Cultural Dimensions in Science, Technology, Engineering and Mathematics: Implications for Minority Retention Research

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Abstract
The college retention rates for underrepresented minorities (URM) in science, technology, engineering, or mathematics (STEM) are lower than other groups. One reason may be that the studies often do not view premature departure from a cultural perspective. This exploratory investigation focused on developing an instrument that employed a cultural perspective to detect differences based on racial/ethnic group affiliation. The instrument derived from the literature is examined using principal components analysis in an attempt to discover the underlying constructs and identify meaningful variables. Multivariate analysis was used for comparing groups. A description of the study is presented and its application with a sample of underrepresented minorities from 15 public and private universities in Ohio.

Introduction

The number of underrepresented minorities (URM) earning college degrees in science, technology, engineering, and mathematics (STEM) are significantly lower than white and Asian students (Armstrong & Thompson, 2003; Astin, Parrott, Korn, & Sax, 1997; Jonides, 1995; Marguerite, 2000; Mashburn, 2000; Morrison, 1995; Swail, Redd, & Perna, 2003; Wyer, 2003). More than half of African-American and Native American students entering

STEM drop out or change majors and two-thirds of Hispanics fail to matriculate (Astin, 1993). Successful persistence is influenced by many factors such as high school preparation, grade point average, past course work in math and science (George, Neale, Van Horne, & Malcom, 2001) and maintenance of interest (White, Altschuld, & Lee, 2006). This study was designed to probe an area needing more investigation - the role of culture and its effect on STEM retention rates (Seymour, 1992; Seymour & Hewitt, 1994; Seymour & Hewitt, 1997).

Review of the Literature

For more than a quarter century, Tinto's (1975, 1987) theory on retention has been one of the models for understanding why some students leave post secondary institutions early. Tinto espouses that in order to be successful, students must adapt to the dominant culture of the institution. In other words, "…the more marginal one's group is to the life of the college, the more likely is one to perceive oneself as being separate from the institution" (Tinto, 1993, p. 60).

His paradigm has not been without critics when applied to minorities (Attinasi, 1994; Kraemer, 1997; Rendón, Jalomo & Nora, 1996; Tierney, 1992). The problem is that the model fails to take into consideration the unique experiences of diverse students (Braxton, Sullivan & Johnson, 1997; Hurtado, 1997; Nieto, 1996; Velásquez, 1996; Zambrana, 1988).

While many studies indicate culture affects student perceptions, and in turn their satisfaction and academic interest (Astin, 1993; Kuh, Schuh, Whitt & Associates, 1991; Pascarella & Terenzini, 1991), universities have been slow to adopt such a cultural lens in programs designed to improve persistence (Kuh, 2001). Mertens and Hopson (2006) note this and suggest institutions "go beyond business as usual" (p. 48) in examining STEM departure. To that end Kuh and Love (2000) offer the following propositions:

1. *The university experience and decision to leave, is influenced by the student's cultural meaning making system.*
2. *The culture of origin influences the importance placed on attending college and persistence toward educational goals.*
3. *Knowledge of students' cultures of origin and cultures of immersion is necessary to understand their ability to successful navigate the culture*

of the institution.

4. *The likelihood of persistence is inversely related to the cultural distance between the student's culture of origin and culture of immersion.*
5. *Students that negotiate greater cultural distances must become acclimated to the dominant culture of immersion or join one or more enclaves in order to persist.*
6. *The amount of time students spend in their culture of origin following matriculation is positively related to level of stress and probability of persistence.*
7. *The likelihood of persistence is related to the degree a student is socio-culturally connected with the academic program and groups of common interest.*
8. *Students who are engaged with one or more enclaves in the cultures of immersion have higher probabilities of persistence if the group values academic success and persistence.* (p. 201)

In the first proposition, the emphasis is on how students view and engage with the university. The second and third acknowledge that college students come from many diverse backgrounds and college campuses are multi-cultural in nature. Numbers 4, 5, and 6 introduce the concept of cultural distance and elaborate on the challenges URM encounter when they arrive on campus. Success is interrelated with how well students traverse the distance between the campus community and culture of origin. Finally, in the last two propositions, the importance of connections with the culture of origin is noted as a determinant for academic success.

