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The Value of Computational Thinking Across Grade Levels

Computational Thinking Module

Heart Transplants and the NFL Draft

STUDENT EDITION

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By

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Heart Transplants and the NFL Draft

A Computational Thinking Module

What Is Computational Thinking?

Computational thinking is a high-level thought process that considers the world in computational terms. It begins with learning to see opportunities to compute something, and it develops to include such considerations as computational complexity; utility of approximate solutions; computational resource implications of different algorithms; selection of appropriate data structures; and ease of coding, maintaining, and using the resulting program. Computational thinking is applicable across disciplinary domains because it takes place at a level of abstraction where similarities and differences can be seen in terms of the computational strategies available. A person skilled in computational thinking is able to harness the power of computing to gain insights. At its best, computational thinking is multidisciplinary and cross-disciplinary thinking with an emphasis on the benefits of computational strategies to augment human insights. Computational thinking is a way of looking at the world in terms of how information can be generated, related, analyzed, represented, and shared.

Introduction to the Module

The purpose of this module is to study situations in which a group of people must decide on whom to select from a group of eligible candidates. For example:

- Given all the people eligible for a heart transplant, how do you decide who gets one? Who should have input into this decision?
- Given all the people eligible for an administrative or executive position in a company, how do you decide whom to hire?
- Almost all major league athletic teams hold entry drafts to distribute the available talent. How does a team choose the best player for its program? How does a player maximize his position in such a draft? How does the NFL create a semblance of fairness and balance among teams?

Unit 1 focuses on valuation procedures for decision making in the awarding of heart transplants and the possible uses of technology in this decision making.

Homework the Night Before Starting the Module

In a warm-up homework activity, you are asked to examine a general question: How are organ transplants distributed to patients? Is it different for heart or lung or kidney?

Answer each of the following questions for each of the three categories (types of organs) and fill in a table with your results. (You may use the table in Appendix 1 or create one of your own.)

1. How many organs are available in each category a year? (Use a full year.)
2. How many recipients need that organ in each year?
3. How many hospitals do transplants? How widely are transplants distributed throughout the country? What is the least number of transplants done in any one hospital? the most done in any one hospital?
4. Who does the matching of organs to recipients?
5. How would you measure success of such matchings?
6. List various ways you might match organs to recipients, and identify criteria for each.

Following are some useful links. Several of these are produced by hospitals affiliated with medical schools, hospitals that are transplant centers. Be sure as you do your research to look at more than one source because different hospitals may have different policies.

- Organ Procurement and Transportation Network (OPTN). This site has good general information about the different types of transplants: http://optn.transplant.hrsa.gov/resources/allocationcalculators.asp.
- Lung Transplants. Information about lung transplants is provided by Columbia School of Physicians: http://www.columbialungtransplant.org/news_las.html.
- Liver Transplants. Good information is available here: http://www.medicinenet.com/liver_transplant/article.htm.
- Heart Transplants. The University of Maryland Medical Center site is a good source for heart transplants: http://www.umm.edu/heart/transplantation.htm

Use the Excel spreadsheet or this table to choose the 12 patients that should (Y for yes, N for no) immediately get hearts. List the reasons you made the choices that you did.

		Heart Transplant Patient Data				12 Available Hearts		
Name/code	**Hospital**	**Ethnicity**	**Gender**	**Age**	**Cause**	**Urgency**	**State of Health***	**Y or N**
10	A	AA	M	75	HAD	EX	P	
11	A	H	M	78	HMD	MOD	E	
12	A	C	M	40	ACCI	EX	E	
13	A	C	M	69	HAD	MOD	G	
14	A	AA	F	75	HAD	MOD	G	
15	B	C	M	2	CONG	EX	E	
16	B	C	F	5	VIRAL	EX	P	
17	B	AA	F	40	ACCI	EX	E	
18	B	C	F	90	HAD	EX	P	
19	B	C	M	76	HAD	EX	G	
20	B	C	M	70	HMD	EX	P	
21	B	C	F	82	ACCI	EX	E	
22	B	H	M	67	HAD	MOD	G	
23	C	C	M	1	CONG	EX	G	
24	C	C	M	85	HMD	MOD	P	
25	C	AA	M	79	HAD	MOD	P	
26	C	C	M	74	HMD	MOD	G	
27	C	C	M	68	VIRAL	EX	G	
28	C	C	F	35	ACCI	EX	G	
29	C	C	M	65	HAD	MOD	P	
30	C	H	M	45	CONG	MOD	P	
		CAUSES			**URGENCY**		**STATE OF HEALTH**	
		VIRAL			EXTREME		EXCELLENT	
		CONGENITAL			MODERATE		GOOD/FAIR	
		ACCIDENT					POOR	
		HEART ARTERY DISEASE (HAD)						
		HEART MUSCLE DISEASE (HMD) (Cardiomyopathy)					*Health independent of heart	

Unit 1: Heart Transplants

Main Question: How are decisions made about who gets hearts for transplant? How should those decisions be made?

