Does Curricular Complexity in Computer Science Influence the Representation of Women CS Graduates?

Albert Lionelle
Khoury College of Computer Sciences
Northeastern University

McKenna Quam
Khoury College of Computer Sciences
Northeastern University

Carla Brodley
Center for Inclusive Computing
Northeastern University

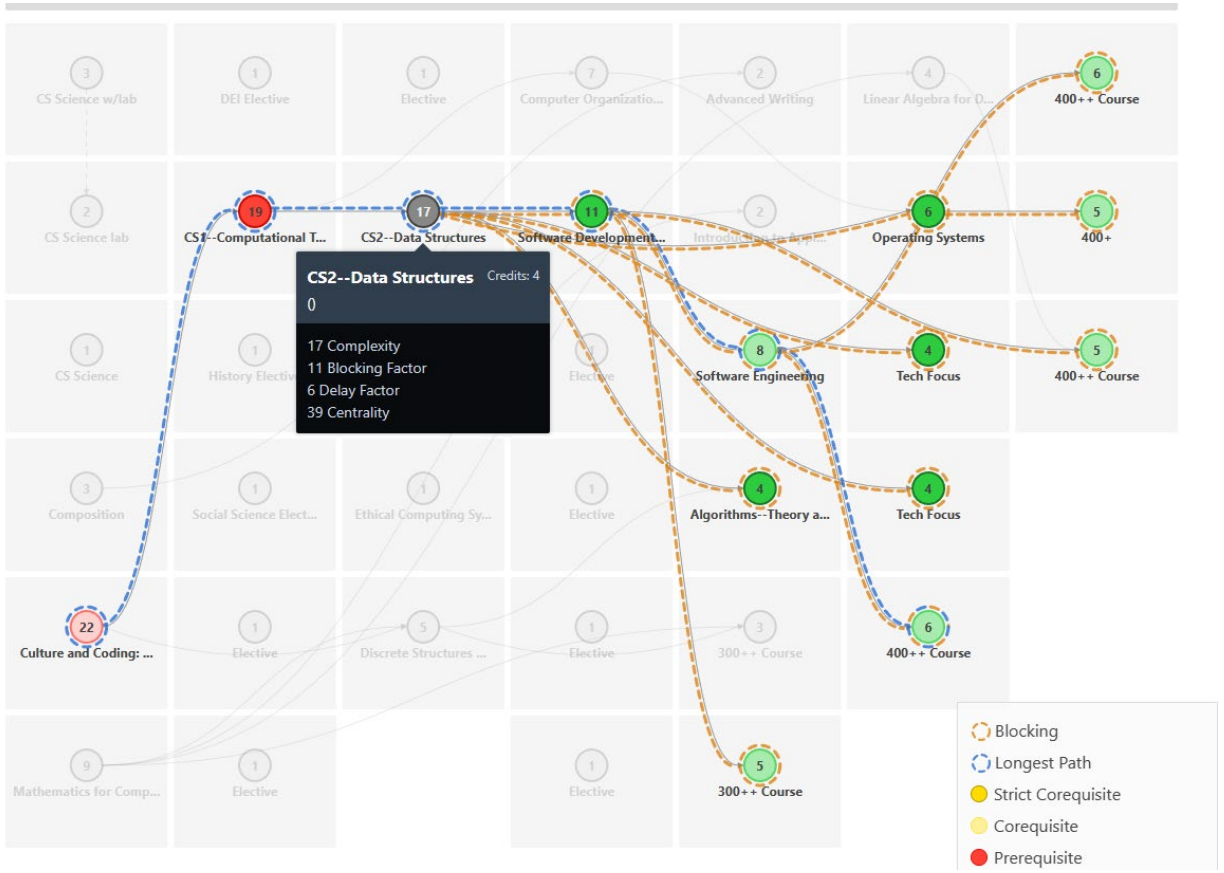
Catherine Gill
Center for Inclusive Computing
Northeastern University

Northeastern
Khoury College of
Computer Sciences

What is Curricular Complexity?

- Curriculums have an innate structure
  - Prerequisites, course requirements
- Curricular Complexity – the complexity of that *structure*
  - Not to be confused with course complexity
- Four measurements to compare curricular structure
    - Developed by Gregory L. Heileman and Ahmad Slim
  - Complexity
  - Centrality
  - Delay Factor
  - Blocking Factor

Curricular Analytics



- Blocking Factor
  - Number of courses that require course. 11 in example
- Delay Factor
  - Measures sequential ordering (max) that it is a member. 6 in the example
- Centrality
  - Sum of delay factors “how many course chains include this course”.
- Complexity
  - Combination of Blocking + Delay
- Curricular Complexity
  - Sum of all course complexities. 175 in example

https://www.curricularanalytics.org/

Why does this matter?

