NC STATE UNIVERSITY

Student Experiences in Community College Precalculus: A Mixed Methods Study of Student Engagement and Understanding

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Background Information

- Measuring the effects of teaching on student learning in undergraduate mathematics is an open question in mathematics education research (Hiebert & Grouws, 2007; Speer, Smith, & Horvath, 2010)
- Not a lot is known about students' experiences in community college mathematics courses (Mesa, Celis, & Lande, 2014)
- However, roughly 50% of undergraduate students taking mathematics courses are doing so at community colleges (Rodi, 2007)
- Historically, community college students struggle to pass precalculus on their first attempt (Barnes, Cerrito, & Levi, 2004)
- Personal investment
- Student engagement is positively associated with academic achievement (Nakamura & Csikszentmihalyi, 2009; Deci & Ryan, 2008; Finn & Zimmer, 2012; Newmann, 1989; Skinner & Belmont, 1993)

Student Engagement in Math

Elementary
- Teacher-reported behavioral engagement
- Declines daily, over the school year, and throughout elementary school
- Positively related to structured environment
- Positively related to mathematical growth

Middle
- Engagement in mathematics declines through middle school
- Classroom-level engagement positively affects individual engagement
- Cooperative group work & structure foster engagement
- Classroom-level achievement negatively relates to individual engagement

Secondary
- Students report lecture is least engaging
- Group work, interesting activities, & technology positively affect engagement
- Assigned seats positively affect engagement
- Females tend to be emotionally disengaged
- Latin@ students especially benefit from group work

Undergraduate
- National Survey of Student Engagement
- Community College Survey of Student Engagement
- Not much research on student engagement in mathematics classrooms

Research Questions

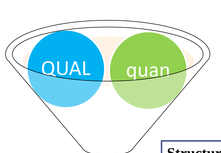
1. What is the nature of community college students' engagement in precalculus during class time, and what role do teaching approaches have on these experiences?
2. Is there a relationship between student engagement and understanding of precalculus concepts, and if so:
   a) What are characteristics of this relationship?
   b) Is there an association between this relationship and teaching approaches?

Method

Convergent Parallel Design

- Quantitative & Qualitative data are collected concurrently and analyzed separately (Decuir-Gunby & Schutz, n.d.)
- Results are blended together to tell a more complete story

- Teacher Interviews
- Initial Student Survey
- Classroom Observations
- Weekly Diaries
- Student Interviews



- Initial Student Survey
- Weekly Diaries
- Precalculus Concepts Assessment

Structure of Data
- 829 occurrences nested within
- 101 students, within
- 15 instructors

Quantitative Analysis Methods
- Hierarchical linear modeling
- Mediation analysis
- Simple descriptive statistics

Results

Research Question 1 - Nature of Student Engagement

Table 1: *Cross-tabulation of engagement codes from weekly posts*

	~Concentrate	~Enjoy	~Interest	Concentrate	Enjoy	Enjoy Neutral	Interest
~Concentrate	40						
~Enjoy	2	195					
~Interest	6	13	47				
Concentrate	0	22	2	172			
Enjoy	6	0	2	24	144		
Enjoy Neutral	2	0	2	3	0	34	
Interest	1	0	0	4	18	1	29

Average Engagement

- The sample average of student engagement was 2.81. Students tended to report high levels of concentration but either high or low levels of interest and enjoyment – as opposed to being emotionally neutral.

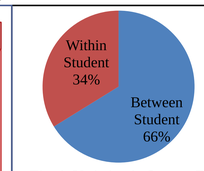


Fig. 1. Variation in Student Engagement

Table 3: *Parameter estimates for three needs and their interactions.*

Fixed Effects	Estimate	p-value
Intercept	2.8	< .0001
Competence	0.28	< .0001
Belongingness	0.21	< .0001
Autonomy	0.05	0.17
COMP*BEL	-0.01	0.8
COMP*AUTO	-0.05	0.087
BEL*AUTO	0.05	0.17
COMP*BEL*AUTO	0.03	0.084
Random Effects		
Intercept	1.3	< .0001
Competence	0.04	0.002
Belongingness		
Autonomy	0.04	0.004
Residual	0.36	< .0001

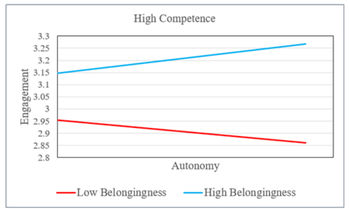


Fig. 2. Decomposing 3-way interaction

Perceived Needs Fulfillment

- Positively associated with student engagement
- Intra-individual differences in the way needs fulfillment is experienced
- Competence & Belongingness are positively related with changes in weekly engagement
- Confident students experience the competence-engagement relationship differently than their less confident peers

Table 4: *Parameter estimates for three needs by challenge-skill balance groups*

Fixed Effects	Estimate	p-value
BORED		
Intercept	3.08	< .0001
COMP	0.17	0.03
BEL	0.23	0.02
AUTO	0.22	0.0004
ANXIOUS		
Main Effect	-1.63	0.0004
COMP	-0.09	0.44
BEL	-0.01	0.94
AUTO	-0.01	0.94
CHALLENGED		
Main Effect	-0.47	0.15
COMP	0.16	0.06
BEL	0.01	0.93
AUTO	-0.16	0.03
COMFORTABLE		
Main Effect	0.28	0.42
COMP	0.26	0.007
BEL	-0.16	0.19
AUTO	-0.14	0.07
Random Effects		
Intercept	1.02	< .0001
Residual	0.43	< .0001

