CS 2202: Discrete Structures 2

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Sections 1 and 2 contain general facts about the course and the students who took it. Section 3 contains my analysis and observations. This section goes on to include some recommendations, **including a full realignment of the course outcomes as a suggestion to the fundamentals committee**.

1 Course Overview and Approach

Detailed learning outcomes are shown in Table 1 and correspond to the labels in the later alignments. This year we used "Connecting Discrete Mathematics and Computer Science" by David Liben-Newell from Cambridge University Press. The book was available both physically and electronically from the publisher, and a pre-print draft was available online from the authors website. This book was used for both CS 2101 (Discrete Structures 1, or DS1 as referred to later) and CS 2202 (Discrete Structures 2, or DS2 as referred to later) with Chapters 5-6,9, and 11 (not in that order) discussed in detail in Discrete Structures 2 and Chapters 2-4 reviewed extensively the first weeks.

All documentation and resources for both DS1 and DS2 (including this report) are available for use in future semesters at github.com/deblasiolab/CS2101.CS2202.Documents.

The course utilized of 4 major resources:

- **blackboard** — used as the primary asycnchronous communication method with assignment information, announcements, and grades posted by the instructional team and assignments submitted by the students.
- **online class "team"** — all students and staff were part of a university approved MS Team where students could ask questions or start discussions 24/7, the instructor and other staff could monitor and intervene; this is also where online office hours are conducted.

2 Assessment Instruments

The three primary sources of assessment came from exams (1 mid-term exam, and a comprehensive final), chapter summary quizzes, and 8 homework assignments (each one assigned over the course of one week). Smaller contributors not included in this report were: in-class participation quizzes and participation. These smaller assessments were not graded for correctness, the participation quizzes are used in place of taking attendance.

2.1 Exams and quizzes

All mid-term exams and chapter quizzes were graded by the instructor, feedback was given individually physically. The final exam was graded as a team, with all instructional team members present. Additionally, a postmortem discussion was provided in class after each exam and quiz.

Table 1: Detailed Outcome Numbering Used

Level 1: Knowledge and Comprehension	
DS2.1.a	Multiple types of graphs and trees, and how they each are relevant to computer science.
Level 2: Application and Analysis	
DS2.2.a	Articulate what counting is and how relevant it is to computer science.
DS2.2.b	Apply the basic principles of counting.
DS2.2.c	Model combinatorial problems using graphs and trees.
DS2.2.d	Describe various types of graphs and their common properties.
DS2.2.e	Identify trees as a fundamental structure in modeling computer science problems.
Level 3: Synthesis and Evaluation	
DS2.3.a	Reason about the complexity of algorithms using counting techniques and properties of graphs
DS2.3.b	Model computer science problems using graphs and trees
DS2.3.c	Lay out a proof plan for existential and universal proofs, be able to identify shortcomings of some types of proving strategies
DS2.3.d	Identify an inductive structure of a set: use it to conduct an inductive proof and to set a recurrence relation.

Delivery method Due to exam security issues in previous semesters several tactics were used to ensure assessment was taken of the individual student and no one else:

- assessments were given in person, on paper, in the classroom
- some, but not all, assessments were shuffled in order
- assessments were not printed until the day of the exam, and each was printed with a unique identifying number
- assessments were close book

In addition, to help ensure unbiased grading, the final exam was separated and graded with only the number available to the grader. The front page of the assessments was the only place the student's name was present.

Scores from the exams and quizzes, and their alignment to the outcomes are listed in Table 4. Because significant material from DS1 was included in the administration of the course, these outcomes were assessed as well. The scores are low compared to the C grade cutoff used, but the inclusion of all students (not just those who passes, see below) likely impacted these numbers.

2.2 Homework

Homework assignments were taken from the texbook, though regenerated in order to allow for changes between the physical and pre-print versions. Students were given one week to complete the assignment. Since much of the homework required the use of mathematical notation, students were asked to submit a PDF (either scanned versions of paper or prepared digitally) in order to eliminated any errors cause in re-display of other formats (such as word). The mapping of the homework to outcomes is shown in Table 2. Because significant material from DS1 was included in the administration of the course, these outcomes were assessed as well. The scores are low compared to the C grade cutoff used, but the inclusion of all students (not just those who passes, see below) likely impacted these numbers.

