# How Salient is the Identity of Engineering Students?

## On the Use of the Engineering Student Identity Survey

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***Abstract*— Despite efforts to diversify the undergraduate engineering student body, recruitment and retention issues still persist. We attempt to address this problem by conducting research to better understand engineering students through the lens of identity theory. Implications of this effort are twofold: (1) to contribute to our understanding of engineering students' identities as well as what factors (experiences and settings) foster the formation and transformation of these identities during the undergraduate experience, and (2) to gain insight into improving recruitment and retention of engineering students, particularly underrepresented students. However, in order to empirically explore the role of identity, we must first have a psychometrically sound measure of engineering student identity. In developing the Engineering Student Identity Survey (E-SIS), our research team administered the survey to four cohorts of engineering students to investigate whether the E-SIS could differentiate, in predictable ways, the salience of engineering identity across cohorts. The measured constructs were derived from extensive theoretical underpinnings in social identity theory (i.e. interest, unified self-concept, sense of belonging, self-enhancement, participation, distinctiveness, social support, in-group cooperation, citizenship behavior, visibility of affiliation). Results indicate that the E-SIS is able to discriminate between first-, second-, and third/fourth-year students, to varying degrees, on all of the ten subscales used in the analyses. Potential applications and improvements are evident based on these results.**

***Keywords—engineering identity, retention, recruitment***

## I. INTRODUCTION

Despite a significant increase in initiatives, interventions, and efforts to recruit and retain more engineering students (certainly those underrepresented in engineering), the decline in engineering enrollment continues. One method for increasing enrollment numbers is to recruit and retain students from populations from which fewer STEM students are traditionally engaged. In engineering, it has been shown that enrollment rates of female students have been consistently low [1]. Studies have shown that while over 40% of students who intend on majoring in engineering end up leaving in favor of another field of study [2], there has also been a gender disparity within the noted enrollment issues of the engineering field. The smaller proportion of female students electing to enroll in engineering is highly alarming [3]-[5].

Although numerous previous studies on recruitment and retention have focused on the number of students, including majority and minority, who enrolled and stayed in engineering, there have been an insufficient number of well-grounded studies that help us answer some of the "why" questions (i.e. Why do students enter engineering? Why do engineering students persist? Why do students leave engineering? etc.). It is these "why" questions that our research group is interested in answering. Specifically, our larger research work is focused on understanding recruitment and retention via the impact of self-concept and the development and transformation of the engineer identity. Having a strong identity as an engineer has been shown to contribute to persistence within engineering [6-7]. Whereas identity has been heavily researched within psychology, there is limited literature focused on identity in engineering education settings. Thus, this research serves as a starting point for further understanding engineering-specific identity development. By understanding the formation of the engineer identity as suggested by social and organizational identity theories, we hope to acquire a more holistic picture of engineering students and what drives them to be engineering students.

By providing insight into students' engineer identity formation and evolution, not only will we better understand how our engineering students develop their engineer identity over time, but we will also gain insight into improving recruitment and retention strategies and practices through the enhancement of engineering identity. This is particularly important for engineering students who are underrepresented in engineering such as women and minorities. To date, we have gained insight into how the engineer identity begins to form (i.e. via influences such as experiences and individuals), how the engineer identity transforms over time (i.e. strength and growth of the engineer identity over time), how the engineer identity differs across various student populations (i.e. persisters vs switchers, men vs women, students of varying academic levels, etc.) [6-9]. However, to further advance our research on the formation and impact on the engineering student identity, we need a psychometrically sound measure of engineering student identity for use in empirical studies.

## II. THE ENGINEERING STUDENT IDENTITY SURVEY (E-SIS)

Recent research and some of our previous work suggest that students' identification with engineering plays a critical role in their decision to pursue engineering and to persist in engineering. During this effort, we examine the role of identity (i.e. the process of identifying with engineering, developing an

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engineer identity, and becoming an engineer) among engineering students through the lens of identity theory. A comprehensive review of the existing theory with knowledge gained from earlier efforts of our project resulted in the construction of the Engineering Student Identity Survey (E-SIS). The descriptions below represent the major identity themes that have emerged from our research conducted through student interviews, open-ended surveys, and an extensive literature review on identity theory and group membership.

