The Role of Challenge in Students' Engagement and Competence in High School Science Classrooms: Hispanic and non-Hispanic Whites Compared

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Author Note : This material is based upon work supported by the National Science Foundation under Grant No: HRD-0827526. Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and do not reflect the views of the National Science Foundation.

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ABSTRACT

This study explores the associations of ethnicity and perceived challenge with high-school students' academic engagement and perceived competence in science. Data were collected through a variant of the Experience Sampling Method in which participants reported on their levels of engagement, perceived competence, and challenge while in science class, in response to signals from a vibrating pager. Hispanic and non-Hispanic White students reported similar levels of engagement in science, though non-Hispanic Whites reported higher levels of confidence. Results suggest that Hispanic and non-Hispanic White students respond differently to features of the learning environment. For example, while challenge was negatively associated with engagement in general, highly challenging science instruction had a less negative impact on Hispanic students' engagement, and a positive impact on their perceptions of competence relative to non-Hispanic White students. Findings highlight the importance of studying students' perceptions of their classroom learning experiences for understanding ethnicity gaps in STEM areas.

The purpose of this study is twofold: 1) to compare the engagement and perceived competence of Hispanic and non-Hispanic White students in high school science classes, and 2) to explore how ethnicity and perceived challenge may interact to contribute to students' daily academic engagement and perceived competence in science classes.

The ethnicity gap in academic achievement between Hispanics and non-Hispanic Whites is particularly wide in fields involving science, technology, engineering, and mathematics (STEM). Hispanics have lower achievement in STEM courses, and as adults are severely underrepresented in STEM fields compared to non-Hispanic Whites

(Taningco Matthew, & Pachon, 2008). Students of different ethnicities may respond to the same classroom learning environments differently. Certain features of the learning environment may be more engaging or enjoyable for one group vs. the other, or because of cultural differences, may be viewed as more or less important for one's future. There could also be ethnic differences in students' perceptions of competence for science that may help explain observed ethnicity gaps in STEM areas. Certain features of science learning environments may have differential impact on students of different ethnicities. Yair (2000) found that Hispanic students responded more positively than their non-Hispanic White counterparts to some features of learning environments.

Drawing upon the empirical and theoretical contributions of Mihaly Csikszentmihalyi (emergent motivation theory (EMT), 1990) this study focused on the role that academic challenge plays in influencing students' engagement and perceived competence in science learning contexts. Specifically, we examine whether Hispanic and non-Hispanic White students differ from one another in terms of the relationship between challenge, engagement, and perceived competence. According to Csikszentmihalyi, challenge can be highly motivating, inviting deeper engagement in a task. As students take on appropriately challenging tasks, they experience a positive affective state, which leads them to engage more deeply and seek out similar challenges in the future. The relationship between challenge and engagement has been supported empirically: Generally speaking, as students perceive greater challenge in their learning activities, they tend to report greater levels of concentration and interest (Shernoff & Schmidt, 2008; Shernoff, Csikszentmihalyi, Schneider, & Shernoff, 2003). This type of engagement in challenge has also been shown to be related to longer-term persistence in academic pursuits (Shernoff & Hoogstra, 2001). In this paper we will examine the relationship between challenge and engagement in science among high school students.

A natural consequence of engagement with challenging academic tasks is that through this experience, students' skills become enhanced. Successful interaction with challenge then, is presumed to deepen student engagement and build up a student's competence and confidence (Csikszentmihalyi, 1990). While there are empirical studies showing the positive relationship between engagement and "objective" measures of competence such as grades (Alexander, Entwisle & Horsey, 1997; Marks, 2000; Voelkl, 1997), what may be more important, from a motivational perspective, is that students perceive themselves as competent. The perception of competence is a theme that runs through many of the most widely researched and accepted theories of human motivation (Bandura, 1989; Deci & Ryan, 1991; Eccles, 1983; Wigfield & Eccles, 2000). For example, Self Determination Theory (SDT, Deci & Ryan, 1991) posits that humans have a fundamental need to feel competent, and that this need directs much of human behavior. Feeling competent is motivating: when students believe they have the skill to accomplish a task, they are more likely to take on the task, will be more persistent in the face of obstacles, will be more likely to discard unproductive strategies, and will ultimately be more successful (Bandura, 1989; Eccles & Wigfield, 1983). An important task for educators then, is to help students feel competent. According to Bandura (1989), challenge plays a very important role in building up students' competence and confidence: success in very low-challenge activities does little to make one feel more competent: the more meaningful (and motivating) successes are those in which one has had to overcome some moderate degree of challenge. Thus it is important to consider the relationship between challenge and perceptions of competence.

