NISTS 2023
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NISTS Award Winner *Research Spotlight*

2806 - Developing a Theory of Curricular Complexity for Transfer Students: Establishing Content and Construct Validity

Credits and Degree Pathways, Partnerships and Collaboration

Challenges in coursework transfer for vertical transfer students are well documented. Less attention has been paid to how transfer students must navigate sequences of courses in academic plans at two- and four-year institutions whose sequences may not align well for timely degree completion. Funded by NISTS, we share progress on our continued development of a novel metric and visualization tool—Transfer Student Curricular Complexity (TSCC)—that quantifies complexities transfer students encounter with course sequencing.

Dustin Grote, *Assistant Professor*
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Developing a Theory of Curricular Complexity for Transfer Students: Establishing Content and Construct Validity

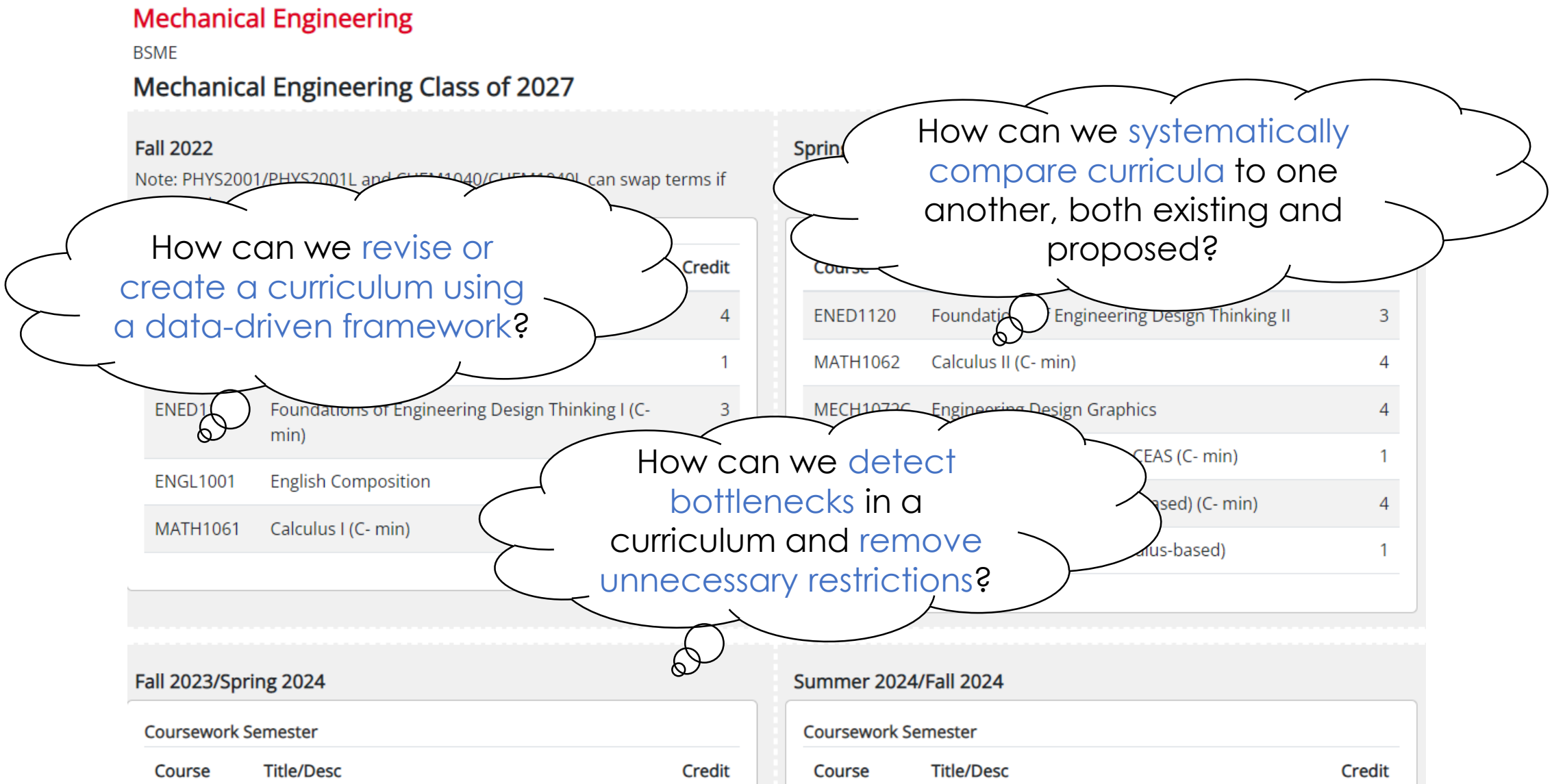
Dustin Grote | *Weber State University*

David Reeping | *University of Cincinnati*

2023 NISTS Conference

February 23, 2023

This NISTS presentation focuses on a framework for quantifying the interconnectedness of a curriculum (Heileman et al., 2018) that attempts to capture the complexities faced by transfer students



Most measures of curricular complexity rely on the relationships between classes, specifically the prerequisites and corequisites

Here, MECH 2010 Thermodynamics has two prerequisites:

CHEM 1040 (with a C- minimum)
and
MECH 2020 (with a C- minimum)

MECH 2010 - Thermodynamics

Course Detail

Career	Undergraduate	
Units	4.00	
Grading Basis	Normal - Cannot Select P/F	
Course Components	Lecture	Required
Academic Group	College of Eng & Appl Sci	
Academic Organization	Engineering & Applied Science	

Enrollment Information

Typically Offered	Annually, Fall, Summer
Enrollment Requirement	To take this course you must: Have taken the following Courses CHEM1040 min grade C-,MECH2020 min grade C-. Be enrolled in one of these Plans ME-BSME, ME-AENG, ME-BSENG. Be enrolled in the following Sub Plan ME-CQ.
Course Attribute	CT Critical Thinking

Description

First and Second Law of Thermodynamics for closed and open systems. Evaluation of thermodynamic properties of pure substances using steam tables, equation of state, and property relationships. Thermodynamic analysis of processes and systems and of complete cycles for power generation and refrigeration. Entropy, Tds equations, isentropic efficiency, availability and exergy analysis. Non-reacting ideal gas mixtures. - Prerequisite Definition: To take this course you must: Have taken the following Courses CHEM1040 min grade C-,MECH2020 min grade C-. Be enrolled in one of these Plans ME-BSME, ME-AENG, ME-BSENG. Be enrolled in the following Sub Plan ME-CQ.

But MECH 2020 also has prerequisites! How can we represent these relationships more efficiently?

MECH 2020 - Statics and Particle Dynamics

Course Detail

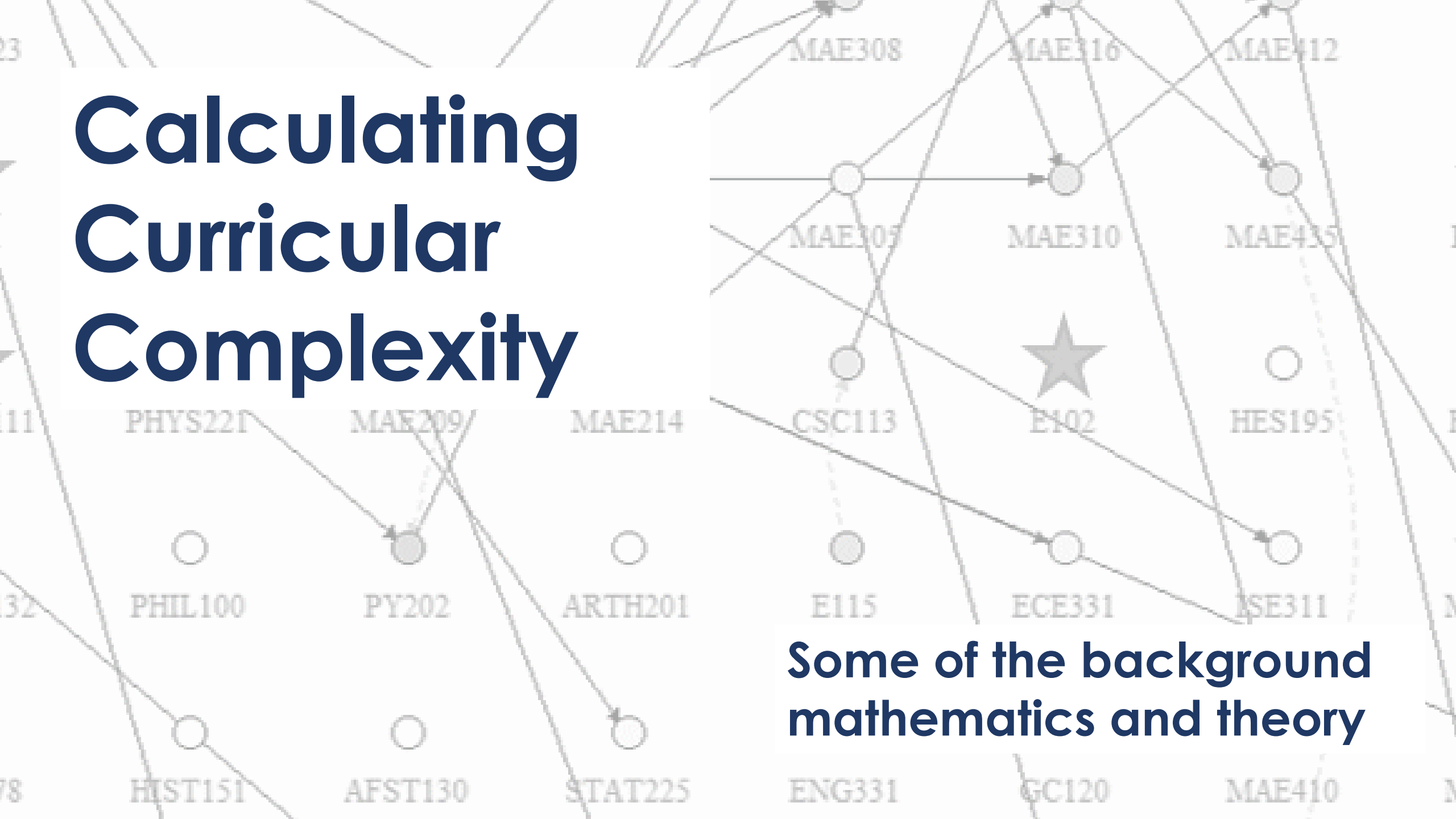
Career	Undergraduate	
Units	3.00	
Grading Basis	Normal - Cannot Select P/F	
Course Components	Lecture	Required
Academic Group	College of Eng & Appl Sci	
Academic Organization	Engineering & Applied Science	

Enrollment Information

Typically Offered	Annually, Fall, Spring
Enrollment Requirement	To take this course you must: Have taken the following Courses PHYS2001 min grade C-,MATH1062 min grade C-. Be enrolled in one of these Plans ME-BSME, ME-AENG, ME-BSENG. Be enrolled in the following Sub Plan ME-CQ.
Course Attribute	CT Critical Thinking

Description

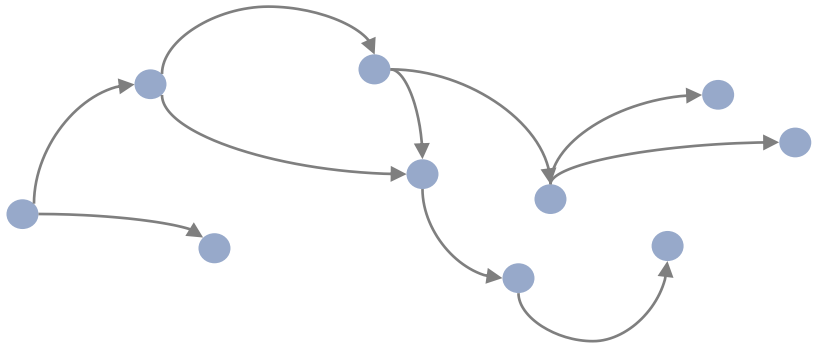
Study of Newton's first and second laws. Linear and rotational motion. Kinetic and Potential Energy. Conservation of Energy and Momentum. Applications to rigid bodies and particles. - Prerequisite Definition: To take this course you must: Have taken the following Courses PHYS2001 min grade C-,MATH1062 min grade C-. Be enrolled in one of these Plans ME-BSME, ME-AENG, ME-BSENG. Be enrolled in the following Sub Plan ME-CQ.



Calculating Curricular Complexity

Some of the background mathematics and theory

Heileman's (2018) framework consists of two overarching constructs, but more focus has been placed on structural complexity

