A Study of the Reliability and Validity of the Felder-Soloman *Index of Learning Styles*©

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Abstract

A study of the reliability and validity of Felder-Soloman *Index of Learning Styles*© (ILS) was performed based on data collected from students at Penn State. Students from three colleges—engineering, liberal arts, and education—were invited to participate in the study in an effort to broaden the range of learning styles represented in the test sample. The instrument was administered on-line and over 500 students completed it. The results were subjected to psychometric analysis to investigate reliability and validity and to extract trends in the data with respect to field of study and gender.

Introduction

The *Index of Learning Styles*©, created by Felder and Soloman,[1] is designed to assess preferences on four dimensions of a learning style model formulated by Felder and Silverman.[2] The ILS consists of four scales, each with 11 items: sensing-intuitive, visual-verbal, active-reflective, and sequential-global. Felder and Spurlin[3] summarize the four scales as follows:

- "*sensing* (concrete, practical, oriented toward facts and procedures) or *intuitive* (conceptual, innovative, oriented toward theories and underlying meanings);
- *visual* (prefer visual representations of presented material, such as pictures, diagrams, and flow charts) *or verbal* (prefer written and spoken explanations);
- *active* (learn by trying things out, enjoy working in groups) or *reflective* (learn by thinking things through, prefer working alone or with one or two familiar partners);
- *sequential* (linear thinking process, learn in incremental steps) or *global* (holistic thinking process, learn in large leaps)."

The Web-based version of the ILS is taken over 100,000 times per year and has been used in a number of published studies.[3] Among those many hits are a number from Penn State faculty members involved in faculty development workshops and Penn State students enrolled in a course to prepare undergraduates to serve as teaching interns. Use of the ILS at Penn State over a number of years and interest in the effect of its dichotomous structure on reliability led to the design and implementation of the study reported here. The primary goals of the study were to

investigate the reliability of the ILS scores and its validity. However, the nature of the sample also provided an opportunity to compare the learning styles of students in different colleges and to investigate the effect of gender.

Internal Consistency Reliability and Factor Analysis

Because past studies with the ILS have shown that engineering students tend to be highly visual, students from three colleges, engineering, liberal arts, and education, were invited to participate in the study to broaden the range of learning styles represented in the test sample. Random samples of 1000 students from each of the three colleges were contacted by email to ask them to participate in the study; both undergraduate and graduate students were invited to participate. The only incentive provided for participation was entry into a random drawing for $100. Participants completed the ILS and also provided feedback on the extent to which they felt that the learning style preferences assigned to them based on their scores represented their actual learning preferences. The instrument was taken on-line and responses to each item were captured for scoring and psychometric analysis.

Table 1 provides a summary of the characteristics of the sample. A total of 572 complete ILS responses were obtained, of which 534 could be assigned to one of the three colleges of interest. The sample was approximately 80% undergraduate students. Students in engineering participated at the highest rate of the three colleges, most likely because the study originated in engineering. The total sample was essentially gender balanced.

Table 1. Sample Characteristics

College	**Number completing instrument**	**Percent Female**
Engineering	235	22%
Education	113	77%
Liberal arts	186	69%
Other	38	50%
Total	**572**	**50%**

To estimate the internal consistency reliability of the scores, the Cronbach alpha coefficient was calculated for each of the four scales of the ILS based on the sample of 572 students. Table 2 compares the results of the current study with those of past studies reported by Felder and Spurlin.[3] The Cronbach alpha values obtained in this study show a similar pattern to past studies and are comparable in magnitude to the values obtained in three of the four studies. The Sensing-Intuitive (S-N) scale and the Visual-Verbal (V-V) scale both were found to have reliability in excess of 0.7, whereas the Active-Reflective (A-R) and Sequential-Global (S-G) scales had Cronbach alphas of 0.60 and 0.56, respectively.

The question is whether the measured alpha values signify acceptable reliability. Tuckman[4] distinguishes between instruments that measure a univariate quantity, such as a test of knowledge of a subject area or mastery of a particular skill, and instruments that measure preferences or attitudes. In tests of the former type, a high level of proficiency in the subject area or skill being

assessed should lead to correct responses to most items and a low level of proficiency should lead to mostly incorrect responses, so that a high level of correlation among the items on the scale and hence a high Cronbach alpha would be expected. On the other hand, if the assessed preferences are situationally dependent and may vary in strength from one individual to another (as learning style preferences do), a lower correlation among the items related to that preference would be anticipated; indeed, a very high correlation would suggest that the items are not assessing independent aspects of the preference but are simply reworded variants of the same question. In light of these considerations, Tuckman suggests that an alpha of 0.75 or greater is acceptable for instruments that assess knowledge and skills and 0.50 or greater is acceptable for attitude and preference assessments. The alpha values for all four scales of the Index of Learning Styles meet this criterion.

