An Integrative Learning Experience with Qwixx

Play, Probability, Partnership, Planning, and Programming

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8/12/2021

Context

Integrative Learning

A Reductive Definition by Contrast

Like interdisciplinary learning, this kind of learning experience combines multiple fields and/or topics. The distinction some pedagogical scholars (e.g. Huber et al. (2005) and Kinzie (2013)) make is that **integrative learning experiences** also **investigate the interaction between fields and topics**.

```
Interdisciplinary_learning ~ Field_A + Field_B
```

```
Integrative_learning ~ Field_A + Field_B + Field_A*Field_B
```

Association and American Colleges and Universities (AAC&U) Definiton

"[. . .] an understanding and disposition that a student builds across the curriculum [. . .], from making simple connections among ideas and experiences to **synthesizing and transferring learning to new, complex situations** [. . .]"

Integrative Learning goals

From the AAC&U's Integrative Learning VALUE Rubric (2009):

- **Connections to Experience** – Connects relevant experience and academic knowledge
- **Connections to Discipline** – Sees and makes connections across disciplines, perspectives
- **Transfer** – Adapts and applies skills, abilities, theories, or methodologies gained in one situation to new situations
- **Reflection and Self-Assessment** – Demonstrates a developing sense of self as a learner, building on prior experiences to respond to new and challenging contexts

The Benefits of Integrative Learning (Ferrett et al. 2013)

Students:

- The fact that their work matters to someone else produces higher student engagement, motivation, and commitment – students get ownership of their work, which serves a larger purpose.
- This is an opportune time for connected science – preparing students to engage with complex problems by "practicing" analysis and action in the real world is critical at this point in human history.
- Students get the opportunity to take a systems-view approach – in this case, students create the probabilistic mechanisms (their program and their strategies) to generate the data they will analyze.

Instructors: gain a keener sense of the whole student.

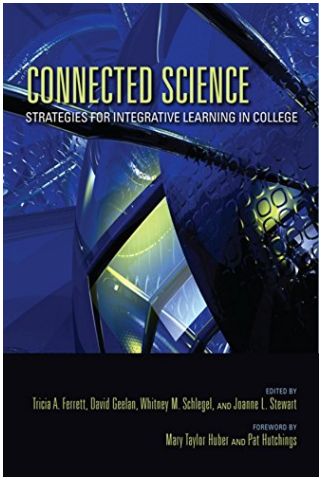
Further Resources on Integrative Learning

Integrative Learning VALUE Rubric (AAC&U 2009)

Integrative Learning: Mapping the Terrain (Huber and Hutchings 2004)

Taking Stock of Capstones and Integrative Learning (Kinzie 2013)

Connected Science (Ferrett et al. 2013)



Sports Analytics

Definition

The study of statistics in sporting contexts; typically includes team sports like baseball and basketball and to a lesser extent, football, soccer, and hockey. Peak outlets: Journal of Quantitative Analysis in Sports, MIT Sloan Sports Analytics Conference, fivethirtyeight.com.

Problems

- Students with understanding of particular sports have advantage, and vice versa.
- It's often white, male, and/or bro-ey.

A Solution

Make more inclusive by broadening sports to many more forms of **competition** including individual and team sports, eSports, board games, and elections. In particular, a Eurogame like Qwixx also keeps everyone engaged and puts most on equal footing at the start.

