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HCI Prerequisite Relations

Third Progress Report

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Client: Dr. Vincent Aleven

Agenda

- Introduction to the project
- Data
  - 3 Workspaces
  - Mathia Grade 7
- Methods
  - Gaussian graphical models and FIML correlation
  - Focus on initial opportunities
  - GLMER and identifying prerequisite relationships
- Results
- Next steps

Introduction

The project aims to investigate whether prerequisite relations among math topics can be detected in log data.

Questions to be addressed

- How do we determine whether two math skills are related?
- What metrics of learning and performance?
- How do we test whether topic/skill/unit A is prerequisite for B?

Data

- 3 Workspaces (Grade 7, 500 Students)
  - A = “Analyzing Models of Two-Step Linear Relationships”
  - B = “Modeling Two-Step Expressions”
  - C = “Using Scale Factor”
- Content in A (and presumably KCs in A) are a prerequisite for (presumably KCs in) B
- C is prior to both A & B, and we have no reason to think that C is a prerequisite for A or B.

Data

- Take A as an example
  - 43039 rows, 28 columns
  - 500 Students, 7 unique KCs
  - 97 Unique problems, 6 Unique steps

	Anon.Student.Id	Problem.Name	Step.Name	First.Attempt	Incorrects	Hints	Corrects	KC..MATHia.
1	00e13422-f660-4da6-a068-5f154aa83ae6	analyzing_models_2step_integers-017	gn-classify-item-5	incorrect	2	0	1	match _slope expression with description.
2	00e13422-f660-4da6-a068-5f154aa83ae6	analyzing_models_2step_integers-017	gn-classify-item-6	correct	0	0	2	interpret scenario with numbers
3	00e13422-f660-4da6-a068-5f154aa83ae6	analyzing_models_2step_integers-017	gn-classify-item-2	correct	0	0	1	match _indep expression with description.
4	00e13422-f660-4da6-a068-5f154aa83ae6	analyzing_models_2step_integers-017	gn-classify-item-4	incorrect	1	0	1	match _linear-term expression with description
5	00e13422-f660-4da6-a068-5f154aa83ae6	analyzing_models_2step_integers-017	gn-classify-item-3	correct	0	0	1	match _dep expression with description.
6	00e13422-f660-4da6-a068-5f154aa83ae6	analyzing_models_2step_integers-017	gn-classify-item-1	correct	0	0	1	match _dep expression with description.
7	00e13422-f660-4da6-a068-5f154aa83ae6	analyzing_models_2step_integers-082	gn-classify-item-6	incorrect	2	0	1	match _intercept expression with description.
8	00e13422-f660-4da6-a068-5f154aa83ae6	analyzing_models_2step_integers-082	gn-classify-item-3	correct	0	0	2	match _slope expression with description.
9	00e13422-f660-4da6-a068-5f154aa83ae6	analyzing_models_2step_integers-082	gn-classify-item-1	incorrect	1	0	1	match _indep expression with description.

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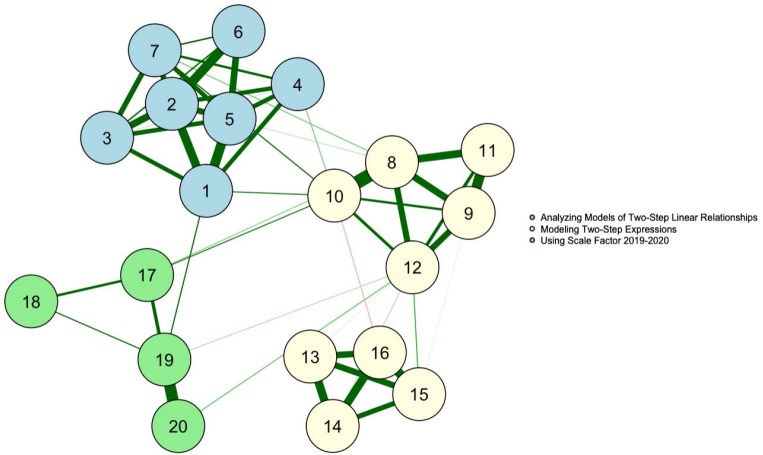
Method - Overview

Gaussian Graphical Model	Initial Opportunities	GLMER
Understand partial correlations between KCs based on Full Information Maximum Likelihood criteria	Better understand students' performance	Figure out the direction of correlations (which one is prerequisite)

Method - Gaussian Graphical Models

- Gaussian graphical models is an exploratory analysis tool that provides relationships between variables in a study.



