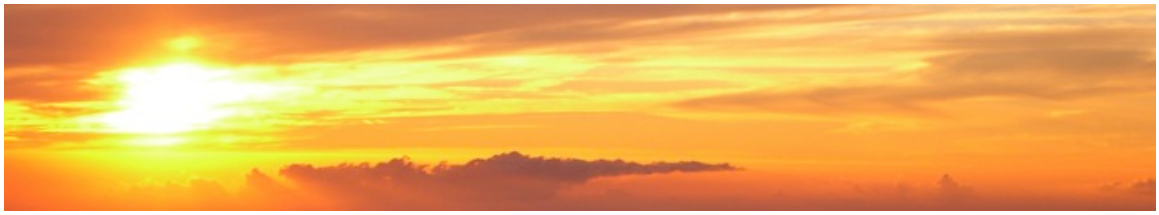


# Instructor's Manual

**Module 8:** ***An Overview of Air Quality in the Mid-Atlantic United States***

**A. Typical class length:**

45-60 minutes (edited); 90 minutes (unedited)

**B. Target students:**

General public

**C. Module objectives:**

The goals of this module are to have the students:

- Understand why they should be concerned about air pollution
- Learn about the important air quality challenges in the Mid-Atlantic US
- Know where to find information about air quality in their community
- Discover how they can help improve the air quality

**D. Instructor preparation:**

Go to the course web site and download all relevant materials for Module 8:

Instructor's Slides (Powerpoint)
Student Handouts (PDF)
Instructor's Manual Overview (PDF)

http://bigmac.cee.mtu.edu/marama/Modules/Modules.html

Review all the materials, particularly terms and concepts. For any terms you might not know, look them up on one of these online glossaries:

Terms and concepts: http://www.epa.gov/oar/oaqps/peg_caa/pegcaa10.html
Acronyms and abbreviations: http://www.epa.gov/air/acronyms.html

Warning! If you need to look up more than a couple terms or concepts, you may not be the right person to teach this class. Research shows that one critical component for a successful class (both retention of knowledge and enjoyment) is having an instructor with expertise in the material being taught.

There is more material provided in the Instructor's Slides than can reasonably (and effectively) be delivered in a standard one-hour class setting. You have two choices: extend the class time (this could take 90 minutes or more to cover everything), or edit the materials. Additionally you should make any changes you feel are necessary for your version of the course, altering it to reflect local air quality issues, timely news events, or

meaningful examples for your particular students. Your class should be unique to you, the provided materials are only a resource to build off. Once you have set the course materials, master it (practice never hurts), then deliver your class!

**E. Understand the sub-module objectives**

Each course module is constructed of a series of sub-modules based on modern learning theory. The sub-module typically focuses on a narrow aspect of the module topic. The module can be viewed as the collection of several discrete topics presented in a fashion more appropriate for the range of learning styles among students in your class. Most sub-modules are constructed around a *motivation-theory-application-analysis* learning cycle. While it is good practice to have this cycle for each sub-module, it is acceptable to have a portion of the sub-modules that do not have all four components of the cycle. In general though, it is poor practice to have only the theory sections, as this will likely achieve the low-retention rates found in lecture-based learning environments. The rest of this manual provides tips and insight into specific slides. Please refer to the *Module 8 Instructor's Slides* to follow along.

**Sub-Module 1: Introduction (Slides 1-5)**

The primary purpose of these slides is to engage the student almost immediately upon entering the classroom. Educational research suggests that in a typical class, the first ten minutes is lost on most students as they are disconnecting from what they were previously doing. A suggested approach for this phase of the module is:

Slide 1 – Have this projecting before the students enter the classroom. Each module starts with a photograph connected to the content. Most students will subconsciously begin thinking about the course material when looking at a photograph. In this case, maybe it simply makes them realize how beautiful the atmosphere can be.

Slide 2 – Introduce the topic. This will make sure everybody in the room belongs in the class.

Slide 3 – This slide serves as the initial motivation section. Feel free to substitute a similar compelling fact, observation, or finding from your own experiences. This slide should be put up long enough for the students to review, and perhaps some short comment from you. Note that the increases in asthma rates is connected to outdoor air pollution (the subject of this course), but is also dependent on exposure to indoor air pollution (which is less regulated and controlled), and perhaps on better diagnosis of the disease. Regardless, because more people have asthma, there is even more urgency in solving problems that can trigger asthmatic attacks (for example elevated ozone and particulate levels).

