Visualizing the Gradebook

As a professor at the University of Puget Sound, I am continually called upon to monitor student progress. As part of this duty, I need to provide student alerts for students who fall behind, and the sooner that I can notice a student falling behind, the better. In looking at the gradebooks for my classes, I noticed that I couldn’t easily tell which students were doing particularly well or particularly poorly. Instead, all I could see was a sea of numbers, and to interpret these numbers, I would have to go through them carefully and critically. Because this process is labor-intensive and time-consuming, I couldn’t do it as often as I would have liked to.

With this in mind, I set out to design a way of visualizing my gradebook with a focus on being able to identify two things:

- which students are falling behind
- in what ways they are falling behind.

For the second item, an example might be: is the student missing a single large project, several homework assignments, some quizzes, or perhaps a combination of these?

My process of developing this graphic can be split into two phases. In the first phase, I designed a preliminary version of a graphic to help with these tasks. After I assessed this graphic and made modifications to my data structure, I then made a revised version of the graphic.

**First phase**

In the first phase of this project, I developed a visualization using the data that was available in my gradebook.
Variables

The available variables for the first phase were: student names, assignments, and grades. “Student names” is self-explanatory. The term “assignments” refers not only to homework assignments and projects, but also tests, quizzes, class participation, and anything else that is graded.

As for the grades, I had been recording a grade for each student on each assignment, but the format of the grade varied. Some assignments were graded on an A-B-C-D-F scale, while others were on a point scale or a percentage scale. I had to convert all of these grades to a consistent scale in order to visualize them. For the first phase of the visualization, I decided to convert all grades to an A-B-C-D-F scale. For assignments that were graded on a point scale, this meant converting to percentages and then using a 90-80-70-60 scale to yield an A-B-C-D-F grade. This caused some difficulties for assignments that were curved, but I postponed dealing with those until later.

Having settled on the grading scale that I would use, I could now generate a draft version of a visualization.

The graphic

The graphic that I designed initially was modeled after my gradebook, but with a colored square in place of a number or letter to indicate a grade. That is, I used a matrix of colored rectangles with each row corresponding to a student and each column corresponding to an assignment. I placed the student names to the left of the rows and the assignments (rotated 90 degrees counterclockwise) below the columns. This gave me a graphic that looked something like the following sketch.

[insert scanned hand-drawn graphic here]

I experimented with various color schemes for A-B-C-D-F grades. I tried using several shades of a single hue varying only in luminance (such as white for A, intermediate shades of grey for B-C-D, and black for F), as is often useful in encoding quantitative or ordered variables. However, I found that this did not allow me to readily hone in on students who were falling behind. Contrary to what I might have expected, I found that a “traffic light” color scheme was most useful: green for A, blue for B, yellow for C, orange for D, and red for F. These colors already had various
meanings and connotations for me similar to what the grades they indicate mean, and with this approach, the F grades stand out clearly, which helps in finding students who are falling behind.

Assessment

While this initial version of my visualization provided more information than staring at the numbers in my gradebook, it still didn’t allow me to identify students falling behind and how they were falling behind as readily as I would have liked. Two main problems appeared:

1. I had been grading some assignments with letter grades and others with numerical grades, which I then converted to letter grades for the visualization. I wanted to give more careful thought to how I was converting these numerical grades, and whether my method was appropriate.
2. An overall grade to date would be helpful, since a glance at the colors corresponding to the various grades provides only an approximation of one.

These two issues turned out to be related.

In order to compute a grade to date, I would need to have a method of combining the various letter grades on the assignments into a single overall grade. However, both a score of 93/100 and a score of 99/100 on an assignment were being converted to an A, but those two different A grades should have a different effect on the overall grade. With this in mind, I decided that although it was most useful to display the grades graphically on a color-coded A-B-C-D-F scale, to compute the overall grade I should really use whatever numerical information was available.

As I considered the problem further, I realized that there really is no obvious appropriate way of converting an assignment that was graded on an A-B-C-D-F scale to a numerical scale. A 4.0-scale is one possibility for such a conversion, as is a 90-80-70-60 scale, but both of these have problems and inconsistencies. For example, on a 4.0 scale, did I really want the difference between the bottom F and the bottom D to be the same as the difference between the bottom A and the bottom D? Probably not. Also, on a 90-80-70-60 scale, what should an A correspond to? What about an A+? There aren’t obvious answers to these questions, and all such choices have implications for a student’s overall grade.
With these considerations in mind, I decided to record scores on all my assignments numerically. In most cases, I would convert the raw score to a 90-80-70-60 scale by expressing it as a percentage of the maximum score. However, in the unusual cases where I wanted to curve an assignment, I would store the maximum score and the lowest A, B, C, D, and F grades for that assignment and then interpolate linearly to arrive at a 90-80-70-60 scale grade. In other words, I resolved to make the difficult decisions about how I would convert a numerical score to a 90-80-70-60 scale at the time when I entered the grade into the gradebook. In doing so, computing an overall grade to date would then be possible as long as I also stored each assignment’s weight.

I thought about storing a single weight for each assignment, but that caused difficulties when, for one reason or another, a student was excused from an assignment. Such situations sometimes arise when the student has an excused absence on a quiz day or for some other reason has to miss a particular in-class assignment. In order to have the flexibility to accommodate such situations, I decided to store an entire matrix of weights, one for each student on each assignment.