Discussion: From your work last night, discuss possible answers to the following questions:

1. How many hearts, lungs, and kidneys are available each year, and how many patients need such transplants?
2. What differences do you see between the need and availability of these organs? Why do you think this variability exists?
3. What problem are you trying to solve regarding transplants?
4. How do you think the decision is made about who gets a heart (or lung or kidney) once a heart (or lung or kidney) becomes available?
5. Who makes these decisions?
6. Whom did you decide to give the 12 available hearts to last night?
7. Why did you make the decisions you did?
8. Compare the results in the class. Were there common themes?
9. After comparing your results with your classmates' results, would you change your allocation? Why or why not?
10. What other information do you wish you had? Do you think it is possible to get this information in general?
11. What role could technology play in making these decisions?
12. When would you want to use a computer?
13. Would applying technology up front in some way make it easier to make decisions once a heart (or lung or kidney) becomes available?

Computational Thinking Alert: Here you will use computational thinking in the process of taking problems that involve making decisions about who gets a heart transplant, analyze the problem of making the decision, think of different ways to solve the problem, and determine how computers can be used to help solve the problem.

Heart Transplant Patient Data				**12 Hearts**			
Ethnicity	**Gender**	**Age**	**Cause**	**Urgency**	**State of**		**Condition after 3 Years**
					Health*		**with Transplant**
AA	M	75	HAD	EX	P		dead
H	M	78	HMD	MOD	E		doing well
C	M	40	ACCI	EX	E		excellent
C	M	69	HAD	MOD	G		dead
AA	F	75	HAD	MOD	G		doing well
C	M	2	CONG	EX	E		excellent
C	F	5	VIRAL	EX	P		dead
AA	F	40	ACCI	EX	E		excellent
C	F	90	HAD	EX	P		dead
C	M	76	HAD	EX	G		doing well
C	M	70	HMD	EX	P		dead
C	F	82	ACCI	EX	E		excellent
H	M	67	HAD	MOD	G		doing well
C	M	1	CONG	EX	G		excellent
C	M	85	HMD	MOD	P		dead
AA	M	79	HAD	MOD	P		dead
C	M	74	HMD	MOD	G		doing well
C	M	68	VIRAL	EX	G		dead
C	F	35	ACCI	EX	G		dead
C	M	65	HAD	MOD	P		dead
H	M	45	CONG	MOD	P		dead
CAUSES			**URGENCY**		**STATE OF HEALTH**		
VIRAL			EXTREME		EXCELLENT		
CONGENITAL			MODERATE		GOOD/FAIR		
ACCIDENT					POOR		
HEART ARTERY DISEASE					*Health independent of heart		
HEART MUSCLE DISEASE							

1. How well do you think you did with your choice of 12 patients to receive heart transplants? Why?
2. Do these data on condition after 3 years surprise you? Why or why not?
3. Do you wish you had data on average survival after 1, 3, 5, and 10 years? Would it have made your decisions any different?
4. What additional data would you like to have seen before making your decisions?

5. Now that you have had time to think about the problem of assigning hearts as they become available, what would you do if you had the power to make such decisions for real?
6. Do you think that decisions about who gets kidneys are easier to make because there are so many more kidneys available, and the donor is not necessarily dead? Why or why not?

Now that you have assigned hearts and considered the results of those assignments, how would you measure your success in making the decisions?

Use one of these measures of success and compare your success with the success of other students in your class. Have the student(s) who was "most successful" by that measure describe how he or she decided to allocate the 12 hearts.

Homework for Unit 1

1. Is there a way to quantify the data provided in the Excel heart transplant spreadsheet to come up with a formula for assigning heart transplants? In other words, can you assign a "value" to each patient awaiting a transplant and then rank the patients, and assign a heart according to the patient's rank when the heart becomes available? Can you measure the success of this ranking system? How could you define success for heart distributions for transplants? Is there a way to quantify the data provided in the Excel spreadsheet to come up with a formula for assigning heart transplants? Can you assign a "number" to each patient awaiting a transplant and then rank the patients, and assign a heart according to the patient's number (rank) when it comes available? Can you measure the success of your system?
2. The spreadsheet for this unit provided 12 hearts for a total of 21 patients who needed hearts. Now assume you have 2,000 hearts and 3,000 patients who need the hearts. How does this change your decision process?

3. Far more kidneys than hearts are available for transplant, especially because kidneys can come from living donors; donors can survive with only one kidney. In 2010, there were 13,524 kidneys available compared to 2,406 hearts. However, there was a need for 96,012 kidneys in 2010 compared to a need for 3,167 hearts the same year.

a. Were you more likely to receive a kidney if you needed one than a heart in 2010? Why or why not?

b. What data do you need to be able to decide who would receive a kidney? How would you make decisions on who gets a kidney transplant? Does this differ from your decisions for heart transplants?

Unit 2: Ranking Systems and the NFL Draft

In Unit 1, we started to develop **ranking systems,** systems that assign numbers to people, together with an indication of how these numbers are to be used, to rank order them for heart transplants.

> A **ranking system** assigns a number, a numerical value, to each object (person) in a set of objects (people, animals, and so on) of size *n*, such that the set can be rank ordered from 1 to *n*, using the respective values, either highest to lowest or lowest to highest.