Classical item analysis was conducted on the ILS items to determine whether any items were negatively affecting the reliability of the scales. A useful output of classical item analysis is determination of the effect of elimination of an item on the reliability of the scale scores. Table 3 summarizes the output of the analysis. The items in blue bold text are the "weakest" item in each scale, i.e., the item whose elimination results in the largest increase in reliability.

Table 2 Cronbach Alpha Coefficients

A-R	**S-N**	**Vs-Vb**	**Sq-G**	**N**	*Source*
0.60	0.77	0.74	0.56	572	Current Study
0.56	0.72	0.60	0.54	242	Livesay *et al.*[5]
0.62	0.76	0.69	0.55	584	Spurlin[6]
0.51	0.65	0.56	0.41	284	Van Zwanenberg *et al.*[7]
0.60	0.70	0.63	0.53	557	Zywno [8]

Table 3 Output of Classical Item Analysis

A-R scale	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted	S-N scale	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
FQ1_A	0.3223	0.2366	0.565	FQ2_S	0.4357	0.2545	0.7451
FQ5_A	0.3709	0.1435	0.5529	FQ6_S	0.5115	0.4261	0.7368
FQ9_A	0.1692	0.1642	0.5991	FQ10_S	0.4177	0.2565	0.7474
FQ13_A	0.2548	0.1542	0.5798	FQ14_S	0.4349	0.2339	0.7452
FQ17_A	**0.0602**	**0.0875**	**0.6229**	FQ18_S	0.5759	0.4352	0.7286
FQ21_A	0.3245	0.1801	0.5658	FQ22_S	0.4170	0.2436	0.7475
FQ25_A	0.3716	0.2356	0.5523	FQ26_S	0.2975	0.1635	0.7623
FQ29_A	0.2462	0.2034	0.5815	FQ30_S	0.3361	0.2003	0.7570
FQ33_A	*0.2311*	*0.0956*	*0.5852*	FQ34_S	0.3761	0.2137	0.7525
FQ37_A	0.3223	0.2408	0.5641	FQ38_S	0.6306	0.5032	0.7203
FQ41_A	0.2596	0.1706	0.5788	**FQ42_S**	**0.1640**	**0.0745**	**0.7776**

Vs-Vb scale	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted	Sq-G scale	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
FQ3_V	0.3298	0.1429	0.7311	FQ4_G	0.2503	0.1635	0.5307
FQ7_V	0.5921	0.4559	0.6936	FQ8_G	0.3158	0.1281	0.5128
FQ11_V	0.5313	0.3500	0.7024	*FQ12_G*	*0.2082*	*0.0735*	*0.5405*
FQ15_V	0.3972	0.1883	0.7225	*FQ16_G*	*0.1684*	*0.0629*	*0.5512*
FQ19_V	0.3605	0.2042	0.7276	FQ20_G	0.3877	0.2252	0.4942
FQ23_V	0.3454	0.2110	0.7302	*FQ24_G*	*0.2071*	*0.0734*	*0.5413*
FQ27_V	0.4691	0.2733	0.7123	FQ28_G	0.3119	0.1650	0.5155
FQ31_V	0.5490	0.4038	0.7005	*FQ32_G*	*0.1041*	*0.0494*	*0.5658*
FQ35_V	0.3391	0.1606	0.7308	FQ36_G	0.3818	0.1936	0.4947
FQ39_V	**0.1694**	**0.0667**	**0.7538**	**FQ40_G**	**-0.0105**	**0.0210**	**0.5952**
FQ43_V	*0.1731*	*0.0788*	0.7462	FQ44_G	0.2952	0.1231	0.5189

Table 4 summarizes the effect of elimination of the items that contribute the least to reliability in each of the four scales on the Cronbach alpha values. The Sequential-Global scale shows the greatest increase in reliability with the elimination of the weakest item in that scale, from 0.56 to 0.60.