In relation to non-white students, criticism of Tinto (1975, 1987, 1993) has primarily focused on the assimilation and acculturation assumptions which somewhat fail to capture their experiences. When Kuh and Love's (2000) propositions are taken into consideration, the disparity between Tinto's theory and practice becomes apparent and as a result, many researchers call for alternatives that examine departure from a cultural perspective (Braxton, Sullivan & Johnson, 1997; Hurtado, 1997; Nieto, 1996; Velásquez, 1996; Zambrana, 1988). The eight propositions are a possibility in this regard.

The Role of Culture and Conflict with the Sciences

Ibarra's (1999) theory of multicontextiality posits that today's postsecondary students are products of multiple cultural contexts. Many minority students come from cultures that value interdependence and collective contribution and do not attend college just for themselves, but rather to benefit family and community (Gregory & Hill, 2000). Choice of academic majors can almost be a collective rather than an individual decision. Expanding on Ibarra's (in press) assumptions, Seymour and Hewitt (1997) see these "cultural imperatives" (p. 337) as significant for persistence in STEM. They are not shared equally across ethnic groups. A comparison of aspects of them is depicted in Table 1.

Table 1
Comparison of Cultural Values

Cultural Value	African American (urban)	African American (suburban)	Hispanic	Asian American	Native American (reservation)	Native American (other)
Community service	Yes	No	Yes	No	Yes	No
Role model	Yes	Yes	Yes	No	Yes	No
Academics and family	Yes	No	Yes	No	Yes	No
Parents define goals	No	No	No	Yes	No	No
Self assertiveness	No	Yes	No	No	No	No
Self reliance and autonomy	Yes	Yes	No	No	No	Yes
Supportive peer group	No	No	Yes	No	Yes	No

Source: Adapted from *Persistence of Interest in Science, Technology, Engineering and Mathematics: An Analysis of Persisting and Non-Persisting Students* (p. 54) by J. L. White, 2005. Copyright © 2005 Jeffry L. White.

For the first entry in Table 1, many minorities report a strong sense of obligation to repay their communities for the support received while in college (Seymour & Hewitt, 1997). This obligation is viewed as an essential component of the student role that cannot be deferred until graduation, which in turn leads to a conflict between the rigorous demands of STEM programs and the need to give back to the community while in school.

Another relevant idea here is the sense of role model obligation (Seymour & Hewitt, 1997). As successful college students, they serve as examples to others. If they begin to struggle in STEM, they'll consider dropping out or moving to another (possibly less rigorous) discipline. In African-American households regardless of economic status, persistence in a particular academic major is not as essential as graduation from college. For the most part, family and friends support the decision to switch to a non-STEM major as long as students do not drop out of college.

Asian-Americans tend to be an exception to this point (Seymour & Hewitt, 1997). They view their parents as taking an authoritarian approach in educational decision making. STEM majors and grades earned are associated with financial success and social prestige. Switching majors is not socially acceptable or culturally valued.

The rigorous nature of STEM can create family problems for some minority students. Conflict arises for some when they have to balance academic demands and family responsibilities reaching even to the extended family (Seymour & Hewitt, 1997). There is a need to return home for celebrations or crises that non-minorities see as important only in the immediate family. The responsibilities for inner-city blacks and Hispanics often include making financial contributions to the family group. This is in stark contrast to Asian-American students who are expected to devote full attention to their roles as students.

Students of color are typically more self-effacing than white students and less likely to take action when encountering problems on campus (Seymour & Hewitt, 1997), except for African-Americans from higher socioeconomic backgrounds. Those from lower socioeconomic strata have longstanding cultural reasons for viewing themselves as being in an oppressive system. This view does not foster assertiveness on campus whereas affluent black students are self-assertive in the pursuit of academic and career goals. The latter have moved to a stance where they will be more action-oriented in this regard.

Many Hispanic, Native-American, and Asian students report problems in developing self-reliance and autonomy on campus (Seymour & Hewitt, 1997). The social norms however, are different for these groups. Asian-Americans have feelings of limited personal control and authoritarian parents. Lower autonomy and self-reliance are also culturally derived for Native-American and Hispanic students. They describe the extended family as their main source of affirmation and its demands can come into conflict with the academic press of STEM disciplines. Native-American and Hispanic students also report being homesick for family-centered activities. This is amplified when few other Native-Americans and Hispanics are around and may lead to a switch to majors that have more representatives from their own ethnicity.