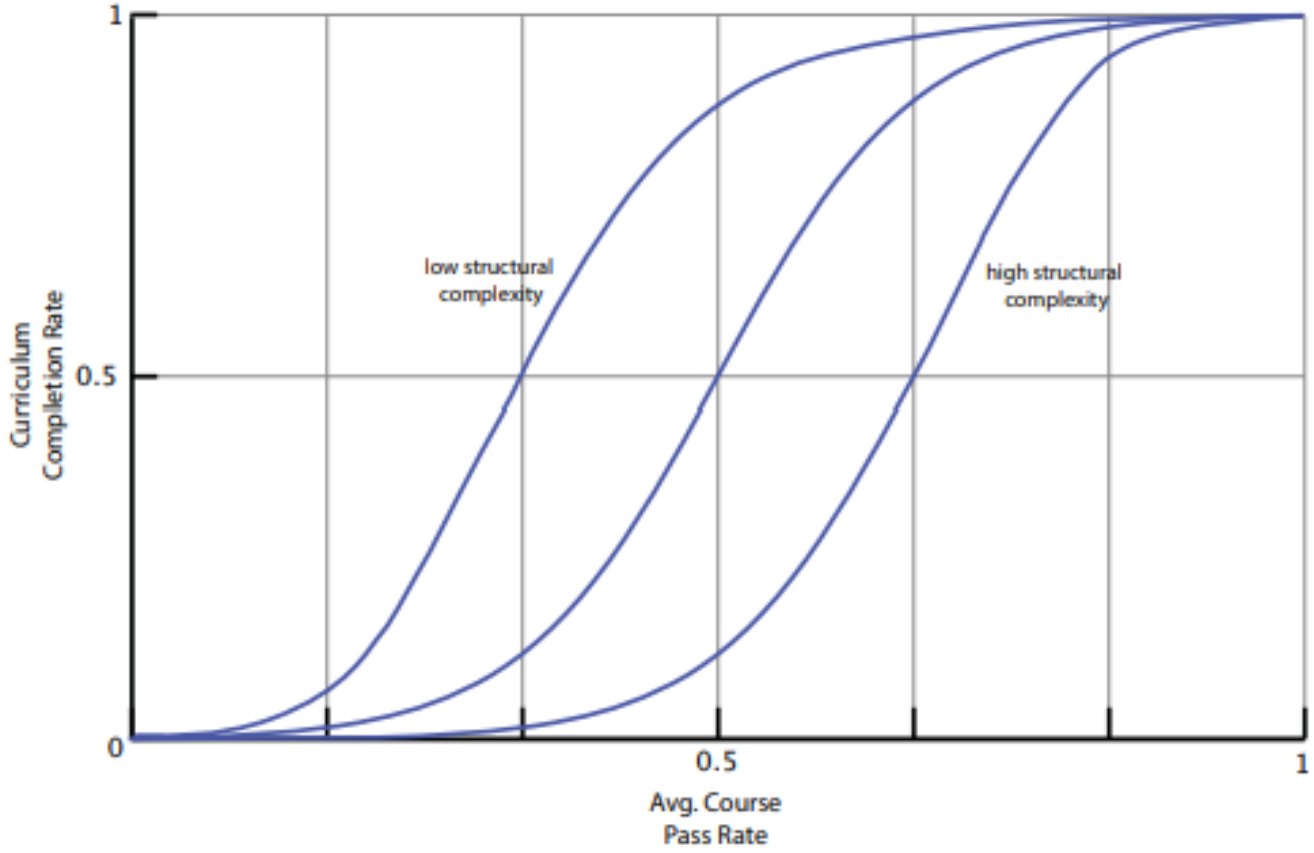


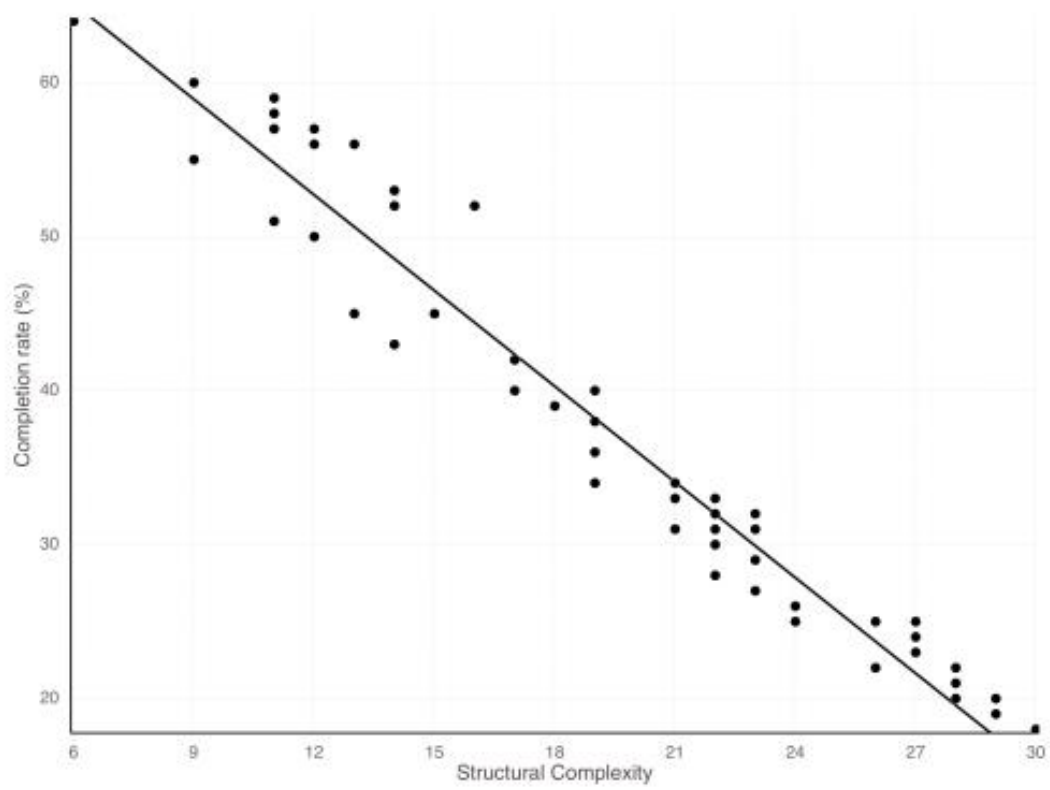
Structural Complexity

ENG 2004 Statics
67% Pass Rate

Instructional Complexity

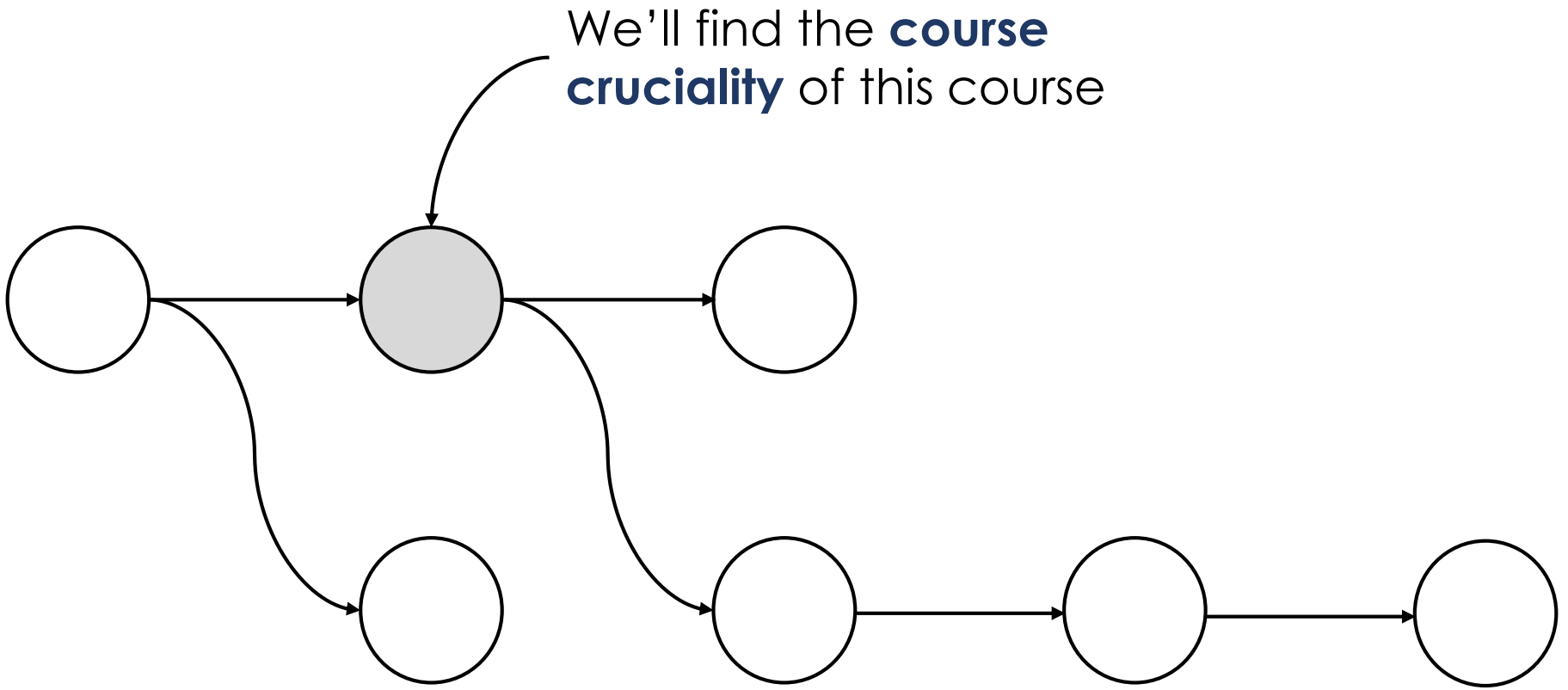
The main assertion of the framework is that degree completion rates are negatively correlated with structural complexity



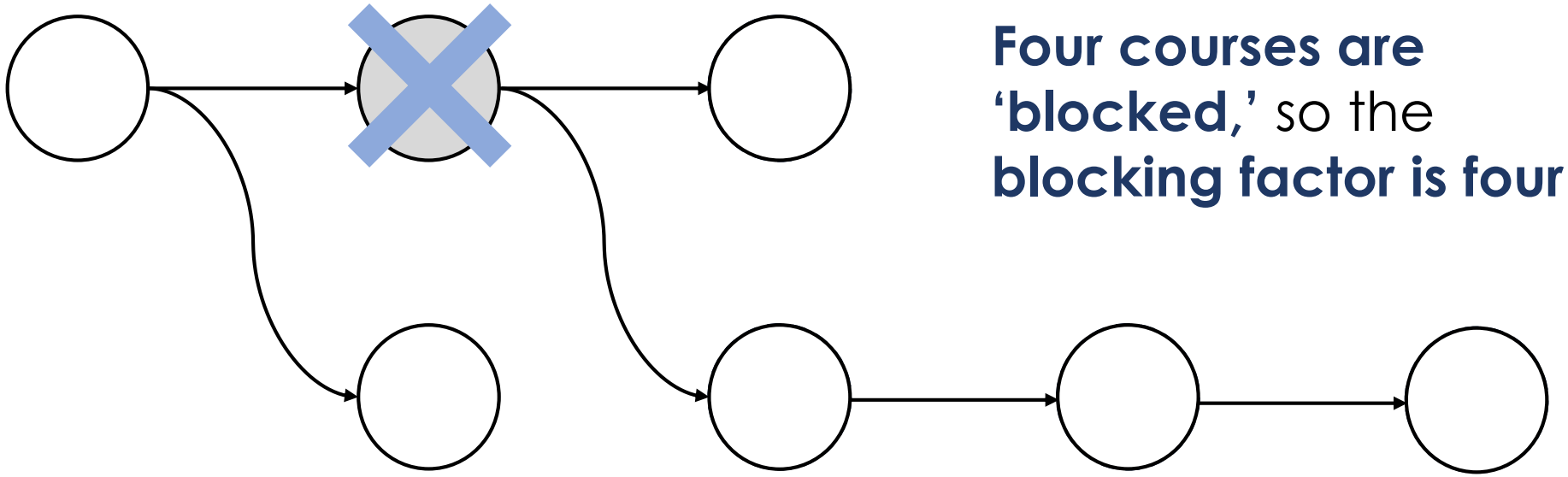


Figures 5 and 6 from Heileman et al. (2018) *Curricular Analytics: A Framework for Quantifying the Impact of Curricular Reforms and Pedagogical Innovations*

Structural complexity is found by adding the course crucialities in a curriculum, which is made up of two components



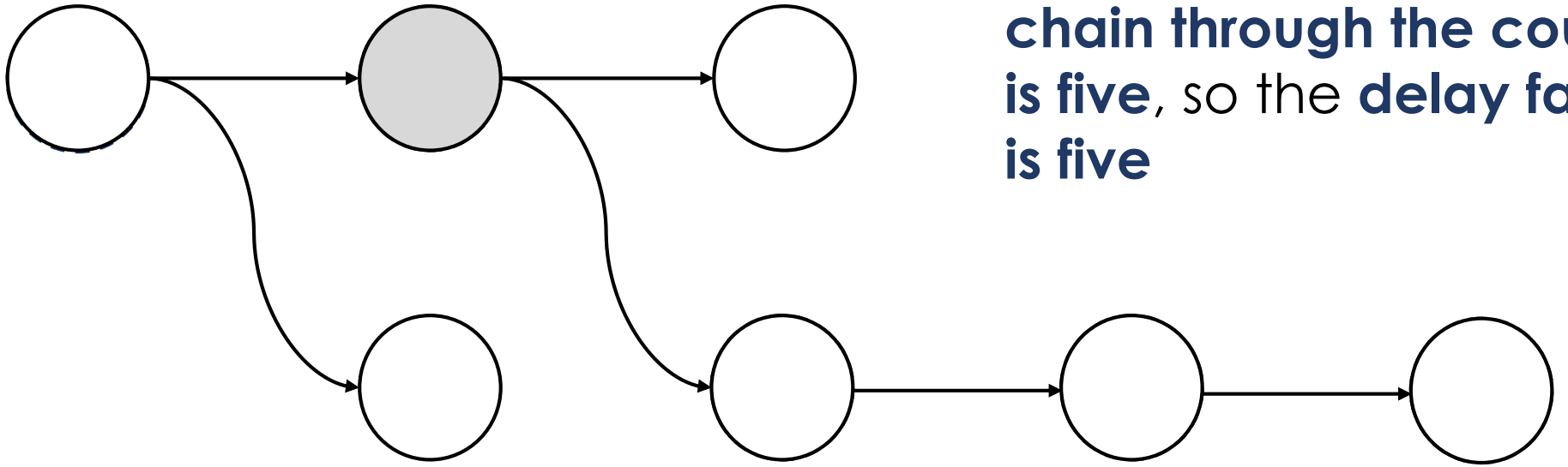
The first component of course cruciality is the blocking factor, which is the number of courses the course 'blocks' if it is failed



Four courses are 'blocked,' so the **blocking factor is four**

Blocking Factor

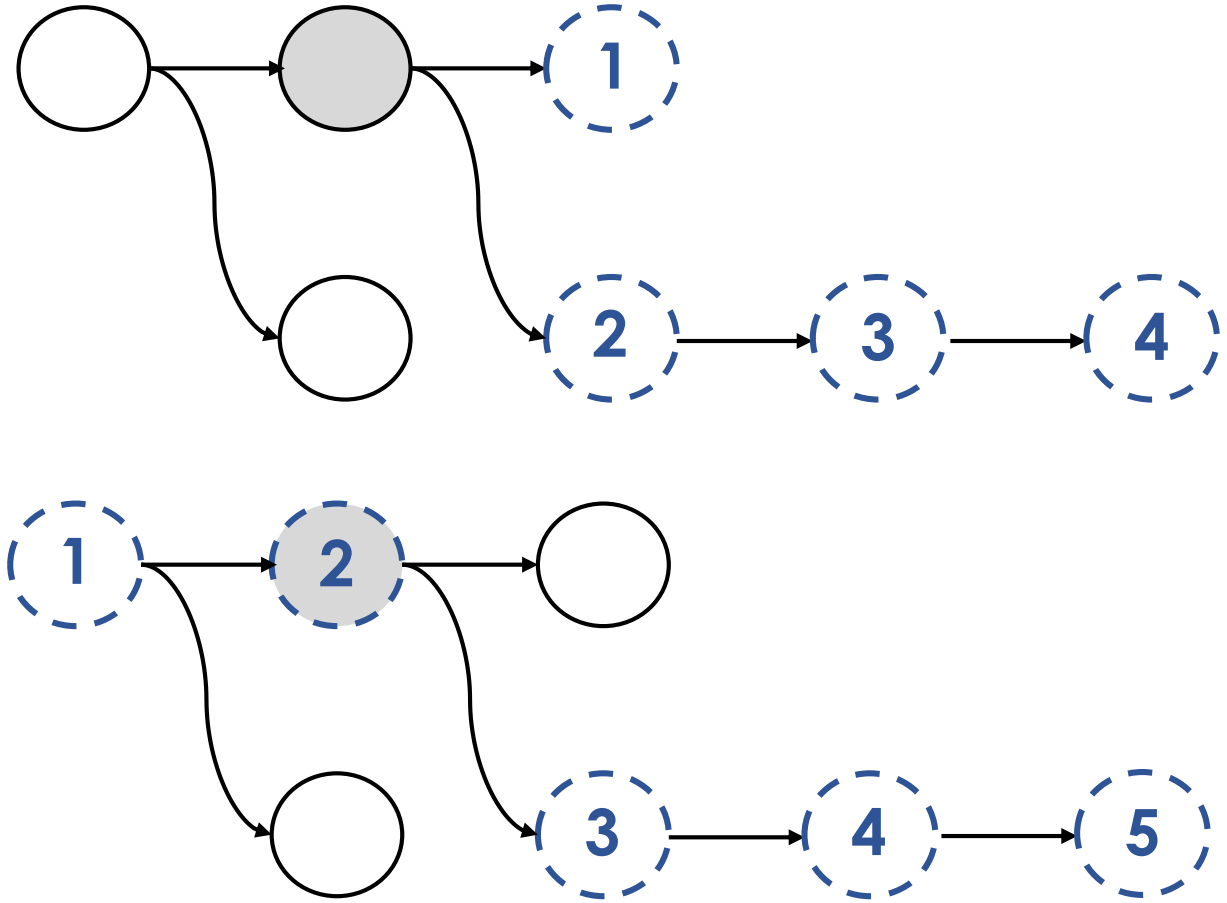
The second component of course cruciality is the delay factor, which is the longest prerequisite chain containing the course