For example, in Unit 1, you may have chosen patients to receive heart transplants based on the age of the patient, youngest to oldest. You would have been using a ranking system that assigns the number 1 to the youngest, the number 2 to the next youngest, and on to the number 21 to the oldest.

We want to be able to tell if these ranking systems meet criteria we set forth in advance and to use these criteria to decide on the success of the ranking system.

In the heart transplant, a criterian for success might be that 70 percent of the patients receiving hearts survive three years. If 70 percent or more patients survive three years when assigned a heart using the age ranking system, then the age ranking system was a success. *How well did your system do?*

Ranking Systems for the NFL Draft

Now let’s look at the National Football League (NFL) draft and find possible ranking systems to aid in the decision making of the teams. We complicate things further by the NFL asking that there be a balanced competitive environment.

What is the NFL draft? Does the NFL, through its draft processes, create a balanced competitive environment? Can this question be answered quantitatively? How has technology changed the way we can make decisions on whom to draft?

A **draft** is a process used in the United States and Canada to allocate certain players to particular sports teams. In a draft, teams take turns selecting from a pool of eligible players. When a team selects a player, the team receives exclusive rights to sign that player to a contract, and no other team in the league may sign the player.

The best-known type of draft is the **entry draft**, which is used to allocate players who have recently become eligible to play in a league. In football, the players must be out of high school by at least three years to enter the draft. Football players mostly come from collegiate teams, although not all do.

The NFL football draft began in 1935 in an attempt to prevent expensive bidding wars for young talent and to ensure that no one team can sign contracts with all of the best young players and make the league uncompetitive. Draft order in the NFL is determined in a reverse-record order (the previous season's worst team picks first; the Super Bowl winner picks last). Expansion teams always pick first, should there be new expansion teams that year.

The NFL draft process is referred to by many as “paralysis by analysis,” and it appears that no one is completely happy with the outcome, not the NFL, not the owners and managers, and not the players. Some say putting names in a hat would be as effective as using technology to analyze tons of data of all sorts.

Background Reading

The NFL Draft Process

Player Scouting

NFL teams put a lot of time and resources into getting ready for the NFL draft. Teams are continuously evaluating their needs and players that may fill those needs. All but five NFL teams pay to belong to one of the two major scouting services, National Football Scouting and BLESTO. These scouting services were founded in the early 1960s and the purpose of these scouting organizations is to help NFL teams evaluate prospective draftees.

National Football Scouting services provides each of its teams a list of draft prospects in the spring, after college teams have completed their spring practices. Teams are given information on players who have been viewed as prospects of interest. This information includes position, weight, size, 40-yard-dash times, bench press, broad and vertical jump, and other significant stats, as well as an overall player grade.

National's scouts include complete personal evaluations on potential draftees. Teams use this information in the process of deciding who they want their scouts to evaluate more closely.

NFL Combine

The NFL hosts the annual Combine at the end of February each year to give players the opportunity to display their abilities. For the past 20 years, it has been held in Indianapolis, Indiana. Participation in the Combine is by invitation only and athletes are showcased by a selection committee that consists of NFL player personnel directors and scouts from both National and BLESTO. Collectively, the event lasts for a week, but a player's individual time there lasts only four days—the schedule is staggered by position. The selection committee usually invites between 320 and 350 players to attend. Each player goes through a number of tests designed to measure both their physical and intellectual abilities. The physical tests include the following:

- Bench press (225 lbs.)
- 40-yard dash (also timing 10 and 20 yards)
- 20-yard short-shuttle run
- 3-cone drill
- Broad jump
- Vertical jump.
- Players are also tested in position-specific drills, and they receive Cybex testing to measure joint movement, physical evaluations by NFL team doctors, and other tests as determined or implemented by the NFL Advisory Board (NFLDAB).

The intellectual tests include the following:

- Written tests, such as the Wonderlic Personnel Test (WPT)
- Interviews; each team is allotted 60 interviews with 15-minute time limits

The four-day experience at the Combine**:**

- Day 1 – Physicals: Pre-exam, X-rays, Cybex tests
- Day 2 – Drug test, physical tests, measurements, Wonderlic test
- Day 3 – Team interviews
- Day 4 – On-field workouts and competitions

The actual NFL draft is held in New York City over a three-day period in April, after the Combine is completed. There are seven rounds of the NFL draft, with each team receiving seven selections. But trading draft choices between teams is common practice and some teams may receive extra picks under some circumstances, so many teams may have more or fewer than seven selections. The order of team picks after any expansion team is shown in Table 1.

Status	Draft picks
Non-playoff teams	1–20
Eliminated in Wild Card round	21–24
Eliminated in Divisional round	25–28
Eliminated in Conference Championships	29–30
Super Bowl losing team	31
Super Bowl champion	32

Table 1: Order of draft picks

Compensatory Picks

In addition to the 32 picks in each round, there are a total of 32 picks awarded at the ends of Rounds 3 through 7. These picks, known as **compensatory picks**, are awarded to teams that have lost more qualifying free agents than they gained the previous year in free agency. Teams that gain and lose the same number of players but lose higher-valued players than they gain also can be awarded a pick but only in the seventh round, after the other compensatory picks. Compensatory picks cannot be traded, and the placement of the picks is determined by a proprietary formula based on the player's salary, playing time, and postseason honors with his new team, with salary being the primary factor. So, for example, a team that lost a linebacker who signed for $2.5 million per year in free agency might get a sixth-round compensatory pick, while a team that lost a wide receiver who signed for $5 million per year might receive a fourth-round pick. If fewer than 32 such picks are awarded, the remaining picks are awarded in the order in which teams would pick in a hypothetical eighth round of the draft. (These are known as "supplemental compensatory selections.") Compensatory picks are awarded each year at the NFL annual meeting, which is held at the end of March; typically, about three or four weeks before the draft.