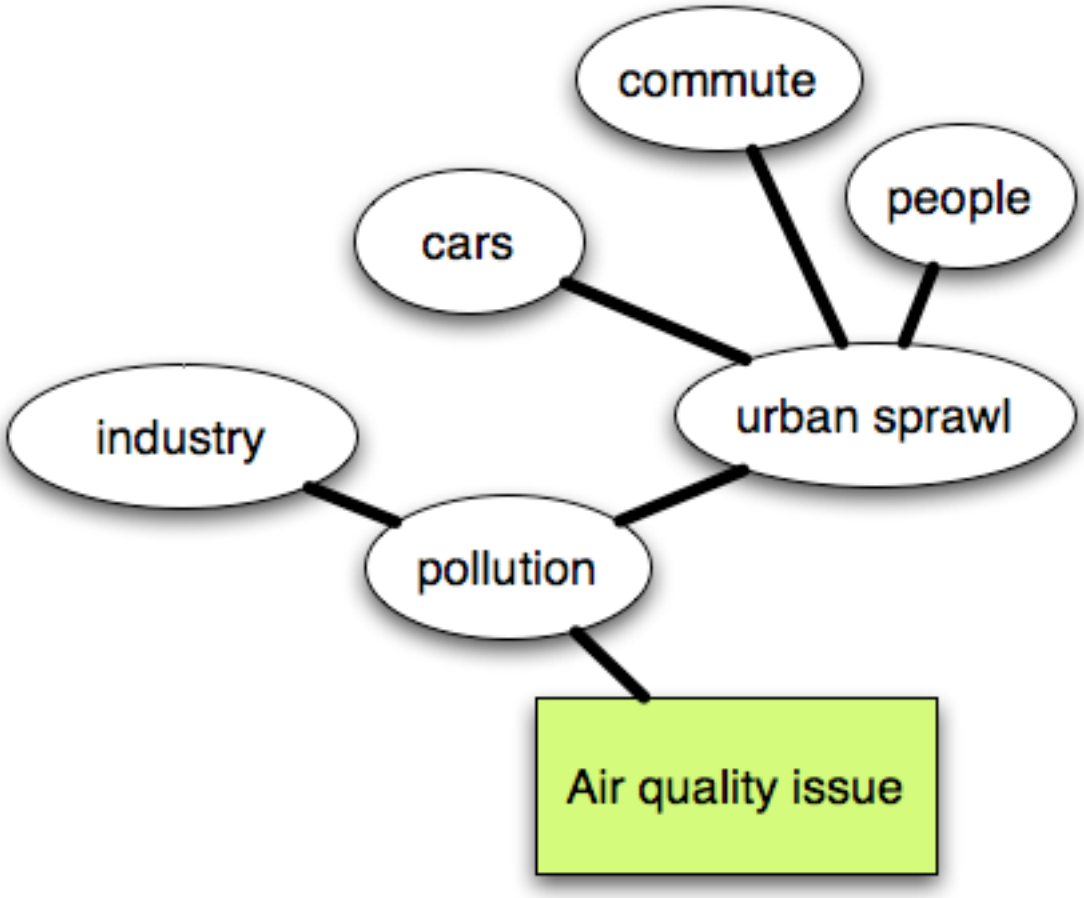
Slide 4 – All modules have a preliminary quiz. The purpose of the preliminary quiz is two-fold: (1) it gets the students thinking more about the subject, and (2) gives you a comparative benchmark at the post-module quiz. Feel free to substitute questions with some of your own, but bear in mind that the total time expended here should be about two minutes. Simply have the students circle the answers on their copies of the student

handouts, or produce a handout quiz if you want to tally the results. One way to engage the class as a whole is simply to ask for a show of hands for each answer. The solutions to this quiz can be found in the post-course quiz slide below (Slide 46).

Slide 5 – The course goals slide is a good one to emphasize. Tell the students clearly what they will learn by the end of the class. If you add to, or delete, any material modify the course goals as needed.

**Sub-Module 2: Impacts (Slides 6-9)**
The primary purpose of this sub-module is to address the first course objective, namely why air pollution is a concern.