The **longest prerequisite chain through the course is five**, so the **delay factor is five**

Delay Factor

Course cruciality is found by adding the blocking factor and delay factor together, so our example course has a cruciality of nine



Blocking Factor

Failing the course will block **four** courses

+

Delay Factor

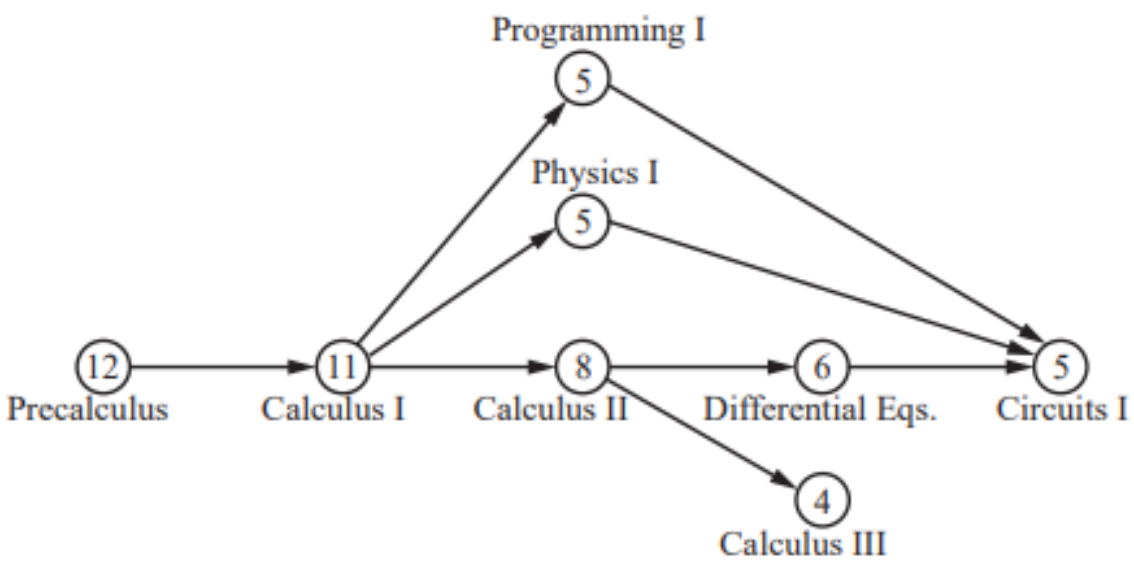
Longest prerequisite chain through course is **five** courses

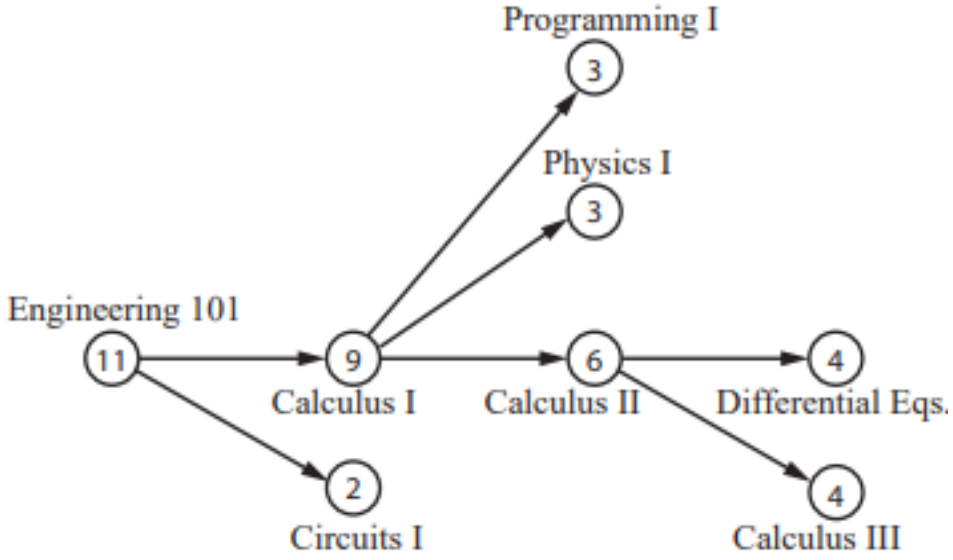
=

"Course Cruciality" of **nine**

Cruciality

Cruciality scores and overall structural complexity allow us to compare different *curricular patterns*



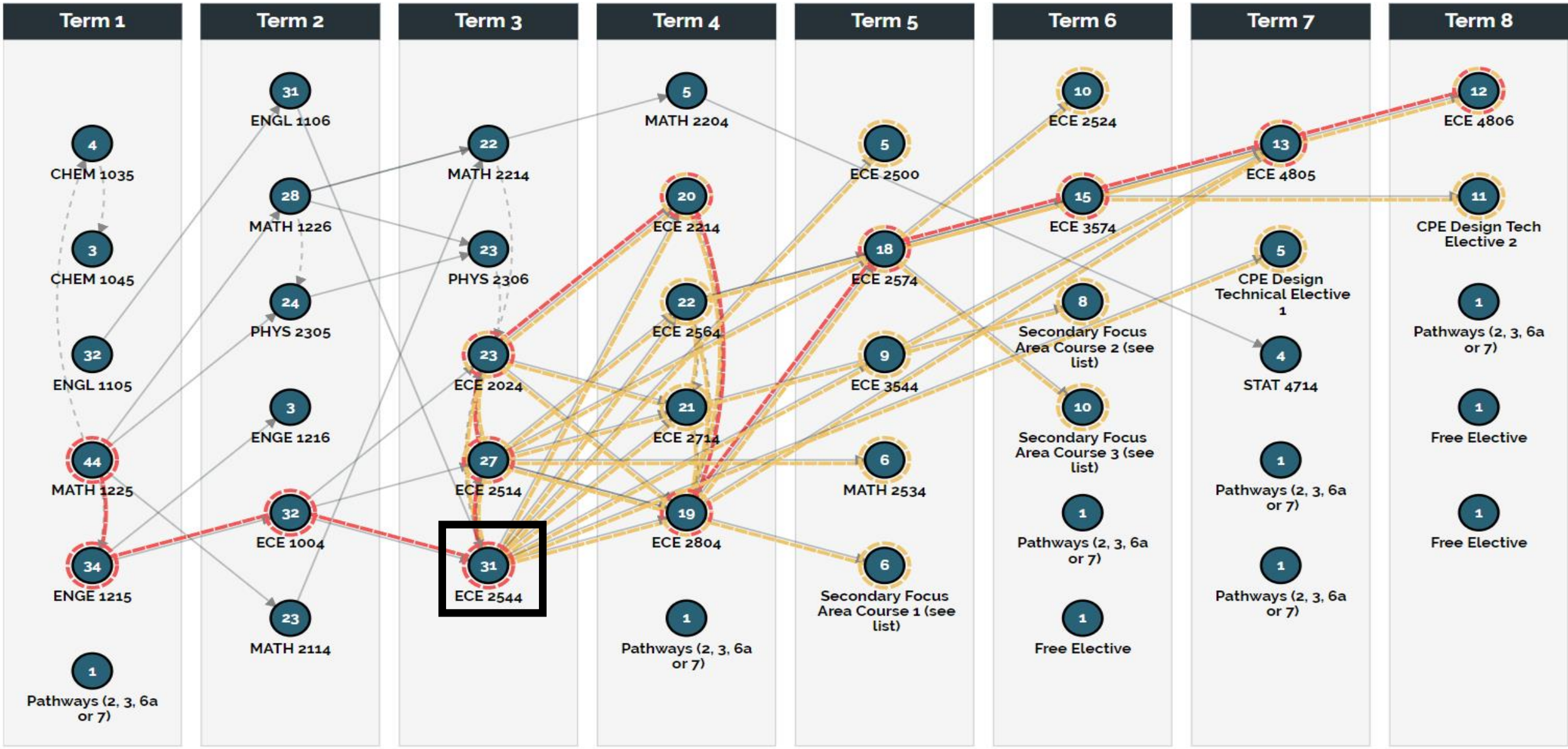


Structural Complexity of **56**

Structural Complexity of **41**

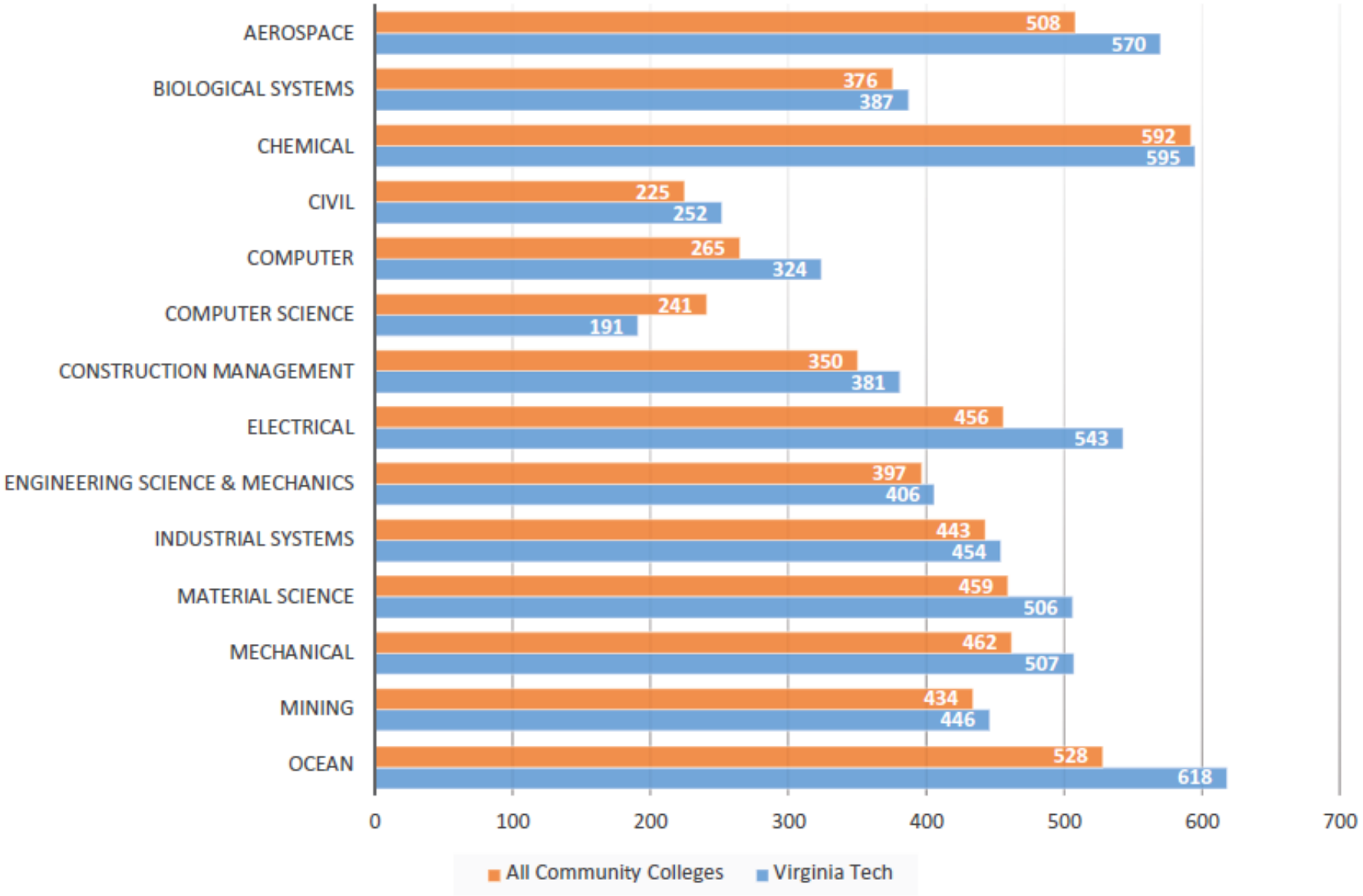
Figures 3 and 4 from Heileman et al. (2017) *Characterizing the Complexity of Curricular Patterns in Engineering Programs*

Exploring the sub-complexity graphs provides a sense of how a potential bottleneck manifests, such as this example from curriculum development in Virginia Tech's ECE program



Curricular Complexity for Transfer Students

How does Curricular Complexity work for transfer students? Here are some findings from previous research.



Grote, D.M., Knight, D.B., Lee, W.C., and Watford, B.A. (2020). Navigating the curricular maze: Examining the complexities of articulated pathways for transfer students in engineering. *Community College Journal of Research and Practice*. https://doi.org/10.1080/10668926.2020.1798303

So, transfer pathways are less complex? Not really – there is more to this story. . .