Questions for Discussion

1. Describe the process as you perceive it from the reading passage.
2. What else do you wish you knew in order to better understand the draft process?
3. What do you believe is valued most by coaches, managers, and owners? Can you tell this answer from the "process" described above?
4. What does a player value? What makes him happiest? Is the player's value reflected in the draft process?
5. Does it appear that the NFL accomplishes its goal of leveling the playing field among teams with this draft process? Why or why not?
6. What are your initial thoughts about what might be done differently and what the impact might be? Think outside the box.

Computational Thinking Alert: Computational thinking involves thinking outside the box to solve problems. Once you think outside the box, think about how you may be able to use a computer to help you figure out the solutions to the problem.

Homework for Unit 2

1. Using Table 2 for quarterbacks:
   a. Identify the major components where data are provided, and indicate if a high number or a low number is desirable.
   b. Assign weights to the events to construct a weighting scheme to compute a player's overall number to be used in a ranking system. What are some ways to determine a final number for each player? Describe your ranking system. For example, you could use speed in the 40-yard dash to determine a ranking system.
   c. Do you think computing a number (value) for each player would affect the draft process? If so, how?
   d. What other data would you like to have about the players?

Name	Position	40-yd. speed	3-cone	Shuttle	Vertical	Broad	Bench	Intellectual tests
Tyrod Taylor	QB	4.47	6.78	4.09	37.5	126	—	Below 20
Jake Locker	QB	4.5	6.77	4.12	35	115	—	20
Colin Kaepernick	QB	4.53	6.85	4.18	32.5	115	—	Below 20
Cam Newton	QB	4.56	6.92	4.18	35	126	—	21
Joshua Portis	QB	4.59	6.84	4.12	40	126	—	Below 20
Blaine Gabbert	QB	4.61	6.84	4.26	33.5	120	—	42
Christian Ponder	QB	4.63	6.85	4.09	34	116	—	35
Jerrod Johnson	QB	4.75	—	—	29	119	—	Below 20
Pat Devlin	QB	4.81	7.08	4.32	33	116	—	Below 20
Andy Dalton	QB	4.82	6.93	4.27	29.5	106	—	29
Jeff Van Camp	QB	4.83	6.87	4.16	31	114	—	Below 20
Greg McElroy	QB	4.84	7.11	4.45	33	107	—	43
Ricky Stanzi	QB	4.87	6.95	4.43	32.5	110	—	30
Scott Tolzien	QB	4.92	6.84	4.12	29.5	116	—	Below 20

Taylor Yates	QB	5.06	6.96	4.12	29.5	104	—	Below 20
Ryan Mallett	QB	5.12	—	—	24	103	—	26
Ryan Colburn	QB	5.12	6.84	4.28	—	—	—	Below 20
Nathan Enderle	QB	5.12	7.13	4.46	25.5	102		Below 20

Table 2: Information on Combine scores of the top 20 quarterbacks eligible for the 2011 NFL draft

2. A second example of a professional league draft is the National Hockey League (NHL) draft. The NHL's entry draft system is different from that of the NFL. At the conclusion of the regular season, the 14 NHL teams that do not qualify for the playoffs are entered into a weighted lottery to determine the initial draft picks for the first round, which are seeded according to regular-season standing. Only the 26th through 30th place teams are eligible to receive the first overall draft pick. The remaining order is determined by the Stanley Cup playoff results, with the Stanley Cup winner awarded the last, or 30th pick, and so on. There is nothing similar to the Combine in the NHL. Unlike the NFL, the NHL has a minor league system with almost every NHL team having a minor league team affiliate. This allows NHL teams to draft players they think are not ready for NHL play but will be ready with more experience. Thus, teams take more chances in the draft. If you were a coach, how would you decide which players to draft. List all the things you would consider. Which system do you think is more fair to the players? Why?

Unit 3 Ranking Systems and Measuring Their Success Relative to Specific Goals

Main Questions of the Unit

1. What does the NFL (or any league) want to accomplish and how would you choose a ranking system for the draft to achieve that goal?
2. What does football team A want to accomplish and how would you choose a ranking system for the draft to achieve that goal?
3. What does football player X want to accomplish and how would you choose a ranking system for the draft to achieve that goal?
4. Is it possible to have one ranking system for the draft that achieves all three goals: for the NFL, for all teams, and for all players? Why or why not?
5. Are the parties in heart transplants—patients, hospitals, OPTN—equivalent to those in the NFL draft? Are the goals of each similar? Is it possible to achieve all the goals with one ranking system for heart transplants?