Among all ethnic groups, African-Americans are the only group to culturally encourage and promote self-reliance (Seymour & Hewitt, 1997). For the most part, they become more responsible at an earlier age such as helping with childcare, assistance with the elderly or having part-time jobs to help support the immediate or wider family. Like older and non-traditional students, they typically will have periods of interrupted education.

The concepts of self-reliance and assertiveness are different. For example, affluent African-American families view assertiveness as necessary for the success of young black men and women (Seymour & Hewitt, 1997). Self-reliance, on the other hand, relates to the economic survival or self-sufficiency of the family unit.

While the demands of extended families can create academic problems for some URM in STEM, they also can be a source of affirmation and emotional support. Students struggling in class frequently turn to family members. When they are unavailable, they will substitute people on campus (Seymour & Hewitt, 1997).

There are also subtle variations in how some groups deal with academics. While nearly all minorities in the STEM disciplines benefit from peer study groups, Native-American and Hispanic students look to them for support similar to that received from family and friends (Seymour & Hewitt, 1997). Conversely, self-reliance and autonomy may clash with the function of the peer study group for African-Americans. A lack of understanding of the rigor of the STEM majors can also contribute to this problem. Many black students arrive on campus without sufficient knowledge of the importance of peer learning to academic progress. These students are particularly at risk for premature departure when they are alone and struggling academically.

For Asian-Americans, peer group work provides little assistance to students experiencing academic difficulties (Seymour & Hewitt, 1997). Asian-American study groups reflect the family values of good grades and pressure to succeed. Success is supported whereas failure elicits rejection and social disapproval. Support and affirmation are given to the students doing well but not to those seeking emotional assistance.

Seymour and Hewitt's (1997) views about culture are somewhat antithetical to the assumption that college students must conform to the institutional culture rather than the system adopting strategies to meet their needs (Ibarra, 1999). Ibarra (in press), in support of Seymour and Hewitt, contends that higher education is at a critical juncture and must redefine itself within a multicultural context. The entries in Table 1 provide an overview of how group membership defines student response to college situations and they may suggest ways of studying underrepresentation in the STEM fields.

Key Questions Guiding the Study

An investigation was undertaken to collect evidence about cultural dimensions. The researchers were interested in creating an instrument with items related to culture and whether they would be useful in differentiating groups.

Context of the Study

The Ohio Science and Engineering Alliance (OSEA) is a group of 15 public and private institutions with the goal of increasing the number of URM earning baccalaureate degrees in STEM. The consortium is a five-year project funded by the National Science Foundation's Louis Stokes Alliance for Minority Participation. The universities are engaged in a variety of retention activities including research internships, mentoring, tutoring, supplemental education, and others. Underrepresented minorities make up approximately 11% (4,304) of the undergraduate enrollment at the OSEA schools (38,848) and have departure rates similar to those nationwide (Hayes, 2002; Ohio Science and Engineering Alliance, 2003).

Methodology

Study Design and Sampling

The study was exploratory. Its purpose was to determine how well the instrument worked and to illuminate differences among students based on group membership. It was conducted in concert with the overall evaluation of OSEA programs and activities (Altschuld, Lee, & White, 2005). Due to the qualitative nature of Seymour and Hewitt's (1997) original work, there was no preexisting scale. Based upon their ideas about culture, the authors constructed a Web-based instrument and distributed it to a sample of URM (n = 1,217) randomly selected from the OSEA database. A MANOVA was employed to detect group differences. Principal Components Analysis (PCA) and internal consistency measures were also used to determine the quality of the instrument.

Descriptive Results

The study achieved a return rate of approximately 14%, consistent with the expectations for on-line surveys (Dillman, 2004). A frequency distribution of the respondents (n = 166) based on gender, class rank, and race/ethnicity is presented in Table 2.

Table 2
Characteristics of Respondents

Variable	Attribute	Frequency	Percent	Cumulative %
Gender (n = 166)	Male	70	42.2	42.2
	Female	95	57.2	99.4
	Missing	1	0.6	100.0
Class Rank (n = 166)	Freshmen	42	25.3	25.3
	Sophomore	39	23.5	48.8
	Junior	34	20.5	69.3
	Senior	48	28.9	98.2
	Other	2	1.2	99.4
	Missing	1	0.6	100.0
Race/Ethnicity (n = 166)	African-American	100	60.2	60.2
	Hispanic	47	28.3	88.5
	Native American	3	1.8	90.3
	Bi-racial	9	5.4	95.7
	Other	6	3.6	99.3
	Missing	1	0.6	100.0
Other Race/ Ethnicity (n = 6)	African	2	33.3	33.3
	Jamaican	1	16.7	50.0
	Missing	3	50.0	100.0

More females responded to the survey (57%) and the distribution was relatively proportionate across class ranks. Nearly two-thirds identified themselves as African-American and less then a third (28%) as Hispanic. Five percent of the sample indicated they were bi-racial and the “other race/ethnicity” classification consisted of African (2) and Jamaican (1) students.