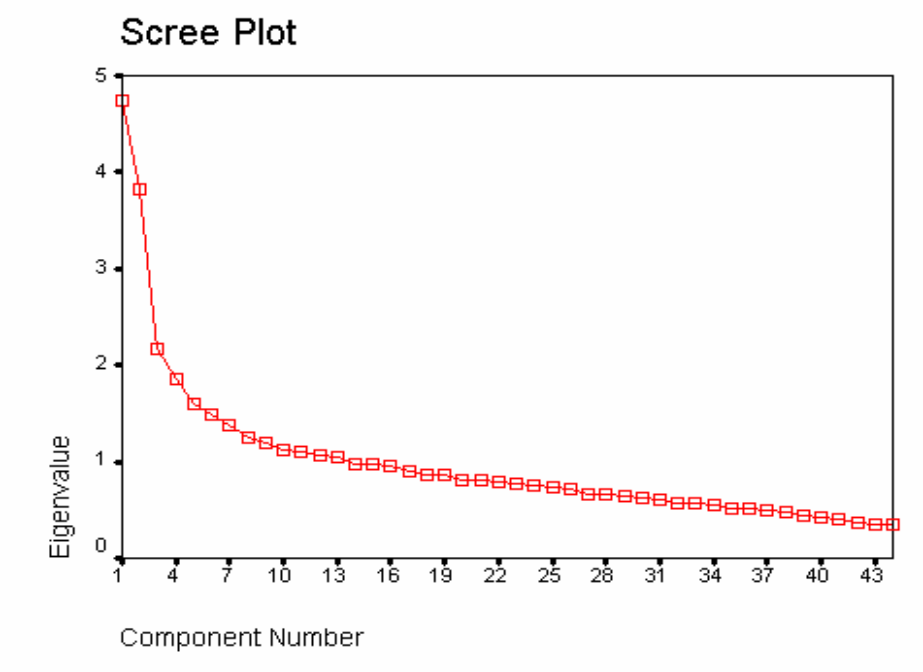
Table 4 Cronbach alpha values for weakest item removed from each scale

Scale	**Alpha Value 11 items**	**Alpha value 10 items**
Active-Reflective	0.60	0.62
Sensing-Intuitive	0.77	0.78
Visual-Verbal	0.74	0.75
Sequential-Global	0.56	0.60

Other potentially problematic items in the scales are identified with red italics text in Table 3. These items fall below the desired level of 0.10 in Squared Multiple Correlation, which indicates that they correlate weakly with the items in the scale. (The Squared Multiple Correlation is essentially the degree to which variance of the item score is accounted for by the scores for the other ten items in the scale.) The scale with the largest number of such items is the Sequential-Global scale, which has the lowest reliability. The low Squared Multiple Correlation values may be due to the fact that the items are poor, or it may be due to the fact that the scale contains multiple factors that are not strongly related. To investigate the latter possibility, exploratory factor analysis was conducted.

The first step in the exploratory factor analysis was to estimate the number of factors in the ILS using a "scree plot" of the eigenvalues, which is presented in Figure 1. In the scree plot, the eigenvalues are plotted in order from the largest to the smallest value. The Kaiser-Gutman criterion (eigenvalue > 1) indicates that are more than four factors in the ILS.

Figure 1. Scree Plot



A series of factor analyses were performed with four to eight factors. For each of the analyses, the Sensing-Intuitive scale maintained consistent structure, with all 11 items consistently loading on a single factor. This result indicates that this scale is measuring one factor. The other scales were found to relate to more than one factor. The results from the eight factor solution are summarized in Table 5. They indicate that the Visual-Verbal and Global-Sequential scales contain two factors and that the Active-Reflective scale contains three factors.

A review of the items related to each of the factors was done to establish the nature of the factors, which are summarized in Table 6. (The ILS is listed in the Appendix to this paper for those who might wish to see the items related to the factors.) The Visual-Verbal scale contains factors related to preferred input mode and preferred mode for memory and recall. The Sequential-Global scale also contains two factors, preference for sequential over random or holistic thinking and emphasis on details over the "big picture."

Finally the Active-Reflective scale has three factors related to action or reflection as an initial approach, being outgoing or reserved in social situations, and favorable or unfavorable attitude toward group work.

Table 6 Factors in the eight factor solution

Scale	#F	Items	Factors
Sensing - Intuitive	1	38, 6, 18, 14, 2, 10, 34 26, 22, ***42, 30***	Preference for concrete information (facts, data, the "real world") or abstraction (interpretations, theories, models)
Visual - Verbal	2	7, 31, 23, 11, 15	Information format preferred for input
	5	27, 19, 3, 35, 43, ***39***	Information format preferred for memory or recall
Sequential - Global	3	20, 36, 44, 8, 12, 32, 24	Linear/sequential or random/holistic thinking
	8	28, 4, 16, ***40***	Emphasize details (the trees) or the big picture (the forest)
Active - Reflective	4	25, 1, 29, 5, 17	Action-first or reflection-first
	6	37, 13, 9	Outgoing or reserved
	7	21, 33, 41	Favorable or unfavorable attitude toward group work

The factor analysis reveals that some items are not well loaded onto any factors in their scale. These items are identified in bold italics in Table 6. Items 42 and 30 of the Sensing-Intuitive scale, listed below, ask students to choose one of two activities in a given context. Neither

42 When I am doing long calculations,
(a) I tend to repeat all my steps and check my work carefully.
(b) I find checking my work tiresome and have to force myself to do it.