Regardless of the way players are ranked for the draft and teams pick players, we would like to be able to say we are successful or not successful in designing the system. With heart transplants, it seems easier: We would like to save more lives through our assignment of heart transplants to patients.

As indicated in Unit 2, all four major sports leagues—NFL, NBA, NHL and Major League Baseball—have developed different ways for distributing new talent to teams. Each has an annual draft where the rights to eligible new players are assigned to teams. Each league has developed a draft system that it hopes is designed to ensure that the league has balanced competition. This means that individual players have little to say on which team they eventually play. There are exceptions to this, and the interested reader should look into how football and hockey players have developed ways to have more control. Each team competes for new talent each year.

Questions: How would you define success for a professional athlete? Write down all the ways you and your classmates define success. How would you define success for a team? How would you define overall success for the league?

There are many ways to define success for an individual professional athlete. Before taking a close look at the NFL draft, let's consider the NHL and some data from the NHL draft of 2005. A professional hockey player might consider success by the number of games played at the minor league level, the number of games played at the major league level, the number of playoff games played, and the player's salary after five years. Table 3 indicates these aspects of players drafted by the NHL in 2005.

Activity 3.1

In groups, choose a measure of success for the professional hockey league player drafted in 2005. For example, you might consider salary five years after the draft, number of playoff games played, or a combination of the two. Compare the ranking determined by success (for example, salary) with the ranking given by the draft. How successful was the draft given your measure of success? Can you quantify your measure of success? What formula did you use to rank drafted players five years out? Could you apply this formula to any draft? Answer the following questions about your formula:

1. How did you come up with your formula?
2. Did you include all four components? If not, why not?
3. Compare your formulas with other formulas created by your classmates.
4. Do you still like yours the best? Why or why not?

Player	Draft Number	Games Played in the Minor League	Regular Games Played	Playoff Games Played	Salary after 5 Years
Sidney Crosby	1	0	412	62	9,000,000
Bobby Ryan	2	80	250	19	3,250,000
Jack Johnson	3	0	282	12	1,650,000
Benoit Pouliot	4	146	183	2	1,350,000
Carey Price	5	12	204	7	2,500,000
Gilbert Brule	6	55	143	0	1,850,000
Jack Skille	7	179	92	0	600,000

Devin Setoguchi	8	23	267	48	1,800,000
Brian Lee	9	123	132	4	825,000
Luc Bourdon	10	46	36	0	n/a
Anze Kopitar	11	0	393	6	6,000,000
Marc Staal	12	0	321	22	3,100,000
Marek Zagrapan	13	227	87	0	n/a
Sasha Pokulok	14	207	0	0	n/a
Ryan O'Marra	15	252	24	0	700,000
Alex Bourret	16	n/a	n/a	n/a	n/a
Martin Hanzal	17	0	288	11	1,500,000
Ryan Parent	18	113	106	27	850,000
Jakub Kindl	19	237	51	0	750,000
Kenndal McArdle	20	166	33	0	803,250

Table 3: 2005 NHL draft data

Now that you have developed ways to use the draft to “predict success” in ice hockey, let’s move on to football. Before doing that, however, it is worth noting an important difference between the two sports. In hockey, there are really only two distinct categories of players: goalies and skaters (forwards and defensemen). In football, there is far more specialization: quarterbacks, linemen, running backs, linebackers, defensive backs, place kickers, punters. For this reason, the NFL draft should be done by position.

Activity 3.2

Tables 4 and 5 show results from the 2002–2005 NFL drafts by two positions: quarterbacks (Table 4) and defensive ends and linebackers considered together (Table 5). The number of games played is for a five-year period beginning with the first season after draft. The salary is the salary at the end of those five years.

Use these data to find measures (formulas) that you could use to determine the success of the draft for a given drafted player in each of the following two categories: games played per year and latest salary. Compare the draft position of the player to the success score of the player. As draft position goes down numerically, does the score go up?

Year	Name	Draft #	Games played	Salary	*S* #
2002	David Carr	1	92	$2,100,000	
2002	Joey Harrington	3	81	$3,503,720	
2003	Carson Palmer	1	97	$9,500,000	
2003	Byron Leftwich	7	48	$2,005,200	
2003	Kyle Boller	19	65	$1,505,200	
2003	Eli Manning	1	121	$6,450,000	
2004	Phillip Rivers	4	100	$11,541,630	
2004	Ben Roethlisberger	11	99	$12,750,000	
2005	Alex Smith	1	54	$1,675,000	

Table 4: Quarterbacks

Did the draft work better in 2004 than 2003 for quarterbacks? Is there enough data to tell?

Year	Name	Draft #	Games played	Salary	*S* #
2002	Julius Peppers	2	142	$16,683,000	
2002	Dwight Freeney	11	138	$6,220,520	
2003	Michael Haynes	14	37	$504,290	
2003	Jerome McDougle	15	37	$1,000,000	
2003	Terrell Suggs	10	125	$15,000,000	
2003	Ty Warren	13	121	$1,482,280	
2003	Calvin Pace	18	107	$10,000,000	
2004	Jonathan Vilma	12	119	$9,300,000	
2004	Will Smith	18	126	$6,670,000	
2004	Kenechi Udeze	20	51	$857,500	
2005	Erasmus James	18	28	$745,000	
2005	DeMarcus Ware	11	96	$1,009,940	
2005	Shawne Merriman	12	92	$2,978,630	
2005	Thomas Davis	14	69	$2,300,000	
2005	David Pollack	17	16	$535,000	
2005	Marcus Spears	20	88	$736,040	
2005	Derrick Johnson	15	90	$1,500,00	

Table 5: Defensive Ends and Linebackers

Does it appear that the draft worked better in 2005 than in 2003 for defensive ends and linebackers, using your success number?

