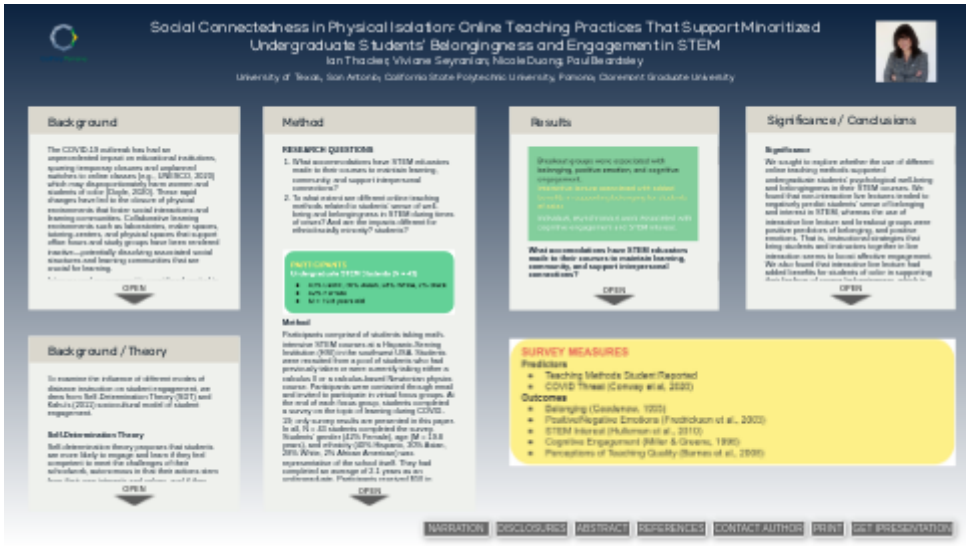
Social Connectedness in Physical Isolation: Online Teaching Practices That Support Minoritized Undergraduate Students' Belongingness and Engagement in STEM



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BACKGROUND

The COVID-19 outbreak has had an unprecedented impact on educational institutions, spurring temporary closures and unplanned switches to online classes (e.g., UNESCO, 2020) which may disproportionately harm women and students of color (Doyle, 2020). These rapid changes have led to the closure of physical environments that foster social interactions and learning communities. Collaborative learning environments such as laboratories, maker spaces, tutoring-centers, and physical spaces that support office hours and study groups have been rendered inactive—potentially dissolving associated social structures and learning communities that are crucial for learning.

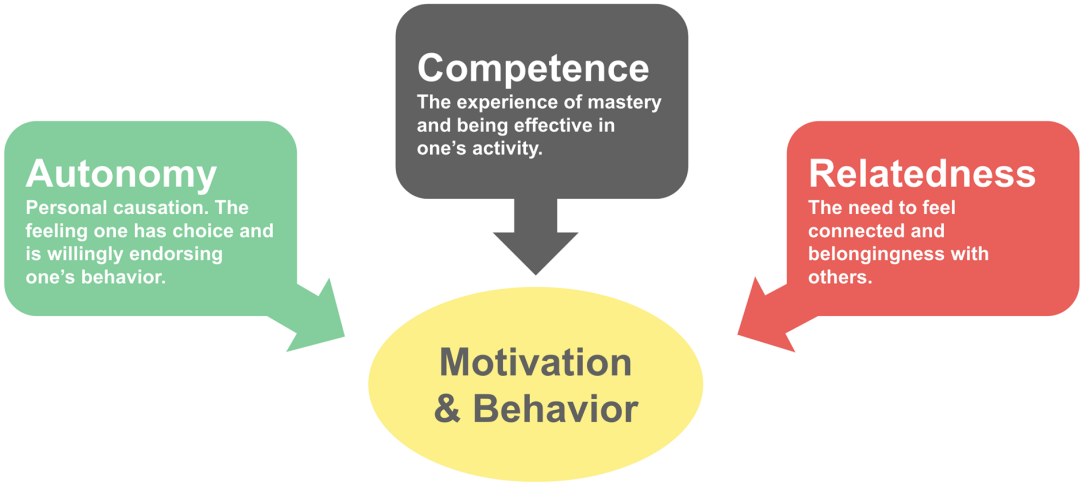
Interpersonal engagement is considered central in sociocultural learning theory (Cobb, Wood, & Yackel, 1993; Nasir, Hand, & Taylor, 2008; Wenger, 1998) and fulfills basic psychological needs to feel connected and to belong in a learning community (e.g., Baumeister & Leary, 1995), which is particularly important for supporting women and students of color persist in STEM fields (Gutiérrez, 2018; Johnson, 2012; Joseph et al., 2017). Schools and educators across the world have made efforts to adapt to rapidly changing circumstances of COVID-19 and to support their students through academic and life challenges (UNESCO, 2020). However, little is known about specific instructional methods that instructors have used to adapt to ever changing circumstances and how these practices affect racially underrepresented students in critical transition classes in STEM. The purpose of this study was to investigate online teaching practices that undergraduate STEM instructors have employed to adapt to the transition to online instruction and their impacts on students affective and cognitive engagement.

