Development Of A Diversity Comfort Inventory for Engineering Students

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Abstract

One of the goals of a new freshman engineering program at the University of Alabama was to increase the value of diversity among students. The Team Identification Comfort Level Inventory (TICLE) was developed to assess an engineering student's comfort with serving on diverse engineering related teams in contrast with the student's comfort level with serving on teams of mostly white, males. The TICLE was given to 399 engineering students for validation. The TICLE displayed a high level of reliability with a Cronbach alpha reliability coefficient of .89, and strong evidence of validity through factor analysis. Results indicated that while there was no statistical difference between gender-based matched pair teams; there were differences in comfort level ratings on race-based teams. White males and white females showed a significant preference for non-diverse teams, while non-white males and females showed a significant preference for diverse teams. Based on the psychometric analyses and initial analyses of group differences, the TICLE shows promise as a diversity diagnostic tool for engineering educators.

Introduction

During the past decade, higher education programs have placed a premium on attracting and retaining a diverse student body. Recently, this emphasis on maintaining diversity has been extended to include an emphasis on diversity awareness [1,2,3]. As a programmatic goal, increasing diversity awareness among students can be difficult to evaluate adequately. Measures that explore a students' understanding of the benefits of diversity are complicated by social, historical, and psychological influencers.

Students of color and female students who experience climates of intolerance or discomfort are at risk in a number of ways. Such environments can negatively affect adjustment, damage cognitive and affective development, and result in low self-efficacy expectations [4,5]. A key in reducing the marginalization of minority students and women on college campuses seems to reside in the active examination of racism and sexism by all students. Many studies have examined the effect of liberal arts education alone on students' attitudes with regard to diversity. Liberal arts education has been associated with a greater regard for civil rights and increased acceptance of issues related to racial tolerance [6,7,8,9,10]. Similarly, students who progress through undergraduate education in general have been shown to adopt less conservative and traditional social views, and gain more liberal ones [11,12].

In contrast, Henderson-King and Kaleta [13] have shown that students who are not exposed to diversity issues through appropriate coursework display less tolerant attitudes over a course of

a semester than they did at the beginning of the semester. These results are consistent with others who find that simply being engaged in college education does not necessarily have an effect on tolerance[14,15,16,17].

The effect of a single course on tolerance underscores the inadequacy of color-blindness as an effective solution to developing comfort and understanding of diversity within college students[18,19,20,21]. Burbles and Rice[18] pointed out that discussion of diversity issues, instead of encouraging divisiveness, promotes tolerance and acceptance. They stated that educational institutions are excellent venues for facilitating discussion on diversity. Schofield[21] indicated that the color-blind perspective devalues racial and ethnic group membership in understanding how individuals are treated. This perspective is supported by the American ideal of respect for the individual, however, ignoring group membership can lead to overlooking policies that negatively affect minority groups, and increase the tolerance for segregation.

The juxtaposition of the color-blind perspective and the lack of discourse on race and gender in colleges can lead to less tolerant graduates at the end of their college careers. Left to their own devices, college students are not well equipped to develop their awareness of the value of diversity. Tatum[22] discussed this sentiment along with the observation that students may not be able to effectively process their emotional responses to issues related to diversity. According to Tatum, simply presenting the cognitive issues of oppression to students without addressing the emotional responses is not effective. She identified three sources of resistance to learning about and discussing racism: 1) Race is considered a taboo topic especially in racially mixed settings, 2) students have been socialized to think of the United States as a just society and 3) students initially deny any personal prejudice.

Astin[23] observed that when left to their own devices, students affiliate with others most like themselves. Students seek peers based on affiliation and perception of equal status with other members of the group. This self-segregation is a major barrier to students understanding of diversity issues[24,25,26]. Dovidio & Gaertner[27] theorized that there is a convergence with the American egalitarian values and cultural influences such as racism. This convergence causes internal conflict in white students, faculty, and staff. This conflict is suppressed by the desire to treat all people equally. White racial group members "develop non-racist self-concepts that they defend strongly but which result in the feeling of discomfort and uneasiness, and/or disgust around or fear of minority group members[28].

Crim[28] found that non-white students experienced "patterns of avoidance" from white students, faculty members, and staff. The students interpreted this avoidance by white students in classrooms and residence halls as feelings of dislike. Furthermore, the avoidance was sensed not only in larger campus contexts, but also in small group settings. The perception of the non-white students in this study was that white students were uncomfortable with non-white students, and unconsciously showed this feeling through avoidance.