30 When I have to perform a task, I prefer to
(a) master one way of doing it.
(b) come up with new ways of doing it.

of these items appears to relate strongly to the concrete vs. abstract nature of the items that are well loaded on this scale. In item 39 students are asked what they would like to read a book or to watch TV for entertainment, not for learning. It may be that the connection to entertainment leads to this item being poorly loaded on the Visual-Verbal scale. It is also likely that most students choose TV because reading for entertainment is becoming much less common. Item 40, which is part of the Sequential-Global scale, asks if an outline presented at the beginning of class is somewhat or very helpful. This item may not offer a clear contrast between details and "the big picture," as an outline may be viewed as providing both (or neither).

Table 5 Eight Factor Solution (Factor loadings less than 0.1 are not listed.)

SCALE	ITEM	FACTORS							
		1	2	3	4	5	6	7	8
Active / Reflective	25	.	.	.	**0.68**	.	.	.	.
	1	.	0.23	.	**0.67**	0.11	.	.	.
	29	0.23	0.18	.	**0.53**	0.22	.	.	.
	5	.	-0.16	.	**0.43**	.	0.31	0.26	.
	17*	.	-0.14	.	**0.42**	.	-0.40	.	.
	13	.	.	.	0.11	.	**0.59**	0.17	.
	37	-0.10	-0.12	-0.17	0.24	.	**0.56**	0.21	.
	9	-0.23	.	.	.	.	**0.50**	.	.
	41	0.22	.	.	.	.	.	**0.63**	0.10
	21	.	0.15	.	.	.	0.20	**0.61**	.
	33	.	.	.	.	.	0.14	**0.60**	.
Sequential / Global	20	0.26	.	**0.53**	.	.	-0.11	.	0.19
	36	0.20	.	**0.52**	.	-0.12	.	0.11	0.22
	44	0.14	.	**0.50**	0.10	.	.	.	.
	8	.	.	**0.46**	.	0.23	.	0.12	0.34
	12	.	.	**0.43**	.	.	0.28	-0.18	.
	32	.	.	**0.42**	.	.	.	0.14	-0.32
	24	0.13	.	**0.40**	-0.22	0.11	0.22	-0.25	-0.10
	4	.	.	0.15	.	.	.	.	**0.62**
	28	0.13	.	0.21	.	-0.18	.	.	**0.60**
	16	0.18	.	0.11	.	.	0.20	.	**0.36**
	40*	-0.12	.	.	.	.	-0.29	.	**0.12**
Sensing / Intuitive	38	**0.75**	.	0.15	0.13	0.11	.	.	0.17
	6	**0.71**	.	.	0.12	0.20	.	.	.
	18	**0.68**	.	0.20	0.18	.	.	.	.
	14	**0.57**	0.12	.	0.11	-0.19	.	.	0.18
	2	**0.52**	.	0.26	.	.	.	.	-0.28
	10	**0.52**	-0.16	0.11	.	0.17	.	.	0.30
	34	**0.46**	0.12	0.19	-0.15	.	.	.	-0.35
	26	**0.44**	0.18	0.12	-0.14	-0.10	-0.13	0.10	-0.18
	22	**0.35**	.	0.45	-0.19	.	.	-0.19	.
	42*	**0.24**	0.12	0.11	-0.24	.	0.52	-0.18	0.16
	30	**0.21**	-0.13	0.57	.	.	-0.11	.	.
Visual / Verbal	7	.	**0.77**	.	.	0.15	.	.	.
	31	.	**0.70**	.	0.17	0.19	.	.	.
	23	.	**0.66**	-0.17	.	.	.	.	.
	11	.	**0.65**	.	.	0.19	.	0.21	.
	15	.	**0.55**	.	.	0.15	.	.	.
	19	.	0.22	.	.	**0.59**	.	-0.10	.
	35	.	0.17	0.17	0.17	**0.54**	.	.	.
	3	.	0.18	.	.	**0.53**	.	0.15	.
	27	.	0.38	.	.	**0.53**	.	.	.
	43	0.16	.	-0.15	.	**0.50**	.	.	.
	39*	0.35	.	0.10	.	**0.19**	.	0.34	.