BACKGROUND / THEORY

To examine the influence of different modes of distance instruction on student engagement, we drew from Self-Determination Theory (SDT) and Kahu's (2011) sociocultural model of student engagement.

Self-Determination Theory

Self-determination theory proposes that students are more likely to engage and learn if they feel competent to meet the challenges of their schoolwork, autonomous in that their actions stem from their own interests and values, and if they feel a sense of social belonging and relatedness in the classroom and academic community. Students must meet these needs to internalize that their academic performance stems from an internal locus of causality, take ownership of their learning, view academic behaviors as stemming from their own volition, and develop intrinsic motivation and engagement (Ryan & Deci, 2000).



Learning Environments, Belonging, and Engagement

Kahu's (2011) sociocultural model of student engagement explains how learning environments can support belonging and engagement by supporting relationships between students and teachers that build affective, cognitive, and behavioral engagement. Notable indicators of engagement are feelings of interest and belonging in STEM, positive emotional states, deep cognitive engagement, and a willingness to deeply engage in course content—all of which are thought to support academic achievement, social well-being, long-term persistence and retention, and personal growth.

An essential indicator of affective engagement in this model is the need to belong. The sense of belonging to one's institution and classroom community is a key factor that motivates students to pursue and persist through undergraduate STEM programs and is associated with achievement outcomes, self-efficacy, interest, and expectancies for success—particularly for women and students of color (Anderman, 2002; Strayhorn, 2012; Goodenow, 1993; Goodenow & Grady, 1993; Gutman & Midgley, 2000; Roeser et al., 1996; Walton & Cohen, 2011).

Consistent with Kahu's (2011) model, instructors can choose online instructional methods that maximize students' sense of belonging and affective and cognitive engagement. The use of online instructional techniques that emphasize synchronous social interaction—such as live discussion, live chat, or breakout groups—could facilitate social relationships and a sense of belongingness when compared with asynchronous slide show presentations, individual work, or live presentations that limit interpersonal interactions (for a review, see Delahunty et al., 2014).

Much of the research on online teaching strategies was conducted in a time when interpersonal connections could be readily reinforced with physical infrastructure. We were interested in how engagement might be maintained and fostered by instructors in a time of forced mass transition to online learning and physical distancing. Towards this end, we conducted online focus-groups, interviews, and surveys with undergraduate students taking math-intensive STEM courses shortly after all courses transitioned online and a local lockdown was instituted during the COVID-19 pandemic.

METHOD

RESEARCH QUESTIONS

1. What accommodations have STEM educators made to their courses to maintain learning, community, and support interpersonal connections?
2. To what extent are different online teaching methods related to students' sense of well-being and belongingness in STEM during times of crises? And are the impacts different for ethnic/racially minority? students?

PARTICIPANTS

Undergraduate STEM Students (N = 43)

- 40% Latinx, 30% Asian, 28% White, 2% Black
- 42% Female
- M = 19.8 years old

Method

Participants comprised of students taking math-intensive STEM courses at a Hispanic-Serving Institution (HSI) in the southwest USA. Students were recruited from a pool of students who had previously taken or were currently taking either a calculus II or a calculus-based Newtonian physics course. Participants were contacted through email and invited to participate in virtual focus groups. At the end of each focus group, students completed a survey on the topic of learning during COVID-19; only survey results are presented in this paper. In all, N = 43 students completed the survey. Students' gender (42% Female), age (M = 19.8 years), and ethnicity (40% Hispanic, 30% Asian, 28% White, 2% African American) was representative of the school itself. They had completed an average of 2.1 years as an undergraduate. Participants received $50 in campus funds for their participation.