STAT375: Statistical Aspects of Competition *at Amherst College*

Pre-Reqs:

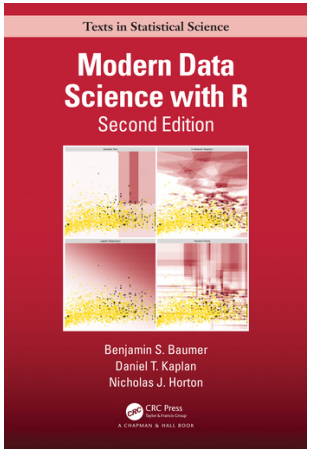
- STAT111/135 (AP Stats ++ with `R`'s `mosaic`)
- COSC111 (Intro **Programming** in Java)
- STAT230 (MLR, ANOVA, model selection, resampling methods, etc)
- STAT231 (**Data Science** with MDSR)

Adjacent courses:

- STAT360/370 (Probability and Mathematical Statistics)

Subsequent course:

- STAT495 (Senior capstone; leads to comprehensive exam/thesis)

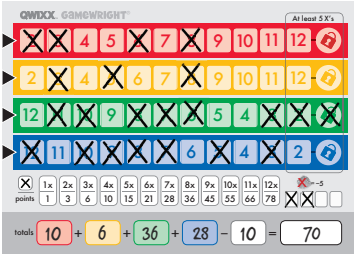


Course Description

Competitions, which can include individual and team sports, eSports, tabletop gaming, preference formation, and elections, produce data dependent on interrelated competitors and the decision, league, or tournament format. In this course, students will learn to think about the ways a wide variety of statistical methodologies can be applied to the complex and unique data that emerge through competition, including paired comparisons, decision analysis, rank-based and kernel methods, and spatio-temporal methods. The course will focus on the statistical theory relevant to analyzing data from contests and place an emphasis on simulation and data visualization techniques. Students will develop data collection, manipulation, exploration, analysis, and interpretation skills individually and in groups. Applications may include rating players and teams, assessing shot quality, animating player tracking data, roster construction, comparing alternative voting systems, developing optimal strategies for games, and predicting outcomes.

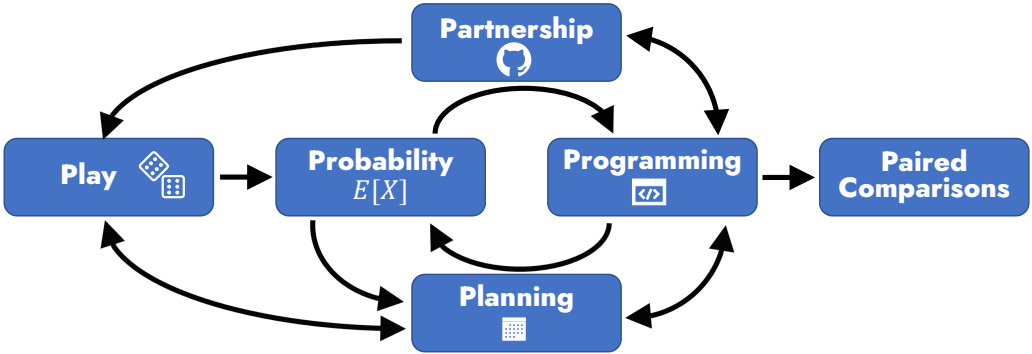
What is Qwixx?

- In Eurogame style, everyone plays for the duration of the game and the highest score at the end wins (see Kay (2018) on Eurogames).
- A dice game where players take turns rolling dice, some "public" and some "private." All players can use the public dice, but only the active player can see and use the private dice.
- Involves both chance and strategy with multiple aspects to consider, including trade-offs.
- Takes 5-15 minutes to play for experienced players.
- Available at e.g. Target for $5 to $12, but most students are not familiar with it (level playing field).
- 5-min vids on how to play Qwixx: A & B

