USING TECHNOLOGY AS A PATHWAY TOWARDS EQUITY, DIVERSITY, AND INCLUSION

Sarah J. Greenwald and Jill E. Thomley
Department of Mathematical Sciences
Appalachian State University
121 Bodenheimer Drive
Boone, NC 28608
greenwaldsj@appstate.edu and thomleyje@appstate.edu

We use technology to cultivate multiple access points in asynchronous web-based courses to teach mathematics and statistics. We also do this in 100% face-to-face classes, where the online activities are typically completed during class meetings in a lab or outside of class. Recent recommendations from professional organizations, such as the Conference Board of the Mathematical Sciences (CBMS) statement "Active Learning in Post-Secondary Mathematics Education" (2016), as on https://www.cbmsweb.org/cbms-position-statements/ and the Mathematical Association of America (MAA) *Instructional Practices Guide* (2018), as on https://www.maa.org/sites/default/files/InstructPracGuide_web.pdf, include active learning as one pathway towards equity, diversity, and inclusion. We share our activities, which include assignments, interactive videos, interactive quizzes, and think-pair-share forums. The course management system we use is Moodle, a free and open-source learning system, into which we incorporate Camtasia, Excel, Google Sheets, LaTeX, Maple, and RStudio. We compare the participation of groups underrepresented in mathematics to their classmates. Appalachian State University's Institutional Review Board has determined this research is exempt from IRB oversight.

To foster and maximize our students' inclusion and engagement, many of our technology-supported learning opportunities are repeatable, which may concern some instructors, since it could be seen as a pathway to procrastination. However, most of our students still meet initial due dates, because our grading systems are robust enough that they do not lower the bar with regard to deadlines, course goals, or rigor. Our grading systems can been seen at our website http://cs.appstate.edu/~sjg/papers/ictcm20/ and in our article "Raising the Bar with Standards-Based Grading" https://www.tandfonline.com/doi/abs/10.1080/10511970.2019.1695237, co-written with Megan E. Selbach-Allen and Amy E. Ksir.

Here, we give an overview of our activities and share detailed how-to-instructions and resources for those who wish to replicate them. We will also highlight some of the ways in which we give feedback to the students on individual assignments as well as their overall course progress and performance. These include the use of rubrics and scales in Moodle, completion tracking, and Google sheets for formative and summative feedback.

Assignments

The Assignment feature in Moodle is quite flexible. We have used it in a variety of ways that require the students to communicate how they have explored mathematics using Excel, Maple, or R. For example, students might complete a handout, scan it, and collate it into a

single PDF for submission, or they could submit a PDF certificate or photo to verify that they have completed an activity in an outside system such as DataCamp. DataCamp is a commercial site that provides free access to content for academic purposes. Assignments in DataCamp include videos, mini-quizzes, and interactive programming exercises with unlimited attempts to develop coding skills. Suggestions and solutions are available, but using them reduces the amount of points a student earns.

In general, students meet completion requirements for an assignment when they earn a passing grade. For example, they might have to complete a course module (engage with all activities) and earn at least 80% of possible points to get full credit (see Table 2). In Figure 1, we can see an assignment second from the bottom, represented by an icon of a hand holding a sheet of paper.