- Curricular Structure
  - Influences students directly
    - How long until graduation, ordering, etc
  - Measure to compare “best practices” in curricular design
- Heileman et al. found[1]
  - Higher ranked programs had lower curricular complexity
- Meaning
  - The structure of the curriculum was less complex
  - Making it easier to
    - Take courses in different orders
    - Transfer into the program later
    - Less assumptions about previous knowledge going into courses (hopefully)

[1] https://doi.org/10.18260/1-2--32677

Our Question

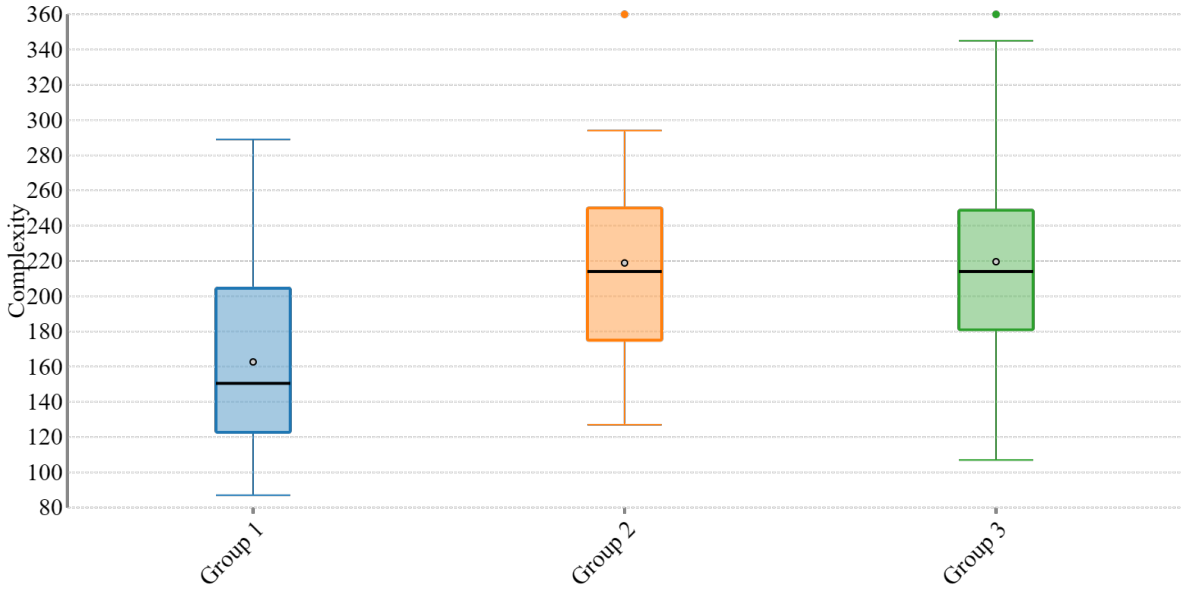
- Is there a relationship between structural complexity and the representation of women in a program?

- IPEDs for graduation rates divided by men and women (CIP 11.01, 11.07)
  - Paper addresses intersectional identity limitations and binary limitations of our data
- Grouped into 3 groups based on normalized percent women graduating
  - > 20%,
  - 20% to 15%
  - 15% and below
- Sampled 60 programs (20 each group)
- Built 60 degree maps
  - By public facing websites
  - Assumed calculus ready, no AP credits, bias towards reduced prerequisites, and ‘quickest path’ to graduation
- Analyzed: structural complexity, blocking, delay, and common courses