Development of the TICLE

As part of the evaluation of a freshman engineering programs goal to increase the value of diversity among students, the Team Identification Comfort Level Inventory (TICLE) was

developed. Although validated diversity related instruments exist such as the Attitudes Toward Diversity Scale[29], and the Quick Discrimination Index[30], none measure a student's comfort with being placed in diverse work-related team settings. More specifically, the TICLE was developed to assess an engineering student's comfort with serving on diverse engineering related teams in contrast with the student's comfort level with serving on teams of mostly white, males.

The framework informing the development of an instrument revolved around the theory that students are more comfortable with homogenous groups, and they are unaware of self-segregating practices[26]. This theory assumes that college students not only have an affinity towards individuals like themselves, but that they have no conscious awareness of this affinity. An instrument needed to be developed that would identify a less-than-conscious comfort level with serving on teams with individuals unlike oneself.

Item Development and Content Validity

In order to better understand the college's progress in the goal to increase the value of diversity among students, the evaluation team developed the 23-item, Likert-type instrument called the Team Identification Comfort Level Inventory (TICLE)[31]. The TICLE presents respondents with a hypothetical situation of serving on a multi-disciplinary team in order to complete an unspecified engineering related problem. The respondent is shown a table containing three hypothetical team members and their associated demographic characteristics. The characteristics for team members are race, gender, engineering experience, socio-economic background, religious affiliation, physical disability, and English speaking ability. The respondent is asked to rate teams on a 10 point Likert-type scale, scaled 0 to 9, as to their pleasure with working on each hypothetical team to solve an unspecified engineering-related task. The 0 to 9 scale was used to coincide with the 10 point response categories on a commercially available SCANTRON answer sheet. For analyses, the responses were recoded to a 1 to 10 scale, with 1 being the lowest comfort level and 10 being the highest.

The TICLE contains ten teams targeted to explore a participant's comfort with racially diverse and racially non-diverse teams (Race Domain), ten teams targeted to explore gender related comfort level (Gender Domain), and three teams designated as appropriate response items. The ten race and ten gender specific teams are each subdivided into five teams considered as diverse and five teams considered as non-diverse. In this context, a diverse team indicates a team that consists of mostly non-white, and/or female members. Therefore, a hypothetical team consisting of three African-American males would be considered a diverse team since it is diverse compared to the overall engineering industry, not necessarily diverse in and of itself. Within each domain (race and gender), five diverse teams are matched exactly with five non-diverse teams on each demographic except the domain specific category. Theoretically, any significant difference in comfort level ratings between the five diverse and five non-diverse teams can be attributed to race and/or gender depending on the domain.

The three items designated as "appropriate response" items are hypothetical teams designed to induce a feeling of discomfort by most any English-as-first-language respondent. These teams consist of three members each of who have little engineering experience and low

English speaking ability. High comfort level scores on the appropriate response items may indicate a desire by the participant to respond to all questions in a socially acceptable manner.

As product of the development, five summed groupings are generated from the TICLE; racially diverse, racially non-diverse, gender diverse, gender non-diverse, and appropriate response. The scores for the groupings are computed by summation of responses across the items representing each grouping. The four race/gender, diverse/non-diverse groupings have a potential recoded score range of 5 to 50, and the appropriate response scale range is from 3 to 30.

Engineering faculty members were asked to assess the appropriateness of the TICLE questions and the hypothetical situation presented to respondents. Additionally, these faculty members along with independent engineering education evaluators assessed the TICLE for readability. Comments and suggestions were incorporated into the design of the instrument by the development team. A pilot administration was conducted using 30 participants. Thirteen of the participants were freshman engineering students, and seventeen were senior level engineering students. Respondents were asked their impressions regarding readability of instructions, ease of administration, and their general perceptions of the TICLE as an instrument. Comments from these pilot participants were used to increase the readability and layout of the TICLE.

Subjects, Data Set, and Context

The TICLE is intended for use with undergraduate engineering students. Its use in other populations will need further research. The data set contains completed TICLE responses from 399 undergraduate engineering students. All respondents were enrolled in the engineering program at the University of Alabama. Seventy percent of the respondents (n=279) were freshmen, 3.8% (n=15) were sophomores, 5.5% (n=22) were juniors, and 20.8% (n=83) were senior level students. Seventy-nine percent of respondents are self identified as non-Hispanic Caucasian students (n=315), seventeen percent are African-American (n=69), and four percent (n=15) are from other racial/ethnic categories. Seventy-seven percent (n=308) respondents are male, and twenty-three percent (n=91) female. The data were gathered over a twelve-month period from spring 2000, to spring of 2001. Engineering students were asked to complete the TICLE during various scheduled engineering class times. Respondents were requested to work on their own as quickly as they could. Although speed was encouraged, there was no time limit for completion. Students were asked to respond without hesitation to ensure that they did not analyze responses while completing the TICLE. Since there are socially appropriate responses to questions pertaining to diversity, the increased speed of the respondent should encourage more honest answers to the items.