There may be individual differences both in students' overall levels of engagement and perceived competence, and in the way that challenge is related to engagement and competence. For example, Shumow and Schmidt (2014) documented gender differences in both engagement and perceived competence in science. Further, they demonstrated that male and female students tended to react differently to challenge in science: While challenge resulted in increased engagement for boys, it resulted in decreased engagement for girls. These individual differences in students' subjective experience in science are consistent with the long standing observed gender gaps in STEM pursuits in post secondary education and beyond. Given the ethnicity gaps that currently exist in STEM education and careers, it may be fruitful to examine the experience of Hispanic and non-Hispanic White students in high school science to determine whether there is variation by ethnicity in students' engagement and perceived competence in science, and to determine whether students of different ethnicities respond differently to the experience of challenge in science. This type of exploration may provide some small insights into existing gaps in our postsecondary institutions and workplaces. Given the importance of response to challenge, engagement, perceived competence for academic success, understanding these individual

differences is critical to providing optimal learning environments for all students.

METHOD

Setting and Participants

Data were collected in 12 science classrooms – three classrooms each in regular-track general science, biology, chemistry, and physics. All classrooms studied were in a single comprehensive high school serving students from a diverse community located on the fringe of a large metropolitan area. The school serves 9th - 12th graders, with an enrollment of approximately 3,300. According to school records, 43% of students in the sample were eligible to receive free or reduced lunch. Hispanic students and students identifying as non-Hispanic White each comprised approximately 40 percent of the student body. While the sample for the larger study (Schmidt & Smith, 2008) included 244 students, the present study focuses on the 180 students characterized as Hispanic (n=85) or non-Hispanic White (n=95). The overall student participation rate across all classrooms was 91%, with half of the classrooms studied having 100% participation. Table 1 displays the demographic characteristics of the subsample examined in this study.

	%
Sex	
Male	53
Female	47
Race/Ethnicity	
Hispanic	53
non-Hispanic White	47
Free/Reduced Lunch	43
Subject	
General Science	19
Biology	30
Chemistry	26
Physics	25
Grade Level	
9th	42
10th	21
11th	35
12th	2
N=180	

Table 1. Sample Demographic Characteristics

Procedures, Instruments, and Measures

Within each of the 12 classrooms, data were collected over two time periods ("waves") during the academic year -- once in fall and once in spring. For both waves, methods of data collection included traditional surveys, experience sampling techniques, and other methods not employed in the current analysis. Data from different sections of the same course were collected during the same time period so that the data collected from all 3 sections would represent the same point in the science curriculum, thus enabling analysis of the effects of particular content units while controlling for the effects of the instructor. Studying two different content units from each course reduces the possibility that findings regarding a particular course were idiosyncratic and entirely attributable to the specific unit examined.

During each wave of data collection, students' subjective experience in each science classroom was measured repeatedly over a period of 5 consecutive school days using a variant of the Experience Sampling Method (ESM; Csikszentmihalyi & Larson, 1987). Participants wore a vibrating pager which was used to signal them unobtrusively using a remote transmitter at 2 randomly selected time points during each day's science class. To minimize the disruption to class flow and maximize the variety of classroom activities recorded, the pool of participants in each classroom was divided in half, with each half following a different signal schedule. In response to each signal, students completed an Experience Sampling Form (ESF) in which they briefly recorded, among other things, their perceived levels of engagement, competence, and challenge. The ESF took approximately 1-2 minutes to complete. Each student provided up to 20 such responses, with the total number of responses being 3,229.

Measures

Engagement, perceived competence, and perceived challenge were measured by Likert-scale items (0=not at all, 3=very much) on the ESM self-report form. Engagement (outcome) was measured by taking the mean of three items where participants indicated how much they enjoyed, were interested in, and wished to be doing present activity (α=.76, M=1.27, SD=.51). Perceived competence

(outcome) was measured by taking the mean of two items where participants reported on how skilled and successful they felt in the activity (α=.85, M=1.67, SD=.51). Perceived challenge (level-1, momentary predictor) was measured by a single item where participants rated the challenge of the activity (single item, M=.89, SD=.47).