First-Time-In-College Correlation

4-Year	**-0.67****
5-Year	**-0.53***
6-Year	**-0.54***

Transfer Correlation

4-Year	**-0.55**
5-Year	**-0.38**
6-Year	**-0.18**

Minimum Semesters to Complete

8 Terms	**93%**
9 Terms	**7%**

Minimum Semesters to Complete

8 Terms	**11%**
9 Terms	**34%**
10 Terms	**41%**

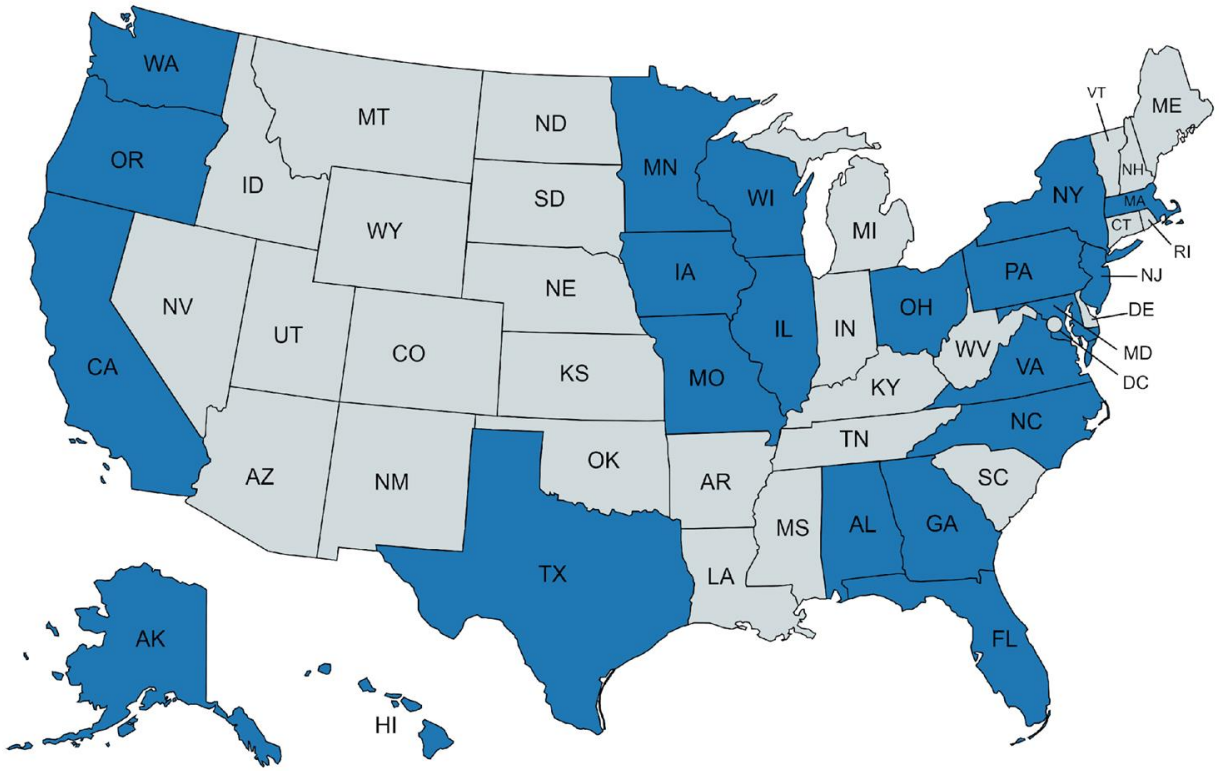
Our NISTS grant research focused on three primary research questions:

1. What are transfer-specific curricular challenges that students routinely encounter?

2. To what extent do the original metrics of curricular complexity and TSCC (more on this later) capture challenges that vertical transfer students encounter when navigating academic plans?

3. In what ways could TSCC be improved or modified to better account for these curricular challenges?

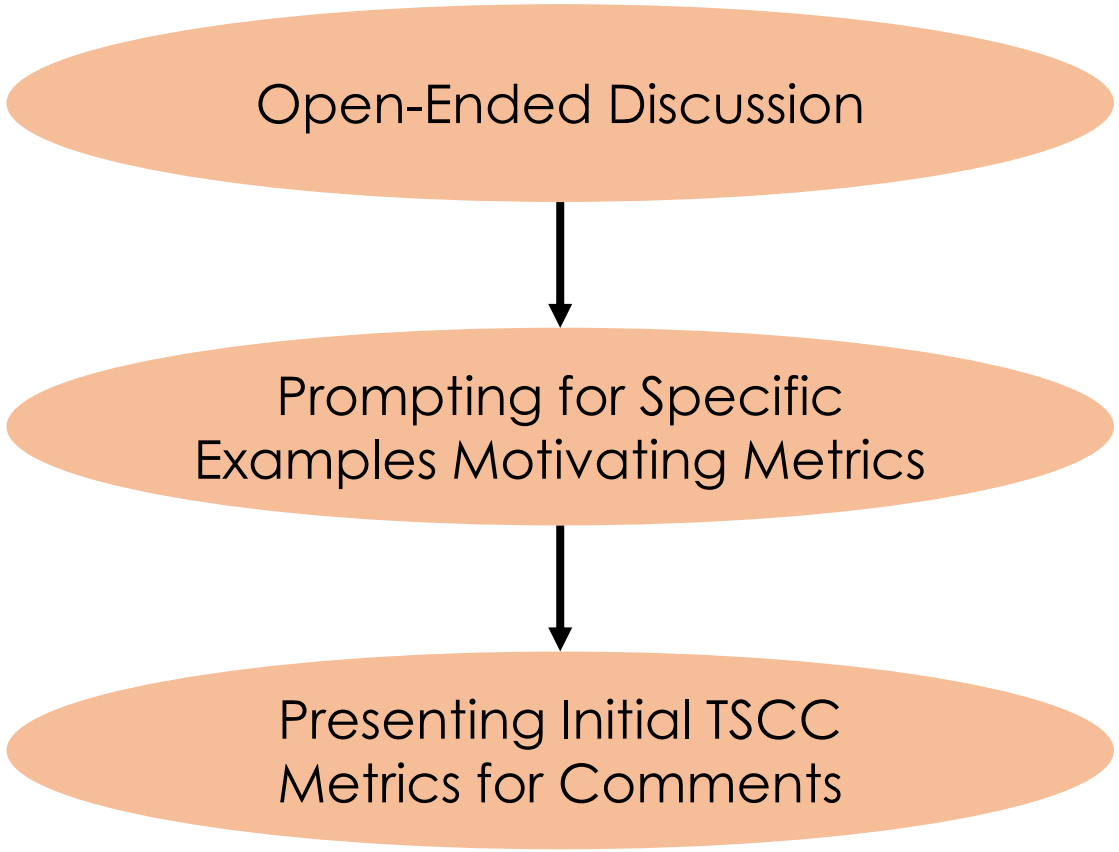
To dig deeper into the idea of Transfer Student Curricular Complexity, seven 90-minute focus groups were conducted (*n* = 38) with individuals having some stake in transfer student success



Key Facts of the Sample

- Representation from 22 states
- 5 men, 33 women
- 2 Asian/Pacific Islander, 3 Black African American, 3 Hispanic/Latine, 29 White, 1 preferred to not disclose
- Participants affiliated with multiple roles
  - 17 described their role as advising
  - 18 described their role as administration
  - 2 described themselves as faculty

We designed the focus groups using the protocol below to both explore participants experiences with curricular challenges for transfer students and also share and gather feedback on the TSCC metrics.

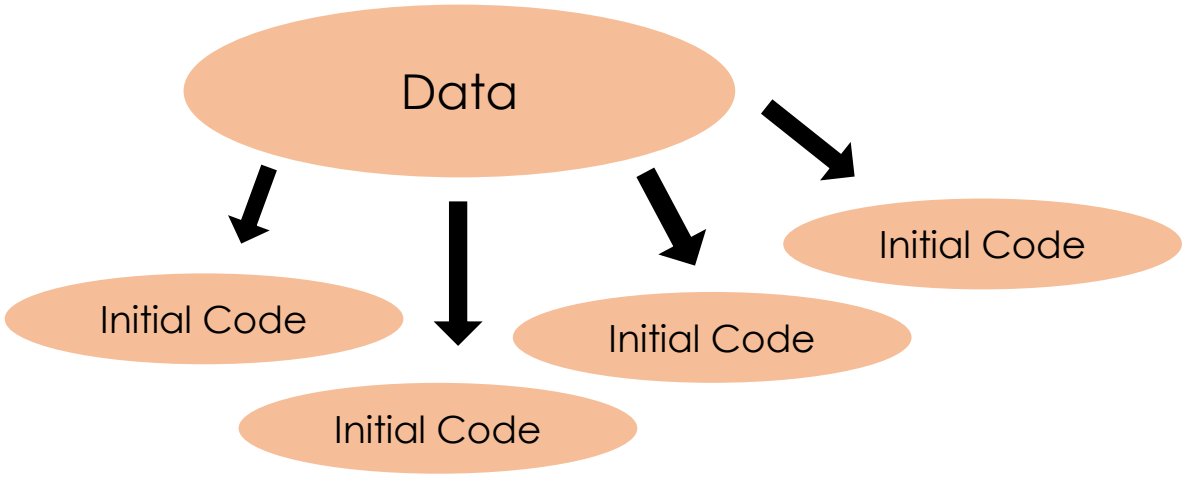


Focus Group Protocol

Focus Group Questions (Q = main question, FQ = follow-up question) Excellent, thanks everyone. Let's begin with our first question...	
Open-Ended Discussion (20 minutes)	**Q:** In your experience, what barriers do transfer students tend to face from a curricular perspective that extends their completion time? **FQ:** What kind of curricular policies help or hinder students' **ability to transition** from one institution to another? **FQ:** What kind of curricular policies help or hinder students' **ability to complete their bachelor's degrees** on time?
Invite Test Cases (20 minutes)	**Q:** If you were to map out a sequence of courses students tend to get stuck in, what do those sequences look like? **FQ:** What kind of courses do these sequences typically contain? **FQ:** What about these courses or sequences make it difficult for students to progress?
Present Measures and Test Cases (25 minutes)	**Q:** The following are measures we have developed so far to address transfer-specific issues. We've adapted existing measures from the original framework to do so. These measures include the inflexibility factor, transfer delay factor, and credit loss to address offering timings, courses that extend students' time to degree, and credits that do not apply to degree requirements. *[Walk through the main idea of each measure]* How do these measures align with your perceptions of curricular barriers for transfer students? *[Use test cases as needed to explain how they work]* **FQ:** What additional measures or constructs would help characterize curricular complexity for transfer students? **FQ:** What would you change about the existing measures? **FQ:** Is there a test case we're not considering?
Usability (10 minutes)	**Q:** We've been developing a tool for calculating these metrics and plotting plans of study to help researchers and practitioners using a free, open-source statistical programming platform called R. Who is familiar with R by show of hands? *[check raised hands, comment on number of raised hands]* **FQ:** What would you need to see in such a tool for it to be useful to you?
Wrap-Up	Considering we're getting close to the hour and a half mark, I want to respect your time and wrap up this focus group. Thank you all for your continued engagement during this focus group. If you have any questions or concerns, please do not hesitate to reach out.

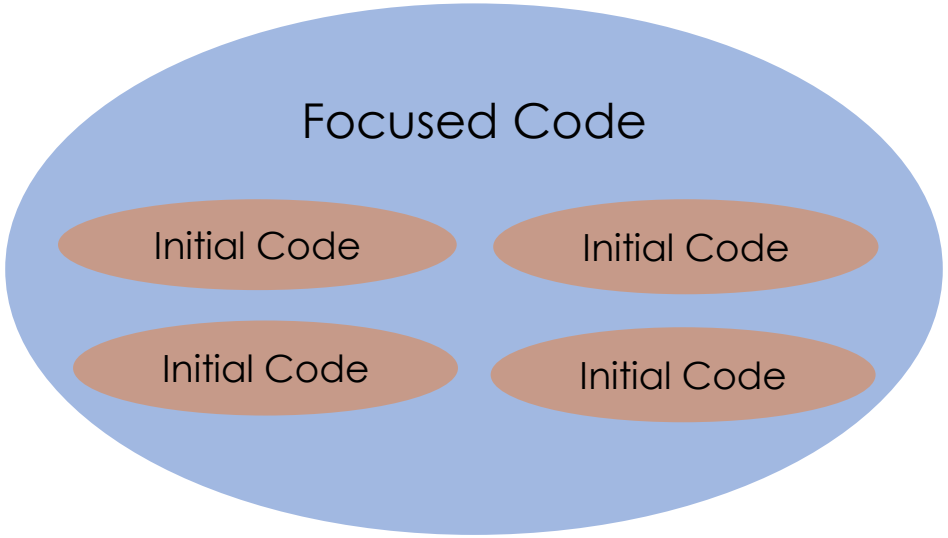
The focus groups were conducted and recorded using Zoom, then transcribed and analyzed using Grounded Theory as described by Charmaz (2014)

Initial Coding



Breaks data down into pieces

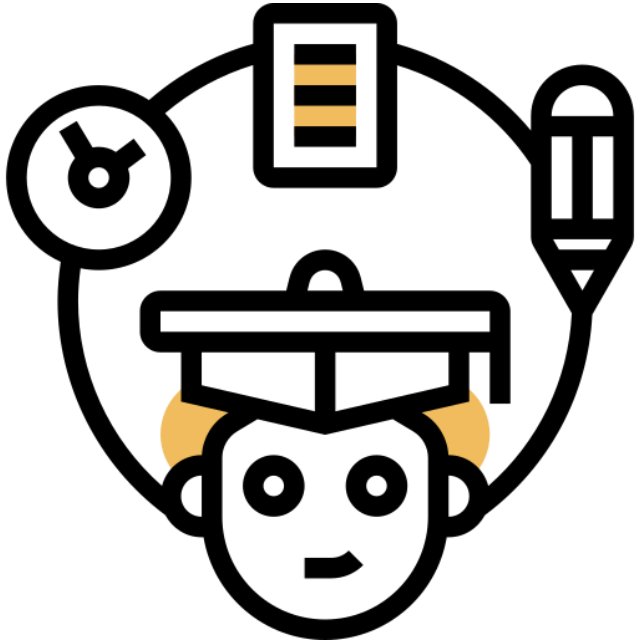
Focused Coding



Brings the data back together

Results

What are transfer-specific curricular challenges that students routinely encounter?



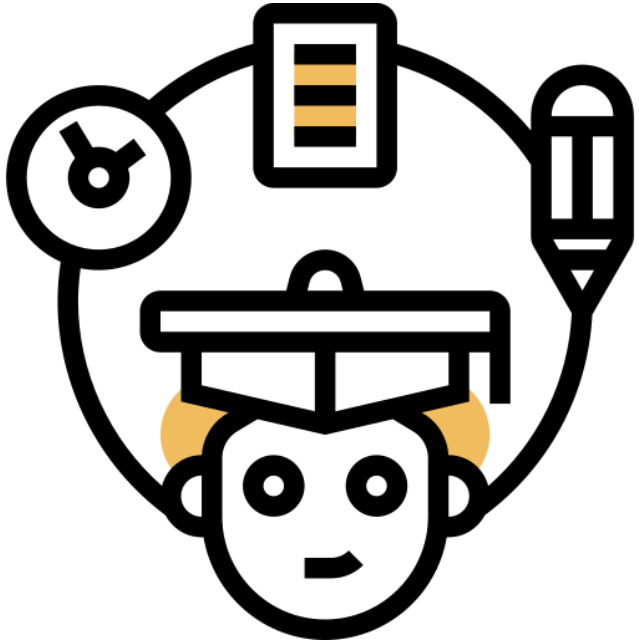
Group Activity

- Before we share our results, we want to hear from all of you. In small groups, take 5-10 minutes and brainstorm answers to this question that our focus group participants also addressed. Be prepared to share out with the large group.