Psychometric Analyses

Pearson product-moment item to total correlation coefficients were computed, and all were high enough to suggest that the theoretical construct of comfort level was represented. The lowest item to total correlation was .341 for item number 5. All other item-to-total correlation coefficients were .450 or higher. Strong item to total score correlations indicate that the items are good indicators of the overall construct comfort with diversity. Individual items with item to total correlation coefficients over .4 are considered to be strong items. With all but one item

displaying Pearson correlation coefficients over .4, the items seem to be strongly related to the overall construct.

A Cronbach's Alpha reliability coefficient of 0.8922 was computed for the total score, and 0.6147, 0.6166, 0.5990, 0.7781, and 0.7891 for the gender non-diverse, gender diverse, race non-diverse, race diverse, and appropriate response scales respectively. The total score Cronbach coefficient of the TICLE indicates evidence of reliability for the instrument and indication of a represented theoretical contract via the items on the TICLE.

An exploratory factor analysis was computed using TICLE items in order to better understand the underlying factors within the instrument, and determine the optimal number of underlying dimensions, or factors, in a reduction of TICLE items. While the TICLE was created with pre-defined domain specific questions separated into diverse and non-diverse categories, the summation of these questions do not necessarily constitute homogeneous factors. The domain specific questions were developed as matched pair items that were consistent on every other demographic category, or "distracter" demographics, other than the domain specific demographic category. The research question of interest is, "Are there underlying dimensions to the TICLE that are related to the "distracter" categories. If so, then the TICLE results can be analyzed at another level of analysis: The sub-scale level.

The principal components extraction method, maximum likelihood method, and the principal axis factoring method were all considered, however, the principal components method seemed to be the most useful in clarifying the simple solution. A varimax rotation method was used to further define the factors. The varimax rotation method is an orthogonal method that mathematically rotates factors in multi-dimensional space in such a way that each factor is totally unique from the others. By using an orthogonal rotation method, the factors will be uncorrelated with one another. This lack of correlation between factors ensures that each factor explains a unique portion of variability within the instrument[32].

A five-factor solution explains 68.4% of the variability in the original 23 items. The five-factor solution meets the Kaiser rule of thumb that suggests using factors with eigenvalues at or over 1.00 [33]. Factor V does have a computed eigenvalue of 0.99, however, the minimal rounding of this value meets the Kaiser rule of thumb. Upon inspection of the items associated with the five-factor solution, this solution seems to be the best in terms of the simple solution. In this context, the simple solution is the rotated factor structure that clearly defines the items within each factor. The delineation of items in the five-factor solution gave the clearest solution with regard to construct commonality among factor items.

The majority of items held moderate to high sum of the squared factor loadings indicating good item fit with the factor solution. Only two items, 2 and 18, had extraction communality estimates lower than .600, at .488 and .549 respectively (see Table 4). The communality estimates for each item is the amount of variability within that item explained by the factor solution. Large communality estimates for most variables indicates that the solution explains a great deal of the initial variability within the original, unreduced data matrix. The communality estimates for the items of the TICLE indicate that a small amount of explained variability within the items was lost due to reduction.

The five factors and their domains are shown in Table 1. Factor I contains seven items all which have in common low to moderate experience of the hypothetical team members. The five items with heaviest loading for Factor II all have at least one non-white team member, with the majority of members having fluent English skills and moderate to high experience. The six items associated with Factor III all have at least one non-white team member, with the majority who have low to adequate English skills with moderate to high experience. Factor IV has two items all of which contain all white members who are fluent in English and male. Factor V contains three items with all female members fluent in English with high experience levels.

Table 1: Items in each factor of the five-factor solution and matched TICLE items*.

Factor I Low Experience	Factor II Non-White Fluent Moderate Exper.	Factor III Non-White Non-Fluent High Exper.	Factor IV White Fluent Male	Factor V Fluent High Exper. Female
13 (AR)	11 (7)	21 (3)	1 (8)	5 (9)
20 (AR)	7 (11)	3 (21)	16 (10)	9 (5)
14 (17)	10 (16)	4 (12)		8 (1)
2 (AR)	6 (15)	12 (4)		
23 (19)	15 (6)	22 (18)		
19 (23)		18 (22)		
17 (14)				

*Number in parentheses denotes the matched domain item on the TICLE. AR denotes an Appropriate Response question.