Computational Thinking Alert: Computational thinking is using your brain to try to figure out a problem as best you can before you use a computer to help solve the problem. In these examples, after you thought about how to solve the problem, you used the Excel spreadsheet software to allow you to do calculations faster and to compare solutions.

Homework for Unit 3

1. We have only looked at the top 20 NHL draft picks for 2005. The first round actually consists of 30 picks, one for each team in the league. Would you have better information if you had looked at all 30 instead of only the first 20? What if you had looked at second-round picks as well? Why or why not?

2. To get better NFL data, you could look at all the draft picks for a given year, instead of cross years as Tables 4 and 5 do. If you were working in groups, how would you do this?

3. You looked at ways of determining success of a draft using playing time and salary as predictors. Can you use salary data to measure the relative worth of each player's position to a football team? How would you test this? Does this make sense for the NHL?

Unit 4: What Are the Goals for Players, Teams, and the NFL, and Are Those Goals Achievable?

In general, the NFL wants to have a “level playing field” so that no team will be seen at the beginning of a season to be the clear winner at the end of the season. Another term used is to “balance the strength of the teams.” The NFL sets the terms of the draft. It wants a distribution of players that assigns both good and not-so-good players to each team; this way, the strongest teams going into the draft get weaker players and vice versa.

The teams want to win the most games and then go to the Super Bowl and win. The teams want to choose the strongest players for themselves, and they choose the players based on the players' positions in the draft, selecting players with a higher draft score first, and so on.

The players want to be drafted, play in as many games as possible, and receive high salaries. They are most likely to accomplish this with the teams that are desperate to get their talent in their position, and with those teams that are most successful overall.

For example, we could assign a value to each quarterback in the draft that is equal to his score on the Wonderlic test and then rank order the quarterbacks from 1 to *n*, corresponding to the highest score down to the lowest score.

In the case of heart transplants, a ranking system assigns numbers to possible recipients in order to rank the patients awaiting a heart transplant. This rank order determines who gets a transplant first, second, and so on. For example, we could use a ranking system that assigns the person’s age as his or her value and rank the patients from youngest to oldest.

A second simplistic example of a ranking system for the draft might be to rank the players by speed in the 40-yard dash, regardless of a player's position. You need only data from the Combine for all players (320–350) who participated in the draft for the 40-yard dash. The fastest player is ranked 1, the second-fastest player is ranked 2, and so on. The players are drafted in that order regardless of anything else. A measure of success could be as simple as getting 32 players on teams by the end of the draft.

Question: Why might this second simplistic ranking system be good? Why might it not be so good?

Question: How can a computer help you design your ranking system?

> ***Computational Thinking Alert*:** Computational thinking is a very complex and complicated way to solve problems, using strategies and many various ideas and forms of thinking.

Activity 4.1

Working in groups of four students and using the homework responses from Unit 1 and Unit 2, develop three possible ranking systems for the NFL draft. For each system:

- Explain how you would divide the set of possible football players.
- List what data you will use.
- Describe a quantitative (numerical) system for how to rank the players in the draft, either in general or for a specific team, or in some other way how to decide if it is a "good," or successful, system.
- In the case of heart transplants, the patients can be viewed as similar to the players—although their goal is to get a heart and live. Major hospital heart transplant centers are similar to teams—their goal is to get as many hearts as possible to give to their patients so that their patients live, and the National Organ Donor Network is similar to the NFL—its goal is to provide a fair system. A ranking system for heart transplants assigns a number to each patient, and then the patients are rank ordered according to that system. In your same groups, and using the information you found the first night, find one possible heart-allocation method.

Homework for Unit 4

1. Write your group answers from the NFL draft questions and the heart transplant questions indicated in the activities in the beginning of this unit.
2. Answer each of the four unit introductory questions for the NHL:
    a. What is the goal of the draft for the NHL?
    b. What is the goal of the draft for hockey team A?
    c. What is the goal of the draft for hockey player X?
    d. Is it possible to have one ranking system that achieves all three goals? Why or why not?
    e. Compare your answers to the answers found for football.
3. List some ways that you can compare the ranking systems across the different groups in your class.
4. List some ways you could test your ranking systems.

Unit 5: Comparisons of Ranking Systems

***Main Question of the Unit**:* How can different ranking systems be compared? What can you do to effectively draw these comparisons? Can you say if one ranking system is better than another in predicting success?

Computational Thinking Alert: Computational thinking is identifying, analyzing, and implementing possible solutions with the goal of achieving the most efficient and effective combination of steps and resources.