Participants reported on their ethnicity (level-2, person-level predictor) in a survey which was recoded such that 0=non-Hispanic White, and 1=Hispanic. Prior science achievement (level-2, control variable) was comprised of participants' self reported grades in science prior to current year (M=2.74, SD=.90, range 0-4).

RESULTS

Simple Ethnicity Comparisons

Simple t-test comparisons revealed that the Hispanic and non-Hispanic White students in this study do not differ from one another in their overall levels of engagement, competence, perceptions of challenge, or prior science achievement. They do, however, differ in the degree to which they aspire to science-related jobs such that Hispanics are far less likely to aspire to science-related careers ($\chi 2 = 7.8$. $p<.05$).

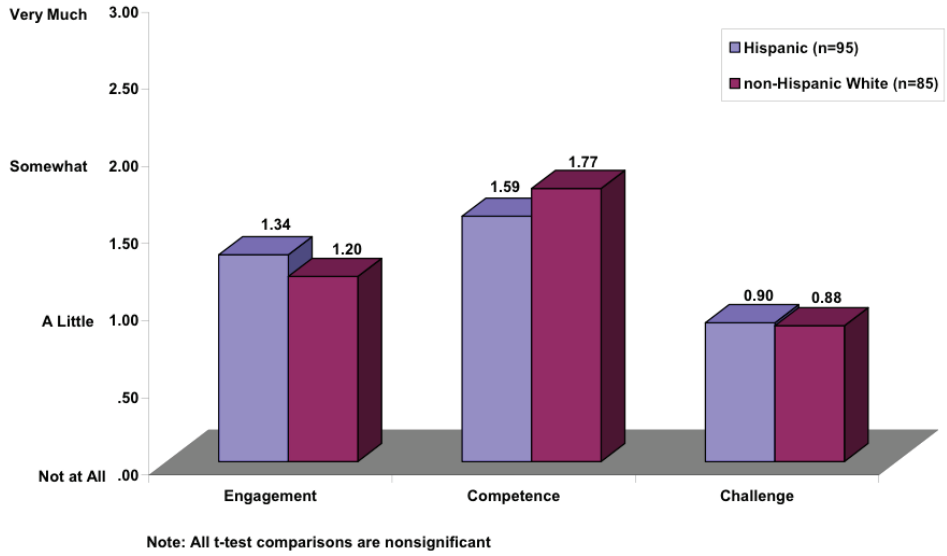

Figure 1. Engagement, Competence, and Challenge in Science by Ethnicity

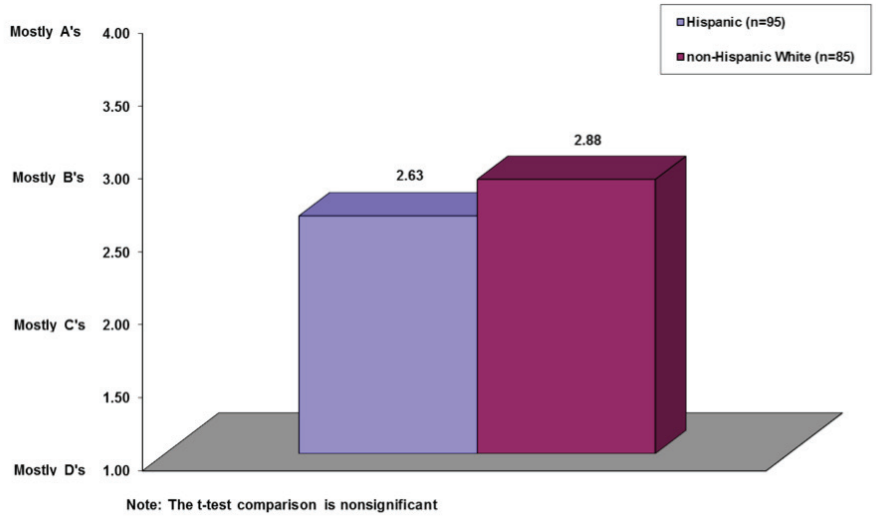

Figure 2. Prior Science Grades by Ethnicity

The Effect of Perceived Challenge on Students' Engagement and Perceived Competence, and the Role of Ethnicity on these Effects

Due to the nested nature of the data, with ESM reports (by students during classroom instruction) nested within students, Hierarchical Linear Modeling (HLM, Raudenbush & Bryk, 2002) was used to test the effect of perceived challenge on students' engagement and perceived competence, and the role of ethnicity on these effects, controlling for students' prior science achievement.