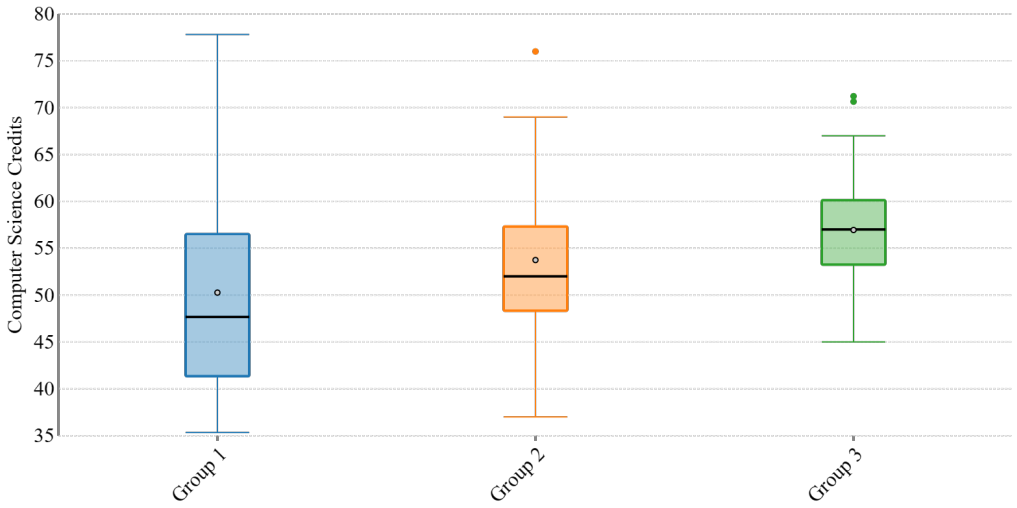
Degree Complexity

	% women	Mean Complexity	Median longest delay factor
Group 1	n > 20%	162.7 ± 12.8	5
Group 2	20% >= n > 15%	218.9 ± 13.1	6
Group 3	n < 15%	219.6 ± 14.4	6

