

# A “tree” model for blended online/in-class learning

David A. B. Miller

*Stanford University, Stanford CA 94305-4088*

*<http://www-ee.stanford.edu/~dabm/>*

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## ***Introduction***

The ability to provide online lectures, quizzes and other course materials offers many new opportunities for teaching and learning. Most university courses have, however, historically been based on conventional “sage-on-the-stage” lectures, together with term papers, problem sets, projects and assignments that are conducted largely outside the lecture classroom. Though we might believe there could be better pedagogical approaches, it is honestly intimidating for the lecturer who has prepared all of this material in the “old” format to imagine how they might restructure it in some “new” format, such as a “flipped classroom” approach where “real time” lectures are abandoned in favor of problem- or exercise-based classes. Indeed, it is not even clear if that approach is viable or valid for some classes, especially some more advanced or conceptual subjects. And if one does consign the lectures to an online platform, what then is the model in which the teacher continues active engagement with the class and adds value to the teaching and learning process?

The model I discuss here is one that I have evolved over some years of teaching with online components, and it attempts to chart a middle course. It uses online lectures, with their benefits of convenience and efficiency for the students (and for the lecturer!). It uses online quizzes and assignments, with their benefits of immediacy of feedback and grading (which saves some grading effort also). It does not require “flipping” the classroom (though it does not prevent that if it is appropriate). It retains active contact between the teacher and the students in class. It retains conventional “paper” problem sets, assignments and projects as appropriate; such conventional approaches work much better for many exercises. It also allows the class to evolve smoothly over time towards “flipped classroom” or other approaches if they are indeed appropriate.

This model is an example of a “blended” approach, with use of both online and conventional teaching, and with the flexibility to add new material and features. It is not based on any claim or presumption that it is the best approach to teaching and learning; rather, it simply offers a progressive, efficient and flexible path to exploiting the benefits of online approaches. I also make no claim that this model is particularly original or radical; it is merely a pragmatic approach taken by one professor.

## ***The “tree” model***

We can understand this model using a metaphor of a “tree” as sketched in Fig. 1. Most of the basic lecture material and some of the exercises are delivered through an on-line platform. This on-line material forms the “trunk” of the “tree” for the learning in the class. It leads the student through the core knowledge and skills in the class, in a progressive, linear approach. For example, in the online material in each course week, there will be a number – such as three – on-line “lectures” that can be built from the standard lectures previously prepared for a conventional class. The lectures are divided into short sections,

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with quizzes after each section (as is quite typical in online approaches). There will also usually be a further on-line assignment each week.

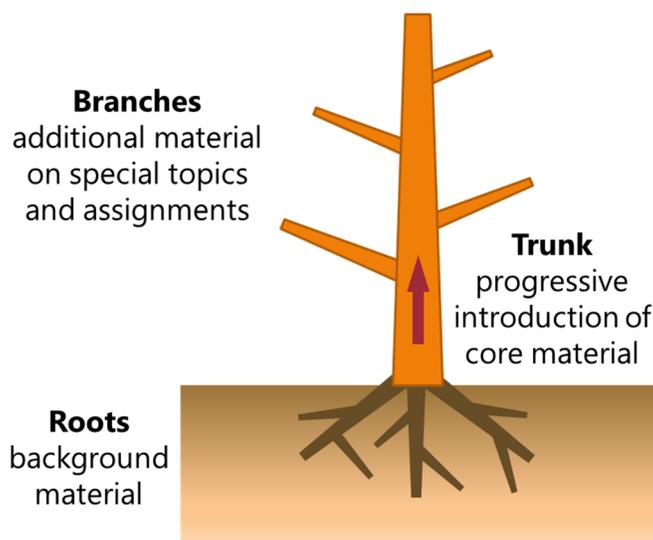


Fig. 1. A “tree” model for a blended class.

In addition to this on-line material, there are in-person classroom sessions each week. One approach I have taken for these is to have a two such sessions. The “Monday” session is usually focused on strengthening the “trunk” of knowledge by review and discussion of the key concepts from the previous week’s material. The “Friday” session usually presents and discusses problems and additional course material beyond that presented on-line, and explicitly supports additional “paper” exercises and larger assignments that the students will complete outside class. These additional topics and assignments do not lie on the “linear” learning path of the “trunk”, but rather constitute “branches” off the trunk. As in a real tree, these “branches” also strengthen the “trunk” by exercising the ideas, and we can add more “branches” as the trunk grows, with each “branch” relying on the material introduced up to that point in the “trunk”.