The factor analysis, combined with the estimates of reliability, provides evidence of construct validity for the ILS. The strongest evidence is for the Sensing-Intuitive scale, for which all items load on a single factor and the Cronbach alpha is high. For the Visual-Verbal scale the evidence of construct validity is also good as there are two factors and they are strongly correlated as indicated by the Cronbach alpha value. For the Active-Reflective and Sequential-Global scales the identified factors appear to be appropriate for the scales; however, the relatively low values of the Cronbach alphas for these two scales indicate that their factors are not as strongly correlated. Four items were identified in the factor analysis that to do not load effectively onto any of the eight factors. Revision of items in these scales, or removal of the problematic items (30, 40, and 42) would increase the reliability of the ILS.

Regarding the issue of removal vs. revision of items, there are several reasons to retain 44 items in the ILS. With 11 items on a scale, there is no possibility for an individual to register a zero preference, and the possible differences between the numbers of responses for each category allow for a convenient categorization of preference strength as mild ($\pm$1, $\pm$3), moderate ($\pm$5, $\pm$7), and strong ($\pm$9, $\pm$11). The instrument structured in this manner has been completed by hundreds of thousands of individuals and used as the basis for numerous research studies. The potential confusion that might be occasioned by switching to a new system of scoring and outcome interpretation could only be justified by a significant improvement in reliability. The Cronbach alpha values of the existing instrument are already well within the region of acceptability, and eliminating an item would not have a meaningful effect on respondents' learning style profiles: the only possible preference change would be from a very mild preference for a category (+1 or –1) to no preference at all. We conclude that the slight gains in alpha resulting from removing items would not compensate for the disadvantages of doing so. On the other hand, the weaknesses of several of the items could easily be addressed with minor word changes, yielding reliability increases without changing the basic structure of the instrument. Such changes are currently under consideration.

Effects of Field of Study and Gender on ILS Profiles

The results of the study were used to investigate trends with respect to field of study and gender. Table 7 presents the 95% confidence intervals of overall means and college means of each scale for those students who could be assigned to a college. When the confidence interval does not include zero (which it does not for the bold-faced entries in the table), the mean is statistically different than zero. For the entire sample the means of the Sequential-Global, Sensing-Intuitive, and Visual-Verbal scales are statistically different than zero, so the students in the sample, on average, are sequential, sensing, and visual. Engineering students in the sample have the same characteristics as the overall sample—that is, their preferences on average are sequential, sensing, and visual, and they tend to be the most extreme in these preferences among the three groups of students. The preferences of the engineering students are generally consistent with those reported in past studies of engineering students.[3] The education students and liberal arts students are on average visual learners. Thus the only common preference for all three colleges is for visual over verbal learning.

Table 7 Means and 95% confidence intervals

LS Type	College	# Obs	Mean	Std Dev	95% Confidence Interval	
					Lower bound	Upper bound
Active(+)/ Refective(-)	Education	113	0.73	4.84	-0.17	1.64
	Engineering	235	-0.02	4.89	-0.65	0.61
	Liberal arts	186	-0.34	4.31	-0.97	0.28
	All	534	0.03		-0.37	0.42
Sequential (+)/Global(-)	Education	113	0.58	4.38	-0.24	1.39
	Engineering *	235	1.34	4.47	**0.77**	**1.91**
	Liberal arts	186	0.12	4.45	-0.53	0.76
	All*	534	0.75	4.47	**0.37**	**1.13**
Sensing(+)/ Intuitive(-)	Education	113	1.02	5.91	-0.08	2.12
	Engineering*	235	2.02	5.26	**1.35**	**2.70**
	Liberal arts	186	-0.45	6.07	-1.33	0.43
	All	534	0.95	5.79	**0.46**	**1.44**
Visual(+) / Verbal(-)	**Education***	113	3.16	5.09	**2.21**	**4.11**
	Engineering*	235	4.27	5.13	**3.61**	**4.93**
	Liberal arts*	186	1.48	5.28	**0.72**	**2.25**
	All*	534	3.06	5.31	**2.61**	**3.52**

* 95% confidence interval does not include zero.