Instrumentation

As noted, the study was exploratory, serving as a base upon which a more comprehensive instrument could be developed at a later time. Due to the nature of the OSEA evaluation, only a small number (10-13) of items could be embedded in the overall evaluation form. With that in mind, an initial pool of survey questions was conceptualized and developed. An item classification table was employed to guide item writing. Items were reviewed by a panel and an outside reviewer and than pilot-tested with a group of STEM students participating in a major OSEA summer activity. Items with little or no variability were excluded and suggestions for rewording or phrasing were incorporated into a final version.

Subjects were asked to rate their agreement with 11 cultural statements. A 5-point Likert scale was used with a neutral mid-point and in which 1 = Strongly Disagree up to 5 = Strongly Agree. The data were treated as being (at a low level) interval in nature (Guttman, 1977; Velleman & Wilkinson, 1993). The means and standard deviations for the 11 items are presented in Table 3.

The overall mean was 3.88 (SD = 1.10). Most of the statements had means averaging 4.00 with two exceptions. In Q6, 28.8% of the students disagreed or disagreed strongly and 17.9% were neutral. In item Q5, more than 45% disagreed or disagreed strongly, 20.2% were neutral, and nearly 30% agreed or strongly agreed with the statement. On the other hand, more than 50% of the respondents to Q1 strongly agreed that their education should be used to improve the quality of life in their community. Less than 6% disagreed or disagreed strongly with this statement.

The Pearson inter-item correlations are presented in Table 4. Since all items are designed to measure aspects of culture, intercorrelations were expected and generally ranged between .10 and .70. The very high and very low correlations are underlined in the table. For example, the correlation between Q2 and Q3 (.763) may have been influenced by placement on the survey - an order effect. It could also be the result of socially desirable responses.

Table 3

Means and Standard Deviations of Survey Items

Survey Items	*N**	*M*	*SD*
Q1: My education should be used to improve the quality of life in my community.	166	4.25	.98
Q2: My STEM study is important for service to my community.	165	3.98	1.01
Q3: I should be a STEM role model for young people in my community.	164	4.07	1.02
Q4: Graduation from college is more important even if I switch to a non-STEM major.	166	4.13	1.24
Q5: I have conflicts between my family responsibilities and the demands of my STEM major.	166	2.80	1.48
Q6: Family and friends play a significant role in shaping my educational goals.	166	3.49	1.34
Q7: I can be assertive in dealing with issues I face on campus.	166	4.08	.94
Q8: I support my friends regardless of their academic performance.	166	4.10	.96
Q9: I feel comfortable in my campus community.	166	4.03	1.05
Q10: I feel comfortable in my STEM classrooms and labs.	165	3.81	1.07
Q11: I am confident in my ability to achieve in my STEM classes.	165	3.99	.99
Average	165.55	3.88	1.10

Note: *Varying *N* indicates non-response to item.

Table 4

Pearson Inter-item Correlation Matrix

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11
Q1	1.00										
Q2	<u>.685</u>	1.00									
Q3	.523	<u>.763</u>	1.00								
Q4	.212	.275	.226	1.00							
Q5	<u>.071</u>	.176	.152	<u>.063</u>	1.00						
Q6	.125	.228	.233	.180	.257	1.00					
Q7	.298	.371	.376	.173	.169	.327	1.00				
Q8	.414	.424	.370	.233	.210	.141	.398	1.00			
Q9	.360	.316	.230	.305	<u>.000</u>	.126	.264	.489	1.00		
Q10	.310	.340	.349	.196	<u>.025</u>	<u>.081</u>	.201	.318	<u>.600</u>	1.00	
Q11	.281	.408	.436	.246	.134	.111	.254	.273	.409	<u>.664</u>	1.00

The correlation between Q1 and Q2 (.685) was not surprising since both statements are related to the student's service to his or her community. Analogously, the correlation (.664) between feeling comfortable in STEM classrooms (Q10) and confident in one's ability to achieve in STEM (Q11) may be due to the similar content of the items. The same rationale may apply to the relationship (.600) of feeling comfortable on campus (Q9) and in STEM classrooms (Q10). When examining low intercorrelations, most were < .300 and associated with Q5 (*I have conflicts between my family responsibilities and the demands of my STEM major*).