We have been looking for solutions to problems such as who gets heart transplants and who gets drafted, based on a set of parameters—for heart patients, based on information such as health and need; for football players, based on skill sets and initial conditions such as what positions teams need to fill. As a class, we have found many solutions, using various valuation schemes. Now we want to test and compare the various valuation schemes (solutions) to see if we can determine if one is better than another. We may also be able to predict the success of our valuation scheme. For example, one group might have ranked patients for heart transplants based only on age, whereas another group might have ranked patients based on state of health and urgency, weighting each equally. How do we test and compare these two solutions?

Computational Thinking Alert: Computer simulation is the attempt to generate a sample of representative scenarios for a model in which a complete enumeration of all possibilities would be prohibitive or impossible. Computer simulation can be used to test various scenarios on a number of data sets, even large data sets. One advantage of today's computer technology is that it is possible to run large-scale simulations.

Easily accessible up-to-the-minute data on heart transplants, as well as other organ transplants, is available at http://optn.transplant.hrsa.gov/latestData/asp. You can use data Excel spreadsheets using the parameters you want to include by building them from drop down menus, or you can go to the advanced data section and build Excel spreadsheets from scratch using your predetermined parameters. You can also manipulate the data by weighting certain parameters, such as using a value equal to twice the age plus three times the state of health and looking at outcomes with that weighting system. Appendixes 3 and 4 include samples of such data.

Activity 5.1

In the groups that were formed during Units 1 and 2, create spreadsheets using the OPTN data that fit the parameters you used to get a ranking of patients for heart transplants. Use the OPTN data for your region on survival along with these parameters and determine the survival rates if your ranking system were used across the data provided. Compare across the groups in your class. Which ranking system seemed to have the most success in terms of patient survival? Was there much difference in survival from the different group rankings? Could you predict success based on your ranking system after looking at all of the OPTN data in your Excel spreadsheet? Can you use a computer simulation to try various ranking options all at one time and compare survival rates?

Activity 5.2

In the groups that were formed during Units 1 and 2, create spreadsheets using the NFL data that fit the parameters you used to get a ranking of players for draft position.

Explain why you used these parameters in creating your spreadsheet. Use the data from four years' worth of data for quarterbacks and defensive ends and linebackers and draft position. If your ranking system were used, how would your draft order compare with what actually occurred? Use games played and salary data to determine how successful your valuation would have been during those years. Compare across the groups in your class. Which ranking system seemed to have the most success in terms of the most valued players? Was there much difference from the different group rankings? Could you predict success based on your ranking system after looking at all the data in your Excel spreadsheet? Can you use a computer simulation to try various ranking options all at one time and compare success? Data can be found at www.nfl.com/draft/history.

Group Homework for Unit 5

1. Experiment with computer simulations using various ranking options. Describe your processes, compare your results, and draw conclusions about which appears to be the most successful valuation scheme as determined by these simulations.
2. Do Activity 5.1 or 5.2, whichever one you did not do in class. As in homework problem 1, experiment with various ranking options and compare your results.

> ***Computational Thinking Alert:*** Computational thinking is generalizing and transferring a problem-solving process to a wide variety of problems. We now try applying what we have learned in this module to various other kinds of decision making, where a ranking is required.

Unit 6: Transfer of Knowledge—Final Assessment

Choose one of the following projects and use what you have learned in this module to solve the problem posed:

1. Look up information regarding your own state's processes for redistricting. What is analogous to the player in the NFL draft? Who are the "teams"? Who might be equivalent to the NFL? What are measures of success? Develop a ranking system for redistricting your state.
2. You are the chief executive officer (CEO) of a large company and you want to choose your chief financial person. You have more than 1,000 applications for the position. Create a ranking system that allows you to rank the applicants for the position.
3. Create a ranking system to design disease protocols—for example, for cancer or heart disease. Consider the treatments as analogous to the players and the patients as analogous to the teams. For example, a cancer patient may receive chemotherapy and surgery as a team gets a quarterback and a lineman in the draft. What aspect of the disease ranking might be analogous to the NFL? How is success determined?
4.

Appendix 1: Data sheet for heart, lung, and kidney transplants

Table for initial homework assignment

	Heart	**Lung**	**Kidney**
Organs available per year			
Recipients needing them per year			
Hospitals doing transplants			
Distribution in the U.S.			
Least number at any one hospital			
Most at any one hospital			
Who does the matching?			
How is success measured?			
Ways to do matching			

Appendix 2: Combine Scores and draft positions as in Table 2. No number indicates the player was signed as an undrafted player