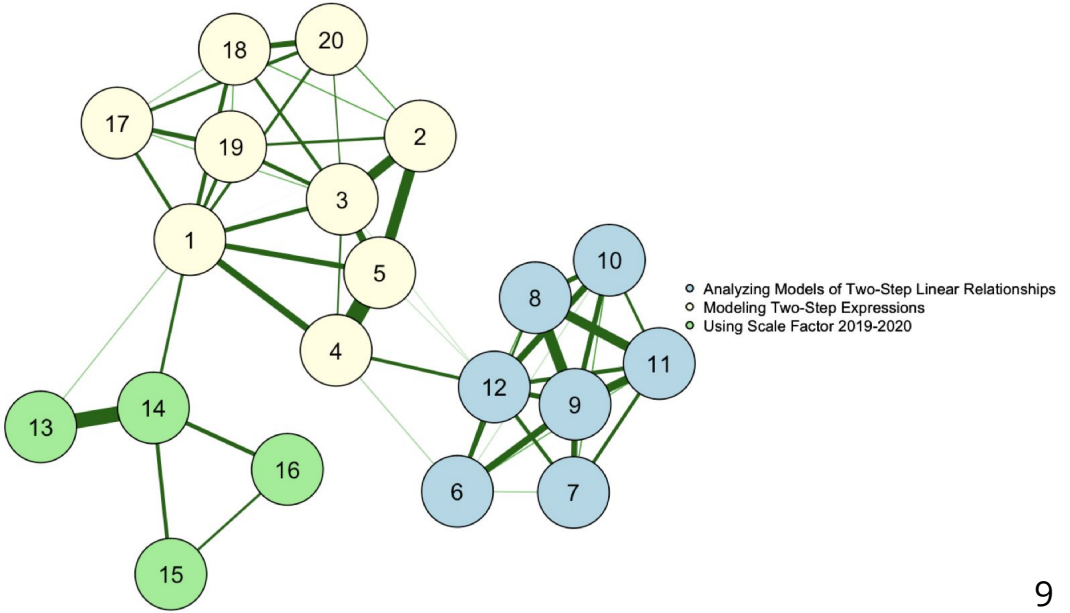
Method - Initial Opportunities

- What is an opportunity?
  - A Step (include all attempts a student made to that step)
- Why initial opportunities?
  - For each KC, steps are given until students demonstrate mastery
  - Using all would smooth out differences among students
  - Better indication of performance

	Anon.Student.Id	Problem.Name	Step.Name	First.Attempt	Incorrects	Hints	Corrects	KC..MATHia.
1	00e13422-f660-4da6-a068-5f154aa83ae6	analyzing_models_2step_integers-017	gn-classify-item-5	incorrect	2	0	1	match _slope expression with description.
2	00e13422-f660-4da6-a068-5f154aa83ae6	analyzing_models_2step_integers-017	gn-classify-item-6	correct	0	0	2	interpret scenario with numbers
3	00e13422-f660-4da6-a068-5f154aa83ae6	analyzing_models_2step_integers-017	gn-classify-item-2	correct	0	0	1	match _indep expression with description.
4	00e13422-f660-4da6-a068-5f154aa83ae6	analyzing_models_2step_integers-017	gn-classify-item-4	incorrect	1	0	1	match _linear-term expression with description
5	00e13422-f660-4da6-a068-5f154aa83ae6	analyzing_models_2step_integers-017	gn-classify-item-3	correct	0	0	1	match _dep expression with description.
6	00e13422-f660-4da6-a068-5f154aa83ae6	analyzing_models_2step_integers-017	gn-classify-item-1	correct	0	0	1	match _dep expression with description.
7	00e13422-f660-4da6-a068-5f154aa83ae6	analyzing_models_2step_integers-082	gn-classify-item-6	incorrect	2	0	1	match _intercept expression with description.
8	00e13422-f660-4da6-a068-5f154aa83ae6	analyzing_models_2step_integers-082	gn-classify-item-3	correct	0	0	2	match _slope expression with description.
9	00e13422-f660-4da6-a068-5f154aa83ae6	analyzing_models_2step_integers-082	gn-classify-item-1	incorrect	1	0	1	match _indep expression with description.