Validity and Reliability of the Instrument

Since these concepts about culture in the literature overlap, it was necessary to look at the underlying dimensions of the scale. Principal components analysis (PCA) is suitable for this situation, i.e., it reduces the data and helps identify meaningful clusters inherent in the dataset (Dunteman, 1989). Consistent with this investigation, PCA is also recommended as an exploratory tool.

The sample size was sufficient (MacCallum, Widaman, Zhang, & Hong, 1999; Stevens, 2002) and an orthogonal rotation was performed, followed by an oblique one. They yielded parallel results, so the simpler orthogonal rotation became the main focus of interpretation (Stevens, 2002). Then the internal consistency of the instrument was examined via Cronbach's (1951) alpha. Table 5 contains a breakdown of the PCA, including the factor loadings, commonalities, amount of variance explained and reliability coefficients.

Table 5
Results of PCA with Item Loadings, Commonalities, Variance Explained and Reliability Coefficients

Derived Variable	Item	Loadings	Commonalities	Variance	Reliability
#1: Obligation to community	Q1	.812	.702	37.2%	.852 (n = 165)
	Q2	.881	.846		
	Q3	.818	.736		
#2: Responsibility to family and friends	Q5	.711	.525	12.6%	.391 (n = 168)
	Q6	.761	.575		
#3: Comfortable and confident feelings	Q9	.815	.687	9.9%	.790 (n = 166)
	Q10	.856	.763		
	Q11	.725	.590		

The Kaiser Criterion (eigenvalues ≥ 1) and Scree Plot indicated retention of three components, accounting for approximately 60% of the total variance. Three items (Q4, Q7, Q8) loaded on two or more of the components and were dropped. From the eight retained items, two (Q5, Q6) had the lowest commonalities and reliability values. This was consistent with the findings from the low mean scores (Table 3) and intercorrelation matrix (Table 4). Two of the retained components had strong factor loadings (.70+) and high alpha coefficients (.80+).

The greatest amount of variability in the instrument (37.2%) is due to the *obligation to the community* derived from Component #1. The smallest amount (9.9%) is found in Component #3, *comfortable and confident feelings*. While Component #2, *responsibility to family and friends*, accounted for 12.6% of the variance, it also had the lowest measure of internal consistency (.391).

Multivariate Analysis of Variance

The group sizes were reviewed for sufficiency before attempting to detect differences. With only a few Hispanic, Native American, biracial and other (no race/ethnicity specified) respondents, a decision was made to collapse these students into one group for comparison with African Americans. The results of the MANOVA are presented in Table 6.

Table 6
Multivariate Analysis of Cultural Dimensions Survey

	Effect	Value	*F*	Hypothesis *df*	Error *df*	*P*	Partial ε^2
Intercept	Pillai's Trace	.774	64.333*a*	8.000	150.000	.000	.774
	Wilk's Lambda	.226	64.333*a*	8.000	150.000	.000	.774
	Hotelling's Trace	3.431	64.333*a*	8.000	150.000	.000	.774
	Roy's Largest Root	3.431	64.333*a*	8.000	150.000	.000	.774
Group	Pillai's Trace	.159	1.626	16.000	302.000	.061	.079
	Wilk's Lambda	.847	1.621*a*	16.000	300.000	.062	.080
	Hotelling's Trace	.174	1.616	16.000	298.000	.064	.080
	Roy's Largest Root	.112	2.115*b*	8.000	151.000	.038*	.101

Note: *a* = exact statistic; *b* = statistic is an upper bound on *F* that yields a lower bound on the significance level; * $p < .05$.