Name	Pos	40-yd. speed	3-cone	Shuttle	Vertical	Broad	Bench	Intellectual Tests	Draft Position
Tyrod Taylor	QB	4.47	6.78	4.09	37.5	126	—	Below 20	180
Jake Locker	QB	4.5	6.77	4.12	35	115	—	20	8
Colin Kaepernick	QB	4.53	6.85	4.18	32.5	115	—	Below 20	36
Cam Newton	QB	4.56	6.92	4.18	35	126	—	21	1
Joshua Portis	QB	4.59	6.84	4.12	40	126	—	Below 20	—
Blaine Gabbert	QB	4.61	6.84	4.26	33.5	120	—	42	10
Christian Ponder	QB	4.63	6.85	4.09	34	116	—	35	12
Jerrod Johnson	QB	4.75	—	—	29	119	—	Below 20	—
Pat Devlin	QB	4.81	7.08	4.32	33	116	—	Below 20	—
Andy Dalton	QB	4.82	6.93	4.27	29.5	106	—	29	35
Jeff Van Camp	QB	4.83	6.87	4.16	31	114	—	Below 20	—
Greg McElroy	QB	4.84	7.11	4.45	33	107	—	43	208
Ricky Stanzi	QB	4.87	6.95	4.43	32.5	110	—	30	135
Scott Tolzien	QB	4.92	6.84	4.12	29.5	116	—	Below 20	—
Taylor Yates	QB	5.06	6.96	4.12	29.5	104	—	Below 20	152
Ryan Mallett	QB	5.12	—	—	24	103	—	26	74
Ryan Colburn	QB	5.12	6.84	4.28	—	—	—	Below 20	—
Nathan Enderle	QB	5.12	7.13	4.46	25.5	102	—	Below 20	160

Appendix 3: Data on Heart Transplants by Age

For Organ = Heart, Area = Region 3, Format = Portrait
Based on OPTN data as of September 2, 2011

region 3

Change Report (Optional) :

Create a New Report

Organ: Heart

Region: Region 3

Go

Add Field to Report :

count flip cols rows both print

portrait landscape

	To Date	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988
All Ages	6,524	137	325	294	289	295	280	278	257	290	272	297	272	287	325	331	312	320	323	303	265	230	217	161	164
< 1 Year	294	10	19	26	24	10	11	9	7	11	12	14	12	16	20	26	14	17	11	13	5	2	5	0	0
1-5 Years	230	9	7	8	13	16	9	12	10	10	13	14	8	12	10	11	11	10	16	9	9	8	3	1	1
6-10 Years	151	5	14	9	16	12	6	7	6	7	4	8	5	4	6	4	6	5	8	6	4	0	4	2	3
11-17 Years	322	11	20	16	16	12	19	19	18	24	13	21	10	11	9	16	17	13	4	13	12	12	8	4	4
18-34 Years	585	10	39	28	22	39	28	35	24	34	33	26	19	17	20	24	28	21	26	27	14	19	17	19	16
35-49 Years	1,368	20	55	54	54	60	54	46	38	63	50	49	61	54	69	54	69	73	87	70	76	61	60	36	55
50-64 Years	3,133	66	134	114	109	114	124	120	129	124	128	145	132	149	178	181	150	170	159	153	137	121	115	97	84
65 +	439	6	37	39	34	32	29	30	25	17	19	20	25	24	13	15	17	10	12	12	8	7	5	2	1
Unknown	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0

Appendix 4: Survivability

A. Survivability Data of Heart Transplant by Age (OPTN)

Survivability by Age

Recipient Age	Yrs. Post Transplant	Alive/Number Functioning	Survival Rate
< 1 year	1 year	180	83.6
1–5 years	1 year	169	87.4
6–10 years	1 year	117	86.8
11–17 years	1 year	266	90
18–34 years	1 year	516	86.9
35–49 years	1 year	1084	88.8
50–64 years	1 year	2552	87.8
65 +	1 year	482	84.3
< 1 year	3 year	190	78.7
1–5 years	3 year	209	77.7
6–10 years	3 year	120	83.9
11–17 years	3 year	275	77.4
18–34 years	3 year	529	75
35–49 years	3 year	1330	81.2
50–64 years	3 year	3312	79.3
65 +	3 year	624	74.7
< 1 year	5 year	185	71.6
1–5 years	5 year	160	74.5
6–10 years	5 year	115	77.5
11–17 years	5 year	228	72
18–34 years	5 year	438	67.7
35–49 years	5 year	1238	74.7
50–64 years	5 year	3138	72.7
65 +	5 year	508	65.4

B. Survivability by Causes

Recipient Condition	**Survival Years Post Transplant**	**Number Functioning/ Alive**	**Number Functioning / Rate**
Cardiomyopathy	1 year	2451	89.4
Congenital Heart Disease	1 year	301	82.1
Coronary Artery Disease	1 year	2148	87.1
Valvular Heart Disease	1 year	111	85.5
Other	1 year	95	88.2
Cardiomyopathy	3 year	2973	81.1
Congenital Heart Disease	3 year	416	73.7
Coronary Artery Disease	3 year	2801	78.4
Valvular Heart Disease	3 year	136	74.6
Other	3 year	79	77.2
Cardiomyopathy	5 year	2641	74.3
Congenital Heart Disease	5 year	366	68.1
Coronary Artery Disease	5 year	2667	71.8
Valvular Heart Disease	5 year	129	71.7
Other	5 year	50	65.6

cardiomyopathy = HMD
other = viral, accident—events that occur spontaneously
artery and valve combined in spreadsheet at beginning

	average survival rates
cardiomyopathy - HMD	81.6
congenital	74.6
artery disease	79.1
valve disease	77.3
other	77

ranking by survival average rates: cardiomyopathy
range is 74.6 to 81.6

- cardiomyopathy
- artery disease
- valve disease
- other
- congenital