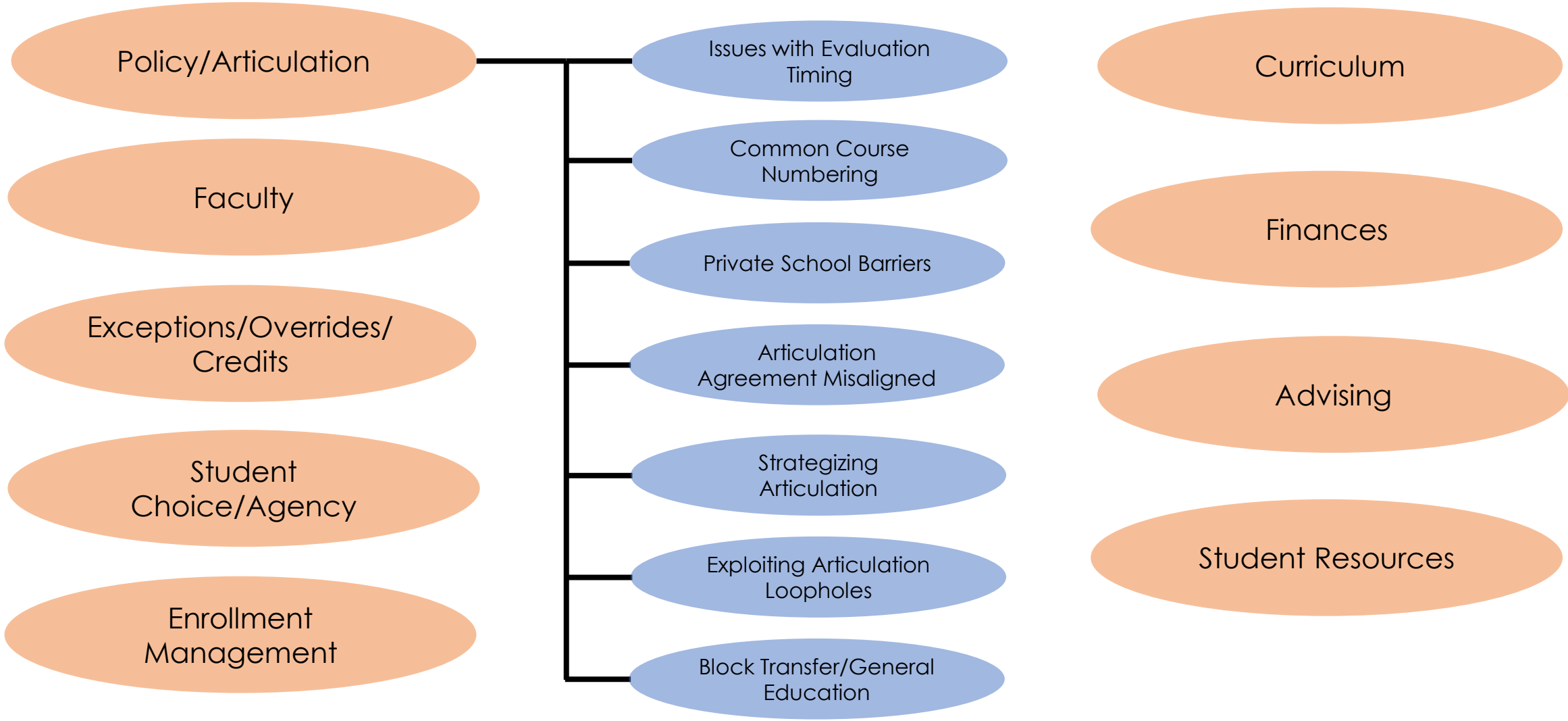
- What are transfer-specific curricular challenges that students routinely encounter?

Results

What are transfer-specific curricular challenges that students routinely encounter?



We've found that our focused codes are nesting in the following larger categories



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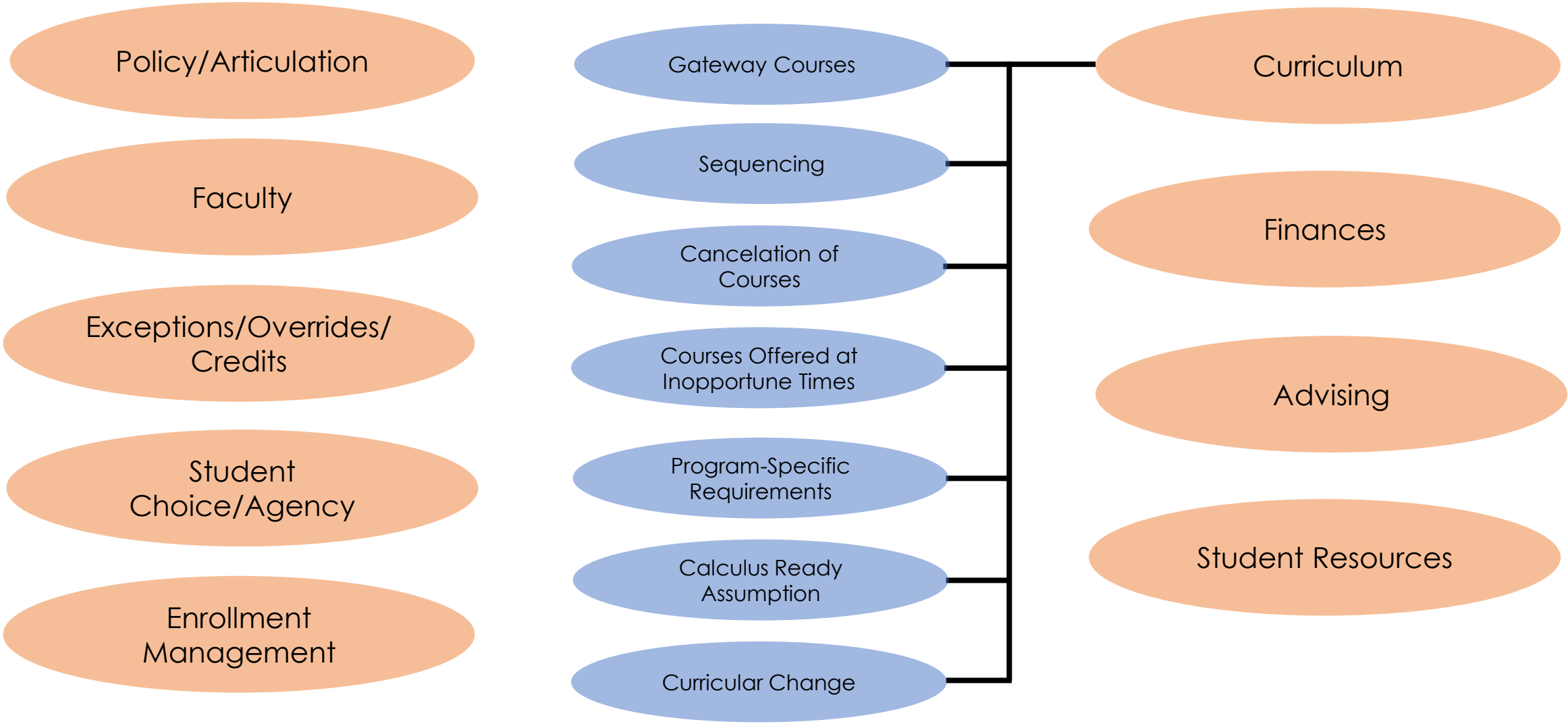
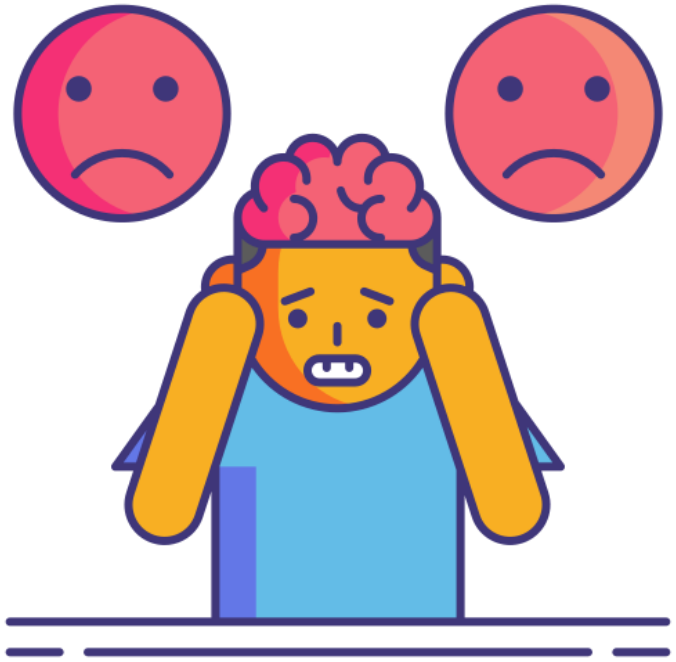
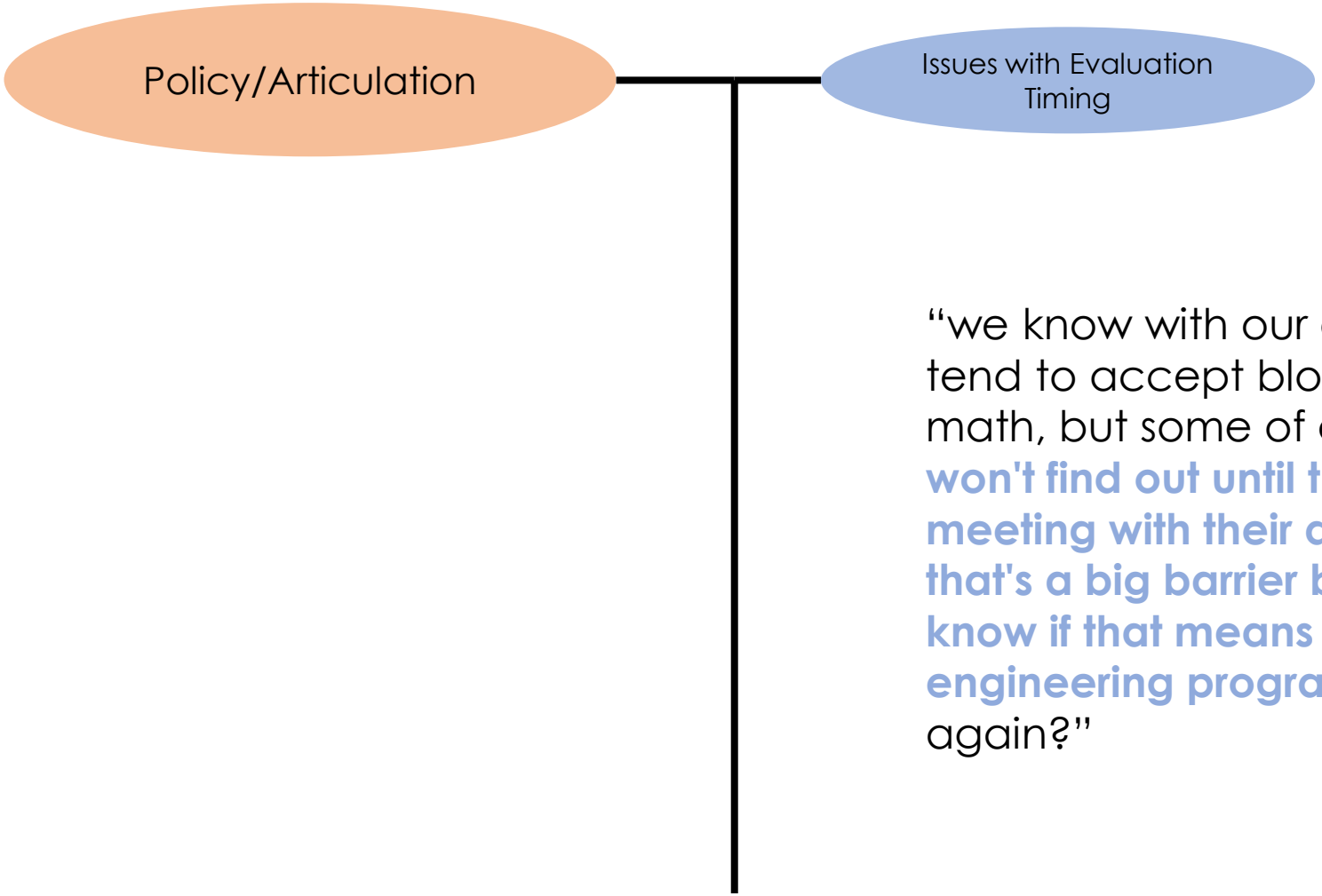


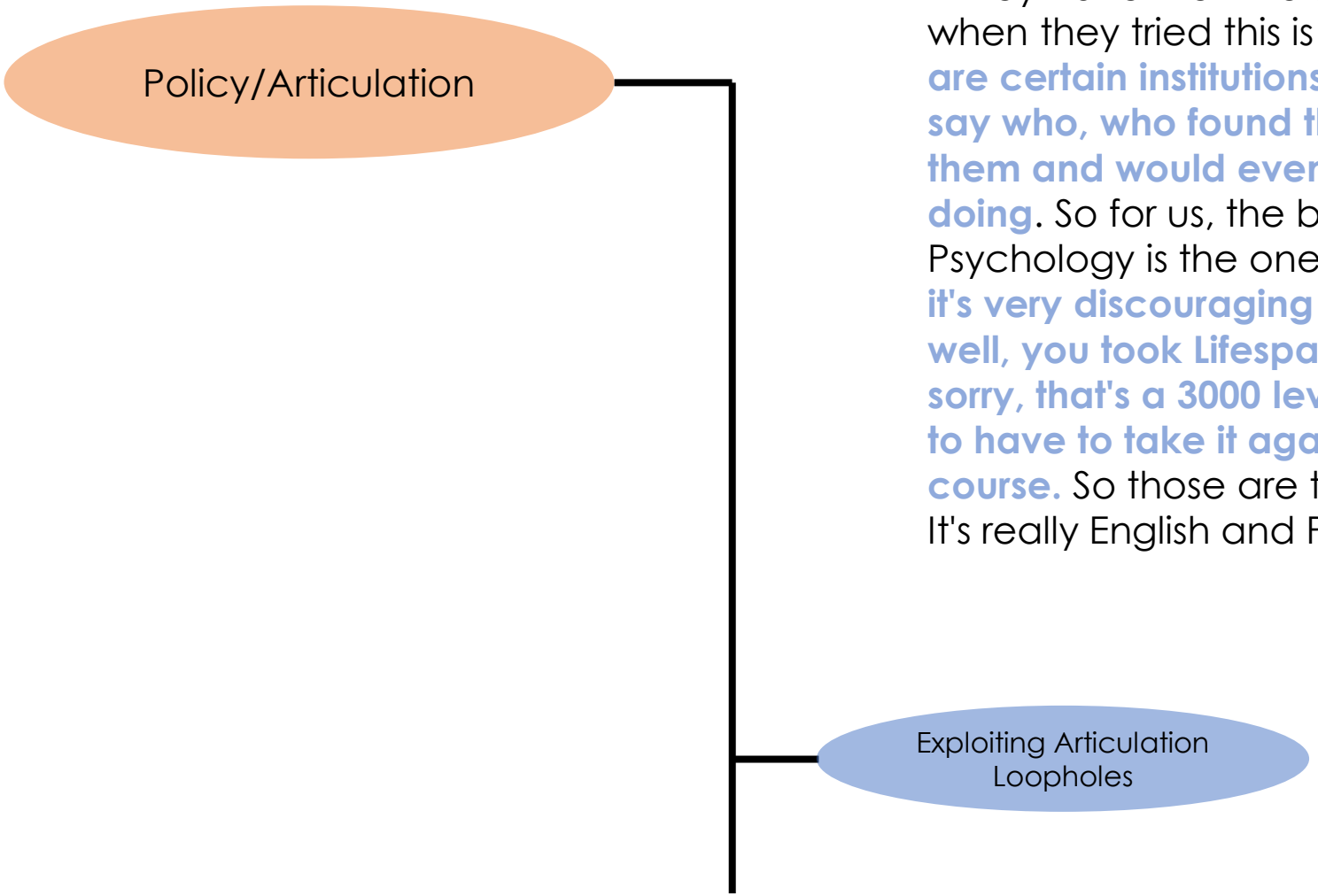
Trigger Warning

- Some of the following material may evoke strong emotions, memories of challenges you have had supporting transfer students, and/or outright dismay and anguish