The Wilk's Lambda value ($\Lambda = .847, p = .062$) indicated non-significance as did the omnibus multivariate statistic Pillai's Trace = .159: $F(16,302) = 1.626$, $p = .061$. Wilk's Lambda is more commonly used for overall significance and Pillai's criterion is more robust with declining sample sizes (Hair, Anderson, Tatham & Black, 1998). Conversely, the *p*-value for Roy's Largest Root indicated significance ($p < .05$). This statistic is the largest characteristic root "difference" (Harris, 1985) and can sometimes be equated with the largest eigenvalue representing the proportion of explained to unexplained variance (Field, 2005). It also measures the maximum possibility of actual differences existing between the groups on an item. From the Partial Eta Squared ($\varepsilon = .101$), approximately 10% of the variability was attributed to the group effect. Post hoc testing (Scheffe) denoted significance ($p < .05$) on one item, (Q1) *my education should be used to improve the quality of life in my community*. It should be noted that the dilemma with Roy's Largest Root is that when dealing with small sample as was the case in this study, it can be less robust than the other multivariate tests.

Conclusions and Recommendations

Based on the results, we postulate that items dealing with culture are a viable option to pursue and study further when conducting retention research. Two of the identified components, *obligation to community* and *responsibility to family/friends*, resonate with the thinking of Seymour and Hewitt (1997) and account for nearly half of the instrument's total variance. The third, *comfortable and confident feelings*, is also found in the literature (Prenzel, 1992; White, Altschuld, & Lee, 2006). These components are most likely important in regard to academic decisions and related to staying in school and/or STEM.

Survey items loading on two or more components will require revision. Item Q4 (*Graduation from college is more important even if I switch to a non-STEM major*) is one such example. This is because graduating from college and graduating with a specific major (STEM or otherwise) are two different constructs. This line of questioning came from the view that, for some groups, graduation from college was paramount regardless of type of degree earned. Q7 (*I can be assertive in dealing with issues I face on campus*) loaded on multiple components for similar reasons. The reason for this may be that it asked for the student's agreement with a statement about assertiveness and whether they confronted (dealt with) the issues they faced on campus. These are unique concepts and the item could be improved if split into multiple ones. Further, *dealing with issues* could be divided into academic, social, family, and other concerns.

For the item *I support my friends regardless of their academic performance* (Q8), which loaded on three components, a socially desirable response cannot be discounted. Dropping the linkage between *support* and *academic performance* might eliminate the problem.

The reliability coefficient (.391) for the *responsibility to family/friends* component is less than desirable (Kerlinger & Lee, 2000) and is likely the result of both the small number of items and the very low intercorrelations of Q5 with Q1 and Q4. By adding more items for this construct, the alpha value would tend to increase. In addition, the overall instrument would benefit from having more items for each component. The revised instrument should aim for four or more survey items with loadings on components greater than .60 or at a minimum of three greater than .80 (Stevens, 2002).

The range of values for the factor loadings presented in Table 5 (.711-.881), fall well within the criteria stated by Stevens (2002). Eight questions in the preliminary form worked well and should be fine-tuned, not discarded. Instead, a new and expanded scale should be constructed using these items as a foundation from which more could be developed.

The study was less conclusive in detecting differences based on ethnic affiliation. This may relate to the size of the sample and small number of Hispanic and Native Americans. A more conclusive examination will require a larger sample of more students majoring in STEM from multiple groups.

Closing Thoughts

The cultural items were far from comprehensive. Aside from more and better items, other things might be done. With regard to different groups, filter questions and perhaps qualitative techniques could be helpful in assigning membership to a particular subgroup such as urban or suburban African American students or Hispanic and Native Americans? Beside the filters, personal interviews may be necessary to determine subtle features of a student's socialization and/or affiliation, such as a Native American student's experiences with extended family on a reservation. It would be beneficial to have experts in the dynamics of various cultures to assist in designing how to capture group membership.

There are other indicators that might be useful for retention research. Can indicators like zip code of residence, socioeconomic status, and secondary school district be employed? Some students graduate from suburban districts yet may reside in low income neighborhoods. At the same time, is income a true indicator? What's important here is that multiple methods and sources of data will be needed before researchers can meaningfully classify students into different groups and socialization patterns as these might affect participation in the STEM fields.

A more comprehensive study of student cultural background as a factor related to entering and staying in STEM is indicated. The number of items should be increased and the quality improved for testing with a more diverse sample from other regions of the country. Knowing more about culture as a factor in STEM persistence, might help counselors and program administrators enhance their retention services.