With all of these things in mind, I restructured the data in my gradebook. All grades were to be entered numerically, and I would store a “curve” for each assignment. In addition to each student’s raw score and the “curve”, I would also store a weight for each student on each assignment, this weight being the proportion of the overall grade that this assignment represents for that student.

**Second Phase**

Now that I had settled on the structure of the data, I could proceed to refining my initial graphic.

**Overall grade to date**

With this new data, I was ready to compute the grade to date. I would simply add up the curved scores on assignments that had been completed times their weights. When I tried this out though, I realized that I would have to add assignments to my gradebook throughout the semester in precisely the order that I graded items, and I wouldn’t know how much of the total grade had been completed. This led me to store a data frame of assignments with a column indicating whether or not I had graded the assignment yet. With that in place, I could now put all of the semester’s assignments
and their weights into the gradebook in advance and then record that each assignment’s grading was complete whenever it was. This allowed me to compute a student’s grade to date at any point in the semester. It also allowed me to compute what proportion of the overall grade had been completed, but I decided not to use that for this visualization because it didn’t help me address my main questions.

I then set out to decide how to display the overall grade to date in this graphic. Because it is the best single measure of a student’s progress, I opted to display it in the first column of the grade matrix, color coded as all of the other grades. Because of the importance of the actual number in assessing a student’s progress (70.2 being quite different from 79.2, even though both would display in the C color), I changed the display to show the actual number for the overall grade to date (with 1 decimal place), with the text still color coded. This makes assessment of a student’s overall performance all the more rapid.

With the addition of the overall grade to date, I could now order the students by overall grade. Even though individual students can’t be looked up quite as speedily with this ordering, this small benefit of having computed the overall grade to date really increases the utility of the graphic. With students ordered by overall grade, figuring out which students are falling behind is much easier: they are all at the bottom of the list of students. This type of view, that changes over the course of the semester, isn’t possible with a static grade book, but it is highly useful.

**Grade weights**

Now that I was storing the weights of each grade, I decided that it would be useful to include that information in the visualization. I tried rescaling the size of the rectangle representing the assignment’s grade so that the area of the rectangle would be proportional to the assignment’s weight. In that way, the total amount of a given color in a particular student’s row would be indicative of the proportion of the total grade that consists of that grade’s color. This was effective, but after much tinkering (with which dimensions would change according to the weight, etc.), I decided that having a colored circle whose area was proportional to the grade weight would allow me to read the desired information from the graph easily.

This addition of weighting information proved to be quite useful. With it, I can tell at a glance whether a student has been doing well or poorly on small, less important
assignments separately from larger, more important assignments. This can reveal patterns that say a lot about a student’s performance. I have often seen cases where students do well on homework assignments but not tests, and vice versa (although that is less common). I have also seen cases where students have almost all of one grade but did better or worse on a single assignment, and it is nice to be able to see immediately whether this single assignment was a large one or not.

**Background color**

Because the colored grade circles now had empty space between them, the choice of background color became more important. My original background color, white, seemed to distract the viewer from the colored circles, so I looked for another one. I didn’t want it to interfere with the traffic light color scheme that I had chose for the grades, and it was apparent that any light color would have the same disadvantage that white had (it would distract the viewer).

After some experimenting, I decided that black would be a good color. It didn’t distract from the circles or interfere with the traffic light color scheme, and the circles stand out against the black well. I wasn’t too concerned with how effective this would be on a projector or when printed, since I was planning to use the visualization myself on my own computer. Otherwise, I might have had to consider other backgrounds and other color schemes.

**Missing assignments**

Missing assignments are a strong indication that a student is falling behind, and they often show patterns of how the student is falling behind. For example, maybe a student’s low overall grade is because the student has not turned in the past two homework assignments, or because the student has missed a quiz or two. Or perhaps the only problem is that the student hasn’t turned in one of the major projects. All of these are different from a situation in which the student has a low grade without any missing assignments, one that stems from having consistently low grades on most assignments.

Originally I had not been displaying missing assignments any differently than I had been displaying F grades. However, a missing assignment is actually a much stronger indicator of a student who is falling behind than an F grade is, so I decided that
missing assignments should have their own colors. I thought that black would be a
good color for missing assignments, to match the black that I had decided on for the
background. That turned out to give the opposite effect from what I had wanted.
Instead of noticing missing assignments at a glance, they became rather unassuming
and inconspicuous. Noticing missing assignments became like trying to notice that
something wasn’t there. Because of this, I tried some bright colors, such as red and
yellow, but I eventually settled on white as a color that would call attention to missing
assignments.

Because a missing assignment has no score, I had to figure out what the size of
the circle representing the assignment should be. In experimenting with this, I came to
realize that it would be even more effective to color not just a circle but the entire
rectangle representing the assignment white in order to call the viewer’s attention to the
missing assignment. This rectangle is bigger than any of the circles being displayed,
and with its white color, missing assignments almost jump right out of the page.

The graphic

The graphic that I arrived at is:
In this graphic, the following information is encoded:

- The students in the class, listed on the left in order from highest grade to date to lowest grade to date
- The assignments that have been graded so far, listed across the bottom row in chronological order
- The weight of each assignment for each student, given by the area of its circle
- The grade on each assignment for each student, given by the color of its circle
- Each student’s overall grade to date, listed as a number but also color coded
- Missing assignments, shown as large white rectangles

A grade scale is shown on the right to help decode the color scheme.
This visualization allows the viewer to readily assess which students are falling behind and how those students are falling behind, the main two questions that we created this graphic to address.