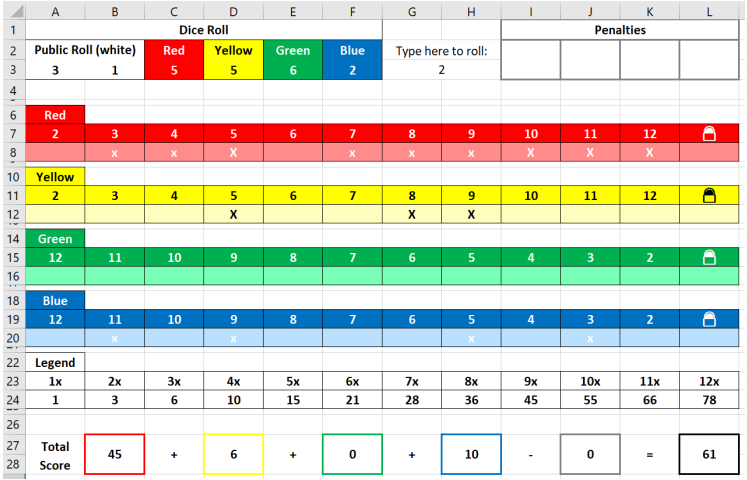


Activity

Goals of Activity



Programming and Playing Qwixx in Excel



	A	B	C	D	E	F	G	H	I	J	K	L
1	Dice Roll								Penalties			
2	Public Roll (white)		Red	Yellow	Green	Blue	Type here to roll:					
3	3	1	5	5	6	2	2					
4												
6	Red											
7	2	3	4	5	6	7	8	9	10	11	12	🔒
8		x	x	X		x	x	x	X	X	X	
10	Yellow											
11	2	3	4	5	6	7	8	9	10	11	12	🔒
12				X			X	X				
14	Green											
15	12	11	10	9	8	7	6	5	4	3	2	🔒
16												
18	Blue											
19	12	11	10	9	8	7	6	5	4	3	2	🔒
20		x		x				x		x		
22	Legend											
23	1x	2x	3x	4x	5x	6x	7x	8x	9x	10x	11x	12x
24	1	3	6	10	15	21	28	36	45	55	66	78
26												
27	Total	45	+	6	+	0	+	10	-	0	=	61
28	Score											

Hands-on Programming with R (Grolemund)

Students skimmed Ch 5 & 6 and read Ch. 7, 8, 9, 11 in advance. Book is free at rstudio-education.github.io/hopr.

5. R Objects
6. R Notation
7. **Modifying Values (* in place, logical operators)**
8. **Environments (scoping, assignment, evaluation)**
9. **Programs (control flow, lookup tables, comments)**
10. S3 (attributes, methods, classes)
11. **Loops (for, while)**
12. Speed (vectorization)

Instructors may want to read Advanced R by Wickham.

Lecture focuses is on function-writing, control flow, and modularity.

Qwixx Program Instructions (Selection)

- As with any program, you should break each part into small, repeatable steps, i.e., functions.
- Don't use global scope – game states should be passed from function to function.
- Refer to the Qwixx rules early and often to make sure your game is being played correctly.
- Include a function that checks whether a move is legal given a board state, locked row indicators, whether someone is active roller or passive roller, and [for active rollers] whether the secret dice move can be played AFTER the public dice move.

Best Student Program

- Had optional debug output $\rightarrow$
- Flexibly permitted the passing of information
- Followed all of HOPR's guidance

```
[1] "=========================PLAYER 2 TURN=========================="
[1] "Qwixx Roll was 1 3 4 6 5 1"
[1] "============================Possible Moves========================="
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12] [,13]
[1,]    0    0    0    0    0    0    0    0    0     0     0     0     0
[2,]    0    0    0    0    0    0    0    0    1     0     0     0     0
[3,]    0    0    0    0    0    0    0    0    0     0     0     0     0
[4,]    0    0    0    0    0    0    0    0    0     0     0     1     0
[1] "================================================================="
[1] "Player 1 Moves: NULL"
[1] "Player 2 Moves: c(2, 9)"
[1] "=========================PLAYER 1 BOARD========================="
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12] [,13]
[1,]    0    1    1    0    0    0    1    0    1     1     0     0     0
[2,]    0    0    0    0    0    0    0    1    1     1     0     0     0
[3,]    0    0    0    0    1    1    1    1    0     1     0     0     0
[4,]    0    0    1    0    1    1    1    1    1     0     0     0     0
[1] "=========================PLAYER 2 BOARD========================="
     [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12] [,13]
[1,]    0    1    0    0    0    0    1    1    1     0     0     0     0
[2,]    0    0    0    0    0    0    1    1    1     0     0     0     0
[3,]    0    1    0    1    1    1    1    1    0     1     1     0     0
[4,]    0    1    0    0    0    0    1    1    0     1     1     0     0
```

Brainstorm, Plan, and Implement a Strategy (Where Integrative Learning Happens!!)