3 Analysis and Observations

Initially 39 students registered for the course across two sections, 32 were enrolled at the time of the final exam. Of these only 27 attended the final exam. The final letter grades assigned and scores needed for each letter are shown in Table 3.

Table 2: Concepts on Homework Assignments

			HW 1	HW 2	HW 3	HW4	HW5	HW6	HW7	HW8
Level 3			70.1%	61.1%	75.2%	79.4%	73.1%	69.9%	51.0%	70.7%
DS2.3.a	1	70.7%								1
DS2.3.b	2	60.5%						1	1	
DS2.3.c	2	56.0%		1					1	
DS2.3.d	1	75.2%			1					
Level 2										
DS2.2.a	1	73.1%					1			
DS2.2.b	2	76.2%				1	1			
DS2.2.c	2	65.2%				1			1	
DS2.2.d	2	60.5%						1	1	
DS2.2.e	2	60.5%						1	1	
Level 1										
DS2.1.a	2	60.5%						1	1	
Level 3										
DS1.3.a	**1**	**61.1%**		1						
DS1.3.b	1	61.1%		1						
DS1.3.c	2	77.3%			1	1				
Level 2										
DS1.2.a	**0**	–								
DS1.2.b	1	70.1%	1							
Level 1										
DS1.1.a	**2**	**76.2%**				1	1			
DS1.1.b	1	61.1%		1						
DS1.1.c	0	–								

Notes:

– Objectives with scores lower than a C are marked in red.

– The inclusion of all students (not just those who passes, see below) likely impacted the concept scores.

Table 3: Letter Grades Assigned

Letter	Cutoff	Count
A	$\geq 90\%$	3
B	$\geq 75\%$	12
C	$\geq 65\%$	8
D	$\geq 50\%$	1
F		8
W		7
I		0

The DF rate was 28.1% (from the students who did not withdraw), and the DFW rate was 41.0% (counting those who completed the welcome survey).

Typically I move the bars for letter grades based on the histogram of scores of students, in most situations a clear quad-modal distribution (or close to) appears as long as enough students are enrolled where separations can be made, this allows me to adjust to the difficulty of assessments in any given semester.

3.1 Observations

1. With this being a new textbook, and my first time administering the course, there were hiccups in policies and changes that could be made to make the continuity more smooth.
2. The chosen textbook is well written in my opinion and aligns well with the approach I wanted to take with the course, but it would have been more effective if students had read the text.

3.2 Recommendations

1. It would be useful to pace the course better with CS2. It was mostly true that students were in both DS2 and CS2 at the same time, so playing off the topics covered worked well when it happened. This was easier than with CS1 since I had taught CS2 several times before, this may be harder to accomplish for someone new and thus its even more important to include the CS2 faculty in the timeline, as this could have helped reinforce on both side. One issue is that while most of the DS2 students are in CS2, some of the CS2 students are in Discrete *Math* which will not align.
2. While it ended up being okay because of the withdraw rate, one IA and one TA for what was originally 128 students (DS1 + DS2) was hard to manage. The feedback on homework was by necessity spartan. If in CS2 for 50 students 1 TA and 2 IAs are assigned, this should be the standard per 50 students. And while this can be adjusted some due to the SCH of these two courses a staff of 3 including the instructor is inadequate by far.
3. The outcomes as stated, in my opinion, do not align with the current 1 hour/2 hour split of DS1 and DS2. There is also lots of ambiguity left. My approach was to find a text that aligned with what I felt was needed in CS2, then teach that. This worked well for most concepts in DS1 (as a side note here, as we will mention some items need to be adjusted in DS2). I also used the feedback from the DS1 students, and the points that needed reinforcement to adjust pacing. The biggest misalignment, in my opinion, is the inclusion of Induction in Discrete 1 outcomes. Students have trouble with simple proofs at this point and I felt it was better to reinforce that then introduce Induction at the end of the semester.