This “branch” idea gives considerable flexibility in the additional material; it can be customized to students’ or teacher’s interests and knowledge, and can be changed easily from year to year to keep the course fresh. This can also be a good approach when a different instructor teaches the class; that instructor can use the existing on-line material as the core “trunk” and introduce their own supplementary “branch” material as they wish.

Online approaches can also be effective for background material that can be available at all times to the students (including possibly even before the start of the class). That background material is like the “roots” of the tree. Such online material could include self-assessment exercises to see if the student has enough background in particular areas. It can very usefully include additional background online modules on specific background topics, designed to bring the student up to speed or review prior knowledge. These modules can have quizzes for the student’s own benefit and learning, though these need not be built into any assessment component in the class. (In online platforms, it is likely straightforward to categorize quizzes like these so they do not contribute to the grading of the class.) Such material could optionally be supported by additional tutorial sessions by course staff if needed for some students. A library of such background modules can be built up over time,

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or material from some central library of material can be linked. Modules from other, prerequisite classes can also usefully be included here as background. It is straightforward to include such material in a typical online platform.

This particular blended approach does not require “flipping” the classroom by having the students do exercises or solve problems during class time, though such sessions could certainly be added or substituted.

### **Example weekly schedule**

Here we give a more detailed example template for one way such a course can be run. The class meets in person for two approximately 1-hour sessions each week, nominally on Monday and on Friday. The schedule is summarized in Fig. 2. This is a “rolling” two-week schedule; new material is introduced each week, so finishing the work for one week’s material overlaps with introducing new material for the next week.

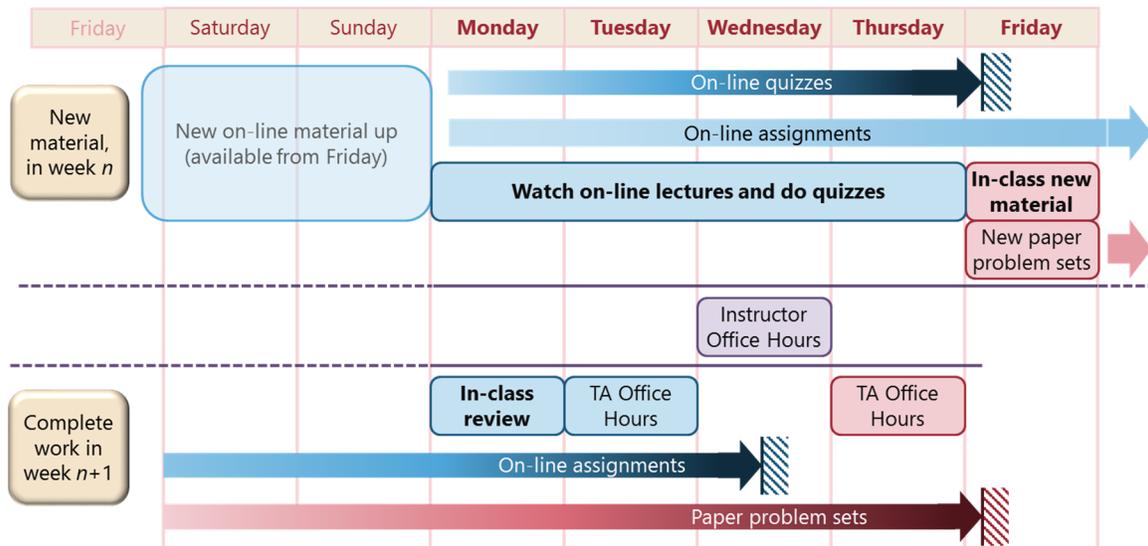


Fig. 2. The example rolling two-week schedule that operates once the class gets to steady-state operation. The upper part shows how the new material will be delivered in a given week  $n$ . The lower part shows how the students will be finishing the material from the preceding week  $n$  in week  $n + 1$  as the class reviews material and completes on-line and paper problem sets. (Other projects or paper assignments operate on whatever schedule is appropriate for them, and these are not shown here.)

### **Monday class session**

The Monday session reviews topics and questions from the previous week. This can cover basic concepts and/or problems from the previous week. It can present alternate approaches or views on the previous week’s material. Topics can be based on input from the students. Posting questions on an online discussion forum (possibly anonymously) is one way to identify the most important topics and areas for more attention. In-class “active learning”, such as asking the students to discuss their questions on the material for a few minutes in small groups, can also be used to stimulate questions in class, for example.