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References

Altschuld, J. W., Lee, Y. F., & White, J. L. (2005, September). *Aspects of minority student retention in STEM: Evaluation of a major retention program.* Paper presented at the Evaluation Summit: Evidence-Based Findings for Math and Science Partnerships (MSP). Minneapolis.

Armstrong, E., & Thompson, K. (2003). Strategies for increasing minorities in the sciences: A University of Maryland, College Park, model. *Journal of Women and Minorities in Science and Engineering, 9*(2), 40-50.

Astin, A. W. (1993). *What matters in college: Four critical years revisited.* San Francisco: Jossey-Bass.

Astin, A. W., Parrott, S. A., Korn, W. S., & Sax, L. J. (1997). The American freshman: Thirty-year trends. Higher Education Research Institution, University of California at Los Angeles: Los Angeles.

Attinasi, Jr., L. (1994, April). *Is going to college a rite of passage?* Paper presented at the annual meeting of the American Educational Research Association. New Orleans, LA.

Braxton, J. M., Sullivan, A. V. S., & Johnson, R. M. (1997). Appraising Tinto's theory of college student departure. In J.C. Smart (Ed.), *Higher Education: A Handbook of Theory and Research, 12*, 107-164. New York: Agathon Press.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika, 16,* 297-334.

Dillman, D. (2004). Internet surveys: Back to the future. *The Evaluation Exchange, 3*, 6-7.

Dunteman, G. H. (1989). Principal components analysis. *Sage University Paper Series on Quantitative Applications in the Social Sciences,* (07-069). Newbury Park, CA: Sage Publications.

Field, A. P. (2005). *Discovering statistics using* SPSS (2nd ed.). Thousand Oaks, CA: Sage Publications.

George, Y. S., Neale, D. S., Van Horne, V., & Malcom, S. M. (2001). *In pursuit of a diverse science, technology, engineering, and mathematics workforce: Recommended research priorities to enhance participation by underrepresented minorities.* Washington, DC: American Association for the Advancement of Science.

Gregory, S. T., & Hill, O. O. (2000). Improving learning outcomes for at-risk multicultural community college students. In S.T. Gregory (Ed.), *The academic achievement of minority students: Perspectives, practices, and prescriptions.* 491-513. Lanham, MD: University Press of America.

Guttman, L. (1977). What is not what in statistics. *The Statistician, 26,* 81-107.

Hair, Jr., J. F., Anderson, R. E., Tatham, R. L., & Black, W. C. (1998). *Multivariate data analysis* (5th ed.). Upper Saddle River, NJ: Prentice-Hall.

Harris, R. (1985). *A primer of multivariate statistics.* Orlando, FL: Academic Press.

Hayes, R. Q. (2002, June). *2001-02 CSRDE Report: The retention and graduation rates in 360 colleges and universities.* Center for Institutional Data Exchange and Analysis. Norman, OK: University of Oklahoma.

Hurtado, A. (1997). Understanding multiple group identities: Inserting women into cultural transformations. *Journal of Social Issues, 53*(2), 299-328.

Ibarra, R. A. (1999, October). Multicontextuality: A new perspective on minority underrepresentation in SEM academic fields. *Making Strides (American Association for the Advancement of Science) 1*(3), 1-9.

Ibarra, R. A. (in press). *Academia at a cultural crossroads: Reframing the context of higher education.* Madison, WI: The University of Wisconsin Press.

Jonides, J. (1995). *Evaluation and dissemination of an undergraduate program to improve retention of at-risk students.* (ERIC Document Reproduction Service No. ED414841).

Kerlinger, F., & Lee, H. (2000). *Foundations of behavioral research* (4th ed.). New York: Harcourt Brace Publishers.

Kraemer, B. A. (1997). The academic and social integration of Hispanic students into college. *Review of Higher Education, 20*, 163-179.

Kuh, G. D. (2001). Organizational culture and student persistence: Prospects and puzzles. *Journal of College Student Retention: Research, Theory & Practice, 3*(1), 23-39.

Kuh, G. D., & Love, P. G. (2000). A cultural perspective on student departure. In J.M. Braxton (Ed.), *Reworking the student departure puzzle,* 196-212. Nashville, TN: Vanderbilt University Press.

Kuh, G. D., Schuh, J. S., Whitt, E. J., & Associates. (1991). *Involving colleges: Successful approaches to fostering student learning and personal development outside the classroom.* San Francisco: Jossey-Bass.