Slide 6 – There is no better way to assess what the current state of knowledge among students than concept mapping. This will be extremely critical for all classes, but particularly one offered to the public. You can use this to fine-tune the terms you use and ways needed to explain concepts. The technique is simple: in the middle of the page write the key concept and put a box around it. In this case it might be "air quality issue". From there, the student groups simply connect concepts to this central concept. For example one related concept might be "pollution", and then connected to pollution, might be "industry" and "urban sprawl", and so on.



There are no right or wrong ways to do a concept map – it's simply a depiction of how somebody (or a group) has information organized in their heads. The maps are likely to reveal misunderstandings and wrong information. Good! The students might learn something in your class. If possible provide some large sheets of paper and markers so the students can share their work. If such paper is not available, blackboards, or transparencies work. Be careful, you can easily eat up a lot of time on this activity. Tell the students they have five minutes to work on this. This activity also helps the class reach a higher comfort level.

Slides 7 – This slide paints a depiction of the big picture. The major components of any air quality issue are depicted here: emissions are then affected by transport and chemistry, resulting in impacts. The impacts (unfortunately) often drive solutions to these problems (instead of doing something up front to avoid such problems in the first place – i.e. pollution prevention approaches). This is also a visual representation of many of the topics that are covered in this class.

Slide 8 – This covers the two main ways that air pollution manifests impacts – human or environmental health impairment. Regulations are usually designed to protect human health (it is assumed that this level of protection will also ensure protection of the environment too).

Slide 9 – The slide has a few findings from a late 1990s report on the Costs and Benefits of the 1990 Clean Air Act Amendments (see the source identified on the page). In general it was found to be a 4:1 benefit-to-cost ratio – a return on money that any investor would love. In general impacts are more severe in the poorest communities of the U.S., where pollution levels are higher and the socioeconomic capacity to cope with disease is the lowest.

**Sub-Module 3: Pollutants (Slides 10-18)**
The goal of this sub-module is to address the second course goal, educating the students about the important pollution problems in the Mid-Atlantic.

Slide 10 – This slide presents several pollutants that are problems for the Mid-Atlantic, and introduces the NAAQS, a method to try to protect the public (and environment) from bad air pollution impacts.

Slide 11 – This is great graphic that shows which counties have problems with the two leading issues, ozone and fine particulate matter (PM2.5). The colored counties have concentrations of one or both of these pollutants that goes about the NAAQS at least once a year. As such, the communities in that area are under pressure from the state regulatory agencies to come up with solutions to reduce the emissions of the pollutants that cause these problems. Much of the Mid-Atlantic region has problems with both. Significant changes will be required to get these areas in compliance. See the Sub-Module 7: Solutions.

Slides 12-13 – With Slide 11 as a motivator for the scope of the problems, Slide 12 covers the basics of the ozone problem – specifically that ozone is not emitted, but rather formed in the atmosphere through a complex series involving hundreds of chemical reactions. The main ingredients are summarized in the chemical "reaction" provided. The challenges to solving the problem are substantial due to the many different sources that emit the organic compounds and nitrogen oxides. Slide 13 connects the problem with the array of sources. Another point worth mentioning is the role of weather. The strength of sunlight is important to drive the ozone production (*photochemistry*), as is the air temperature (in general warmer air makes the production happen faster and with greater results). This combination of processes: emissions, then chemistry, result in peak concentrations of ozone being formed by mid-afternoon. During the night, in the absence of sunlight, ozone is destroyed by various chemical reactions and the concentration generally decreases. At sunrise with an increase in emissions and sunlight, the cycle starts again. However, sunlight and temperature vary from place-to-place and day-to-day, so each day and place is different. Another complexity is the movement of pollutants (pre-cursor compounds or ozone) from upwind communities.

Slide 14 – This slide is an important one. The general public (and more than a few technical professionals) confuse the stratospheric ozone layer issue with the tropospheric ozone pollution (aka smog) problem. This slide attempts to clearly differentiate the two issues.

Slides 15-16 – These slides address the second major pollution issue for the Mid-Atlantic: airborne particulate matter. Slide 15 covers some of the types of sources (*primary*: direct emission, or *secondary*: made via reactions). Concentrations of PM are less variable than ozone due to less dependence on temperature or sunlight. Slide 16 covers some of the common sources of PM.