### **Friday class session**

The Friday class session introduces new “branch” material and problems, centered round deeper (paper) problems, assignments or projects the class will be doing. Generally, paper problem sets will be handed out in this session, and the students’ attempts at these problem sets will be due the following Friday, in class.

These Monday and Friday sessions can also be varied as required. Possibly in some weeks, both of them would be used for review, and review and new “branch material can be mixed. Other types of in-class sessions, such as “flipped classroom” or other problem solving sessions, in-class demos, or guest lectures can be substituted as appropriate.

### **On-line sessions**

On-line lecture material, equivalent to approximately three lectures per week, is released at the beginning of a given week. This release can be just after the Friday lecture in the previous week, giving the students the maximum flexibility in when they watch it over the entire next 7 days. (Of course, this material remains accessible to them throughout the whole of the rest of the class.)

These on-line lectures are divided into a few sections, with quizzes between the sections. The quizzes test the material just presented in the previous section. The quizzes are graded, but count for only a relatively small fraction of the grading; their main purpose is to reinforce learning rather than to assess the students. The grading policy can be generous (for example, unlimited attempts), but there should be a deadline, preferably just before the Friday class. This helps keep the students on track, and means they have engaged with the week’s material before the Friday class. That, in turn, allows the Friday class to build on the week’s material if desired. For a ten-week class, there may be nine weeks of such on-line material.

There will also be on-line assignments for the week’s material, and these will count for more marks; the grading for these may be stricter, such as allowing only limited numbers of attempts at each question. These assignments must also be completed by a weekly deadline, though this can be later than for the quizzes. For example, these might be due on the following Wednesday by the middle of the day.

It is likely relatively easy to set up online grading to build in a certain amount of tolerance for mistakes, such as by having the grading program drop the weakest few quiz scores and the weakest online assignment score (OpenEdX offers this, for example). That allows the course staff to operate an otherwise completely strict policy of no other exceptions of any kind on the online grading, which saves staff time!

### **Teaching Assistant (TA) office hours**

There are TA office hours on the Tuesday (i.e., before the on-line assignment deadline) and on the Thursday (i.e., before the in-class (“paper”) assignment deadline). The primary purpose of these office hours is to help resolve difficulties with problem sets and assignments (both on-line and paper) and to provide another forum for students to discuss or ask questions about the course material and concepts.

### **Instructor office hours**

Instructor office hours are on Wednesdays, after the on-line assignment deadline. In these open office hours, the instructor can deal with any topics, questions, or, especially, concepts related to the material that students would like to discuss further in person. This timing of the instructor office hours makes it more likely that the students will use these instructor office hours to discuss more conceptual questions rather than the details of getting the right answers to the problems or assignments they are due to hand in the next day.

### ***Example approach to assignments, examinations and grading***

How the class is graded and examined will obviously vary depending on the needs of the course and the preferences of the instructor. One example approach is given here. Many variations on such a model are possible, just as there are many different ways of approaching the assessment and grading of conventional classes.

The class grading can be a sum of scores from material on which the students can collaborate openly, deeper assignments to be completed without collaboration or with limited collaboration or teamwork, and conventional examinations. In this example approach, the students are allowed to discuss the online quizzes, online assignments and paper problem sets with other students (and anyone else), though they are expected not to copy or plagiarize, enforced only by an honor code.

#### *On-line quizzes and assignments 25% of the course grade*

The online lectures include quizzes, which count for 20% of the on-line points (so 5% of the course grade), and weekly on-line assignments, which count for the remaining 80% of the on-line points (so 20% of the course grade).

*Paper problem sets* are generally weekly, due one week later, for a total of 15% of grade. These problem sets will allow different kinds of problems from those possible in the on-line assignments, including, in particular, preparation for the more substantial graded “paper” assignments (see below). These are graded by hand, with solutions handed out or posted after the submission deadline.

#### *Midterm – 10% of the course grade.*

There is a conventional midterm exam, at the end of the fifth week of a 10-week class (so based on material from the first four weeks of such a class).

#### *Assignments– Two assignments, each 10% of the course grade*

Two longer assignments are handed out at different times in the class (for example, at the beginning of the seventh week and the beginning of the ninth week in a 10-week class), with at least 10 days to complete each of them. These assignments should be done by the student on their own, without collaboration with others. Students may, however, ask the TA’s and the instructor questions or discuss the assignment with them.