Pascarella, E. T., & Terenzini, P. T. (1991). *How college affects students.* San Francisco: Jossey-Bass.

MacCallum, R. C., Widaman, K. F., Zhang, S., & Hong, S. (1999). Sample size in factor analysis. *Psychological Methods*, *4*, 84-99.

Marguerite, B. H. (2000). Pathways to success: Affirming opportunities for science, mathematics, and engineering majors. *Journal of Negro Education, 69*(1-2), 92-111.

Mashburn, A. J. (2000). A psychological process of student dropout. *Journal of College Student Retention, 2,* 173-190.

Mertens, D. M., & Hopson, R. K. (2006). Advancing evaluation of STEM efforts through attention to diversity and culture. *New Directions for Evaluation, 109,* 35-51.

Morrison, C. (1995). Retention of minority students in engineering: Institutional variability and success. *NACME Research Letter, 5*, 3-23. National Action Council for Minorities in Engineering: New York.

Nieto, S. (1996). *Affirming diversity: The sociopolitical context of multicultural education* (2nd ed.), New York: Longman.

Ohio Science and Engineering Alliance. (2003) *LSAMP: The Ohio Science and Engineering Alliance*. (NSF Cooperative Agreement No. HRD-0331560). Columbus, OH: The Ohio State University.

Prenzel, M. (1992). The selective persistence of interest. In K. A. Renninger, S. Hidi & A. Krapp (Eds.), *Interest in learning and development* (pp. 71-98). Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.

Rendón, L. I., Jalomo, R. E., & Nora, A. (1996). Theoretical considerations in the study of minority student retention in higher education. In C.S. Turner, A.L. Antonio, M. Garcia, B.V. Landen, A. Nora, & C.L. Presley (Eds.) *Racial and ethnic diversity in higher education* (2nd ed.), (pp. 584-600). Boston: Pearson Custom Publishing.

Seymour, E. (1992). The problem iceberg in science, mathematics, and engineering education: Student explanations for high attrition rates. *Journal of College Science Teaching, 21*, 230-238.

Seymour, E., & Hewitt, N. M. (1994, April). *Talking about leaving: Factors contributing to high attrition rates among science, mathematics, and engineering undergraduate majors.* Bolder, CO: Bureau of Sociological Research, University of Colorado.

Seymour, E. & Hewitt, N. M. (1997). *Talking about leaving: Why undergraduates leave the sciences.* Boulder, CO: Westview Press.

Stevens, J. (2002). *Applied multivariate statistics for social sciences* (4th ed.). Mahwah, NJ: Lawrence Erlbaum Associates.

Swail, W. S., Redd, K. E., & Perna, L. W. (2003). *Retaining minority students in higher education: A framework for success*. ASHE-ERIC Higher Education Report. Jossey-Bass Higher and Adult Education Series.

Tierney, W. G. (1992). An anthropological analysis of student participation in college. *Journal of Higher Education, 64*, 604-618.

Tinto, V. (1975). Dropout from higher education: A theoretical synthesis of recent research. *Review of Education Research*, *45*, 89-125.

Tinto, V. (1987). *Leaving college: Rethinking the causes and cures of student attrition.* Chicago: University of Chicago Press.

Tinto, V. (1993). *Leaving college: Rethinking the causes and cures of student attrition.* (2nd ed.), Chicago: University of Chicago Press.

Velásquez, P. M. (1996, April). The integration and persistence of Chicano students in higher education: Student and institutional characteristics. Paper presented at the annual meeting of the American Educational Research Association. New York.

Velleman, P. F., & Wilkinson, L. (1993). Nominal, ordinal, interval and ratio typologies are misleading. *The American Statistician, 47*(1), 65-72.

White, J. L., Altschuld, J.W., & Lee, Y.F. (2006). Persistence of interest in science, technology, engineering, and mathematics: A minority retention study. *Journal of Women and Minorities in Science and Engineering, 12*(1), 47-65.

Wyer, M. (2003). The importance of field in understanding persistence among science and engineering majors. *Journal of Women and Minorities in Science and Engineering, 9*(3-4), 76-90.

Zambrana, R. E. (1988). Toward understanding the educational trajectory and socialization of Latina women. In T. McKenna & F.I. Ortiz (Eds.), *The broken web: The educational experience of Hispanic American women,* (pp. 61-77). Claremont, CA: Tomás Rivera Center.