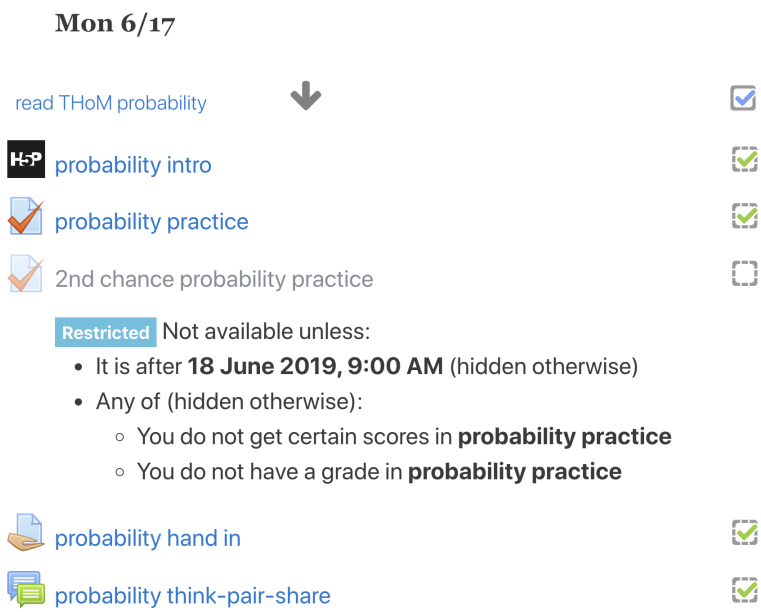

Figure 1: Completion Credit in Moodle

Moodle rubrics we design allow us to quickly grade assignments and communicate consistent and effective feedback to the students.

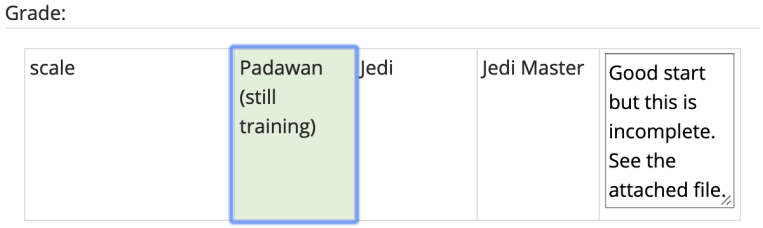

Figure 2: Rubic in Moodle

In the Moodle settings under submission types, we can choose to accept only a particular kind of document like a PDF. For feedback, we select Annotate PDF. We can also provide

feedback in the comment area of the rubric, as shown in Figure 2. Grading occurs at least once prior to the due date. We allow the attempt to reopen automatically until the deadline passes if a student doesn't initially achieve completion. In the grading settings, we have set up a scale, rubric, and grade to pass in order for completion to be indicated. In some cases, we have adopted familiar Star Wars™(https://www.starwars.com/) terms. Padawans are training to one day become a Jedi. Jedi Knight is a rank within the Jedi Order, referring to Jedi who complete their training and pass the Jedi Trials to become full members. A Jedi Master has demonstrated exceptional achievement.

Interactive Videos

Moodle H5P allows us to enhance videos with interactive features in a way that seamlessly integrates a student's successful completion as a part of the course grade. We can create a video in a program like Camtasia or link to an existing video on YouTube. In Moodle, we import the video and program it to pause at designated points. At each pause, our students engage in an interaction that we design before they proceed. There are a variety of options such as repeatable quizzing, where students use the check feature on the interactive questions in order to help them redo the responses until they get them correct. The instructor can also prevent students from fast forwarding the video and give credit only to students who watch the entire video and submit the correct answers.

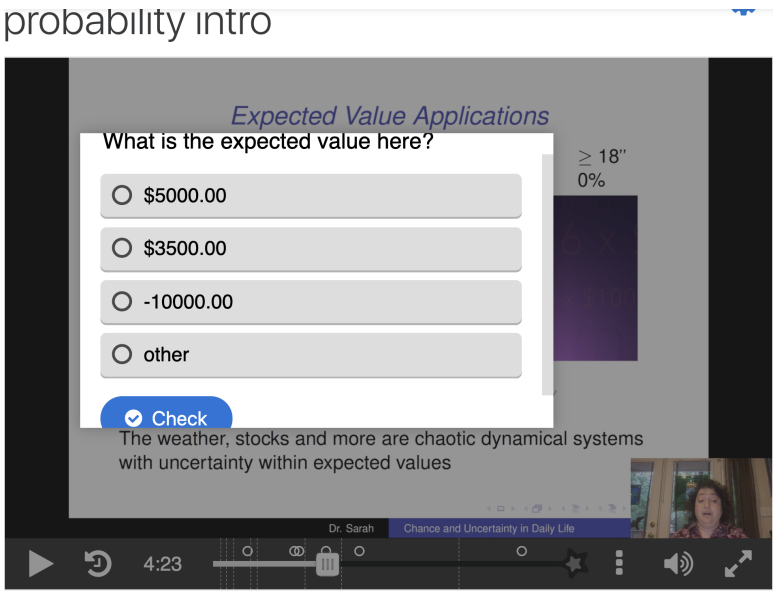

Figure 3: Interaction in an Interactive Video in Moodle H5P

Some students will not have seen these kinds of activities before, so we provide instructions similar to the following to orient them:

> To earn credit you'll watch the entire video and submit the correct answer. You'll use the check feature on interactive questions in order to help you so you can redo the responses until you get them correct. You can rewind the video and resubmit to enter correct responses as needed. Be sure to submit all correct responses at the very end of the video for completion credit.