#### *Final examination – 30% of the course grade*

This is a conventional final exam (given, for example, in the eleventh week after a 10-week course).

### ***Some practical advice for the online components***

Having run courses with online components for a few years, I have learned a few lessons (often the hard way) about some practicalities of running the online parts.

#### **Constructing online questions**

Constructing good questions for quizzes and online assignments does take some work and it does take some “getting used to”. One core piece of advice here is to keep the format of the answer entry by the students as simple, foolproof, and error-tolerant as possible. In my experience, students get very frustrated if they think they are understanding the material and have done the question correctly but cannot manage to enter the answer successfully online. They also really hate having only one attempt to get the answer right. They will make “fat finger” errors like accidentally clicking too soon, or simply typing the answer in incorrectly even when they know the correct answer. Frustrations like these get in the way of the educational goals. So, though online platforms may offer answer formats such as entering formulas or expressions or other more sophisticated approaches, try if at all possible to keep answer entry simple; wherever possible, use simple multiple choice or true/false answer types, or answers that require entering just one integer number or just one real number to a very clearly specified level of precision (and with tolerances that are in fact a little more forgiving than you ask for so as to avoid minor issues with rounding).

When asking the student to enter a numerical answer, it usually causes no problems to allow them multiple attempts. Structuring multiple choice questions with a relatively large number of choices (e.g., 4 or more) does permit offering multiple attempts. Obviously, though, it is not very successful to offer multiple attempts to a true/false question! One other question approach that I constructed for my classes, with apparent success and without creating substantial frustration in the students, is what I call a “compound true/false” question. In such a question, the student is asked to choose which ones of a set of statements is true or false, and they are told how many statements are true. (Usually it is best to set up such a question with approximately equal numbers of true and false statements.) This approach allows multiple attempts. If the first attempt is not deemed correct, then the student has an opportunity to reason for themselves as to what their errors were (and they must have made at least two errors), which can be educationally useful. This kind of approach can be used to construct quite complex questions that probe relatively deeply into the student’s understanding of the material. I discuss this “compound true/false” approach in more detail in Appendix 1.

#### **Structuring course material on the course platform**

The details of structuring course material may vary from platform to platform. There will, however, be a very large number of different course objects of one kind or another (lecture “chunks”, quiz questions, additional materials, etc.). It is very helpful to have a consistent way of labeling those so it is easy to identify them for discussion (“In question 3 of quiz 3.2.2, we see that ...”) and to have that labelling reflect whatever is the hierarchical structure of the platform so that you can easily identify your course objects within it. Be very organized about this from the start – it will save you a lot of time later. I have put some specific recommendations appropriate for the OpenEdX platform in Appendix 2.

**Choice of the core online material (the “trunk”)**

For the core online material, choose the material that you would always want to present in any version of the course. Part of the reason for doing this is that editing the online material, such as videos, is more time-consuming than changing the conventional lectures you would normally give. Use the “conventional” in-class parts of the course for customization and variation of the course.

The core online material can also usefully contain all of the progressive development of the core ideas and techniques of your course, and this may be best way to decide what to put into the online material. The fact that you can rely on all the core ideas being contained in the online “trunk” material also frees you in any additional “branch” material you want to present or discuss. You do not have to make sure you introduce some concept in your “branch” material that the students are going to need later on for the core understanding in the class; all of that kind of material is already built in to the “trunk”. Having all this “core” material available for review by the students by going back to the online lectures is also a useful resource for the students as the course progresses. It does help to be quite clear about what this core material should be before creating the online “trunk”.

**Running a MOOC version**

In this model, one straightforward way of running a Massive Open Online Course (MOOC) version of your class is simply to put up the online “trunk” of your class as that MOOC, making the MOOC the “lite” free version of your class. You may, of course, be considering that the primary function of your class is to educate your own students; even with that as your main motivation, there can be several reasons why you might also consider running a MOOC. Obviously, MOOCs can have various “public relations” benefits, of course, both for the instructor and the institution, and they are a genuine public good. But, one further reason to run a MOOC version is that it can debug and improve your online course materials.

There are likely many more students in the MOOC version than you would ever have in your physical classroom, and those online students can be relatively uninhibited in discussion forums. Though that means that you as instructor must have a “thick skin”, those students will genuinely identify anything that is not clear, and they will find all errors in the online materials and any bugs in questions and solutions. They will also find any conceivable way that it is possible to misinterpret your most clearly written questions. You can also use the discussions on the forum to construct “frequently-asked questions” and answers that you can incorporate into your course materials. All this can improve the quality of your course materials.