**Unified Self-Concept**: The degree to which students perceive themselves as having a unified self-concept such that who they are in engineering is not drastically different from who they are in different contexts. It is well known that self-presentations are contextualized in order to match the different social and organization roles that one simultaneously occupies [10]. As a result, it is theorized that self-concept differentiation occurs when individuals perceive themselves as having to be a fundamentally different person within these diverse roles thereby creating a sense of disharmony in the self-concept [11]. Self-concept differentiation is positively related to indices of maladjustment, depression, and anxiety [10-11]. Such negative psychological experiences are hypothesized to prevent strong cognitive attachments with an individual's multiple identities.

**Distinctiveness**: The degree to which students feel that majoring in engineering distinguishes or sets them apart from others. Distinctiveness is suggested by Vignoles et al. [12] as a distinct motive that drives identity development. It is a motive for identification because clear boundaries and definitions of self-concept satisfy a deep cultural need to feel differentiated from others. Perceived distinctiveness is thought to facilitate in-group pride by increasing in-group favoritism and self-esteem [13]. Thus, the urge for distinction can lead to increased strivings for membership in groups that are perceived as distinctive as well as identity salience of current members [14].

**Participation**: The level and intensity of participation or involvement in engineering activities (i.e., class contribution, laboratory involvement or participation in engineering-related clubs). This concept has a clear relation to identity salience as participation in engineering related activities both signifies an already present feeling of association with engineering and increases identification by increasing exposure to positive aspects of group membership, potential sources of social support, and experiences that may guide self-definition.

**Self-Enhancement**: The degree to which students believe that being an engineering student is an attractive quality. Membership with a group that is perceived as attractive enhances self-esteem by allowing qualities portrayed by the group to be reflected on the self through association [15]. This allows for a more positive self-image and fulfills inner strivings to feel important as a valued member of something respected by others.

**Social Support**: The level and intensity of exposure and interaction with other group members. Increased contact with group members increases visibility of affiliation as well as a person's perceptual readiness [16] to self-categorize and define oneself as a member of the group.

**In-Group Cooperation**: The level of cooperation with others in the engineering community. Perceived social support and a sense of social embeddedness has a demonstrated effect on reducing and preventing psychological distress as well as the negative impacts of life stress and strain [17]. Self-categorization of oneself as a valued member of a group is facilitated by the perception that one is more similar to in-group members than out-group members [13]. Furthermore, a sense of cooperation with group members is related to greater satisfaction with group membership [18].

**Visibility of Affiliation**: The degree to which students attempt, whether consciously or unconsciously, to make their association with engineering visible to others. Visibility of affiliation behaviors include outward or public displays of group membership such as visual demonstrations, acts of community involvement on behalf of the group, visible proximity to physical locations associated with the group, and visible proximity to other well-known group members. Dutton, Dukerich, and Harquial [15] theorized that increased visibility of affiliation offers more frequent reminders of group membership and thus, increases the availability and strength of the group characteristics as a source of self-definition. Furthermore, Tetlock and Manstead [19] discuss how public awareness that a person is affiliated with an organization results in general expectations that such person will act in accordance with the attitudes and behaviors typical of that group. If a person engenders pride and views the organization as attractive and as having a positive external image, than these expectations will be a welcomed stereotype that, in return, further strengthen identification [15].

**Sense of Belonging**: The degree to which students feel that engineering is the right "fit" for them and that the decision to major in engineering matches their self-concept. Belonging, in the academic sense, strengthens identification by increasing student's task value, openness, and feelings of social acceptance as well as motivation and attachment to the program [20].

**Citizenship Behaviors**: The degree to which students engage in citizenship behaviors will indicate depth of group membership through willingness to conduct oneself in a way that enhances commitment to engineering. This concept originated in the management literature in which "organization citizenship behaviors" in the workplace are used to analyze and predict company performance [21-22]. Organ [23] defined citizenship behaviors as "behavior(s) of a discretionary nature that are not part of the employee's formal role requirements, but nonetheless promote the effective functioning of the organization," but Graham [24] more broadly defined it as a "global concept that includes all positive organizationally relevant behaviors of individual organization members." Citizenship behaviors are hypothesized to enhance group morale, cohesiveness, loyalty, commitment, and sense of belonging improving an individual's attraction to and retention in the particular group membership. Thus, students that rate higher on these items are more likely to strongly identify with the engineering major.