Materials and Procedure

Student surveys contained ten scales, seven of which are presented in detail in the current study. Two scales were used in our models as explanatory variables and five were included as separate response variables. Explanatory variables were student reports of online teaching methods and basic needs impacted by COVID-19 (Conway et al., 2020). Response variables were measured with scales for course belonging (Goodenow, 1993), positive and negative emotions experienced during STEM classes (Fredrickson et al., 2003), STEM interest (Hulleman et al., 2010), cognitive engagement (Greene & Miller, 1996), and perceptions of instructor quality (Barnes et al., 2008). All scales had a Cronbach's alpha coefficient of at least $\alpha = .85$. Instrument details as well as all survey materials are included in the Supplemental Materials. Mean time to complete the survey was 29 minutes.

SURVEY MEASURES

Predictors

- Teaching Methods Student Reported
- COVID Threat (Conway et al, 2020)

Outcomes

- Belonging (Goodenow, 1993)
- Positive/Negative Emotions (Fredrickson et al., 2003)
- STEM Interest (Hulleman et al., 2010)
- Cognitive Engagement (Miller & Greene, 1996)
- Perceptions of Teaching Quality (Barnes et al., 2008)

RESULTS

Breakout groups were associated with belonging, positive emotion, and cognitive engagement.

Interactive lecture associated with added benefits in supporting belonging for students of color.

Individual, asynchronous work associated with cognitive engagement and STEM interest.

What accomodations have STEM educators made to their courses to maintain learning, community, and support interpersonal connections?

To answer our first research question, we tabulated and compared descriptive statistics (see Table 1). Results show that students reported that their instructors most frequently required individual work from students (Median = “80-100% of the time”), interactive live lecture (Median = “40-60% of the time”), noninteractive live lecture (Median = “40-60% of the time”), prerecorded lecture, (Median = “20-40% of the time”), breakout groups (Median = “20-40% of the time”), and least frequently engaged in synchronous discussion (Median = “0-20% of the time”).

Which teaching methods explain belonging and engagement?

To answer our second research question, we ran three OLS regression models for each of the four response variables (belonging, emotions, cognitive engagement, and STEM interest). The first included teaching methods as explanatory variables, the second included the same predictors as well as the COVID-19 threat and impacts scale, and the third included interactions between race and teaching methods (see Table 2 for full results). For race interactions, an indicator variable was created to represent Black and Hispanic students (making up 42% of the sample, hereafter referred to as “nonwhite”).

Belonging. After adjusting for COVID threat, belonging was negatively predicted by reported use of non-interactive synchronous lectures and was marginally but positively predicted by the use of breakout groups. We found similar results after including the “nonwhite” indicator and interaction terms, as well as a significant and positive interaction effect of nonwhite students who reported greater rates of interactive lectures.

Emotions. When positive emotions were the main outcome, we found that reported use of breakout groups was a positive predictor after adjusting for COVID threats and interactions. When negative emotion was the main outcome, we found that they were positively predicted by use of individual learning techniques, and marginally associated with prerecorded lecture. After including COVID threat, however, teaching methods were no longer significant predictors of negative emotions. No significant interactions with race or gender were found.

STEM Interest. The use of non-interactive lecture predicted lower reported interest in STEM for all three models. When COVID threat was included as a predictor, asynchronous individual work positively predicted STEM interest, and COVID threat negatively predicted it. No interactions with race or gender were found.

Cognitive Engagement. Cognitive engagement was positively predicted by the use of individual teaching methods for all three models. Reported use of breakout groups was significant only after adjusting for COVID threats, and there was a negative main effect of nonwhite students on cognitive engagement.

SIGNIFICANCE / CONCLUSIONS

Significance

We sought to explore whether the use of different online teaching methods supported undergraduate students' psychological well-being and belongingness in their STEM courses. We found that non-interactive live lectures tended to negatively predict students' sense of belonging and interest in STEM, whereas the use of interactive live lecture and breakout groups were positive predictors of belonging, and positive emotions. That is, instructional strategies that bring students and instructors together in live interaction seems to boost affective engagement. We also found that interactive live lecture had added benefits for students of color in supporting their feelings of course belongingness, which is consistent with previous findings (see e.g., Delahunty et al., 2014).