Method - Initial Opportunities

- Decide based on the structures of GGMs generated by different cutoffs
- Initial 2 opportunities give the best graph
  - more lines between A and B



Method - Determine the Direction of Correlations

If KC2 is a prerequisite for KC1, then whether a student knows KC2 would influence their performance of KC1

Logistic regression with mixed effects (glmer)

- KC1 Performance
- 1 + KC1 Opportunity + know_kc2 + KC1 Opportunity : know_kc2 + (1|Anon.Student.Id)

Result - Determine the Direction of Correlations

KC1:

write expression, negative intercept

KC2:

define variable

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	-2.0202	0.8536	-2.367	0.0180	*
Opportunity..MATHia.	0.7575	0.4404	1.720	0.0854	.
know_kc2	2.4565	1.0698	2.296	0.0217	*
Opportunity..MATHia.:know_kc2	-0.4497	0.4553	-0.988	0.3234	

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	-0.29270	0.09363	-3.126	0.00177	**
Opportunity..MATHia.	0.20865	0.01969	10.598	< 2e-16	***
know_kc1	1.35662	0.12671	10.706	< 2e-16	***
Opportunity..MATHia.:know_kc1	-0.16505	0.02022	-8.163	3.25e-16	***

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Results - Mathia Grade 7

- Intentionally choosing 32 KCs

```
 [1] "select combine like terms-1"
 [2] "combine like terms-1"
 [3] "select perform division-1"
 [4] "perform division"
 [5] "select simplify fractions-1"
 [6] "select apply exponent-1"
 [7] "apply exponent-1"
 [8] "select perform multiplication-1"
 [9] "perform multiplication-1"
[10] "select combine like terms, unary coefficient"
[11] "select combine like terms within parens"
[12] "enter given triangular prism dimension of base"
[13] "enter given prism volume"
[14] "find area of base of triangular prism"
[15] "find prism height"
[16] "work with triangular prism in standard position"
[17] "enter given prism height"
[18] "enter given rectangular prism dimension of base"
[19] "find rectangular prism dimension of base"
[20] "find area of base of rectangular prism"
[21] "work with prism in context"
[22] "find triangular prism dimension of base"
[23] "work with prism out of context"
[24] "enter given pyramid side length of base"
[25] "enter given pyramid height"
[26] "find area of base of pyramid"
[27] "find pyramid volume"
[28] "work with pyramid in standard position"
[29] "enter given pyramid volume"
[30] "find pyramid height"
[31] "work with pyramid out of context"
[32] "work with pyramid in context"
```

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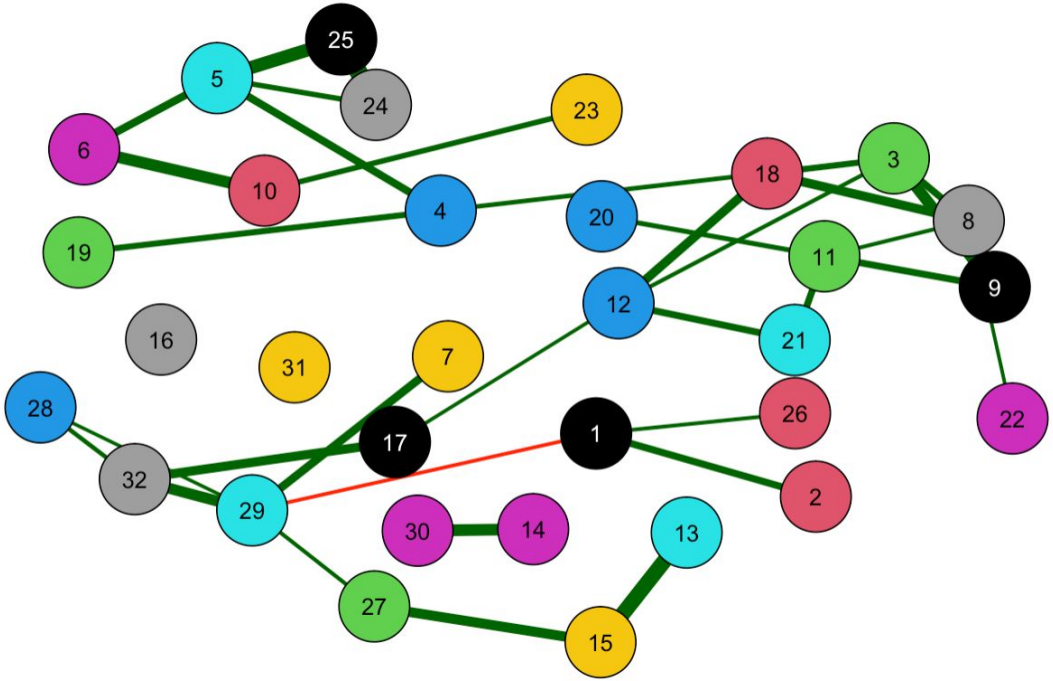
Results - Mathia Grade 7