A two-way analysis of variance on each of the four scales of the ILS was conducted to test whether there are significant mean differences among the colleges and between genders. The results in Table 8 indicate that there are no significant interaction effects, but there are significant mean differences among colleges on all scales and between genders on all scales except for active-reflective. The insignificant interaction effect means that the significant mean differences among colleges are relatively consistent across the two gender groups. Four main effect plots in Figure 2 show the trends in gender and college mean differences. The relatively parallel lines for the two gender groups also indicate the insignificant interaction effect. Tukey-Kramer *post hoc* tests were run to see to what the significant college effect can be attributed on each of the four scales. Table 9 summarizes the results and shows that the engineering students were statistically significantly different from the liberal arts and education students on the Sq-G and S-N scales and from the liberal arts students on the Vs-Vb scale, and the liberal arts students are significantly different from the education students on the A-R and Vs-Vb scales. The fourth column in Table 9 includes the estimated mean differences between two colleges in the second and third column, and the last column gives the p-value adjusted for the multiple comparisons (the experiment-wise error) on each scale. As a result, it is concluded that the engineering students are significantly more sequential and more sensing than the liberal arts and education students and significantly more visual than the liberal arts students.

Table 8 Two-way analysis of variance on each of four scales

Effects	DF	Active(+)/ Refective(-)		Sequential(+)/ Global(-)		Sensing(+)/ Intuitive(-)		Visual(+)/ Verbal(-)	
		F	Pr > F	F	Pr > F	F	Pr > F	F	Pr > F
College	(2, 518)	**3.70**	**0.0252***	**9.60**	**<.0001***	**16.00**	**<.0001***	**9.18**	**0.0001***
Gender	(1, 518)	0.83	0.3620	**13.01**	**0.0003***	**13.34**	**0.0002***	**4.14**	**0.0425***
College*Gender	(2, 518)	2.36	0.0952	0.77	0.4653	0.02	0.9756	1.74	0.1762

* p-value < 0.05

Figure 2. Main effect plots (All - ○, Female - □, Male - △)