We also found that higher reported levels of asynchronous individual work were associated with more negative emotions in some cases, and curiously, greater cognitive engagement and STEM interest overall. One explanation for this finding is that individual work may require students to exert more effort which may have been captured in the engagement measure. Generally, this finding reflects the complex nature of group vs individual work found in the existing literature showing that the effectiveness of group work is dependent on a host of contextual factors (Delahunty et al., 2014; Guerin, 2010; Micari et al., 2010). Future research might investigate why and under what conditions individual work is supportive of student engagement outcomes, and when it is not.

Conclusion

Our findings support the idea that students, particularly students of color, benefit from live human interaction during times of crisis. Findings from this study might be useful for college instructors and policy makers redesigning online learning environments to best support students' cognitive and emotional engagement and who aim to close the race-gap in STEM.

Appendix

Table 1.

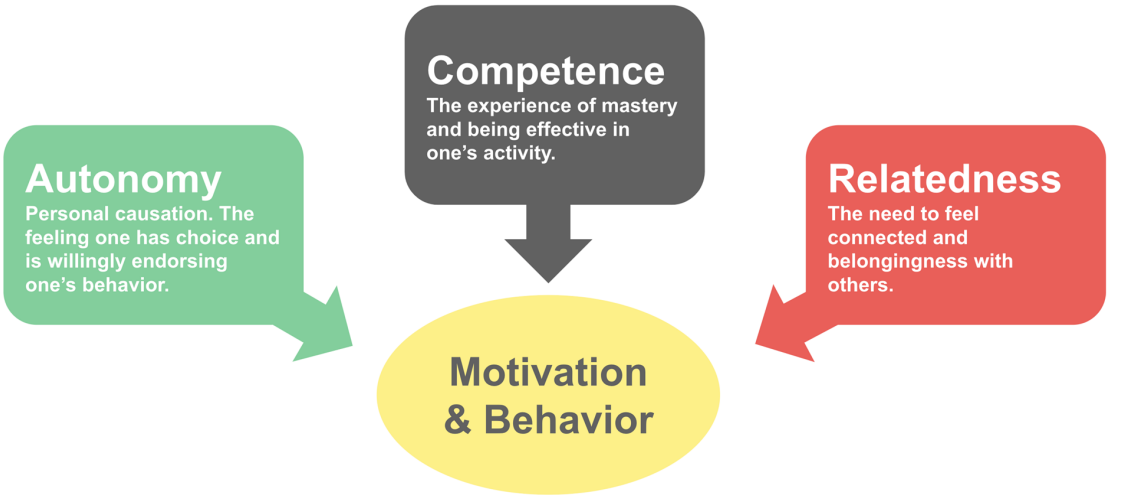
Descriptive Statistics for Student Characteristics (N = 43).

Variable	n	%	Mean	SD	Min	*Med*	Max
Hispanic	43	40%					
Black	43	5%					
Female	43	42%					
Time (minutes)	43		29.14	8.75	12.07	29.4	56.67
Age	43		19.81	2.16	18	19	30
Year	43		2.12	1.42	1	2	7
Belonging since COVID	34		4.86	0.94	2.62	4.81	6.76
Importance of COVID	43		5.79	1.06	1	6	7
Positive emotion	43		2.89	1.4	0.9	2.6	6
Negative emotion	42		2.52	1.58	1	1.81	7
Perceptions of teaching quality	43		5.33	1.4	1	5.3	8
Loneliness	43		3.59	1.4	1.43	3.57	6.14
Flourishing	42		4.9	1.68	1	5.12	8
Cognitive engagement	43		4.35	1.02	1.62	4.62	6.12
Interest in STEM	42		4.94	1.66	1	5	7
Reported Frequency of Instructional Method							
Prerecorded lecture	43		2.81	1.61	1	2	6
Noninteractive live lecture	43		2.84	1.59	1	3	6
Interactive live lecture	43		2.86	1.66	1	3	6
Discussion	43		1.7	0.91	1	1	5
Breakout groups	43		1.91	0.95	1	2	5
Individual work	43		3.81	2.06	1	5	6
COVID Threat							
Concern about COVID	43		4.8	1.44	1	4.75	7
Financial impacts	43		4.52	1.91	1	4.5	7
Impacts on resources	43		3.03	1.47	1	3.5	6.5
Psychological impacts	43		3.03	1.47	1	3.5	6.5
Mean of COVID Threat Variables	43		4.31	1.16	2.3	4.4	6.6