When creating the activity, we use settings such as the “show” button that allows students to rewind the video 10 seconds. We require that students get every question correct to earn task completion before proceeding. In the settings, we find the poster interaction (as shown in Figure 3) better than the smaller button option for both clarity and accessibility. We have the grade to pass match the maximum grade for the activity. Under activity completion, the activity is complete using the setting that students must receive a grade to complete this activity. The video is the second activity in Figure 1, shown by the dark square icon with H5P inside.

We have also embedded videos in tutorial slides that are created using R and RStudio and accessed via Moodle. Students watch a video that presents traditional statistics content and then experiment using guided questions and R code that replicates or extends the concepts presented in the video. This facilitates the students making connections between traditional and computationally-intensive methods.

Interactive Quizzes

Moodle includes a quiz feature that can be flexibly configured to offer a variety of question types, as well as repeated opportunities for completion and different levels of feedback to students about their performance. We typically use these quizzes as opportunities for practice, with the goal of solidifying concepts and demonstrating some level of proficiency. These serve as a gateway to other course activities. Another significant benefit of Moodle quizzes is that they can be easily connected to Moodle glossary entries. This connection creates links that are available to click on at any point in the process to help internalize the concepts. Figure 4 shows an example with glossary entry links to the terms Gaussian, pivot, and solution.

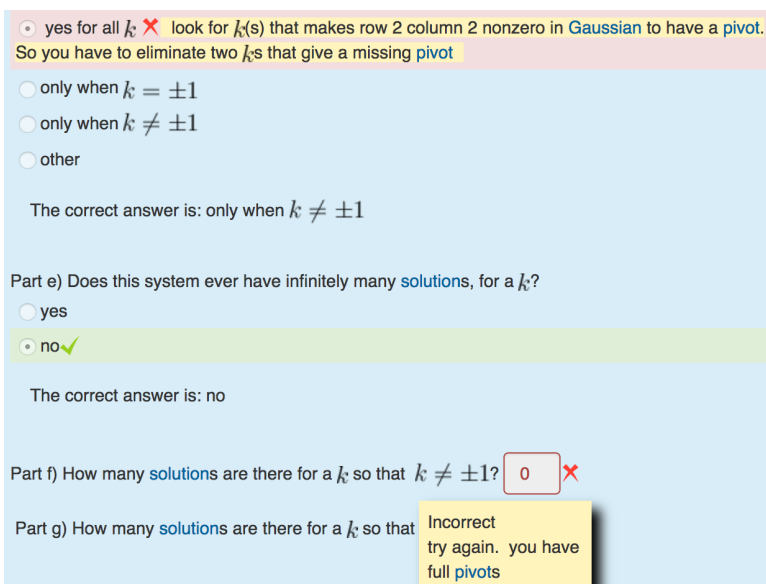

Figure 4: Quiz Question with Instant Feedback and Glossary Entries

After a student submits a quiz, general feedback opens below the question with more substantial comments, as shown in Figure 5. In some other quizzes, solutions include the R

code needed to compute quantitative answers, which encourages students to solidify connections between content knowledge and computing skills.