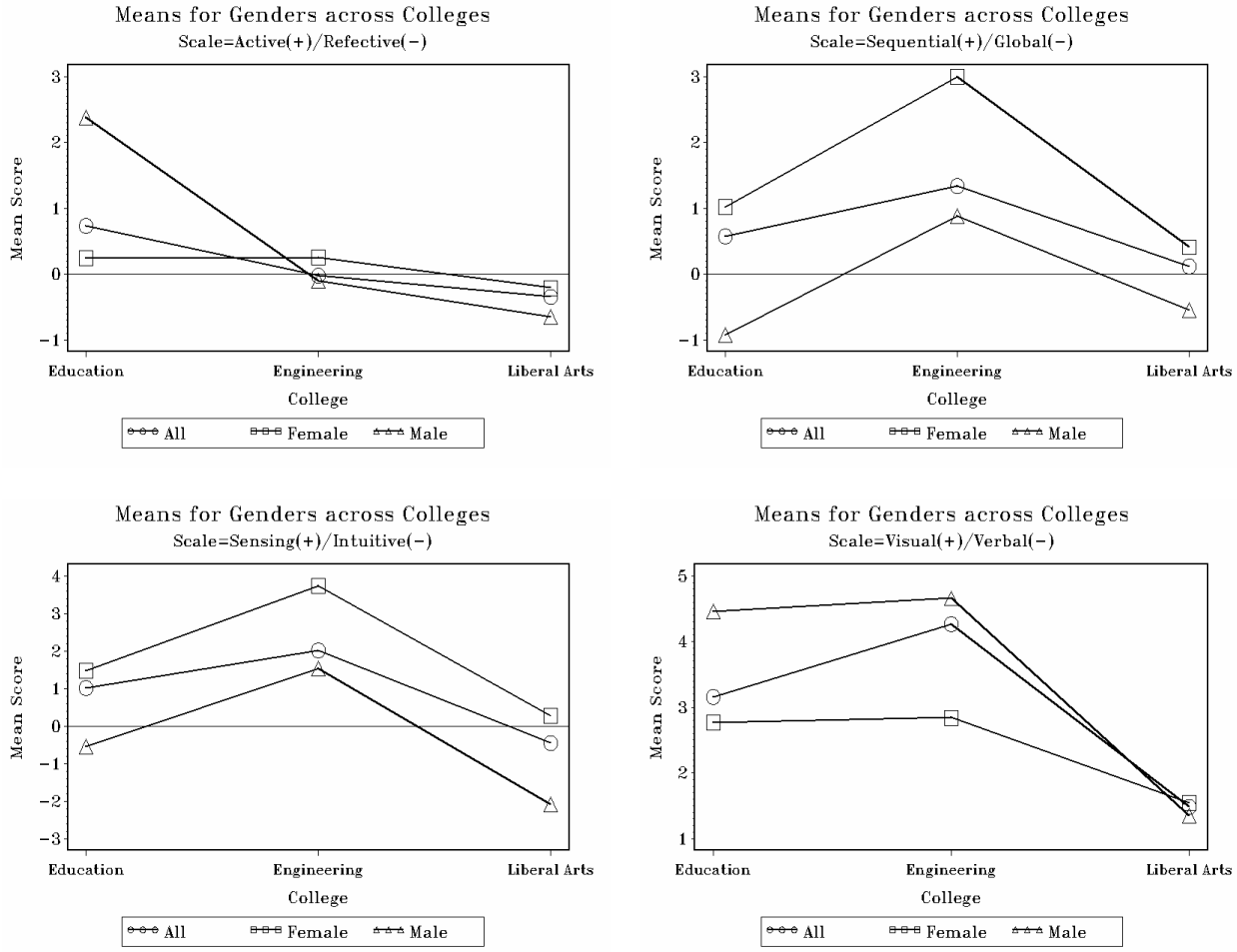


Table 9 Test of difference between colleges on each scale

LS Type	College (i)	College (j)	LS Mean Diff. (i-j)	St. Err.	DF	t	Pr > |t|	Adj P**
Active(+)/ Refective(-)	ED	EN	1.23	0.64	528	1.93	0.0543	0.1317
	ED	**LA**	**1.74**	**0.64**	**528**	**2.72**	**0.0068**	**0.0186***
	EN	LA	0.51	0.52	528	0.97	0.3334	0.5973
Sequential(+)/ Global(-)	**ED**	**EN**	**-1.89**	**0.60**	**528**	**-3.14**	**0.0018**	**0.0050***
	ED	LA	0.12	0.60	528	0.19	0.8469	0.9796
	EN	**LA**	**2.01**	**0.49**	**528**	**4.07**	**<.0001**	**0.0002***
Sensing(+)/ Intuitive(-)	**ED**	**EN**	**-2.17**	**0.77**	**528**	**-2.82**	**0.005**	**0.0138***
	ED	LA	1.38	0.77	528	1.79	0.0742	0.1744
	EN	**LA**	**3.55**	**0.63**	**528**	**5.63**	**<.0001**	**<.0001***
Visual(+)/ Verbal(-)	ED	EN	-0.14	0.71	528	-0.19	0.8459	0.9794
	ED	**LA**	**2.17**	**0.71**	**528**	**3.07**	**0.0023**	**0.0064***
	EN	**LA**	**2.31**	**0.58**	**528**	**3.99**	**<.0001**	**0.0002***

* p-value < 0.05 ** Tukey_Kramer is adopted to adjust p-value for multiple comparisons.

The final *post hoc* tests were conducted to investigate possible gender differences within the engineering student sample on each of scales. The results in Table 10 indicate that female engineering students are, on average, more sequential, more sensing, and less visual than male engineering students. Although the differences are statistically significant, they may not be substantial enough to be of practical importance. As this is the first report of significant gender differences in ILS-assessed learning style preferences, additional study will be undertaken to see if the results can be reproduced and generalized.

Table 10 Comparison of mean scale scores for female and male engineering students

LS Type	LS Mean			St. Err.	DF	t	Pr > |t|
	Female (i)	Male (j)	Diff (i-j)				
Active(+)/Reflective(-)	0.25	-0.10	0.35	0.74	528	0.48	0.6337
Sequential(+)/Global(-)	3.00	0.88	2.12	0.70	528	3.05	**0.0024***
Sensing(+)/Intuitive(-)	3.75	1.54	2.20	0.89	528	2.47	**0.0137***
Visual(+)/Verbal(-)	2.84	4.66	-1.82	0.82	528	-2.23	**0.0261***

* p-value < 0.05

Summary

The reliability estimate of the scores for the four scales of the ILS based on Cronbach alphas ranged from 0.56 to 0.77. Classical item analysis showed that the reliability of the scale scores can be improved by elimination of the weakest item in each scale, with the greatest benefit occurring for the Sequential-Global scale, which went from 0.56 to 0.60. Factor analysis of the ILS identified eight factors associated with the four scales. Analysis of the underlying construct

for each of the factors revealed that they are appropriately matched to the intent of the scales, providing evidence of construct validity for the instrument. The data set was used to compare students in Engineering with those in Education and the Liberal Arts. The analysis revealed that the engineering students are significantly more sequential and more sensing than the liberal arts and education students and significantly more visual than the liberal arts students. The data was also used to explore possible gender differences in learning style preferences between male and female engineering students. The female engineering students tended to be more sequential, more sensing, and less visual than the male engineering students, but the practical implications of these trends and their generality remain to be investigated.