Table 2.
Standardized OLS Regression Coefficients for Instructional Practices Predicting Psychological and Cognitive Well-Being Outcomes

	Belonging			Positive Emotions			Negative Emotions			STEM Interest			Cognitive Engagement			Perceptions of Teaching Quality		
Prerecorded Lecture	0.108	0.159	0.198	-0.126	-0.1	0.011	**0.270~**	0.206	0.094	-0.197	-0.128	-0.038	0.06	0.127	0.239	0.055	0.076	-0.089
	(0.189)	(0.188)	(0.228)	(0.189)	(0.192)	(0.293)	**(0.155)**	(0.159)	(0.242)	(0.158)	(0.152)	(0.219)	(0.164)	(0.149)	(0.229)	(0.155)	(0.149)	(0.229)
Noninteractive Live Lecture	**-0.339~**	**-0.454***	**-0.554***	-0.066	-0.129	0.057	-0.051	0.110	0.087	**-0.487****	**-0.684****	**-0.502***	-0.084	-0.249	-0.016	0.043	-0.009	-0.072
	(0.192)	**(0.204)**	**(0.248)**	(0.156)	(0.174)	(0.264)	(0.155)	(0.162)	(0.250)	**(0.147)**	**(0.152)**	**(0.222)**	(0.158)	(0.166)	(0.239)	(0.145)	(0.162)	(0.251)
Interactive Live Lecture	-0.122	-0.093	-0.452	0.144	0.140	0.102	0.087	0.095	-0.001	-0.092	-0.104	-0.004	0.106	0.097	0.333	**0.397***	**0.395***	0.054
	(0.253)	(0.248)	(0.276)	(0.192)	(0.193)	(0.291)	(0.190)	(0.180)	(0.275)	(0.179)	(0.164)	(0.244)	(0.195)	(0.184)	(0.264)	**(0.179)**	**(0.180)**	(0.277)
Discussion	-0.201	-0.095	-0.208	-0.085	-0.056	-0.259	0.021	-0.053	-0.278	0.178	**0.279~**	0.100	0.167	0.242	-0.053	0.030	0.054	0.197
	(0.190)	(0.199)	(0.274)	(0.181)	(0.185)	(0.310)	(0.179)	(0.172)	(0.293)	(0.170)	(0.160)	(0.260)	(0.183)	(0.176)	(0.281)	(0.168)	(0.172)	(0.294)
Breakout groups	0.216	**0.360~**	**0.712***	**0.440***	**0.513***	**0.524~**	-0.074	-0.259	-0.083	-0.075	0.112	0.329	0.216	**0.403***	**0.438~**	0.164	0.223	0.187
	(0.186)	**(0.207)**	**(0.251)**	**(0.171)**	**(0.192)**	**(0.259)**	(0.173)	(0.182)	(0.245)	(0.162)	(0.163)	(0.219)	(0.173)	**(0.183)**	**(0.235)**	(0.159)	(0.179)	(0.246)
Individual work	-0.247	-0.095	-0.019	0.166	0.221	0.141	**0.361***	0.221	0.148	0.235	**0.371***	**0.589***	**0.314~**	**0.455***	**0.517~**	-0.133	-0.088	-0.253
	(0.230)	(0.248)	(0.292)	(0.174)	(0.186)	(0.281)	**(0.176)**	(0.177)	(0.266)	(0.165)	**(0.159)**	**(0.236)**	**(0.176)**	**(0.178)**	**(0.254)**	(0.162)	(0.173)	(0.267)
COVID Threat		-0.379	**-0.617***		-0.166	-0.124		**0.420***	**0.426***		**-0.476****	**-0.584****		**-0.429***	-0.291		-0.135	-0.211
		(0.258)	**(0.251)**		(0.196)	(0.214)		**(0.183)**	**(0.203)**		**(0.172)**	**(0.191)**		**(0.187)**	(0.194)		(0.183)	(0.203)
Nonwhite (Black or Hispanic)			-0.210			-0.404			0.090			0.377			**-0.659***			0.168
			(0.375)			(0.346)			(0.334)			(0.304)			**(0.314)**			(0.329)
Prerecorded Lecture*Nonwhite			0.599			-0.286			0.376			0.051			-0.213			0.276
			(0.416)			(0.346)			(0.335)			(0.290)			(0.314)			(0.329)
Noninteractive Lecture *Nonwhite			0.424			-0.398			0.042			-0.331			-0.353			-0.035
			(0.387)			(0.348)			(0.332)			(0.293)			(0.316)			(0.331)
Interactive Lecture *Nonwhite			**1.578****			0.179			0.089			-0.008			-0.391			0.644
			(0.520)			(0.434)			(0.411)			(0.367)			(0.394)			(0.413)
Discussion*Nonwhite			0.356			0.387			0.443			0.114			0.619			-0.242
			(0.399)			(0.423)			(0.400)			(0.354)			(0.383)			(0.402)
Breakout groups*Nonwhite			-0.561			0.003			-0.437			-0.487			-0.264			0.167
			(0.401)			(0.418)			(0.429)			(0.358)			(0.379)			(0.397)
Individual work*Nonwhite			0.446			0.414			0.020			-0.368			0.148			0.263
			(0.475)			(0.407)			(0.393)			(0.351)			(0.369)			(0.387)
Observations	34	34	34	43	43	43	42	42	42	42	42	42	43	43	43	43	43	43
R^2	0.209	0.27	0.571	0.204	0.22	0.337	0.223	0.328	0.413	0.313	0.44	0.54	0.183	0.29	0.455	0.311	0.322	0.401
Adjusted R^2	0.033	0.073	0.255	0.071	0.064	0.005	0.090	0.189	0.109	0.196	0.325	0.301	0.047	0.148	0.182	0.197	0.186	0.101