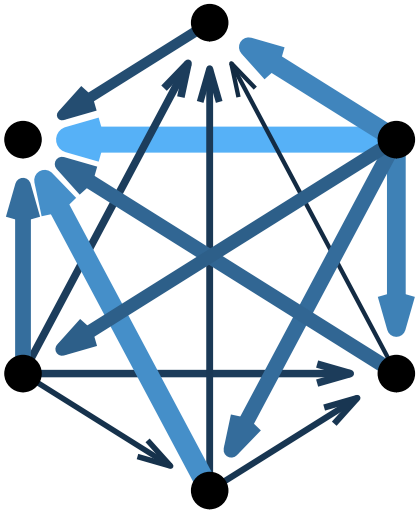
The "best" program is distributed in advance. Students read someone else's code and think about how they might call those functions.

- In their pairs, students brainstorm –
  - they describe how they play the game and try to solidify those thoughts in writing;
  - they imagine what they could do with computer power available in `R`.
- Students plan their "software" with a control flow diagram and/or pseudocode.
- Students implement their planned strategy.

Competitive Simulation

Establish "Truth" with a very large Simulation Comparing Strategies

- All of the simulated results are the product of student work! In essence, it's **student-generated data** that *isn't about grades, study time, or sleep or from a haphazard survey*.
- We compare every pair of strategies, i.e. $\binom{6}{2}$ comparisons with $M = 10,000$ replications.
- We can also examine transitivity or vs intransitivity a la Kendall and Smith (1940)!



Explore Effects of Tournament Structure, Seeding, Number of Games

- How often does best strategy win in various formats? **Because we know the "truth"**, we can answer questions about "short seasons." In particular, we can
  - examine simulation results in various tournament structures (single-elimination, double-elimination, round-robin, double round-robin),
  - compare rankings in single iteration, or with $M = 100$ replications, and
  - examine the effect of accurate vs inaccurate seeding.
- We can also explore rank aggregation.

Closing

Evidence for Integrative Learning from the Student Perspective

*What did you most **enjoy** about the project?*

- "It was interesting to learn more about functions and **coding in `R`, I had basically never done** it before this"

Transfer

*Did this exercise strengthen your **programming skills** and **algorithmic thinking**? If so, in what ways?*

- "Yes, very much. Writing an entire program is very involved. It requires a strong understanding of how to translate tasks into separate functions, and how to **organize and combine** these **functions together** into a working and meaningful program."

Reflection and Self-Assessment

***What did you learn** from this experience that you'd like to carry forward into future projects?*

- "A lesson in **perseverance in coding** and practice in debugging."
- "I think that the **same thought process** could very easily translate into other simulator. I've made a **baseball simulator** of sorts before [. . .], but I would be curious about how I can now do the same in R which would allow for further statistical development."

Connections to Experience

Schedule Overview

- *Day 1*: †Learning Qwixx (**Play**)
- *Day 2*: **Programming** in `R`
- *Day 3*: †Editing Programs
- *Day 4*: †Strategy Brainstorm (**Planning**)
- *Day 5*: †Strategy Implementation (**Probability** Extensions)
- *Day 6*: Competitive Simulation (**Paired Comparisons**)

†GitHub Classroom template repos $\Rightarrow$ collaboration $\Rightarrow$ deliverables

Contact

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Special Thanks to Sarah Bunnell, Associate Director and STEM Specialist for the Center for Teaching and Learning

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