**Interest**: Interest is a basic springboard for identity formation [25] because it speaks to a student's general concern and engagement with engineering-related activities. Does the person actually find the subject matter of engineering intriguing, interesting, exciting, or worthwhile? This construct is highly important for understanding identity processes, as this concept is perhaps the most readily accessible and often utilized reason that students indicate as the purpose for choosing engineering, or in some cases, switching out of engineering. Interest can be considered a fundamental building block for identity formation regarding group memberships that require personal choice (as opposed to inherent group membership such as ethnicity or gender).

**Attitudes towards Becoming an Engineer**: Students' opinions toward having a career in engineering after college. This information is necessary for determining student's plans for retention with engineering beyond just the academic program. Furthermore, responses may also have implications for identity strength as students who plan to have a career in engineering are more likely to strongly identify which the field as a whole.

A set of 105 items was compiled for an initial piloting phase. Each item was developed to assess one of the identity themes described above. These items were piloted using a large sample, reviewed by content experts, and redundant items were eliminated on methodological and theoretical grounds. This process resulted in a final item pool of 38 core items. Sample items associated with each of the identity themes are presented in Table 1.

**Table 1:** Sample items by identity theme

| Subscale | Sample Item |
|---|---|
| **Unified Self-Concept** | I feel like I am fundamentally the same person when engaged in engineering and non-engineering activities. |
| **Distinctiveness** | Being a member of the engineering community is something that distinguishes me from others |
| **Participation** | I actively seek out participation in engineering-related activities |
| **Self-Enhancement** | Being an engineering student makes me feel important |
| **Social Support** | I have peers in engineering with whom I can share my joys and sorrows |
| **In-group Cooperation** | I feel comfortable around other engineering students |
| **Visibility of Affiliation** | I can often be seen off campus with other engineering students |
| **Sense of Belonging** | I feel a strong sense of belonging to engineering |
| **Citizenship Behaviors** | I feel a great deal of loyalty toward engineering |
| **Interest** | I find engineering topics intriguing or exciting |
| **Attitudes toward Becoming an Engineer** | I can see myself becoming an engineer when I am done with school |

On each of the final 38 items, participants were asked to rate "the extent to which you agree" with each item on a 6-point Likert scale, with 1 being "Completely Disagree" and 6 being "Completely Agree." The overall ESIS score ranges from 1 to 6 with higher scores indicating a more developed overall engineering identity. The item scores for each subscale were averaged to create subscale scores. Thus, ranges for each of the subscales also ranged from 1 to 6. Estimates of reliability for each of the subscales was adequate (Cronbach's $\alpha = .69 - .90$).

## III. Methods

### *A. Participants*

Two hundred and sixty students registered as engineering majors and enrolled at a mid-sized mid-Atlantic primarily undergraduate institution participated in this study. All four cohorts of students (73 first-year students, 94 second-year students, 51 third-year students, 42 fourth-year students) were assessed at the end of the Fall 2011 semester. The sample consisted of 203 students who identified as male, 53 who identified as female, and four who did not identify. All appropriate human subjects procedures were followed. The measure was administered to students via online survey software.

### *B. Data Analysis*

Data were exported from Qualtrics and analyzed using SPSS 23. Descriptive statistics (means, standard deviations, skew, and kurtosis) were used to explore levels of and variability of Engineering Identity dimensions across four student cohorts. Reliability of each of the subscales was assessed using both Cronbach's alpha and the Feldt-Gilmer coefficient.

Between-subject ANOVA procedures were conducted for each subscale to detect any statistically significant mean differences between cohorts on the E-SIS. Results were supplemented with Tukey's post-hoc examinations and measures of practical effect size (Eta-Squared) in cases where it was of interest to examine the observed difference in more detail. Graphical depictions of the results are used to illustrate the observed trends. Those looking for guidance using ANOVA procedures are directed to [26].

Multivariate Descriptive Discriminant Analyses (DDA) were conducted to determine if a weighted linear composite of the set of subscales on the E-SIS could adequately discriminate between the cohorts. Results were supplemented with Tukey's post-hoc examinations (on the multivariate composite) and measures of practical effect size (R-squared canonical) in cases where it was of interest to examine the observed differences in more detail. Graphical depictions of the results are again used to illustrate the overall trends. Those looking for guidance using DDA should consult [27].