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Next Steps

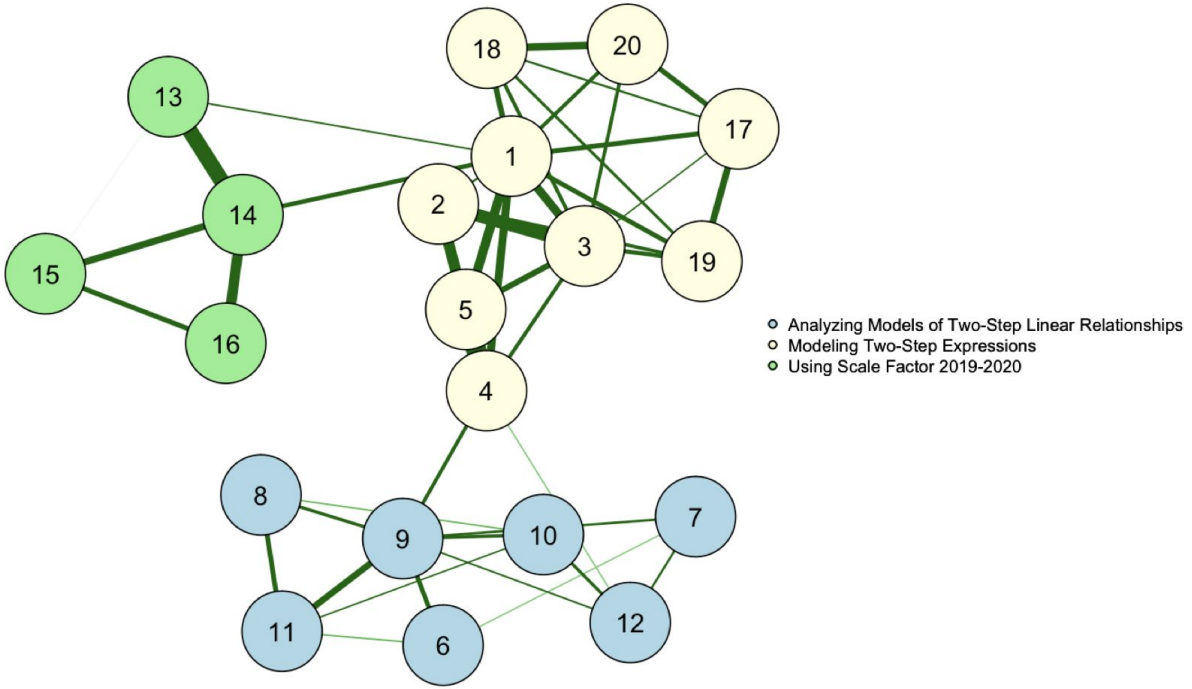
- Working on the relationships identified and finding out prerequisite relations among Mathia dataset.

- Use more predictors in the glmer model.

Thank you for your time!