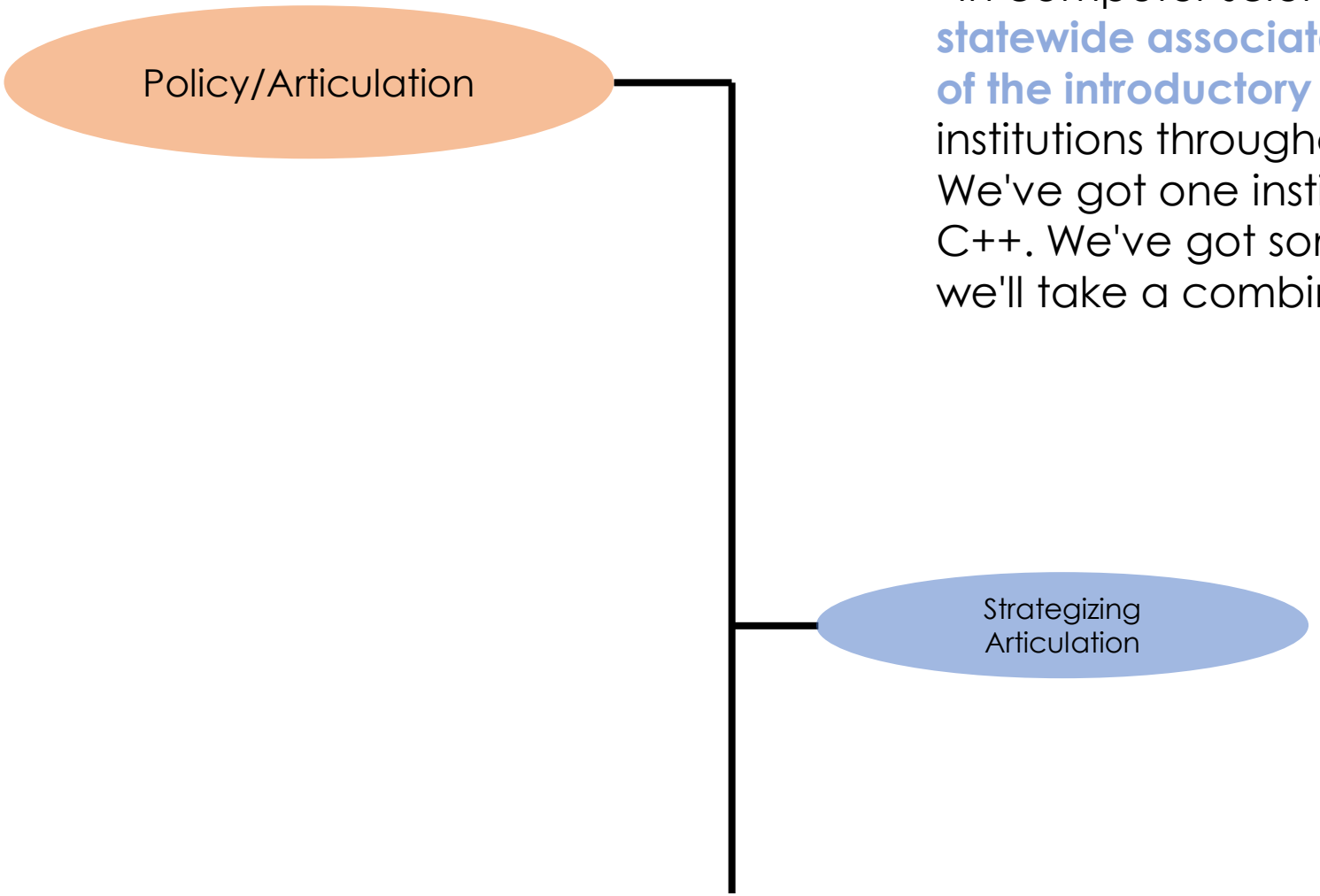




"we know with our arts and sciences programs, they tend to accept block credit for natural science or math, but some of our other colleges won't. And **they won't find out until they're a confirmed student and meeting with their advisors**. So I just want to add that, **that's a big barrier because they're like, well how do I know if that means that I'm where I need to be in this engineering program**? Or will I have to retake it again?"

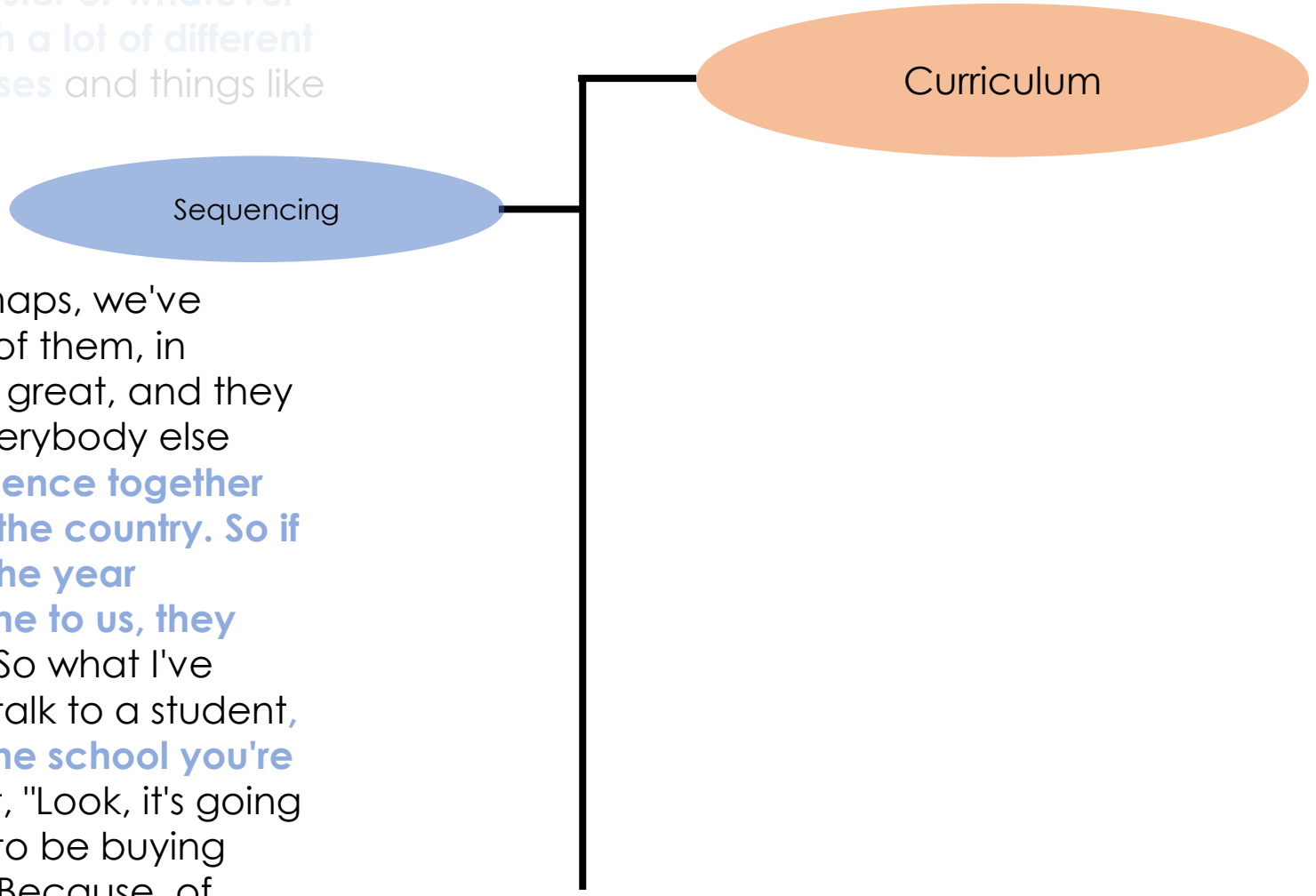


"And the way it's supposed to work is, it's supposed to transfer as a block and then these institutions are not supposed to require any lower level courses after that point, if they have the whole block. What happened in the past when they tried this is that, **there were loopholes. And there are certain institutions within the state of [State], and I won't say who, who found these loopholes. And they exploited them and would even tell you that that was what they were doing**. So for us, the biggest ones that we really, and Psychology is the one that really bothers me the most, . . . **it's very discouraging to me and to the students to hear, well, you took Lifespan, Growth and Development here, but sorry, that's a 3000 level course over there. So you're going to have to take it again, even though it's a higher level course.** So those are the areas that we really struggle with. It's really English and Psychology for us."



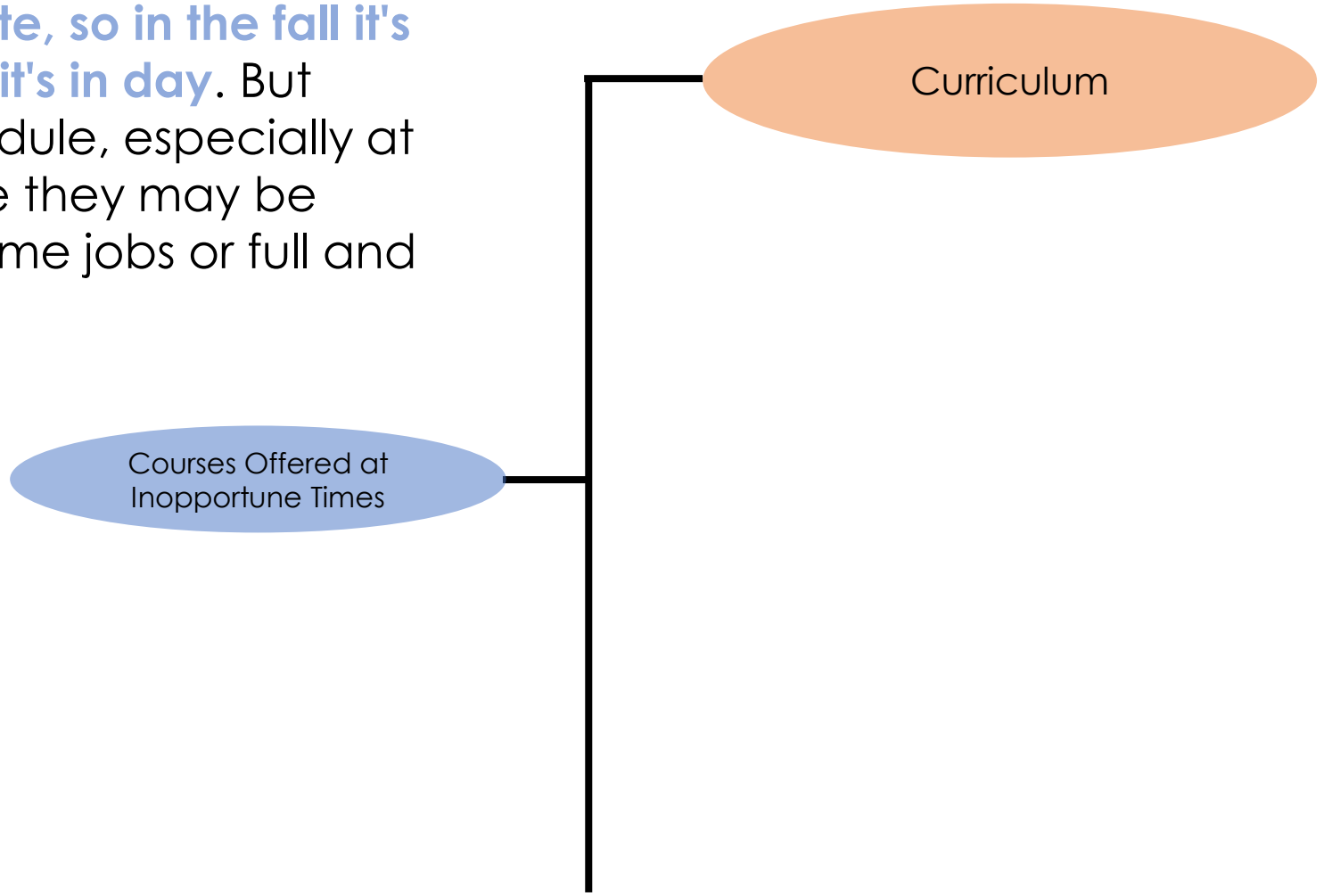
"In computer science, **trying to come up with a statewide associates degree we've got the problem of the introductory language**. And we've got institutions throughout the state that insist on Java. We've got one institution in the state that insists on C++. We've got some institutions that are like, oh, we'll take a combination of Java and Python"

"I was actually just going to agree with that and saying with the varying start dates of certain courses, let's face it, a lot of the direct entry programs are made for a student to start [at the receiving institution]. **A transfer student, they may come in spring semester, in summer semester or whatever else and that causes a lot of problems with a lot of different programs because of sequencing of courses** and things like that."