The majority of the items loaded on the same factor as their domain matched pair. The exception to this is evident in racially imbalanced pairs that cross over factors as in items 10 and 16, or gender imbalanced pairs that cross over factors as in items 8 and 1.

Cronbach alpha reliability coefficients were computed for each of the factors. Factor I through Factor V had Cronbach alpha levels at 0.85, 0.86, 0.84, 0.71, and 0.76 respectively. These moderate to high reliability coefficients indicate reliable TICLE sub-scales derived from the exploratory factor analysis.

Between Group Differences

The data gathered for validation of the TICLE were analyzed to address the following research question: For the four groups, white males, non-white males, white females, and non-white females, is there a within group difference between ratings on both levels of the race and gender domains?

A two-way unbalance repeated measures analysis of variance was computed with diversity categories as two levels of the repeated measures factor for exploration of the research question. The race and gender domains were treated separately, with an analysis performed for each.

For the gender domain diversity categories, the within subjects analyses (Table 2) indicated that there is no interaction effect between race and sex of the respondent on the repeated measure diversity category $[F (1, 395) = 0.005, p = .944]$, nor any significant effect by race of respondent $[F (1, 395) = 1.003, p = .317]$ or sex of respondent $[F (1, 395) = 2.232, p = .136]$. The repeated measures main effect of diversity category was also not statistically significant $[F (1, 395) = 0.000, p = .990]$. Similarly, the between subjects analyses within the gender domain indicated no statistically significant differences for the interaction of race and sex $[F (1, 395) = 3.602, p = .058]$, or for the main effects of race $[F (1, 395) = 0.658, p = .418]$ or gender $[F (1, 395) = 2.829, p = .093]$.

Table 2: Repeated measures analysis of variance within subjects table for the Gender Domain.

Source	df	F	MS	*p*
GENDOM[1]	1	0.000	0.0014	.990
GENDOM X Gender	1	2.232	19.865	.136
GENDOM X Race	1	1.003	8.930	.317
GENDOM X Gender X Race	1	0.005	0.0435	.944
Error	395	(8.900)		

Note. Value enclosed in parentheses represents mean square error.
[1] – GENDOM is the repeated measures variable consisting of Gender Diverse and Gender Non-Diverse teams

The within subjects analyses for the Race Domain categories (Table 3) indicate there is no interaction effect between race and sex of the respondent on the repeated measures variable $[F (1, 395) = 0.005, p = .944]$, nor any effect by sex of respondent $[F (1, 395) = 2.089 \ p = .149]$. The Race Domain repeated measures main effect of diversity category was also not statistically significant $[F (1, 395) = 2.408, p = .122]$. However, the effect by race of respondent on the repeated measures variable was significant at the .05 alpha level $[F (1, 395) = 27.744 \ p < .001]$. White respondents had higher racially non-diverse team comfort ratings and lower racially diverse team comfort ratings than non-white respondents.

Table 3: Repeated measures analysis of variance within subjects table for the Race Domain.

Source	df	F	MS	p
RACEDOM[1]	1	2.408	31.451	.122
RACEDOM X Gender	1	2.089	27.288	.149
RACEDOM X Race	1	27.744	362.39	<.001
RACEDOM X Gender X Race	1	0.005	0.0647	.944
Error	395	(13.062)		

Note. Value enclosed in parentheses represents mean square error.
[1] – RACEDOM is the repeated measures variable consisting of Race Diverse and Race Non-Diverse teams

The between subjects analysis (Table 4) indicates that while the main effects of sex [F (1, 395) = 0.287, p = .593] and race [F (1, 395) = 0.723, p = .396] were not significant, the interaction effect of sex by race of respondent was [F (1, 395) = 7.217, p = .008]. The average ratings between diverse and non-diverse categories for white females [M = 34.477, SEM = .724] and non-white males [M = 34.228, SEM = .768] are higher than those of non-white females [M = 31.685, SEM = 1.115] and white males [M = 32.779, SEM = .366].

Table 4: Repeated measures analysis of variance between subjects table for the Race Domain.

Source	df	F	MS	p
Gender	1	2.870	19.258	.593
Race	1	0.723	48.564	.396
Gender X Race	1	7.217	484.766	.008
Error	395	(67.169)		

Table 5: Descriptive statistics for domain and category ratings by sex and race of respondents.