   To that end, I have included suggested reorganization of the outcomes for Discrete Structures 2 in Appendix A.

   A mapping from old to new can be found in Appendix B. Note that in this proposal several current outcomes are moved to DS1, but as you will see in the corresponding report, some items are moved forward from DS1 into DS2.

Table 4: Concepts on Exams and Quizzes

			Midterm							Chapter 5 Quiz			Chapter 9 Quiz					Chapter 11 Quiz					Final Exam										
			1	2	3	4	5	6	7	1	2	3	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	6	7	8	9	10	11
Level 3																																	
DS2.3.a	2	49.0%																													1	1	
DS2.3.b	1	47.3%																			1												
DS2.3.c	3	56.7%							1								1																1
DS2.3.d	4	60.8%					1	1															1	1									
Level 2																																	
DS2.2.a	1	79.0%											1																				
DS2.2.b	9	69.3%			1	1							1	1	1	1											1	1			1		
DS2.2.c	2	55.5%			1							1																					
DS2.2.d	5	46.4%																1	1	1		1						1					
DS2.2.e	3	58.1%																			1					1				1			
Level 1																																	
DS2.1.a	7	49.9%																1	1	1	1	1							1	1			
Level 3																																	
DS1.3.a	3	44.6%							1															1									1
DS1.3.b	0	–																															
DS1.3.c	6	60.6%					1	1	1								1							1	1								
Level 2																																	
DS1.2.a	0	–																															
DS1.2.b	4	51.6%	1	1									1										1										
Level 1																																	
DS1.1.a	8	70.6%			1	1							1	1	1	1											1	1					
DS1.1.b	0	–																															
DS1.1.c	1	56.9%																							1								

Notes:

– No time was available for a chapter 6 quiz.

– Quiz scores not recorded at a question level, but most were over the same concepts.

– Objectives with scores lower than a C are marked in red.

A Suggested Outcomes

1. Level 1: Knowledge and Comprehension
   (a) Intuition complexity classes in general
   (b) Major running time of open problems in Computer Science and their relevance in relation to other topics in the class (i.e. Traveling Salesman when discussing graphs, SAT when studying propositional logic, etc.)
2. Level 2: Application and Analysis
   (a) Identify and Know Relevant Properties of:
      i. Graphs (weighted and unweighted, directed and undirected)
      ii. Trees (weighted and unweighted)
      iii. Binary Trees
   (b) Reason about the complexity of algorithms using
      i. Simple analysis of non-complex methods
      ii. Counting for algorithms with loops
      iii. Recurrence Relations for algorithms with recursion
3. Level 3: Synthesis and Evaluation
   (a) Proof by Induction: proving statements and algorithms using
      i. "weak" induction
      ii. strong induction
      iii. structural induction (primarily on graph and trees)
   (b) Counting and its relevance to computer science

B Mapping of Old Outcomes

1. Level 1: Knowledge and Comprehension
   (a) Multiple types of graphs and trees, and how they each are relevant to computer science. [new DS2:2:a]
2. Level 2: Application and Analysis
   (a) Articulate what counting is and how relevant it is to computer science. [new DS2:3:b and DS2:2:b:ii]
   (b) Apply the basic principles of counting. [new DS2:2:b:ii]
   (c) Model combinatorial problems using graphs and trees. [eliminated/new DS2:1:b]
   (d) Describe various types of graphs and their common properties. [new DS2:2:a]
   (e) Identify trees as a fundamental structure in modeling computer science problems. [eliminated/new DS2:2:a or DS2:1:b]
3. Level 3: Synthesis and Evaluation
   (a) Reason about the complexity of algorithms using counting techniques and properties of graphs [new DS2:2:b]
   (b) Model computer science problems using graphs and trees [new DS2:2:a and DS2:1:b]
   (c) Lay out a proof plan for existential and universal proofs, be able to identify shortcomings of some types of proving strategies [new DS1:2:a]
   (d) Identify an inductive structure of a set: use it to conduct an inductive proof and to set a recurrence relation. [new DS2:3:a:iii]