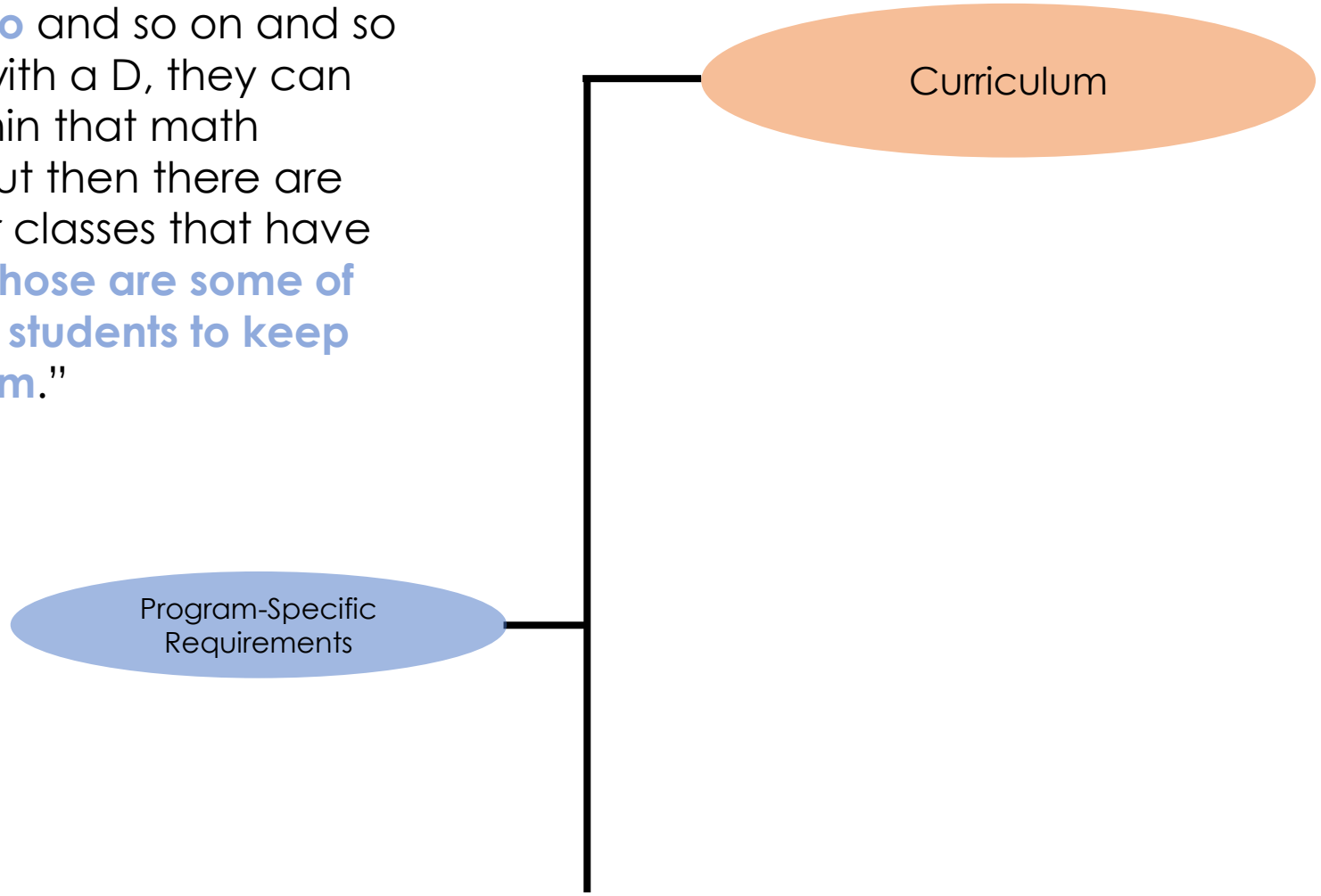


"So we, through doing our major transfer maps, we've discovered a number of these issues. One of them, in particular, our Biology Department, they're great, and they know how to teach biology better than everybody else does. **They have put the three-course sequence together differently than almost any other school in the country. So if a student doesn't take that full sequence, the year sequence at another school, and they come to us, they force them to retake the entire sequence.** So what I've done, and our staff does now is, when we talk to a student, **"If you're in a sequenced class, finish it at the school you're at, doesn't matter."** And I always talk about, "Look, it's going to save you in textbooks. You're not going to be buying another two to $300 textbook for biology," Because, of course, we use a different one than everybody else does."

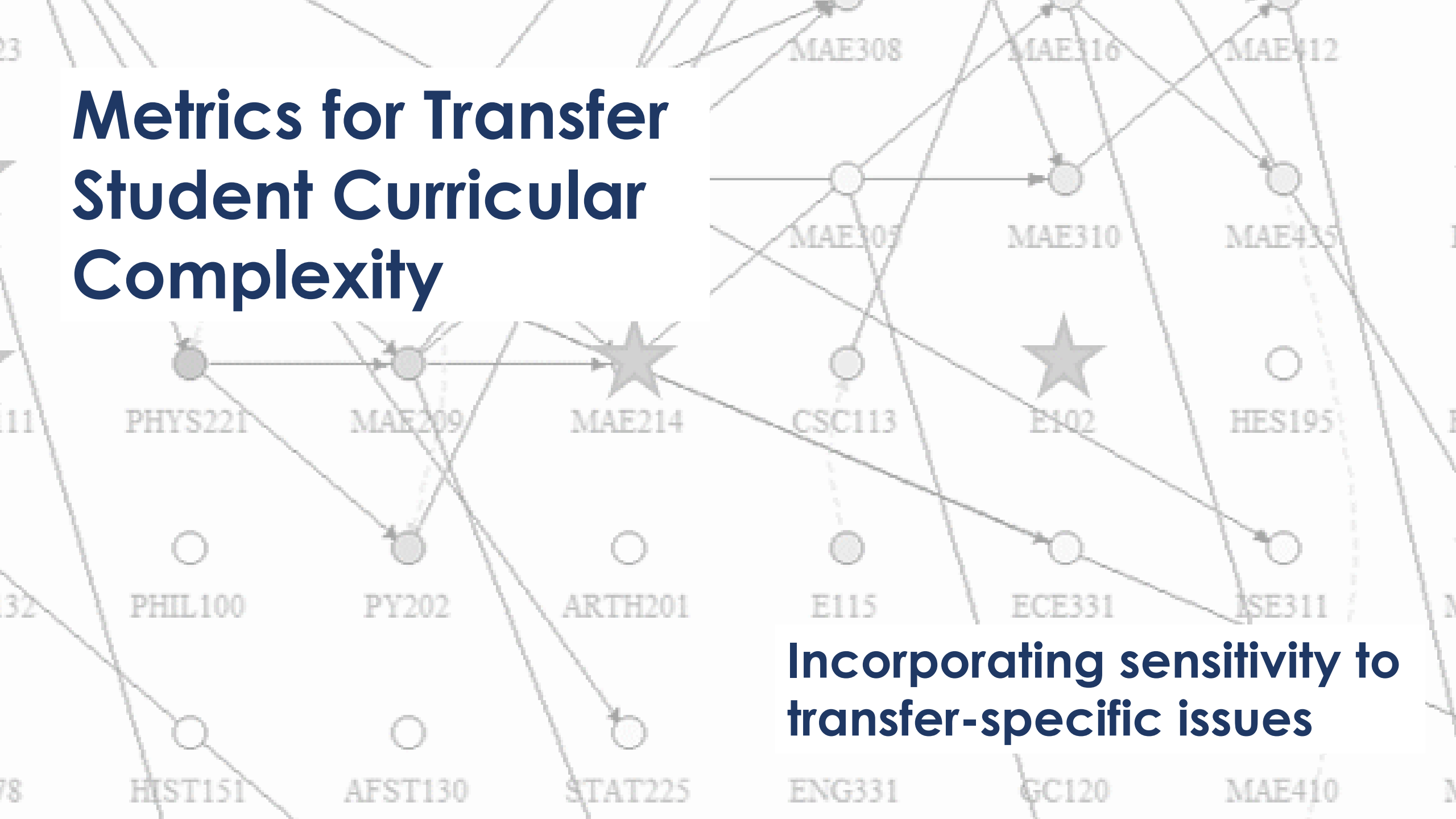
“Sometimes there is a course offered each semester, but **it's always offered in the evening**, which then impacts anybody who can't do a evening class. **Or they alternate, so in the fall it's in the evening and the spring it's in day**. But sometimes it's at student schedule, especially at the community college where they may be balancing two or three part-time jobs or full and part-time, family, et cetera..”



"But with our calculus, specifically, **you can pass with a D, but to progress you need a C**. So, to get a D in calculus one, students are going to **have to repeat Calculus I to go on to calculus two** and so on and so forth. But, if they pass Calculus I with a D, they can go on to Physics I. So, it's only within that math progression that you need a C. But then there are some degrees that have in major classes that have that C to progress guideline. So, **those are some of the things that make it difficult for students to keep moving and keep their momentum**."

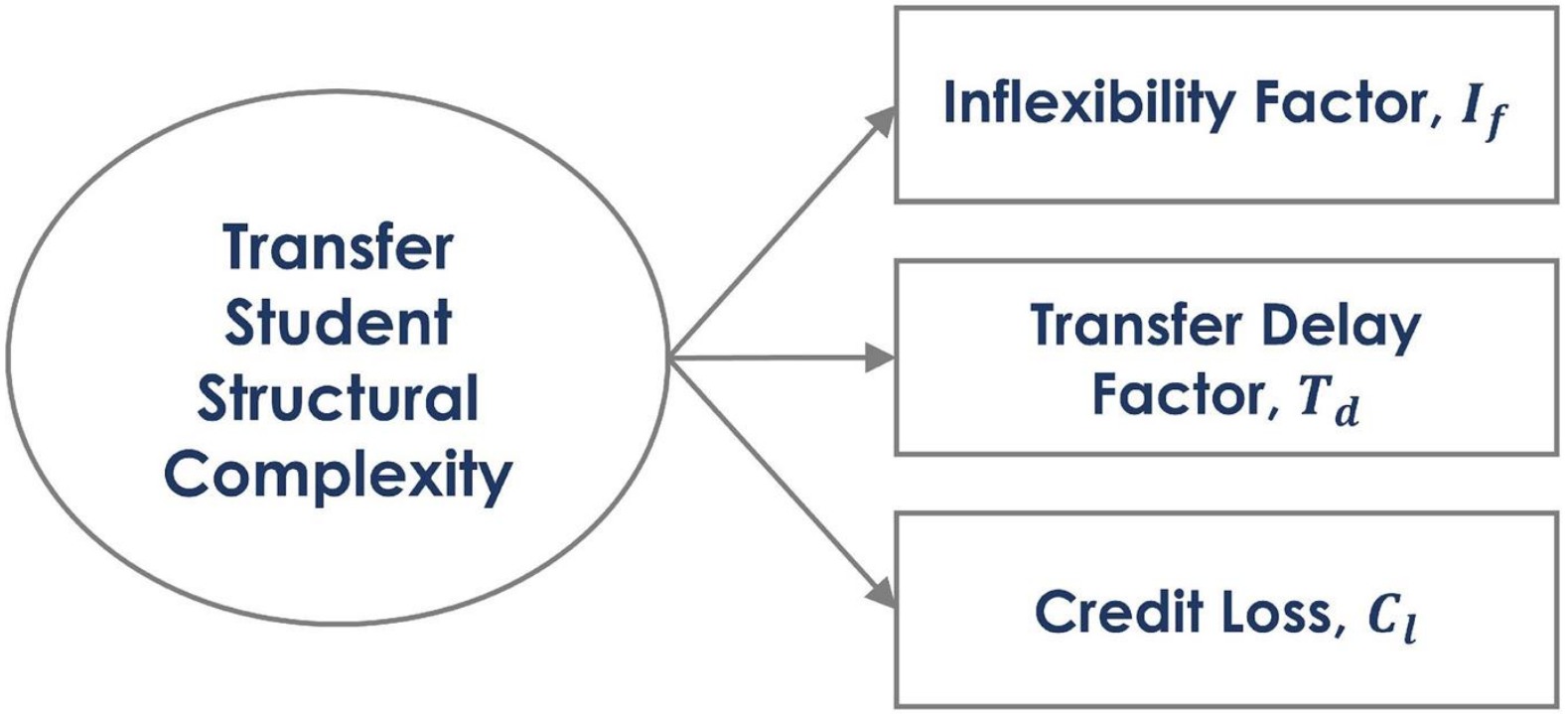


Metrics for Transfer Student Curricular Complexity

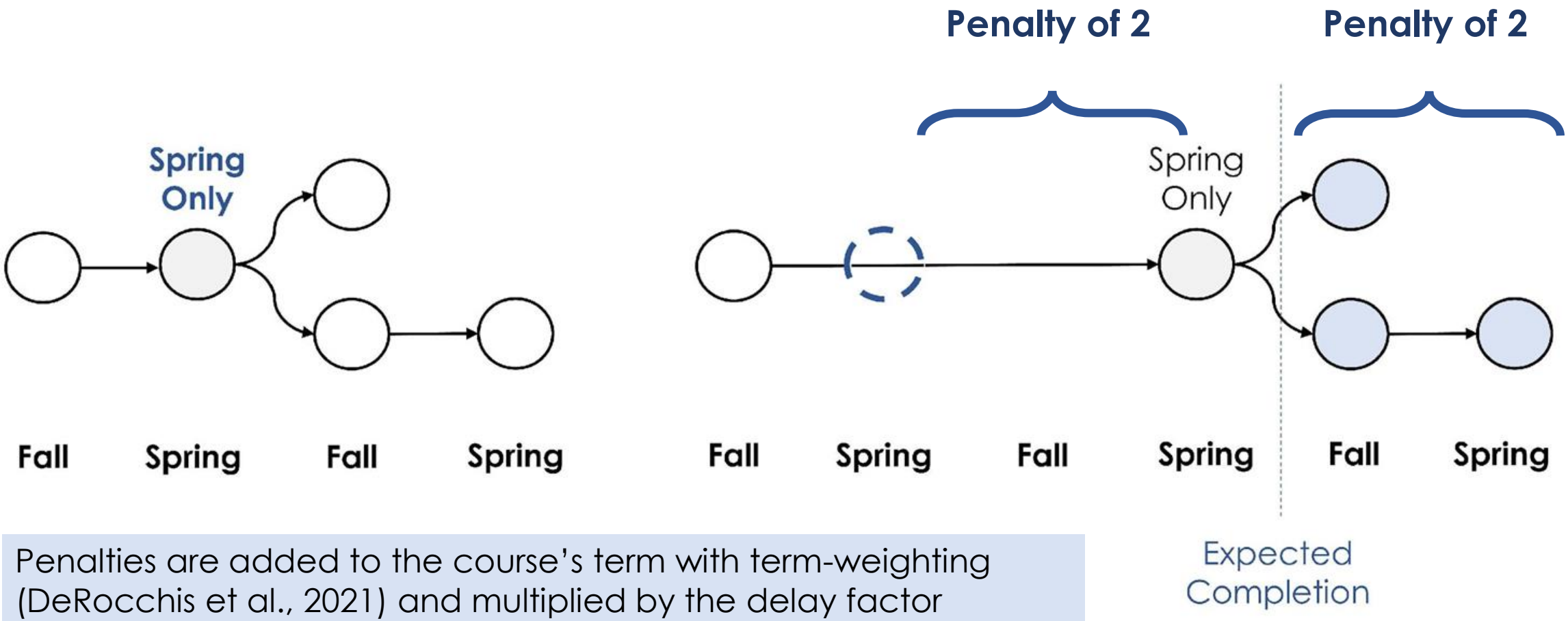


Incorporating sensitivity to transfer-specific issues

Our initial attempt to adjust complexity for transfer issues built off Grote's (2020) previous research to form a conceptual model for what we're calling transfer student structural complexity and developed measures for each issue