## IV. Results

### *A. Univariate Analyses*

Table 1 contains descriptive statistics for each one of the E-SIS subscales across four student cohorts. Internal consistency indices, computed separately for each subscale, are also presented in Table 2. All subscales of the E-SIS reached an acceptable level of reliability using both coefficient alpha and the Feldt-Gilmer Coefficient (.69 or higher). The professional engineering subscale was dropped from analyses due to high skew and kurtosis issues. Items on this subscale will be examined and rewritten in the future.

**Table 2.** Descriptive information for each subscale by cohort

| Subscale | 1st Year ($N$ = 73) | | 2nd Year ($N$ = 94) | | 3rd Year ($N$ = 51) | | 4th Year ($N$ = 42) | |
|---|---|---|---|---|---|---|---|---|
| | *M* | *SD* | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| Unified Self-concept | 4.5 | 0.8 | 4.8 | 0.8 | 5.1 | 0.7 | 5.1 | 0.7 |
| Distinctiveness | 4.4 | 0.9 | 4.7 | 0.8 | 5.2 | 0.8 | 5.2 | 0.8 |
| Participation | 4.0 | 1.1 | 4.3 | 1.1 | 4.9 | 0.9 | 4.6 | 0.9 |
| Self-enhancement | 4.9 | 0.8 | 5.1 | 0.8 | 5.4 | 0.8 | 5.3 | 0.7 |
| Social Support | 3.8 | 1.2 | 4.5 | 1.2 | 5.4 | 0.8 | 5.1 | 0.9 |
| In-group Cooperation | 4.3 | 1.0 | 4.7 | 0.9 | 5.3 | 0.8 | 5.3 | 0.8 |
| Visibility of Affiliation | 3.1 | 1.3 | 3.9 | 1.3 | 5.0 | 1.0 | 4.8 | 1.0 |
| Sense of Belonging | 4.5 | 0.9 | 4.9 | 1.0 | 5.4 | 0.7 | 5.2 | 0.8 |
| Citizenship Behaviors | 4.7 | 0.8 | 5.0 | 0.8 | 5.5 | 0.7 | 5.3 | 0.6 |
| Interest | 4.8 | 0.8 | 5.1 | 0.8 | 5.5 | 0.6 | 5.3 | 0.7 |
| Professional Engineer | 5.0 | 0.9 | 5.2 | 1.0 | 5.5 | 0.7 | 5.3 | 0.7 |

Table 3 exhibits the ANOVA results for the differences between cohorts on each of the E-SIS subscales. All subscales were able to statistically significantly discriminate between cohorts at an alpha level of .005. The alpha level was adjusted for multiple statistical tests using a Bonferroni correction (.05/10 = .005). Table 3 exhibits the Tukey post-hoc comparisons of cohort discrimination for all significant subscales.

**Table 3.** ANOVA results: cohort by subscale

| Subscale | *df* | *F* | *p*-value | Partial Eta Squared |
|---|---|---|---|---|
| Unified Self-Concept | 3, 256 | 9.29 | <.001* | 0.10 |
| Distinctiveness | 3, 256 | 13.67 | <.001* | 0.14 |
| Participation | 3, 256 | 8.02 | <.001* | 0.09 |
| Self-Enhancement | 3, 256 | 5.35 | .001* | 0.06 |
| Social Support | 3, 256 | 22.59 | <.001* | 0.21 |
| In Group Cooperation | 3, 256 | 17.85 | <.001* | 0.17 |
| Visibility of Affiliation | 3, 256 | 32.17 | <.001* | 0.27 |
| Sense of Belonging | 3, 256 | 13.37 | <.001* | 0.14 |
| Citizenship | 3, 256 | 11.81 | <.001* | 0.12 |
| Interest | 3, 256 | 8.85 | <.001* | 0.09 |

* Statistically significant at the .005 level. Bonferroni adjustment of alpha (.05/10 = .005)

The most sizeable difference across cohorts was observed for Visibility of Affiliation - the extent to which students attempt to make their association with engineering visible to others. On average, third-year students and fourth-year students reported statistically and practically higher levels of Visibility of Affiliation than first-year students (Mean differences = 1.88 and 1.74). Second-year students' average level was also significantly higher than that of first-year students, although this difference was smaller in size (Mean difference = 0.80). Third-year students also scored statistically and practically higher than second-year students (Mean difference = 1.08). As expected based on overall trends, the difference between third-year students and fourth-year students was negligible.