Extra Slides

When K = 1,



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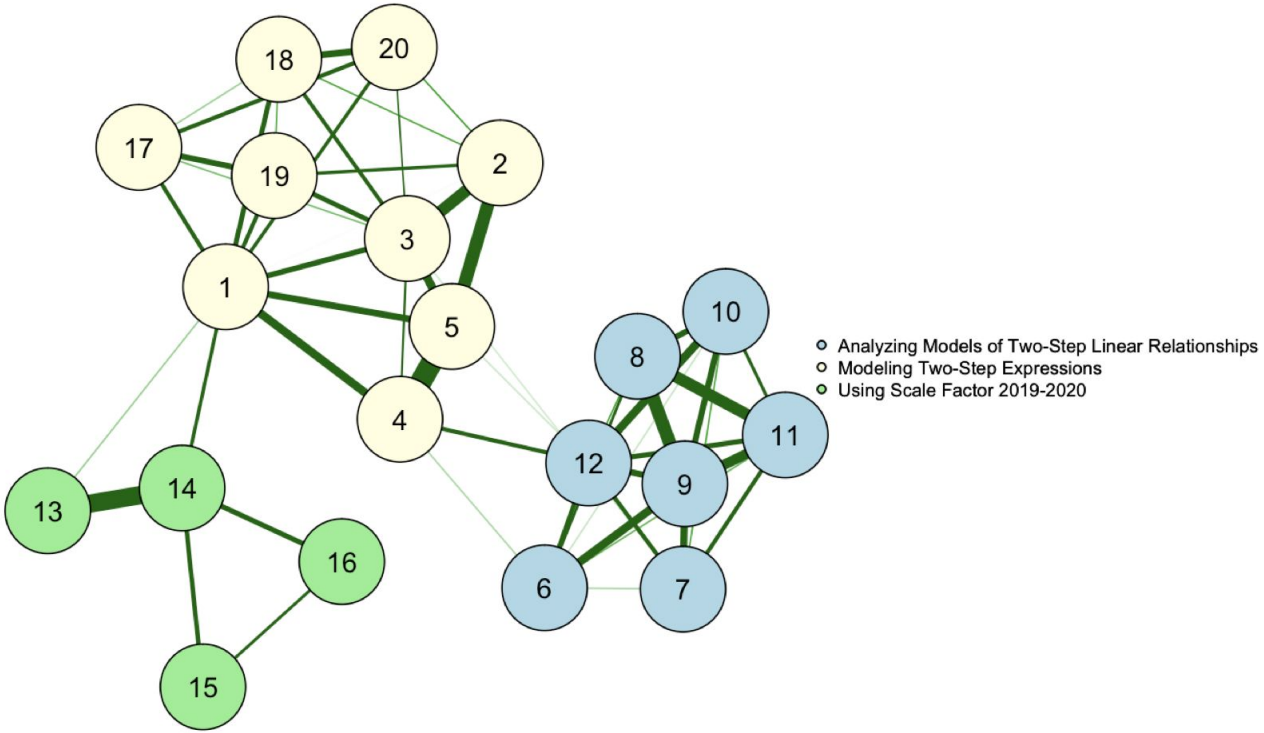
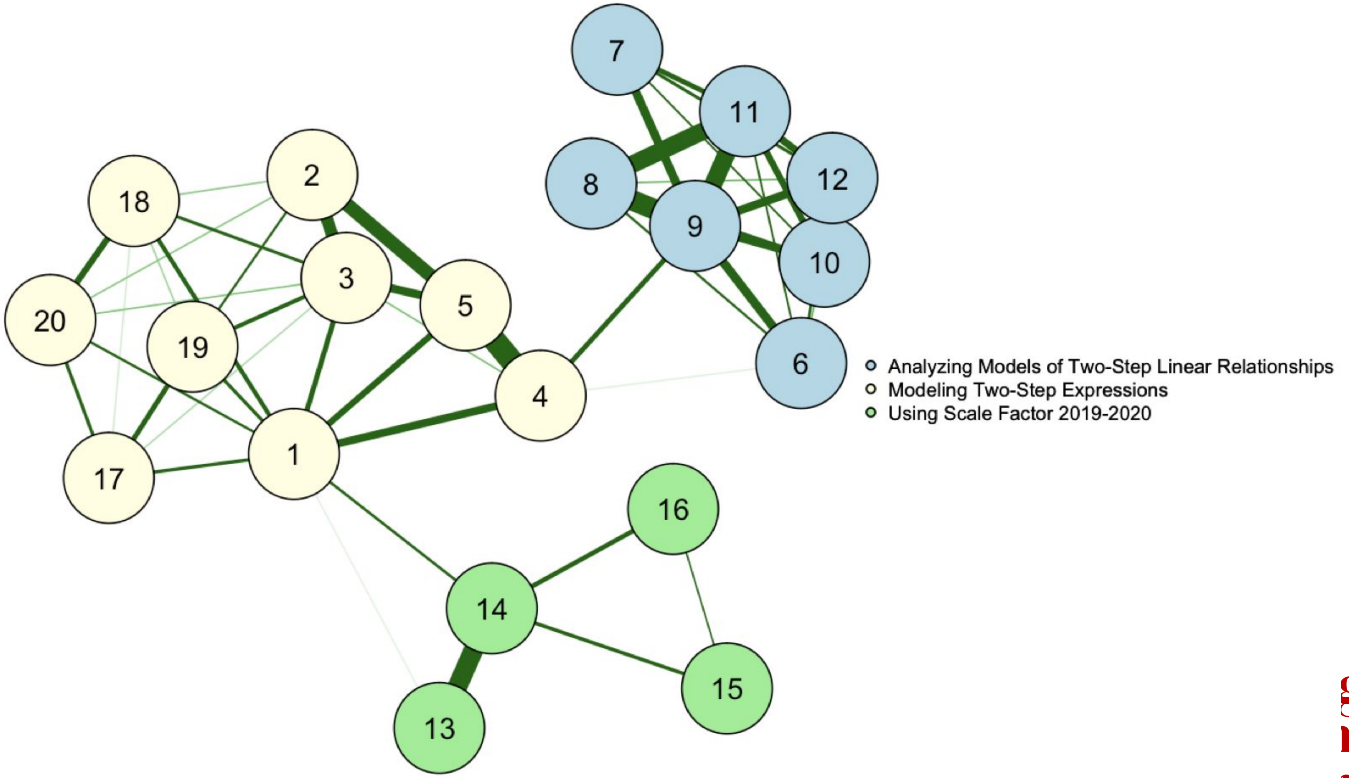
Extra Slides