Slide 17 – An important point to get across is that particles come in many different sizes (Many different shapes, actually. None are truly spherical, but to make comparisons easier we estimate an approximate diameter for all particles.) Different sources create different sized particles (and different compositions too). The size is critical to its environmental behavior (how long it stays in the air, for example) and how it impacts people or the environment. The smaller particles have more severe health (respiratory) impacts as they can travel to the deepest parts of the lungs. These particles also make the skies hazy. Unfortunately, the smallest particles are the most difficult to control with modern emission control technologies. Like most pollution problems, it would be better if we could re-design products that currently generate fine particles in ways that they no longer do.

Slide 18 – This slide talks about trends. In general, ozone levels have not changed much over the past 15 years despite emission reductions on individual sources. Then why haven't ozone concentrations decreased? Ask the class. Growth in the number of sources is one problem. Engineering has improved, cultural habits have not. This may suggest something about the challenges to solving these problems.

**Sub-Module 4: Information (Slides 19-24)**
The goal of this sub-module is to address the third objective of the course module, identifying air pollution information resources.

Slide 19 – The AQI is introduced. The takes daily criteria air pollutant measurements and converts them into one number, hopefully making the general air quality easier to understand. For each large community (population > 300,000) the AQI is estimated for the coming few days. If it is expected that the AQI will be above 100, then health advisories are issued. While there are many locations in the Mid-Atlantic with AQI greater than 100 on several days of the year (often in summer), it is much rarer to see values exceed 200. The color coding is used by all media outlets to try to serve as a quick visual cue to the public.

Slide 20 – Several important points are demonstrated on this slide. An excellent online resource is introduced, AirNow.gov. If the classroom resources permit (and time allows), consider showing a few features of this web site to the students (this can consume a good deal of time, though, be careful). The graphics show one way that the AQI data is displayed at the AirNow site. The graphics also show an example of how AQI can change dramatically between locations and seasons.

Slide 21 – This is another data product at the AirNow site. These interactive maps show extra information when the mouse is moved over one of the communities on the map. In this case, Wilmington, Delaware shows that it is expected to experience a code orange day (AQI>100), and it is because of high levels of ozone.

Slide 22 – Information provided from the Delaware Department of Natural Resources and Environmental Control web site. This is typical of the kind of detailed information public available in most states. In this example, today and tomorrow's AQI forecast are provided with health advisories. Also details on the forecast are provided, in a similar fashion to weather forecasts. Some states even allow people to sign up for AQI alerts via email.

Slide 23 – This is an activity to get the students to think about what influences the AQI. Have them work in small groups if time permits (group work is slower), then offer an idea from the group. If time is short, then simply have the students offer ideas after a short amount of time reflecting. The AQI changes, because the criteria air pollutant concentrations change every day – due to changes in source emissions and atmospheric conditions (sunshine, precipitation, upwind source transport, etc.).

Slide 24 – Some publicly available resources to explore air quality measurements and data. Again, if time and resources permit, consider showing off a few of these sites. Consider finding the appropriate state air quality site for your audience too.

**Sub-Module 5: Sources (Slides 25-31)**
The goals of this sub-module are to address the second and fourth objective of the course, further understanding the problems (there is often a source connection) and beginning to understand the potential solutions (there is often a source connection here too).

Slide 25 – This slide introduces some important source terminology: whether the source moves or not (*mobile* or *stationary*), and an approximate geometric shape (*point* or *area*). Have the students offer a few sources near their homes. Encourage them to describe them with the terminology introduced on this slide.

Slide 26 – An example for one area for one pollutant. This is usually the way that emission totals are created. In this case, estimated nitrogen oxides emissions for North Carolina in 2007. The biggest emissions are *point* sources, followed by *mobile* sources. In North Carolina, some of the specific sources within each category include:

Area: residential fuel burning
Non-road: trains, airplanes, lawn mowers, off-road vehicles
Mobile: cars and trucks
Point: industries and power plants

With this mix of sources, what challenges exist to reducing $NO_x$ concentrations? Ask the students.