A similar, although less pronounced, trend was observed for the rest of the E-SIS subscales (Table 4). The most notable differences across cohorts were observed for Social Support (the level and intensity of the exposure of the interaction with other group members) and In-Group Cooperation (a sense of being embedded with the social group). All subscales were able to discriminate first-year students from either third- or fourth-year students. Only self-enhancement, social support, visibility of affiliation, and sense of belonging were able to discriminate first-year students from second year students. All subscales, aside from participation, were able to discriminate between second- and third-year students. Only unified self-concept, self-enhancement, social support, and in-group cooperation were able to discriminate between second- and fourth-year students. None of the subscales were able to discriminate between third- and fourth-year students. Evidently, all subscales were not able to significantly differentiate between cohorts in the same way. Coupled with earlier findings, this observation may indicate that students come in with and maintain certain strong aspects of Engineering Identity and develop others as they progress through the program.

**Table 4.** ANOVA post-hoc mean comparisons

| Subscale | 1st year v. 2nd year | 1st year v. 3rd year | 1st year v. 4th year | 2nd year v. 3rd year | 2nd year v. 4th year | 3rd year v. 4th year |
|---|---|---|---|---|---|---|
| USC | -0.26 | -0.63* | -0.60* | -0.37* | -0.34 | 0.03 |
| Dist. | -0.31 | -0.81* | -0.78* | -0.50* | -0.46* | 0.03 |
| Part. | -0.26 | -0.86* | -0.58* | -0.60* | -0.32 | 0.28 |
| Self Enh. | -0.18 | -0.51* | -0.41* | -0.33 | -0.23 | 0.10 |
| Soc. Sup. | -0.62* | -1.51* | -1.24* | -0.88* | -0.61* | 0.27 |
| In Group | -0.47* | -1.00* | -0.99* | -0.52* | -0.52* | 0.01 |
| V of A | -0.80* | -1.88* | -1.74* | -1.08* | -0.95* | 0.13 |
| S of B | -0.37* | -0.94* | -0.73* | -0.58* | -0.37 | 0.21 |
| Citizen | -0.31* | -0.75* | -0.61* | -0.44* | -0.30 | 0.14 |
| Interest | -0.29 | -0.66* | -0.51* | -0.37* | -0.23 | 0.15 |

*significant difference at the alpha = .05 level adjusted using Tukey HSD.

### B. *Multivariate Analyses*

It is evident, by examining the pattern of univariate group differences (Table 1), that the subscales may be discriminating between cohorts in different ways. Descriptive Discriminate Analyses were conducted to determine if a set of E-SIS subscales could be combined via a weighted linear composite to maximally separate the cohort groups. Univariate skew and kurtosis indicators are not extreme enough to warrant concern with the multivariate normality of the scales. Correlations between the subscales are very high (.49 - .84) for the total sample. This suggests that multicolinearity between the subscales may become an issue. Box's *M* test (Box's $M$ = 307.12, $F$ (165, 81246) = 1.717, $p < .001$) was significant which suggests that the within-group variance/covariance matrices may not be equal; however, a visual examination of the log determinants of these matrices suggests that they are similar enough to proceed with the analysis.

Multivariate analyses revealed that the first discriminant function reliably differentiated among the four cohort groups ($\Lambda$ = .648, $\chi^2$ (30) = 109.31, $p < .001$, $R^2_c$ = .33), but the second function and third functions did not provide further reliable differentiation amount the three groups ($\Lambda$ = .962, $\chi^2$ (18) = 9.68, $p$ = .942, $R^2_c$ = .03; $\Lambda$ = .994, $\chi^2$ (8) = 1.45 $p$ = .994, $R^2_c$ = .001). The first function accounted for 92.6%, the second function accounted for 6.3%, and the third function accounted for 1.1% of the between-group variability. Table 5 presents the standardized and structure coefficients for the first discriminant function. These coefficients suggest that only unified self-concept, distinctiveness, participation, self-enhancement, visibility of affiliation, and citizenship uniquely and reliably contribute to the multivariate function that best discriminates cohorts.