Fixed Effects	Engagement (SEB)		Competence (SEB)	
Intercept, γ_{00}	1.15 ***	(.14)	1.45 ***	(.17)
Hispanic, γ_{01}	.11	(.08)	-.23 *	(.09)
Prior Science Achievement, γ_{02}	.02	(.02)	.07 *	(.03)
Challenge slope, γ_{10}	-.25 ***	(.07)	-.14	(.09)
Hispanic, γ_{11}	.08 †	(.04)	.13 *	(.05)
Prior Science Achievement, γ_{12}	.03 *	(.01)	.01	(.01)

Note. n (level-1 units)=3229, n (level-2 units)=180

† p<.1, * p<.05, ** p<.01, *** p<.001

Table 2. Two-Level HLM Models testing the Effect of Perceived Challenge on Students' Engagement and Perceived Competence, and the Role of Ethnicity on these Effects

Engagement. Hispanic students did not differ from non-Hispanic Whites in mean engagement levels (γ01=.11, ns). Higher levels of challenge were associated with lower engagement (γ10=-.25, p<.001) for non-Hispanic White students. The negative effect of challenge on engagement was less pronounced (albeit marginally) for Hispanics than non-Hispanic Whites (γ11=.08, p=.052). In other words, Hispanic students' levels of engagement were affected less negatively when they perceived science instruction to be highly challenging). The negative effect of challenge on engagement was also moderated by prior achievement (γ12=.03, p<.05) such that students with higher prior achievement did not evidence the same negative relationship between challenge and engagement.

Perceived competence. Hispanic students reported lower levels of competence compared to non-Hispanic Whites (γ01=-.23, p<.05). When science instruction was perceived to be more challenging, competence of non-Hispanic White students remained constant (γ10=-.14, ns). Hispanics showed an increase in competence when science instruction was challenging, relative to non-Hispanic Whites (γ11=.13, p<.05). (i.e., Hispanic students' ratings of competence increased when they perceived science instruction to be highly challenging. In comparison, non-Hispanic White students' competence ratings were not affected by challenging science instruction).

DISCUSSION AND CONCLUSIONS

Findings from this study provide important insights into the role that ethnicity and challenge play in high school students' feelings of engagement and competence in science.

Contrary to what is predicted by EMT (Csikszentmihalyi, 1990), challenge was negatively associated with engagement in this sample. A possible explanation for this finding might be found in the central principles of EMT--that students need to possess enough skill to successfully overcome the challenging tasks so that they feel more engaged in these tasks. In other words, students in this sample may not have felt skilled enough in the face of challenging science tasks which may have frustrated them and in turn may have resulted in decreased levels of engagement. The finding that prior achievement ameliorated the negative relationship between challenge and engagement supports this explanation. It is important, then, for teachers to provide students with challenging tasks appropriate to students' skill levels.

A second possible explanation for these findings has to do with the degree to which students value the tasks they are asked to do in science. According to Csikszentmihalyi (1990), in order for challenge to be motivating, the actor has to perceive some value in the challenging task. In recent research, Shumow & Schmidt (2014) found that students in this sample generally saw little value in their science activities. It could be that many students in the present sample did not respond to challenge by engaging, because they did not perceive the challenging activity as worthwhile.

Consistent with other research (Uekawa, Borman & Lee 2007; Yair, 2000), our findings suggest that Hispanic and non-Hispanic White students respond differently to

features of the learning environment. While Hispanic and non-Hispanic White students reported similar levels of engagement, our results showed that Hispanic students' levels of engagement were affected slightly less negatively when they perceived science instruction to be highly challenging, relative to non-Hispanic White students. Following the same principles of EMT just mentioned, Hispanic students may have viewed their challenging science tasks as more valuable than non-Hispanic White students did, which might explain the less pronounced negative impact of challenge on engagement.

Further ethnic differences were observed in students' ratings of competence both in general and in relation to challenge. In general, Hispanic students reported feeling less competent in science class than non-Hispanic White students. When science instruction was perceived to be more challenging, however, Hispanic students reported increased levels of competence, as opposed to non-Hispanic White students whose competence remained constant. This suggests that challenging science instruction can be especially beneficial for Hispanic students' feelings of competence in science class.