Slide 27 – Another example for North Carolina is provided to show the students how the source mix changes with pollutant. In this case a majority of the volatile organic compounds come from *biogenic* sources. Specifically,

Biogenic: trees
Area: dry cleaners, household paint and chemical usage
Non-road: trains, airplanes, lawn mowers, off-road vehicles
Mobile: cars and trucks
Point: industries and power plants

How could North Carolina possibly limit VOC emissions if most comes from trees? Ask the students. For ozone control, there is plenty of VOC in the air, but less NOx. Since both ingredients are needed (and much of the VOC emissions are from a desirable resource, trees), North Carolina's ozone reduction strategy focuses on reducing NOx emissions. Less NOx, less ozone, regardless of what the VOC levels are.

Slide 28 – A different perspective, now comparing emissions of the same pollutant emissions among the Mid-Atlantic states. Ask the students for any observations. One is that this pollutant has one major source type (*point*; specifically in this case, coal-fired power plants). Another clear point is that there are large differences in total emissions among the states. Why? Population. Energy generation differences. An important point is that some of the $SO_2$ is converted into fine particles in the air and can drift to downwind communities, elevating PM levels there.

Slide 29 – An example of emission data that is available at one online resource, AirData, via the U.S. EPA's web site.

Slide 30 – Time for the students to pause, reflect, and discuss in small groups. Hopefully they will point out the clear connections between population and $NO_x$ emissions (traffic, power generation, and non-road sources are particularly influential).

Slide 31 – The purpose of this activity is to connect this new knowledge to something the students have great experience with – driving! Solutions could include engineered solutions (changes to the vehicle), regulatory solutions (driving restrictions), voluntary solutions (taking mass transit), or others. Write the solutions on the white board or a blank Powerpoint slide. Ask the students which of the proposed solutions might be most successful, least successful.

**Sub-Module 6: Transport (Slides 32-39)**
The goal of this sub-module is to address the second objective of the course module, understanding air pollution problems that afflict the Mid-Atlantic.

Slide 32 – This slide covers in very basic terms some of the ways pollutants are transported. Most students should have personal experience (and hence intuition) about the wind and precipitation effects. The vertical movement due to temperature may be more challenging, and better explained by describing how a hot air balloon floats upwards or downwards depending on its temperature difference with the surrounding air. If it is hotter if floats, if cooler it sinks. Pollutant emissions can behave similarly as they are release out a smoke stack, for example.

Slide 33 – A schematic depicting how simultaneous scales of transport processes result in movement of air pollution through the Mid-Atlantic. Within each broad category there are several specific processes:

> Long range: global circulation, high/low pressure systems, jet stream
> Regional: channeling from the Appalachians, winds aloft
> Local: sea/land breezes, urban canyon channeling, vertical mixing, inversions

This is a complex subject, made more challenging because humans have little capacity to directly observe these phenomena. Keep the conversation simple, or refer students to an offering of Module 3: Air Pollution Transport in the Mid-Atlantic.

Slide 34 – An example of how transport processes add to the challenges in solving the Mid-Atlantic region's summertime air quality problems. This stationary high brings clear skies and nice weather, but also poor air quality. Which would the students rather do without?

Slide 35 – Another example of location, location, location. Flow channeled by the mountain range creates a unfortunate air quality problem. In this case the chain of urban

areas along I-95 makes for a succession of major metropolitan emissions each adding pollutants to the air as it flows northeasterly. What is a downwind community to do?

Slide 36 – This slide depicts the problem associated with restricted vertical mixing of the air (this phenomenon is referred to as an *inversion*). Due to the decreased vertical mixing pollutant emissions cannot disperse easily and the pollutant concentrations build-up in the air. Eventually, the air changes (either through the sun setting, or a front passing through the area), and the pollutants can disperse. The photos show how conditions can change dramatically in the course of a few days. In the top photo, the build-up of particles restricts the visibility (to about 10 miles), then four days later with change in weather visibility improves (around 50 miles).

Slide 37 –Some common topographical influences on the movement of air (and pollutants). Are there communities in the Mid-Atlantic that have two or three of these features?

Slides 38-39 – This is an activity for students to look at high-resolution images of ozone concentrations in the Mid-Atlantic over the course of one day (Slide 39). Explain that the colors are connected to the ozone concentrations (oranges and reds are above the NAAQS for ozone). The role of sunlight (and temperature) will hopefully be evident to the students. Also note the connection to urban areas (higher emissions, and generally more stagnant air).

**Sub-Module 7: Solutions (Slides 40-45)**
The goal of this sub-module is to address the fourth objective of the course, identifying potential solutions to the air quality problems of the Mid-Atlantic.