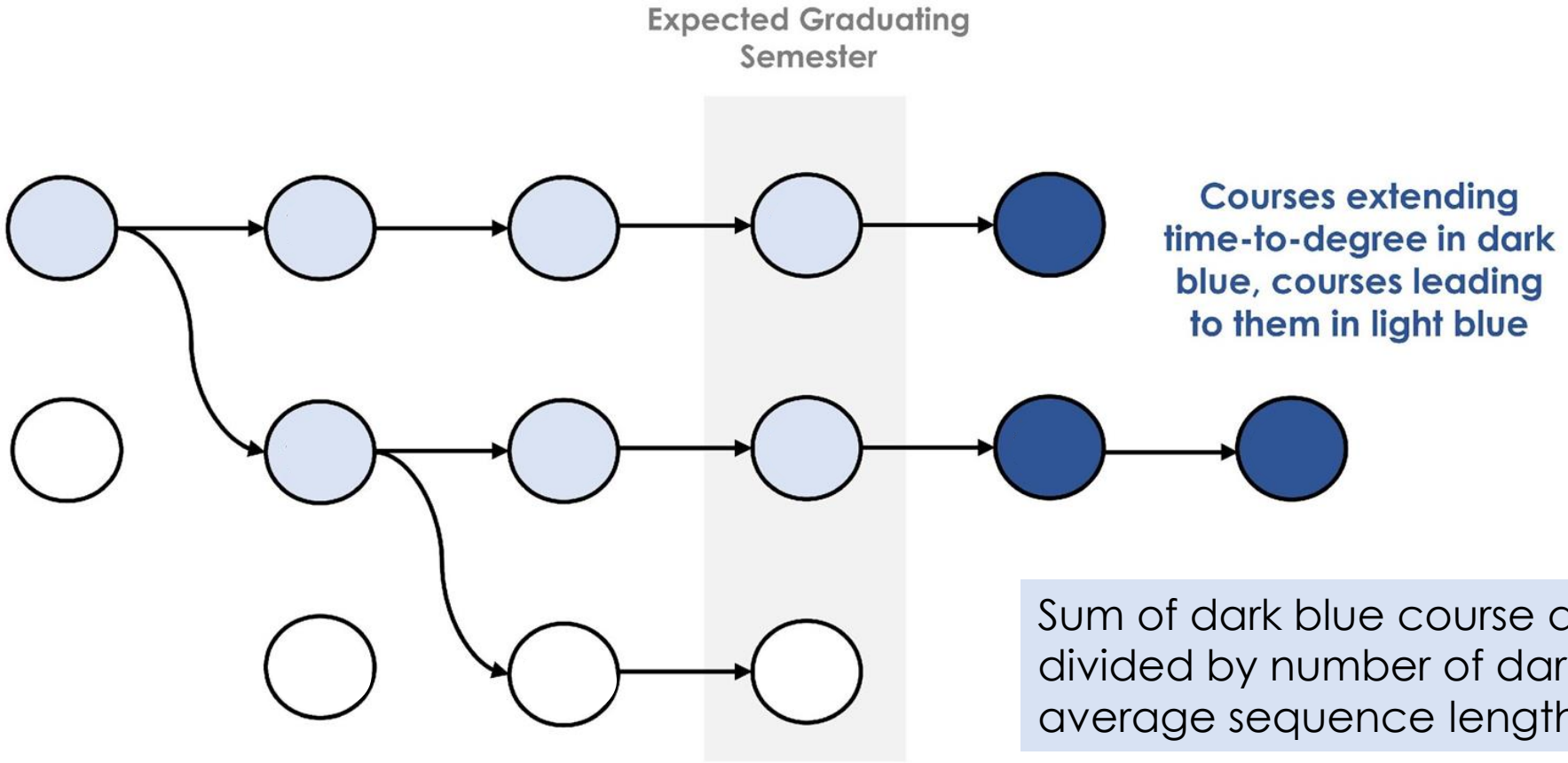
Transfer students are impacted by the timing of course offerings, especially for courses later in the curriculum; therefore, we apply penalties based on how long students have to wait



Penalties are added to the course's term with term-weighting (DeRocchis et al., 2021) and multiplied by the delay factor

Inflexibility Factor

Sequencing is captured well in Heileman et al.'s (2018) original conceptualization using the delay factor; we focus on the sequencing that leads transfer students past the intended time to dearee

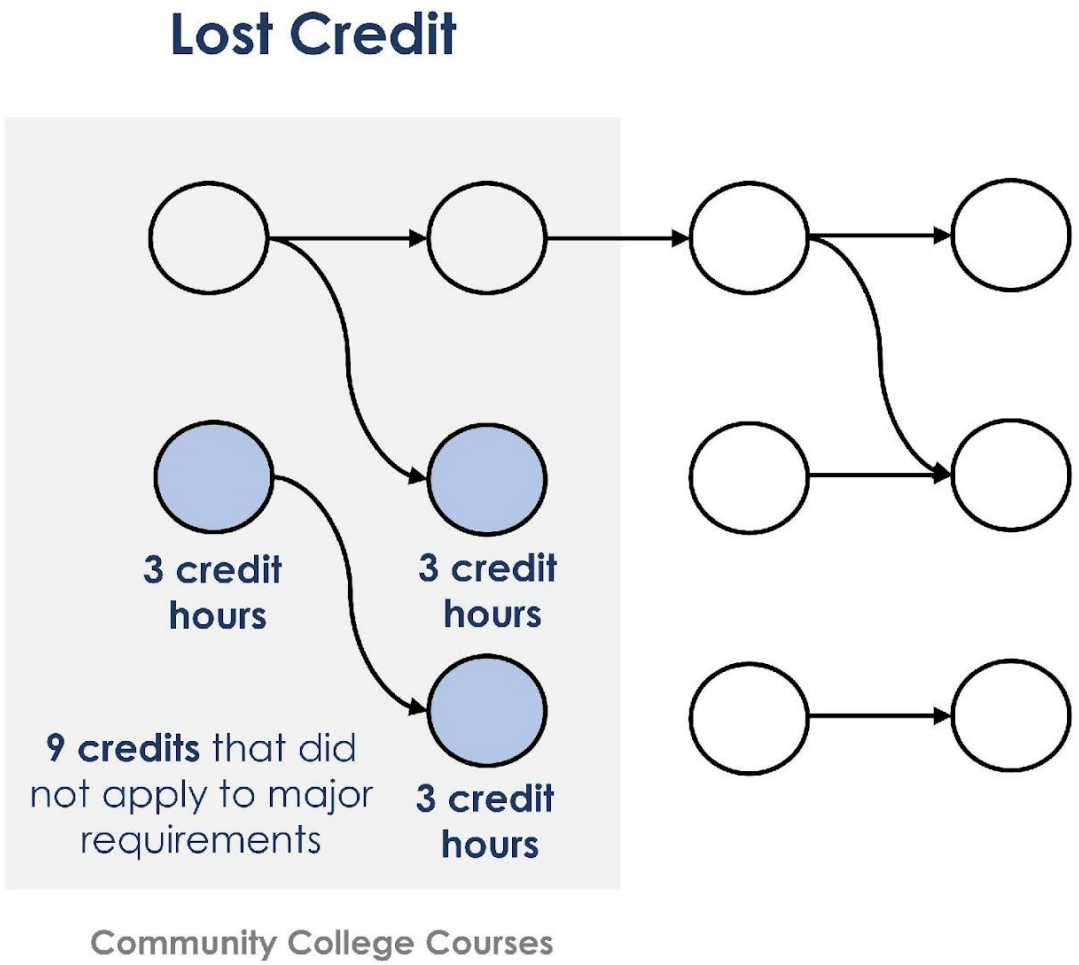


Sum of dark blue course delay factors, could be divided by number of dark blue courses to yield average sequence length

Can also find structural complexity of all blue courses and find percentage of overall complexity explained by them

Transfer Delay Factor

For Credit Loss, we tally the number of credits lost to electives and non-transfer to account for credit loss being predictive of transfer students not graduating



Next steps on this project include…

- Synthesized Member Checking with participants (Birt et al., 2016)
- Compiling focused codes into model to highlight relationships among categories
- Refining curricular complexity metrics and initial refinements based on relevant themes

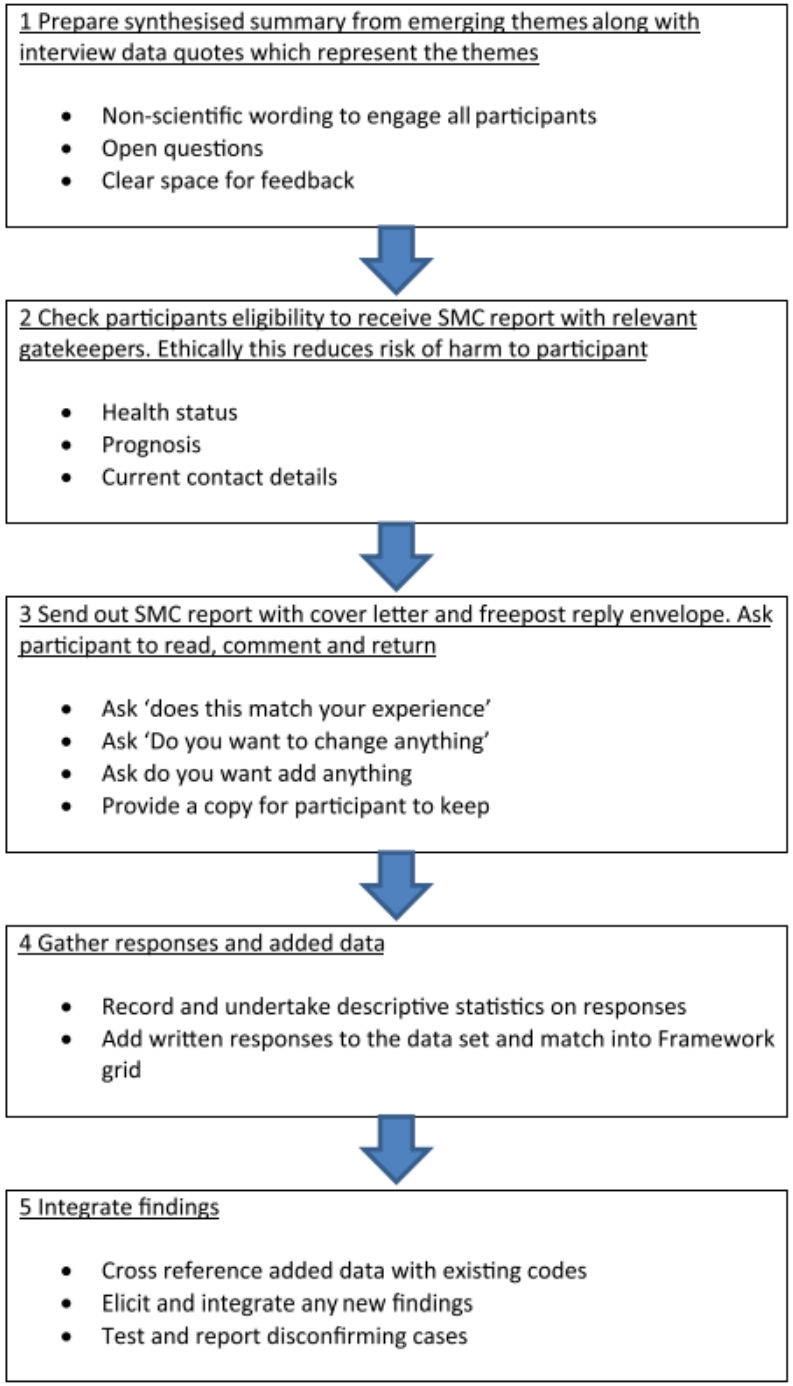
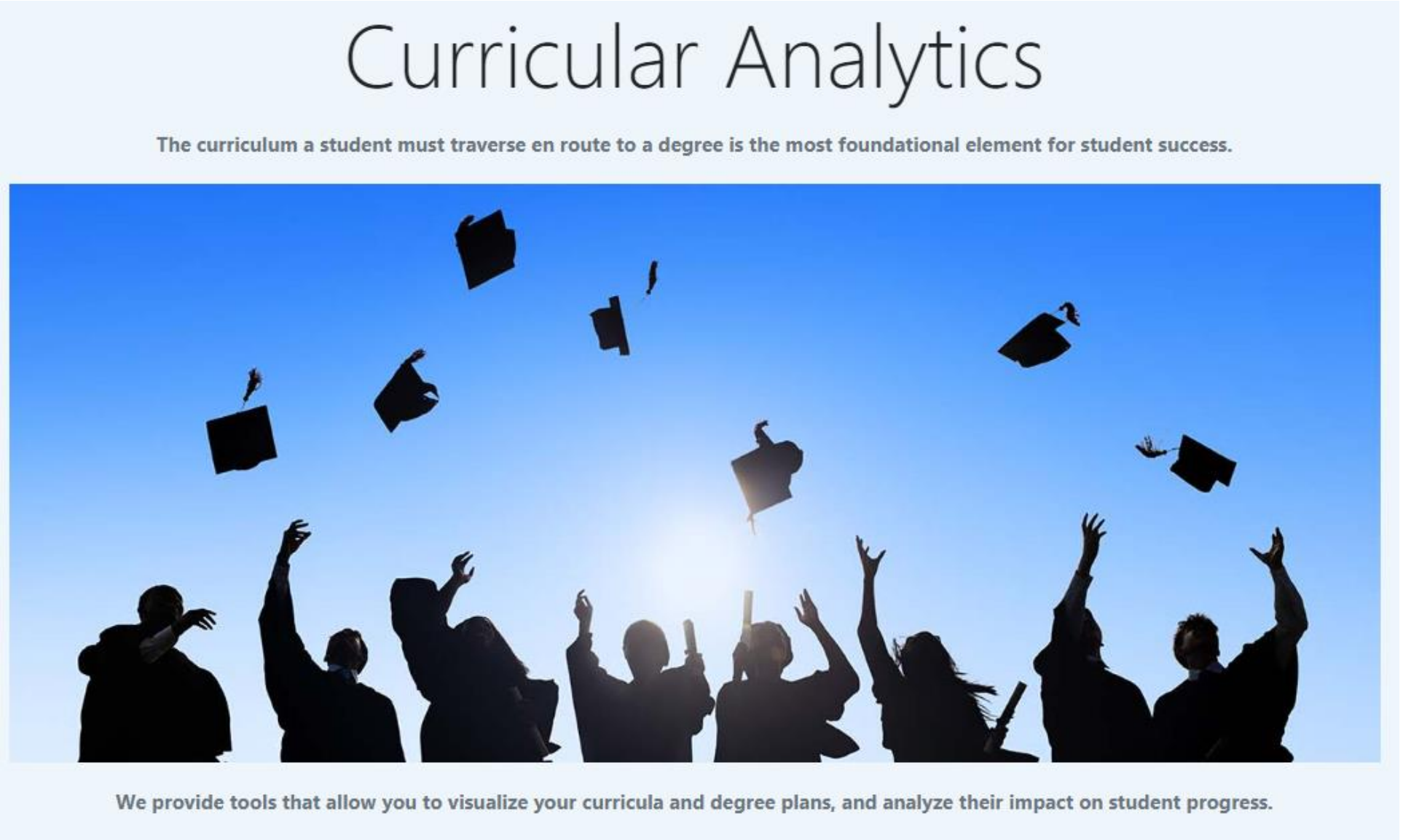


Figure 1 from Birt et al. (2016) *Member Checking: A Tool to Enhance Trustworthiness or Merely a Nod to Validation?*

If you'd like to give any of this a try, visit curricularanalytics.org!* An R package to calculate the base metrics for TSCC is under development



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Developing a Theory of Curricular Complexity for Transfer Students: Establishing Content and Construct Validity

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