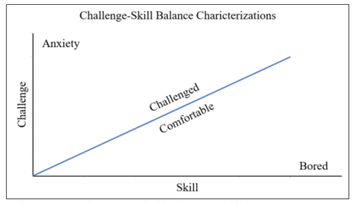


Fig. 4. Visualization of Challenge-skill groups

Challenge-Skill Balance

- Weeks characterizing students as bored tended to correspond with highest levels of engagement
- Aggregated across the semester, anxious students tended to report being drastically less engaged than peers (needs fulfilment does not dampen this effect)
- Posts reflecting boredom suggest low engagement, especially when course materials are perceived as easy
- Confidence is important when materials are perceived as hard

Table 5: *Themes of confidence-engagement relationship*

Related theme	Example Posts
Concentration	
Hard work	Precalculus is starting to get challenging but I like a challenge.
Enjoy	
"I understand"	I'm beginning to like calculus more lately & I find it easier to understand topics; I feel more confident within myself and my success in this class.
Competence	I took my first precalculus test and it went fairly well. I'm enjoying the class more than I thought I would.
Enjoy material	Math was interesting this week. I enjoy working with logarithms. Challenging but not impossible. Confident for the next test
Teaching Positive	Thanks to the teacher now I know my stuff.👍😎
Hard work	I feel like passing this class will be a hard yet exciting challenge
Interest	
What's next?	Interesting topic this week, building on what I have learned so far. Can't wait for what's next.
"I understand"	math this week was amazing and interesting because i understood most of them

Research Question 2 – Engagement-Understanding Relationships

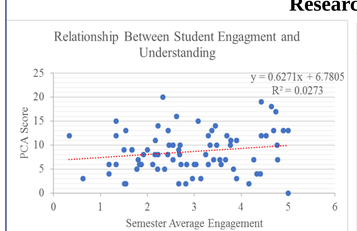


Fig. 7. Understanding-Engagement Relationship

Engagement-Understanding Relationships

- Quantitative results did not reveal significant differences in understanding between classes
- No association between student engagement and understanding in this sample
- Qualitatively, differences in students' understanding were associated with different levels of enjoyment in task-based interviews
- Regardless of understanding, students can exhibit high levels of engagement while working challenging tasks
- Qualitative results from task-based interviews leaves open the possibility of a relationship between understanding and engagement existing on a larger scale

	~Enjoy	~Interest	Enjoy	Interest
Static Shape Thinking	•Challenging •Confusing •Low Confidence •Too much autonomy			•Challenging •Open-Ended
Emergent Shape Thinking	•Low confidence (Patricia & Marianne)	•Too much autonomy (Patricia)	• Challenging • Promotes problem solving • Relatable context	•Challenging •Promotes problem solving •Promotes autonomy

Fig. 9. Relationship between engagement and understanding from task-based interviews

	Balanced	Meaning-Making	Student-Supportive	Traditional
~Concentration	(23) Boredom	(8) Confidence	(3) Easy	(6) Boredom
~Enjoy	(60) Confused Anxiety ~Competent Hard Teaching Negative	(90) Confused ~Competent ~Belong Fast-paced	(9) "I don't like math"	(36) ~Competent Test
~Interest	(30) Boredom Too Long	(12) ~Enjoy		(5) ~Enjoy ~Prepared
Concentration	(63) Confidence Prepared ~Prepared Teaching Positive Enjoy ~Enjoy	(68) Confidence Enjoy ~Enjoy Test Confused	(10) Confidence Test	(31) ~Enjoy Enjoy Test
Enjoy	(37) Competent Confidence Teaching Positive Concentrate	(52) Confidence Competent Test Concentrate Interest	(21) Test Confidence Belong	(34) Competent Test
Enjoy Neutral	(12) Teaching Positive	(13) Confidence	(2) Test Confidence	(7) Test
Interest	(6) Enjoy	(9) Confidence Enjoy	(3) Enjoy	(11) Enjoy Confidence

Fig. 6. Nature of student engagement by teaching approach category (post count)

Teaching Approaches

- Regardless of their instructor's teaching approaches, students tended to report similar levels of engagement
- However, the ways in which this level of engagement was attributed to various themes differs based on teaching approaches

Theoretical Framework

Flow Theory
- Interest
- Enjoyment
- Concentration

Teaching Approaches

Traditional
- Privilege content over mastery
- Teacher is math authority

Student-Support
- Content mastery is not primary goal
- Focus on student affect

Meaning-Making
- Promote deeper learning and connections
- Emphasis on understanding

Understanding of Precalculus Concepts

Reasoning about Graphical Representations
- Static Shape Thinking - "Operating on a graph as an object in and of itself" (Moore & Thompson, 2015, p. 784)
- Emergent Shape Thinking - Understanding a graph *simultaneously* as what is made (a trace) and how it is made (covariation)" (Moore & Thompson, 2015, p. 785)