**Benefits and conclusion**

This blended approach can offer major efficiencies for the students and the instructor through the on-line portions while preserving and even enhancing the in-class interactions. The on-line portions are more efficient for the students overall because they can watch them at a pace that best suits them. If the material is easy for them, they can move quickly through it (in a blow to professorial ego, students will often watch the videos at accelerated rates, with 1.5x speed-up being quite a common choice!). Because the students themselves can move back in the videos to review material, the on-line lectures require much less

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“looping back” by the instructor, so the actual lecture segments take less time than the same lecture material would in a conventional class. Students also seem to like the schedule flexibility of the on-line material.

Once the on-line portions are generated, this approach can be very efficient for the instructor, removing the work associated with the repetitious presentation of the same core material each time the class is taught; that material may also necessarily involve some relatively unexciting material, such as proofs and derivations, that can be handled in the on-line version, relieving everyone’s boredom to some degree! The greater efficiency of presentation of the core material allows for more free-flowing conceptual discussion in class and for presenting new and possibly more stimulating material on interesting “branches”. The on-line platform also likely supports discussion forums that can be used as the main discussion forum for the class.

For both the instructor and the students, the on-line material, with its simple deadlines and its inherent guarantee that certain material will be covered by a certain time, means the schedule of the course can be very predictable and evenly paced. Students have commented that they like this even pace and the discipline of “keeping up” that the weekly on-line scheduling enforces on them.

As we mentioned earlier, unlike a purely “flipped classroom” approach, which may be difficult for instructors to conceptualize for many classes, this blended approach does not require a wholesale change from the structure of a traditional lecture model, which makes it easier for instructors to adopt. It also leaves open the possibility of subsequently “flipping the classroom” if the right kind of in-class exercises can be constructed and the right facilities are available for operating the class in that format. The progress towards such different formats can proceed in an evolutionary fashion over some time. This approach is also very compatible with a different instructor using the existing on-line material in their own customized and personalized teaching of the class. This may be the most efficient use of instructor time and makes changing instructors relatively easier.

Overall, in my personal experience, this blended approach allows more material to be covered more effectively and efficiently from the perspectives of both the instructor and the students, and delivers substantial teaching benefits and successful learning outcomes.

### **Appendix 1 – Compound true/false questions**

Here we will explain the reasons for, and benefits of, using what we can call a “compound true/false” question form and give some advice for the student on how to complete such a question.

True/False questions can be very useful when examining conceptual material. Students also can readily successfully enter the right answer when they know it; in contrast, students often experience difficulty successfully entering their correct answers for questions with numerical or text answers because of various answer syntax problems.

Students, however, generally do not like True/False questions when the grading matters. Obviously, the examiner cannot give the student multiple attempts at a True/False question if the answer is to be revealed after each attempt. So only a single attempt can be allowed. As a result, minor conceptual errors or errors of accidentally clicking the wrong answer cannot be corrected, and the frustration and stress levels with such questions can therefore be high.

In a "compound True/False" question, the student has to answer multiple True/False questions, and has to get them all right. However, the student is given multiple attempts at the question. After an attempt, the student is told if their complete set of answers is correct; if it is not correct, they are not told which specific answers are wrong. They can, however, be given multiple attempts at such True/False questions.

Now, such a question could be regarded as harder because the student has to get everything right to get any marks. And for, say, six such questions, the chance of getting them all correct by random choice is small –  $1$  in  $2^6 = 64$ . If, however, we also tell the student that exactly 3 of the answers are True (and therefore that 3 are False), we significantly improve the chances. There are now only  $6!/(3!3!) = 20$  correct possibilities (i.e., the number of ways of choosing 3 from 6, irrespective of order). However, the odds are effectively tilted much more in the student’s favor than this ratio of 20 and 64 might suggest. Before even submitting the answer, the student can use the questions where the student is more secure in their answer to help them answer the others. Furthermore, to get the answer to the entire set wrong, the student has to make at least two errors - one of the student's True answers must in fact be False, and one of the False answers must be True. So, though the student still has little chance of getting the question right by mere guesswork, the student has many additional error checking possibilities.

This approach also opens an important learning strategy for the student: When the student is told that their overall answer attempt is not correct, the student then has to confront some contradiction in their own mind, and resolving such contradictions is generally viewed as being a very successful learning approach - once such a contradiction is resolved by the student's own actions, the student tends to remember the result.