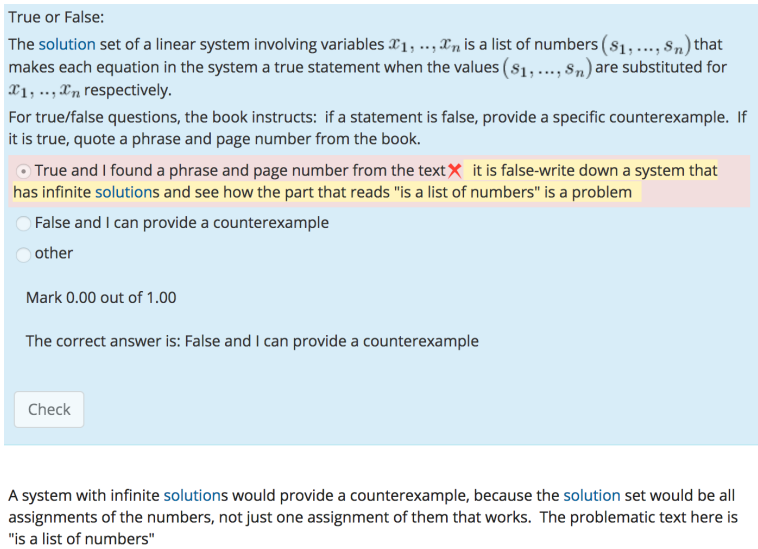

Figure 5: General Feedback at the Bottom of a Moodle Quiz

To cultivate multiple access points in interactive homework, our second chance homework is repeatable and builds in hints to common errors. The second chance may concern some instructors, since it could be seen as a pathway to procrastination. However, most students still meet initial due dates because the second chance homework has a higher bar. In Figure 1, interactive quizzes are indicated by icons with checks and are called "probability practice" and "2nd chance probability practice" and it shows a student who has completed everything on time. In their view, the student doesn't see the 2nd chance since they met the original practice completion. Here are some sample instructions:

> Online homework practice with instantaneous feedback check from me are repeatable until the deadline to obtain a completion checkmark. The point is to practice and examine the feedback to make sure you understand rather than obtain a perfect score. I only use the checkmark for your grade, not the specific score. If you weren't able to succeed by the first deadline then a second chance will stay open until the relevant exam, but the checkmark is easier to obtain when it is originally due (60% correct instead of 90%).

In Moodle, we create two duplicate quizzes with different settings. The original quiz closes at the desired date and time, and when time expires, open attempts are submitted automatically. The grade to pass is a certain threshold value, say 60% or 70%, and students are allowed 5 attempts, with their highest grade counted. An adaptive mode setting reduces credit for attempts after the first. This can help dissuade students who might try to just randomly guess. During the attempt the students can see whether they are correct, their points, and specific feedback. It is only after the attempt or after the entire quiz closes, depending on how we choose to set it up, that they can also see general feedback, the right answer, and

overall feedback. For activity completion, in Moodle's settings, students must meet certain conditions to receive a grade and we have to set the required passing grade. Figure 6 illustrates the Moodle interface appearance of these restrictions on the main Moodle course page.

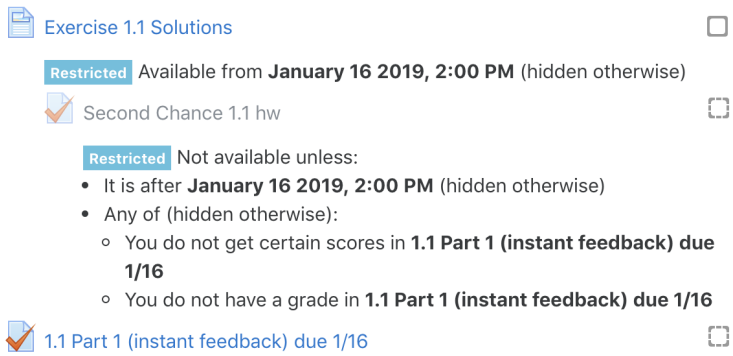

Figure 6: Moodle Access Restrictions

The 2nd chance quiz opens when the original quiz closes and is open until the next exam. The grade to pass is higher (90%), but students have unlimited chances, with their highest grade counted. We hide the second chance until the date it opens and it is always hidden for students who have already earned the threshold grade on the original quiz.