Slide 40 – This slide serves to introduce some potential solutions, but also get the class discussing what general approaches they favor. Encourage input from as many students as possible by calling on people.

Slide 41 – The heart of the challenge is given here: emissions *must* be reduced to improve air quality. There is no other approach. How we reduce the emissions is what must be figured out, and then implemented in a way to ensure success. Which part is more difficult (ways to reduce emissions, or the implementation methods)?

Slide 42 – Engineering solutions. American society places much faith in technology to fix our problems (technology usually caused most of the problems too). A few technological fixes are listed here. See if the students can give some specific examples, like:

Energy efficiency: hybrid vehicles, compact fluorescent light bulbs, etc.
Less-polluting chemicals: low VOC paints, pump (versus spray) hair products, etc.
Emission control systems: catalytic converter, power plant scrubber, etc.
Industrial process changes: automated paint booths, water-based solvents (instead of VOC-based), etc.

Slide 43 – This slide underscores that resources are limited. We need to choose where to focus are efforts to achieve the biggest return. Some air quality problems are aggravated by the contributions of local and regional sources – very different approaches are needed for such problems. Regional solutions require more agreement among states (or leadership at the federal level). For ozone improvements, new approaches (the Clean Air Interstate Rules) involve the Midwest in helping decreasing the concentrations found in the Mid-Atlantic, for example.

Slide 44 – The importance of this slide is two-fold: (1) to have the students realize that everyday activities have air quality impacts, and (2) that voluntary choice (and action) by the public can help. In addition to the starter list provided, there are many other possibilities, including:

Energy efficient appliances and furnaces
High gas mileage vehicles
Keeping tires at proper inflation
Respecting burn bans
Conserving fuel from heating/cooling

Consider asking the students which one(s) they are currently doing. Give an award to the student with the highest number.

Slide 45 – This slide serves one purpose: to connect air quality to economics (and perhaps more broadly, choice). In this case, when fuel prices rise (dramatically), people drive less, use less fuel, and hence generate less emissions. The decrease in mobile source emissions clearly would impact several air quality problems, most notably ozone. However, increased fuel prices disproportionately affects the poor, so this is not an effective solution, rather simply a forced consequence.

**Sub-Module 8: Conclusion (Slides 46-49)**
These slides provide a meaningful ending to the learning. Don't underestimate their importance.

Slide 46 – The post-quiz goes here. The students should only need 30-60 seconds. Collect their responses, if assessment is needed, else a show of hands with discussion is fine. The purpose of the post-quiz is simply to force retention of key points. The answers for this quiz are:

1.) *d)*, *People with preexisting lung or heart problems*. This is why they are the first category of people to be issued alerts in the AQI system. Infants are next most sensitive.
2.) One or more criteria pollutants has exceeded the NAAQS when *d) AQI > 100.* Then NAAQS were established to protect human health. The AQI is a simple way to communicate whether those concentration limits have been exceeded.
3.) This has two answers: *c) Particulate matter*, and *d) Ozone* are big problems for the Mid-Atlantic. Full credit only if both are identified!

Slide 47 – This slide has some resources for the students to learn more on their own. Add to it, as relevant. Encourage additional learning with references that you know to be particularly helpful. The first two (AirNow and AirData) are great resources to see real-time, historic, and forecast air quality data (look up some state web sites appropriate for the location of your class). The third resource, from a non-governmental organization, has similar data, but in a very easy to use interface (enter your zip code and read the results). The MARAMA Guide is particularly relevant for what's happening in the Mid-Atlantic. It is written in a very easy-to-read manner, yet has substance, and mentions several good references too.

Slide 48 – The moment to reflect is an important pause before concluding the class. It helps the student sort and summarize what they have learned, and if desired can be a good summative assessment for your efforts. For example, as an assessment tool, simply ask the students to write their response to the question on a scrap of paper and leave it behind following the class. Read through the responses to adjust any future offerings of the class. It will be extremely illuminating to learn what the students plan to do now that they know more about air quality. If time permits, have them share their thoughts. Are there similarities in planned actions, or large differences? This activity could take some time, so set time limits up front. Nevertheless, this activity will probably leave the students talking as they leave the course. Exactly what you want!

Slide 49 –Thank the class for coming and for their participation! This is a simple yet powerful way to end the class.