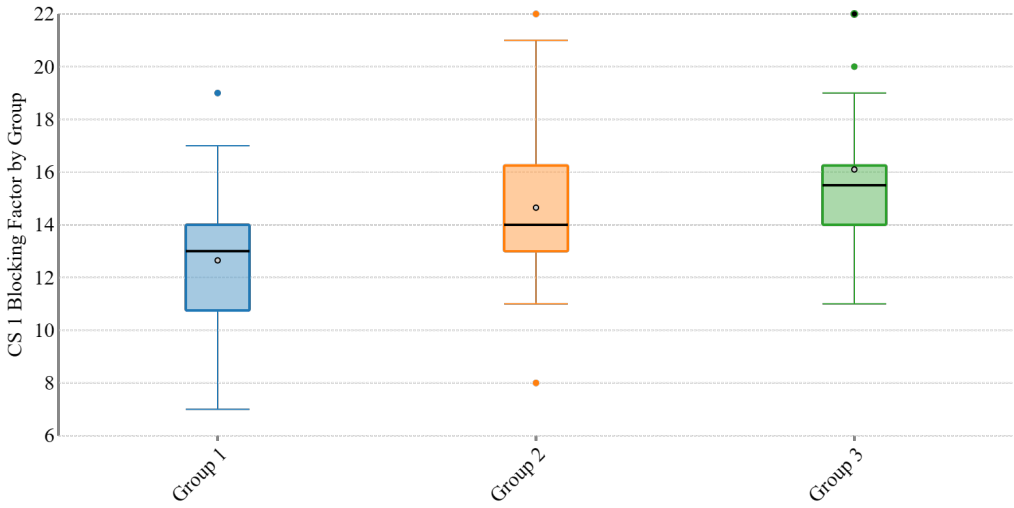
p = 0.003



Computer Science Credits



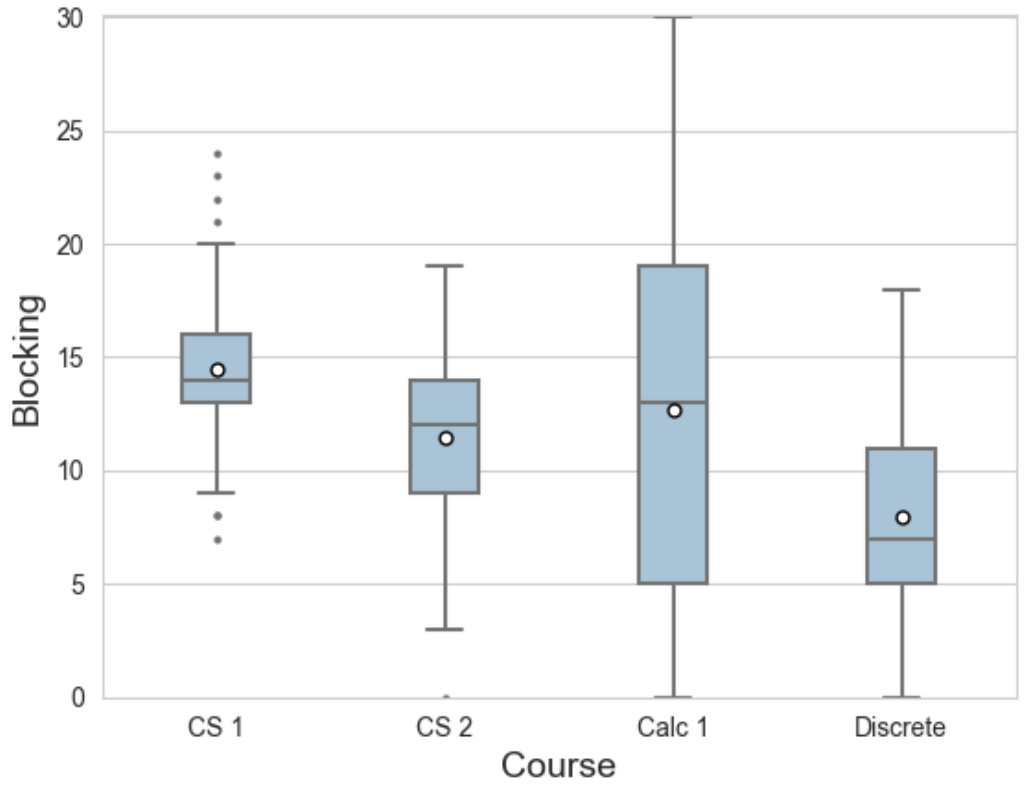
- Normalized to 120 credit degree programs
- Between 40-60 required CS credits common
  - 53 median credits (across all schools)
- Greater diversity has slightly less CS credits
  - 50 median



- While CS 1 blocks progress
- Slightly less in programs with greater diversity
  - Observation: due to optional pathways to take

Blocking Overall

- Blocking prevents progress
- Across all 60 schools
  - CS 1 should be blocking (mostly)
  - Calculus I, no consensus!



Best Practices Observed

- Comparing programs via structural complexity can build best practices
  - Five Best Practices we observed
    - Minimize Delay on Transfer Students
    - Eliminate choke points preventing progress
    - Offer flexibility around when calculus must be completed
    - Small core, with flexible options after core
    - How you communicate degree plans matter

Minimize Delay on Transfer Students

- The number of transfer students
  - Increase every year
  - Primary concern: time to graduation
- Use curricular maps to look at time to graduation
- Reduce if transfer students have “added” complexity
  - Extremely common!

Flexibility

- Programs with greater representation had
  - More options for students at various points
  - Smaller core requirements
    - 26% - group 1 compared to 33% group 3
  - Group 1 is characterized by minimal prerequisite
    - Often 300/3000 lvl upper division only required Data Structures

Choke Points and Calculus

- Choke points
  - Very evident in a curricular map
  - Programs with greater diversity often had ‘pathways’
    - Allows progression to prevent frustration of a choke point
- Calculus 1 – if placed early becomes a choke point
  - Yet, there is NO consensus between programs
  - Suggestion:
    - Only require it *as needed* for a course
    - Delay when it is needed
      - Allows time for precalc requirements
    - CS2023: ACM/IEEE-CS/AAAI Computer Science Curricula

Communication Matters

- Students do use websites
- We found:
  - Some programs made it very difficult to find information
    - Requirements often listed across multiple pages (university, college, degree)
    - Often contradicting information
    - Sometimes prereqs listed, sometimes not
  - Nearly everyone had a single “calc ready” suggested plan
- Suggestion:
  - Have a clean page that lists / links to courses, prereqs and plans.
  - Have multiple degree plans
    - Calc ready
    - No mathematical background
    - Transfer student plans (internal and external transfers)
  - These present to the students that everyone belongs

Additional Reading: Top Ten List for Making a Great “Major Requirements” Web Page
McKenna Quam - https://cic.northeastern.edu/resources/

Conclusion

- 60 School degree maps, looking at
  - Structural complexity
  - Blocking factor
  - Delay factor
- Is there a relationship between structural complexity and the representation of women in a program? YES
  - Schools with greater representation of women had less structural complexity to their degrees
  - Often complexity is not needed
    - Both from performance and representation
- Additionally
  - No consensus on calculus among the programs
  - Call for future research on best practices

Thank you!

https://dl.acm.org/doi/10.1145/3626252.3630835