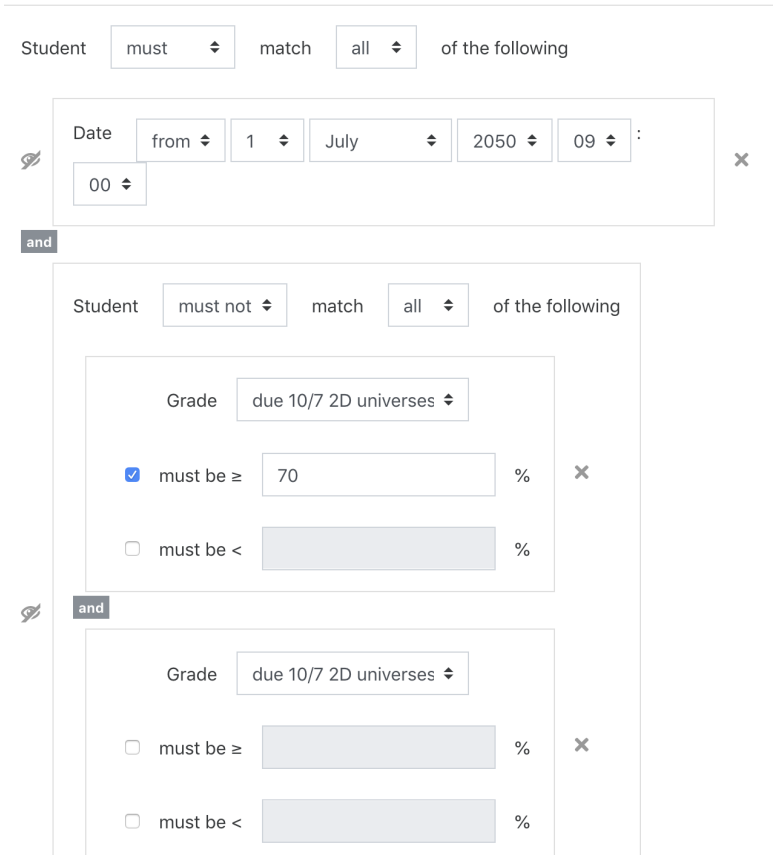

Figure 7: Grade Less than a Threshold or No Grade in Moodle Quiz Settings

Moodle allows us to set conditional access to a quiz. To do this using Moodle's logical quantifiers, we designate that students must have a grade less than the threshold or have no grade, which is reflected as a grade with no checkmark following it. To make this work, we must set it up as the negation of having a grade. So, students must *not* match both of the following:

A The grade in the original assignment must be greater than or equal to the threshold value.

B There is a grade in the original.

Moodle interprets this as the negation of the first statement—or—the negation of the second statement, i.e. the assignment is open to students with too low a grade in the original or to students that never interacted to receive any grade. This is as we would expect it logically: $\neg(A \cap B) = \neg A \cup \neg B$. The settings for establishing this logic are shown in Figure 7. The symbol of a crossed-out eye means it is hidden to the student otherwise.

Think-Pair-Share Forums

We have used forums to ask students to respond to a variety of different types of questions with their own thoughts and then respond separately to someone else's post with something new that justifies their position on at least one of the questions:

> Don't just say, "Yeah, I agree." Instead, say, "Yes, but we also need to consider..." Or, "I don't agree because..." You might also pose questions, answer questions, extend ideas, or compare and contrast your responses and summarize what you chose and why. Both posts must be rated as Jedi for a checkmark (you can revise as needed by completing/revisiting the instructions). If only one of your posts has been rated, you may temporarily see a checkmark before the other is rated. After the deadline, I'll respond to the shared posts within the successive days activities (in the next day or two) or within a class announcement.

Moodle allows us to specify both how many posts students must contribute and of what quality in a way that pairs reasonably well with completion tracking. The think-pair-share forum is the last activity in Figure 1. We rate the posts using a grading scale similar to our rubrics to provide quick formative feedback.

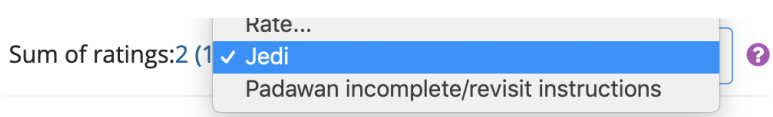

Figure 8: Discussion Grading Scale in Moodle

We also respond to the collective set of posts, including questions that arise, after the deadline for replies. This might be done orally or in some kind of written form, depending on the type and depth of feedback we feel is needed.