	White Males (n=251)		White Females (n=64)		Non-white Males (n=57)		Non-white Females (n=27)	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Gender Non-Diverse	32.58	5.74	32.34	6.62	33.18	6.30	29.89	8.39
Gender Diverse	31.89	5.78	32.47	6.71	33.04	6.01	30.63	8.78
Race Non-Diverse	33.69	5.32	34.86	5.33	33.28	6.59	30.26	8.12
Race Diverse	31.87	7.09	34.09	5.93	35.18	6.79	33.11	8.82

Conclusions

Upon inspection, the TICLE displayed sound evidence of reliability with a total score Cronbach alpha reliability coefficient of .892. Combined with the high item to total correlation coefficients, the TICLE can be described as being well developed in terms of its theoretical construct. The pre-defined subscales held smaller reliability coefficients. It should be noted that those scales are not true sub-scales of the TICLE, they are groupings of matched pair items on one of either the race or gender domain. The high instrument reliability is evidence of construct related validity.

An exploratory factor analysis of the TICLE using principal components extraction and varimax rotation indicated that a five-factor solution explaining 68.4% of the variability within the instrument was the best simple solution. These five factors were clear groupings of items based on similar team characteristics and were labeled; Low Experience (Factor I), Nonwhite-Fluent-Moderate Experience (Factor II), Nonwhite- Not fluent-High Experience (Factor III), White-Fluent-Male (Factor IV), and Fluent-High Experience-Female (Factor V).

The multidimensional nature of the TICLE allowed for unique, layered factoring as seen in the factor analysis. This factoring of the items indicates that respondents utilized categorization schemes that give an insight into the level of importance placed on certain team member traits. Experience of the potential team members is of the most importance in judging the acceptance of a hypothetical team. Those teams that had the majority of team members with low experience levels, regardless of any other characteristic, factored together well. Those with high to moderate experience factored on different team characteristics. When determining ideal work teams, engineering students seem to place a great deal of emphasis on experience of the team members. After experience, sub-scales seemed to be determined by English fluency of the team members. Once fluency was assessed, race of team members and gender of team members played a role in factoring.

The different levels associated with comfort of team assignment indicate that students are most concerned with whether or not team members are competent and can communicate effectively with English only speakers. Beyond these assessments of team utility, race and even gender, to some degree, play a role in a students' feelings of comfort. This exploratory factor analysis does seem to support the theoretical construct that engineering students will self-segregate based on race and gender.

Although more validation analyses need to be undertaken with the TICLE, it does show evidence of strong reliability and of content and construct validity. Subsequent research will focus on the TICLE's ability to distinguish comfort level between groups of students, as well as utilization of item response theory to analyze difficulty and ability patterns for each TICLE item.

The analyses of TICLE scores seem to support the contention that students prefer homogenous groups. While the analyses show that students from different racial backgrounds and of different genders indicate no difference in comfort with serving on teams in general based on overall TICLE scores, the analysis of matched pair domain items indicates that they do seem to prefer homogenous teams with regard to race.

The repeated measures analysis of variance results for Gender Domain items showed that students from each of the four demographic categories white males, white females, non-white males, and non-white females all had statistically similar rankings for gender diverse and gender non-diverse teams. This indicates that in regard to the gender makeup of hypothetical teams, engineering students in this sample did not show a preference for serving on teams that consist mostly of the same gender as the respondent. While other factors such as experience level of team members and English speaking ability may have an effect on the overall comfort a student has with serving on a team, this level of comfort is consistent for engineering students when the gender makeup of the same teams is reversed.

In terms of the race domain, white and non-white students showed a preference for teams that consisted of team members with similar racial makeup to the respondent. To be precise, the racially non-diverse teams consisted of all or majority white team members, while the racially diverse teams consisted of all or majority non-white members. White students gave higher comfort scores to teams that had mostly or all white members in the matched pair teams within the race domain. Non-white students gave higher comfort scores to teams that did not consist of mostly white students.

Discussion

The TICLE is presented as a tool that can be used by engineering educators in one of three ways. First, using raw TICLE scores, educators can simply explore student comfort with serving on teams in general. With an increasing emphasis placed on teamwork in both industry and engineering programs, this feature of the TICLE can be useful in assessing team comfort.

Secondly, the TICLE can be used as a diagnostic tool by educators to develop a better understanding of student comfort with serving on teams consisting of individuals from various racial backgrounds, and teams made up of majority male or female members. This diagnostic use of the TICLE may aid engineering programs in steps toward developing specific programs aimed at increasing student understanding of diversity issues.

And thirdly, the TICLE may be used as a pre-post measure of program effectiveness. Changes in student comfort levels either at a general team level, or team diversity level can be assessed by administering the TICLE before program activities and at points along a diversity awareness programs' existence. This use of the TICLE may prove to be very valuable for engineering educators; however, more research is needed to assess its evaluative use.

Acknowledgement

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