Given the reality of the ethnicity gap in science achievement and STEM occupations, our findings are very promising because, as reviewed earlier, several theories of human motivation suggest that higher perceptions of competence in any given task is a critical factor in continued success and persistence in that task. Thus, providing challenging tasks may be one way to improve Hispanic students' perceptions of competence in science class, which may then lead them to seek more careers in STEM fields in the future. Alarmingly, however, we observed that the teachers tended to assiduously reduce the challenges in the science classes with high numbers of Hispanic students, believing that the students were overwhelmed by science (Shumow & Schmidt, 2014). It is important for science teachers to understand the counterproductive nature of that tendency.

Together, these findings highlight the importance of studying students' perceptions of their classroom learning experiences for understanding ethnicity gaps in STEM areas. Future studies aimed at understanding the socialization practices that contribute to the Hispanic students responses to challenge are warranted and could uncover pathways to increase the number of Hispanic students seeking to study and pursue STEM careers.

REFERENCES

Alexander, K. L., Entwisle, D. R., & Horsey, C. S. (1997). From first grade forward: Early foundations of high school dropout. *Sociology of Education, 70*, 87-107.

Bandura, A. (1989). Human agency in social cognitive theory. *American Psychologist, 44(9)*, 1175-1184.

Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience.* New York: Harper Perennial.

Csikszentmihalyi, M., & Larson, R. (1987). Validity and reliability of the experience sampling method. *Journal of Nervous and Mental Disease 175*, 526-536.

Deci, E., & Ryan, R. (1991). *A motivational approach to self: Integration in personality. In R. Dienstbier (Ed.), Nebraska symposium on motivation, 1990: Perspectives on motivation*, Vol. 38 (pp. 237-288). Lincoln: University of Nebraska Press.

Eccles, J. S. (1983). Expectancies, values and academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motives* (pp. 75-146). San Francisco: Freeman.

Marks, H. M. (2000). Student engagement in instructional activity: Patterns in the elementary, middle and high school years. *American Educational Research Journal, 37*, 153-184.

Raudenbush, S. W., & Bryk, A. S. (2002). Hierarchical Linear Models: Applications and Data Analysis Methods, Second Edition. Newbury Park, CA: Sage.

Schmidt, J. A. & Smith, MC (2008). Looking inside high school science classrooms: Examining males and females subjective experience. Grant proposal funded by the National Science Foundation. Washington, DC.

Shernoff, D. J., & Schmidt, J. A. (2008). Further evidence of an engagement-achievement paradox among U.S. high school students. *Journal of Youth and Adolescence, 37*, 564-580.

Shernoff, D. J., & Hoogstra, L. (2001). Continuing motivation beyond the high school classroom. *New Directions for Child and Adolescent Development, 93,* 73-87.

Shernoff, D. J., Csikszentmihalyi, M., Schneider, B., &

Shernoff, E. S. (2003). Student engagement in high school classrooms from the perspective of flow theory. *School Psychology Quarterly, 18*, 158-176.

Shumow, L. & Schmidt, J. A. (2014). Enhancing Adolescents' Motivation for Science. Thousand Oaks CA: Corwin.

Taningco, M. T., Matthew, A. B., & Pachon, H. P. (2008). *STEM professions: Opportunities and challenges for Latinos in science, technology, engineering, and mathematics. A review of literature.* The Tomas Rivera Policy Institute, University of Southern California. Retrieved 4/10/14 from http://files.eric.ed.gov/fulltext/ED502063.pdf.

Taningco, M. T. V., & Pachon, H. P. (2008). Computer use, parental expectations & Latino academic achievement. The Tomas Rivera Policy Institute. Retrieved from http://trpi.org/wp-content/uploads/archives/115235%20Quant%20Study%20PRINT%2004-16%20lr.pdf

Uekawa, K, Borman, K., & Lee, R. (2007). Student engagement in America's urban high school mathematics and science classrooms: Findings on social organization, race and ethnicity. The Urban Review, 39, 1-106.

Voelkl, K. E. (1997). Identification with school. *American Journal of Education, 105*, 294-318.

Wigfield, A. & Eccles, J. S. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology, 25*, 68-81.

Yair, G. (2000). Reforming Motivation: How the structure of instruction affects students' learning experiences. *British Educational Journal, 26*, 191-210.

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