Grading Systems

We commonly use completion tracking to communicate progress on Moodle assignments (see Figure 1). To convert these to an overall course grade, we have experimented with a variety of mastery-based and standards-based grading systems, samples of which can been seen at http://cs.appstate.edu/~sjg/papers/ictcm20/. Greenwald has used a Google Sheets gradebook. A sample sheet of the student view is https://docs.google.com/spreadsheets/d/1CICFe73ZsB9HMGpfaIpcWJc1YQUdGHjTWN9EloJaJ0c. Regular communication from the instructor about completion and how it connects to the overall grade is essential to help students understand their progress and what they still need to complete. Aside from the view in Figure 1, Moodle does not presently handle mastery or standards-based grading systems in ways students can easily view. For example, its rubrics do not allow us to assess completion and level of achievement as separate scores in an assignment. Rather, they can only sum all items into a single score or rating. Moodle's gradebook doesn't handle particularly well any methods of compiling grades across items that are not sums or averages. So, we create a typical student gradebook in Google Sheets, where each student is tracked in a row. Sample commands in Google Sheets to handle the mastery component are as follows:

- Column A: View/Freeze
- G3
  =countif(I3:O3,"Jedi or Jedi Master")/(COUNTIF(I3:O3,"*")
  -if(countif(I3:O3,"Padawan (still training)")>=2,2,0)-if(countif(I3:O3,"Padawan (still training)")=1,1,0))*100
- H3
  =countif(I3:O3,"Padawan (still training)")
- To obtain the checkboxes: Data/Data Validation/Checkbox, Use custom cell values

Last Updated: May 19						Collated through "percent practice"	Lowest 2 dropped	Personal Fin
Name	**Final Project 15%**	**Exams**	Exar	Exa	Exar	**Effective Class Engagement 40%**	**Padawan #**	5/28 face- Is
Turanga Leela		90	88	92		100	1	☑
Homer Simpson		43	44	42		80	3	☑
Doctor Who		85	98	72		100	1	☑

Figure 9: Instructor View of Google Sheets Gradebook

Each student has their own sheet that we create, which refers back to their row in the instructor sheet. The instructor sheet is not shared with anyone. The student sheet is shared with the student at their official university account so that they can view but not edit the sheet. We are a G Suite institution. Currently, Google documents that are in an official university accounts are considered to have adequate security for these purposes, as on https://security.appstate.edu/policies-standards-and-guidelines/secure-file-storage-and-sharing.

Instead of forcing the student to scroll, we use the transpose command in the student sheet in order for view that allows them to more easily see their progress:

- A1
  =Transpose(IMPORTRANGE("spreadsheet web address", "grades!A1:AN2"))
  Note: my sheet tab is named grades, and I pull the web address in

- B1
  =Transpose(IMPORTRANGE(“spreadsheet web address”, “grades!A2:AN2”))
- C1
  =Transpose(IMPORTRANGE(“spreadsheet web address”, “grades!A*:AN*”))
  where * is the row number in my spreadsheet view

A	B	C
Last Updated: May 19	Name	Turanga Leela
	Final Project 15%	
	Exams 45% (can revise 1)	90
	Exam 1	88
	Exam 2	92
	Exam 3	
Collated through "percent practice"	Effective Class Engagement 40%	100
Lowest 2 dropped	Padawan #	1
Personal Finance and Beyond	5/28 face-to-face activities	☑
	Is 80% asynchronous 1010 a good fit for you?	☑
	syllabus	☑
	what is mathematics	☑
	profile picture	☑
	real-life rates	☐
	percent practice	☑
	lump sum practice	☐

Figure 10: Student View of a Google Sheets Gradebook

Equity, Diversity, and Inclusion Considerations

What works to help our struggling students engage in active learning, what are their demographics, and how can we still encourage on-time completion of coursework for most students? Our linear algebra course has calculus II with analytic geometry as a prerequisite and is required for students in computer science, computational geology, and mathematics. In the most recent semester of our linear algebra, 33% of students were in groups underrepresented in mathematics, which we define as people of color, women or non-binary gender, or physical impairment under ADA. The remaining students are seemingly not underrepresented in mathematics. For instance, we gave students an opportunity to indicate their preferred gender, but some did not and we subjectively assigned a gender based on other cues (as might happen in many real-world contexts). Thus, this may be an imperfect count of who is genuinely underrepresented in mathematics.