Note: ~p<0.1; *p<0.05; **p<0.01



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OLS Regression Results

	Belonging	Positive Emotions	Negative Emotions	STEM Interest	Cognitive Engagement	Perceptions of Teaching Quality
Pre-Recorded Lecture	0.198	0.011	0.094	-0.038	0.239	-0.089
Noninteractive Live Lecture	**-0.554***	0.057	0.087	**-0.502***	-0.016	-0.072
Interactive Live Lecture	-0.452	0.102	-0.001	-0.004	0.333	0.054
Discussion	-0.208	-0.259	-0.278	0.100	-0.053	0.197
Breakout groups	**0.712***	**0.524~**	-0.083	0.329	**0.438~**	0.187
Individual work	-0.019	0.141	0.148	**0.589***	**0.517~**	-0.253
COVID Threat	**-0.617***	-0.124	**0.426***	**-0.584****	-0.291	-0.211
Nonwhite (Black or Hispanic)	-0.210	-0.404	0.090	0.377	**-0.659***	0.168
Pre-Recorded Lecture*Nonwhite	0.599	-0.286	0.376	0.051	-0.213	0.276
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*Note: ~p<0.1; *p<0.05; **p<0.01*

Breakout groups were associated with belonging, positive emotion, and cognitive engagement.

Interactive lecture associated with added benefits in supporting belonging for students of color.

Individual, asynchronous work associated with cognitive engagement and STEM interest.

DISCLOSURES

This material is based upon work supported by the National Science Foundation under grant no. 1832405

ABSTRACT

The COVID-19 outbreak spurred unplanned closures and transitions to online classes. Physical environments that once fostered social interaction and community have been rendered inactive. We examined undergraduate STEM students' feelings of social connectedness, interest, and engagement while in physical isolation and identified online teaching modes associated with these feelings. Surveys from a racially diverse group of 43 undergraduate students revealed that interactive synchronous instruction was positively associated with feelings of interest and belonging, particularly for students of color, while noninteractive instruction had the opposite relation. Curiously, asynchronous individual assignments were associated with negative emotions but also greater cognitive engagement and interest. Findings reflect the complexity of interpersonal interaction yet reaffirm that live interaction supports feelings of belonging for minoritized groups.

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