When K = 2,



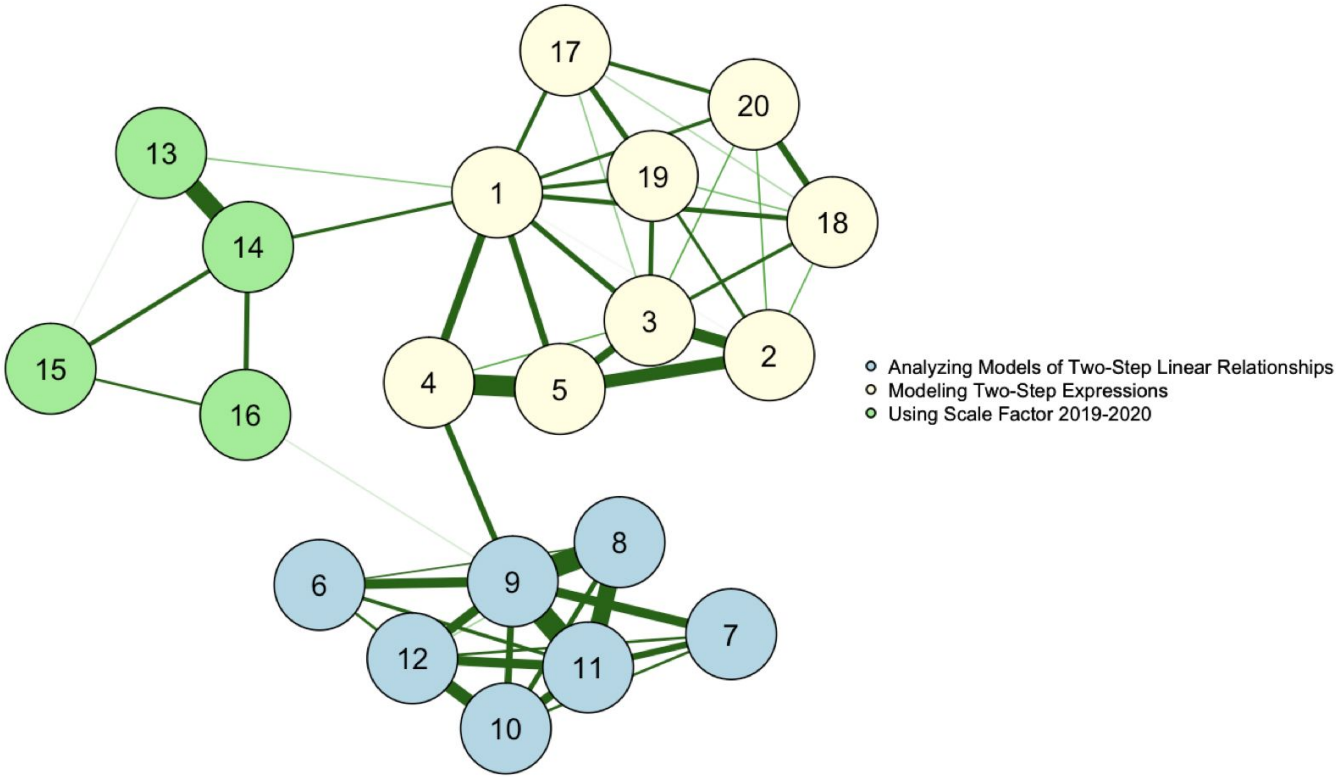
Extra Slides

When K = 3,



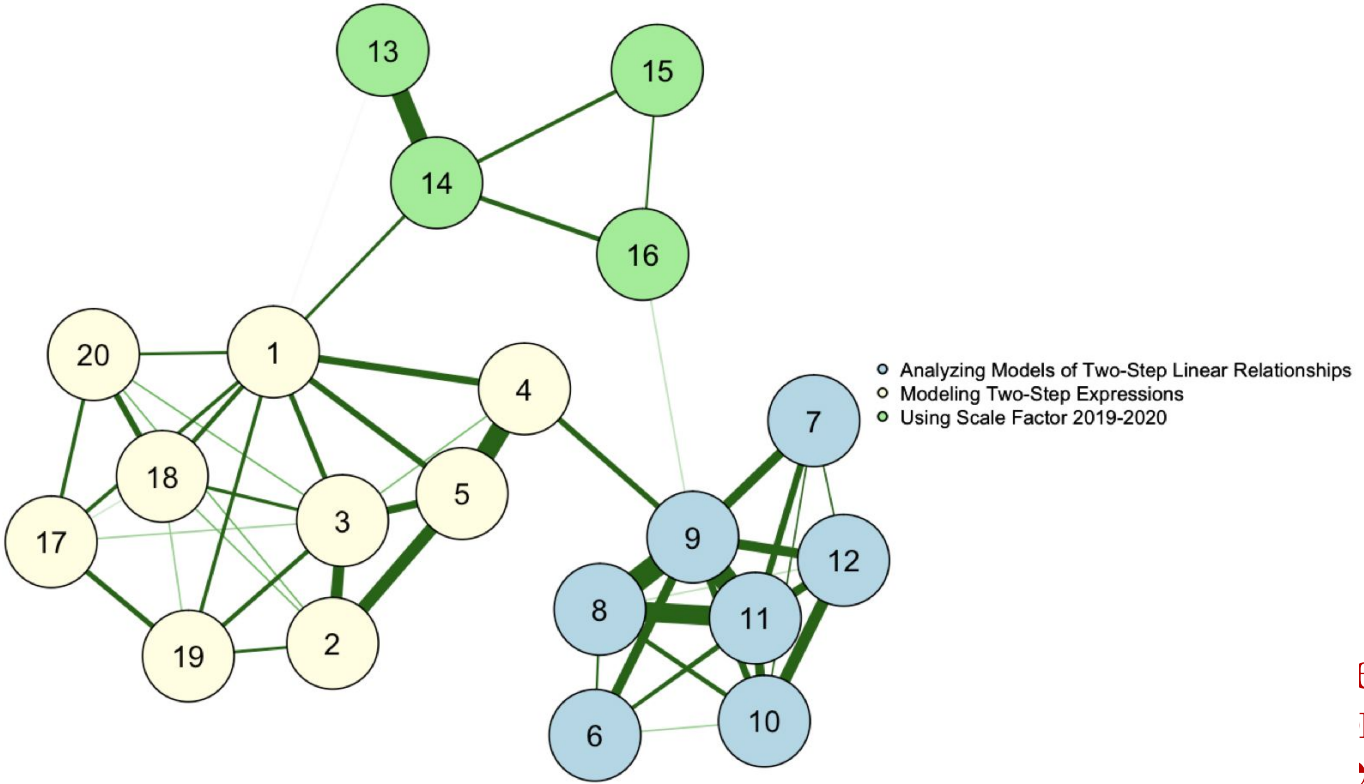
Extra Slides

When K = 4,



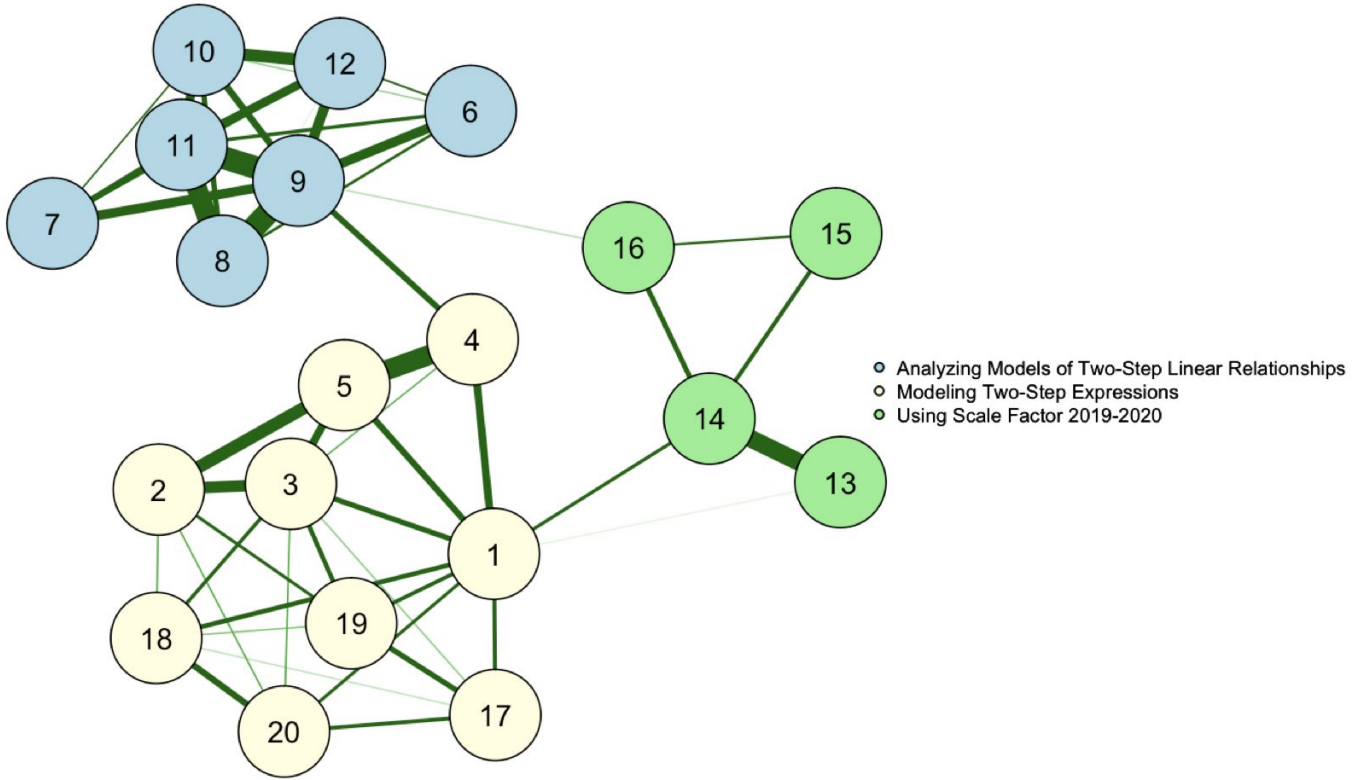
Extra Slides

When K = 5,



Extra Slides

When K = 6,



```
 [1] "define variable-1"
 [2] "enter given, reading numerals-1"
 [3] "enter given, reading words-1"
 [4] "find y, any form-1"
 [5] "identifying units-1"
 [6] "interpret scenario with numbers"
 [7] "interpret scenario with words"
 [8] "match _dep expression with description."
 [9] "match _indep expression with description."
[10] "match _intercept expression with description."
[11] "match _linear-term expression with description."
[12] "match _slope expression with description."
[13] "scale-drawings-3-determine unknown measure, complex scale factor."
[14] "scale-drawings-3-determine unknown measure, simple scale factor."
[15] "scale-drawings-3-enter scale factor units."
[16] "scale-drawings-3-enter scale factor value."
[17] "write expression, negative intercept-1"
[18] "write expression, negative slope-1"
[19] "write expression, positive intercept-1"
[20] "write expression, positive slope-1"
```