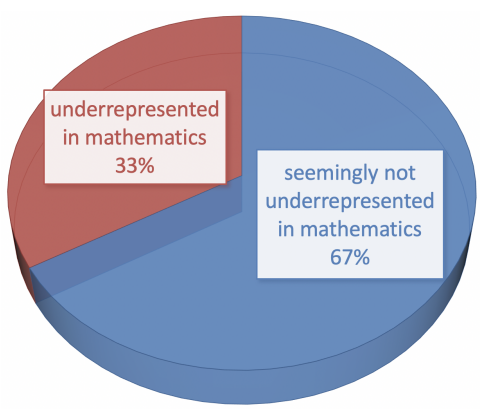

Figure 11: Demographics in Linear Algebra

We used interactive quizzes such as the one shown in Figures 4 and 5. Most students kept up with the interactive quizzes: 15 out of 27 students missed no homework and 8 missed exactly one assignment. The other 4 students missed 2, 3, 5, and 7 assignments. The students who had missed more than 30% were both in underrepresented groups. Both of these students took advantage of the second chance homework. One made up all 5 and the other made up 5 of the 7, and at least engaged with 1 of the 7, but not at a high enough level for completion. Here are the overall participation rates:

	seemingly not	underrep
kept up entire semester	61%	56%
completed some 2nd chance hw	17%	33%
could have but didn't	22%	11%

Table 1: Homework Participation Rates in Linear Algebra

Overall, the students interacted reasonably well with the online homework system, and the higher bar set for the second chance homework worked well to minimize procrastination. Students valued the homework system and had only positive comments about it, such as "The homework helped me understand things the most, especially because you could take it multiple times in order to actually get the chance to learn what you did the first time and then correct it and know whether or not your new answer is correct," and "Homework's [sic] asked us to think critical to understand that concept deeply."

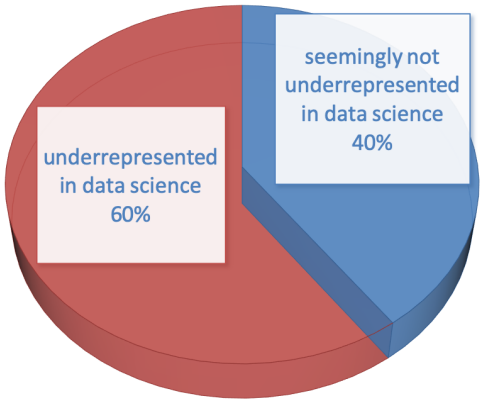

Figure 12: Demographics in Data Science

The only prerequisite for our introductory data science course is a passing score our mathematics placement test, a decision that was made for the express purpose of attracting a diverse pool of students interested in this growing field. The most recent offering had a majority of students in underrepresented groups as shown in Figure 12.

Overall, students in underrepresented groups had a higher completion rate. Two of the three students in the underrepresented group who did not complete all 11 assignments only missed one (and they partially engaged with some of those activities). They also were able to demonstrate proficiency in fundamental skills in other assessments.

	seemingly not	underrep
completed all 11 assignments	70%	80%
number completed for others	5, 7, 9	7, 10, 10
average points for completed	97 / 100	90 / 100

Table 2: Assignment Participation Rates in Data Science

Students were frustrated with DataCamp at times. For example, there were many comments similar to one student's feedback of "This DataCamp course was irritating to complete due to the lack of clear instructions given." At the same time, students generally rated DataCamp as a valuable use of their time. Several comments echoed a student's sentiment of "I really appreciate the practice Datacamp gives me."

Figure 13: Making the Impossible Possible

We share the data above because paying attention to our students helps us understand what works well and what doesn't so that we can make improvements in the future. None of the data is statistically significant but it does reveal the reality of the students who were in our most recent classes. For example, in the linear algebra class, students from underrepresented groups were less likely to complete all the assignments (initially) while in the data science course underrepresented students were more likely to complete all assignments.

Students achieve when we set high expectations for them but also provide strong support for their learning (see Figure 13). In our experience, especially when we are trying to be inclusive of underrepresented groups in mathematics, statistics, or data science, student learning activities such as those we have discussed above provide multiple entry points to the concepts and skills we want our students to learn, practice, and integrate. They also provide flexibility for students who may be ill (either one time or with a chronic condition) or who may have a weaker background in one or more important areas. The emphasis is generally on engagement with the material, persistence, and a growth mindset versus earning a points-based grade. These activities are a foundation upon which more summative assessments maybe built. Rigor and student accountability don't have to mean inflexibility!