For example, we might ask the following question:

Select all the prime numbers in the following set of six numbers. (Note: three of these numbers are prime and three are not.)

- a) 17
- b) 644

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- c) 49
- d) 193
- e) 239
- f) 91

You likely already know that 17 is prime, 644 is not prime (it is an even number), and 49 is not prime (it is 7 squared). Of the remaining three numbers, it will be easiest to check 91, which you will soon be able to verify is not prime. Hence you conclude, correctly, that the remaining two, 193 and 239, are both prime numbers. You could check your reasoning and calculations by directly verifying that both 193 and 239 are prime by trying to divide by all odd prime integers up to approximately the square root of each (i.e., 3, 5, 7, 11, 13).

So, you select a), d) and e).

A good strategy for answering such an overall compound true/false question is to start with or emphasize the individual questions where the student is most secure in their answer, and use the overall required consistency to help suggest the answers for the others (which is essentially the strategy we used above).

Students should also note the following two important points here about answering such questions:

- 1) The automatic grader may not be very sophisticated. This has two consequences:
  - a) It may not give partial credit for the parts you do get right, and
  - b) it may not itself enforce the right total number of “True” answers. That is, even if we tell you that only three answers are “True”, the grader may let you select any number of “True” answers even though any number other than three is doomed to failure. So you have to make sure you only select three.
- 2) Do make a note of each set of answers you enter so that you don’t enter that set again!

## **Appendix 2 – Numbering schemes in OpenEdX**

### **Hierarchical structure in OpenEdX**

The online platform may have a hierarchical structure. In the case of OpenEdX, the levels are as follows:

#### *Sections*

Different “sections” can usefully contain different “weeks” of the class that are released progressively. They can also be used for major collections of background or reference material that are available throughout the course. These sections will contain one or more “subsections”.

#### *Subsections*

Subsections can correspond to different “lectures”. This level can also be used for a weekly online assignment, and for containing additional or supplementary materials for a week, such as links to additional downloadable materials or resources, frequently asked questions, and lists of typographical errors. Subsections will contain one or more “units”.

#### *Units*

Units can contain lecture “chunks”, or quizzes, or possibly other items. Units contain “components”.

#### *Components*

Components are the “containers” for specific course objects, which can be video, problem, html, discussion, or some other object.

The OpenEdX platform effectively has a specific internal automatic numbering associated with this structure, a numbering scheme that shows up when you want to look at the histogram results of quizzes and assignments, for example. It can be helpful to have your numbering system correspond to that implicit one, or at least be closely enough related to it to allow you to sort out what is going on. One good way of numbering is therefore as follows.

Sections – number by course week (as in labelling a section “Week 3”) or major division. These can be labelled without using numbers because OpenEdX does not directly use any numbering from this section level, but you want some unique label here to identify elements; numbering is one simple and economical way to accomplish that, and choosing labels that are in alphabetic/numeric order is useful because of the automatic alphabetic/numeric ordering of discussion topics (see below).

Subsections – subnumber by the lecture in that week or section (as in “3.2 History of Transistors” being your name for the second lecture in Week 3).

Units – further subnumber these, as in

- 3.2.1 Video: The invention of the transistor
- 3.2.2 Quiz: The invention of the transistor
- 3.2.3 Video: Germanium point contact structures
- 3.2.4 Quiz: Germanium point contact structures

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Components – further subnumber problems within your quizzes (or assignments) as Q1, Q2, etc.

Then, when you look at your histogram of question responses in a given week “*n*”, “2.4.3” will correspond to Q3 in quiz or assignment *n*.2.4. (Note that the “week” number *n* is not shown in the histogram numbering, which is one reason why “week” numbering is optional.)

### **Discussions**

It can be useful to include a discussion component in each unit, and to label it using this scheme. Specifically, inside the discussion component properties, for each discussion in, e.g., week 3, enter “Week 3” as the “Category” and, e.g., “3.2.3 Video: Germanium point contact structures” as the “Subcategory”. All this discussion is then available by viewing this specific discussion component in the online platform. The overall online discussion forum for the class collects these also in an ordered form (ordered in the usual alphabetic and numeric fashion), which is yet another reason why a numbered scheme is useful. Using this labelling, you will easily be able to find all the discussion associated with each unit because the discussion forum software also offers a categorization tree of the discussion by alphabetical/numerical order using these Categories and Subcategories.