**Table 5** Weights for the first discriminant function

| Subscale | Standardized | Structure |
|---|---|---|
| Unified Self-Concept* | -0.26 | 0.88 |
| Distinctiveness* | 0.36 | 0.73 |
| Participation* | -0.33 | 0.66 |
| Self-Enhancement* | -0.55 | 0.57 |
| Social Support | 0.14 | 0.56 |
| In Group Cooperation | 0.19 | 0.53 |
| Visibility of Affiliation* | 0.89 | 0.47 |
| Sense of Belonging | -0.06 | 0.46 |
| Citizenship* | 0.39 | 0.36 |
| Interest | 0.13 | 0.42 |

*used to label the discriminant function

Figure 1 presents a graphical depiction of the multivariate results. Specifically, the group centroids are plotted on the labeled function to facilitate interpretation. Based on this sample, those who were earlier in their engineering education were further to the left of the function. The left side of the function is defined by lower scores on each of the contributing subscales. The composite scores were calculated by applying the structure weights to standardized raw scores. The composite scores were used to conduct Tukey's HSD test to identify which of these groups differed significantly on the function. Based on this sample, first-year students exhibited significantly lower scores on the function than the people in the other cohorts; second-year students exhibited significantly higher scores than first year students and significantly lower scores than third- or fourth-year students; third- and fourth-year students exhibited significantly higher scores than first- or second-year students but were not significantly different than each other.

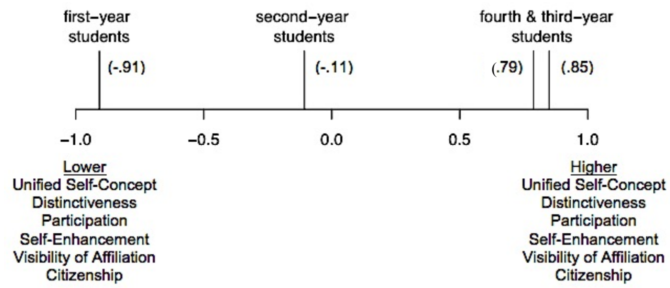


**Figure 1**. Graphical depiction of the first discriminant function.

## V. Discusssion

### A. *Differences across Cohorts*

The E-SIS subscale structure and items are grounded in the identity literature as well as informed by previous work involving both student interviews and open-ended survey research. If it is assumed that engineering student identity increases with length of time in an engineering program and the E-SIS is a measure of engineering student identity, we would expect the E-SIS to be able to detect differences in those identity areas that differ from first-year to fourth-year. Results indicate that the E-SIS is able to discriminate between first-, second-, and third/fourth-year students, to varying degrees, on all of the 10 subscales used in the analyses. Additionally, when considered together, a multivariate linear composite of unified self-concept, distinctiveness, participation, self-enhancement, visibility of affiliation and citizenship was best able to discriminate between the four cohorts. These findings reveal preliminary support for the E-SIS's ability to distinguish among cohorts in expected ways, providing initial evidence for the validity of the E-SIS.

### B. *Limitations*

The four student samples available are independent, cross sectional, student samples. As such, any differences observed across cohorts could be attributed to any differences across samples. Following a single sample of students from first-year to final year will allow for measuring growth in the dimensions of Engineering Identity over time. Although we cannot make conclusive statements about students' growth over time due to the cross-sectional nature of the design, the trend consistency serves as convincing evidence that more experienced engineering students have a stronger sense of Engineering Identity than younger students. In addition, several analyses involved comparison of unequally sized groups; however, the smallest groups also exhibited the smallest variances. This pattern of sample sizes and variances suggests that our power to detect differences is lowered in this study; however, the chance of finding a false positive has not been affected. A discriminant analysis was conducted in this study to answer the multivariate question dictated by the theory behind the E-SIS. However, given the extremely high correlations between the E-SIS subscales, a discriminant analysis may be less informative than other statistical models (exploratory/confirmatory factor analysis, structural equation modeling, etc.).

### *C. Future Research*

While our goal is to examine the identity development of specific groups within engineering and use the results for targeted intervention, such uses of the scale are not possible before evidence is available to support them. Thus, future research will focus on scale development issues including an examination of the factor structure of the scale using more appropriate statistical approaches. Once sufficient reliability and validity evidence has been gathered, then research will examine how the E-SIS can inform intervention efforts.

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