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Appendix

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1. I understand something better after I
   (a) try it out.
   (b) think it through.
2. I would rather be considered
   (a) realistic.
   (b) innovative.
3. When I think about what I did yesterday, I am most likely to get
   (a) a picture.
   (b) words.
4. I tend to
   (a) understand details of a subject but may be fuzzy about its overall structure.
   (b) understand the overall structure but may be fuzzy about details.
5. When I am learning something new, it helps me to
   (a) talk about it.
   (b) think about it.
6. If I were a teacher, I would rather teach a course
   (a) that deals with facts and real life situations.
   (b) that deals with ideas and theories.
7. I prefer to get new information in
   (a) pictures, diagrams, graphs, or maps.
   (b) written directions or verbal information.
8. Once I understand
   (a) all the parts, I understand the whole thing.
   (b) the whole thing, I see how the parts fit.
9. In a study group working on difficult material, I am more likely to
   (a) jump in and contribute ideas.
   (b) sit back and listen.
10. I find it easier
    (a) to learn facts.
    (b) to learn concepts.
11. In a book with lots of pictures and charts, I am likely to
    (a) look over the pictures and charts carefully.
    (b) focus on the written text.
12. When I solve math problems
    (a) I usually work my way to the solutions one step at a time.
    (b) I often just see the solutions but then have to struggle to figure out the steps to get to them.
13. In classes I have taken
    (a) I have usually gotten to know many of the students.
    (b) I have rarely gotten to know many of the students.
14. In reading nonfiction, I prefer
    (a) something that teaches me new facts or tells me how to do something.
    (b) something that gives me new ideas to think about.
15. I like teachers
    (a) who put a lot of diagrams on the board.
    (b) who spend a lot of time explaining.

16. When I'm analyzing a story or a novel
    (a) I think of the incidents and try to put them together to figure out the themes.
    (b) I just know what the themes are when I finish reading and then I have to go back and find the incidents that demonstrate them.
17. When I start a homework problem, I am more likely to
    (a) start working on the solution immediately.
    (b) try to fully understand the problem first.
18. I prefer the idea of
    (a) certainty.
    (b) theory.
19. I remember best
    (a) what I see.
    (b) what I hear.
20. It is more important to me that an instructor
    (a) lay out the material in clear sequential steps.
    (b) give me an overall picture and relate the material to other subjects.
21. I prefer to study
    (a) in a study group.
    (b) alone.
22. I am more likely to be considered
    (a) careful about the details of my work.
    (b) creative about how to do my work.
23. When I get directions to a new place, I prefer
    (a) a map.
    (b) written instructions.
24. I learn
    (a) at a fairly regular pace. If I study hard, I'll "get it."
    (b) in fits and starts. I'll be totally confused and then suddenly it all "clicks."
25. I would rather first
    (a) try things out.
    (b) think about how I'm going to do it.
26. When I am reading for enjoyment, I like writers to
    (a) clearly say what they mean.
    (b) say things in creative, interesting ways.
27. When I see a diagram or sketch in class, I am most likely to remember
    (a) the picture.
    (b) what the instructor said about it.
28. When considering a body of information, I am more likely to
    (a) focus on details and miss the big picture.
    (b) try to understand the big picture before getting into the details.
29. I more easily remember
    (a) something I have done.
    (b) something I have thought a lot about.
30. When I have to perform a task, I prefer to
    (a) master one way of doing it.
    (b) come up with new ways of doing it.
31. When someone is showing me data, I prefer
    (a) charts or graphs.
    (b) text summarizing the results.

32. When writing a paper, I am more likely to
    (a) work on (think about or write) the beginning of the paper and progress forward.
    (b) work on (think about or write) different parts of the paper and then order them.
33. When I have to work on a group project, I first want to
    (a) have "group brainstorming" where everyone contributes ideas.
    (b) brainstorm individually and then come together as a group to compare ideas.
34. I consider it higher praise to call someone
    (a) sensible.
    (b) imaginative.
35. When I meet people at a party, I am more likely to remember
    (a) what they looked like.
    (b) what they said about themselves.
36. When I am learning a new subject, I prefer to
    (a) stay focused on that subject, learning as much about it as I can.
    (b) try to make connections between that subject and related subjects.
37. I am more likely to be considered
    (a) outgoing.
    (b) reserved.
38. I prefer courses that emphasize
    (a) concrete material (facts, data).
    (b) abstract material (concepts, theories).
39. For entertainment, I would rather
    (a) watch television.
    (b) read a book.
40. Some teachers start their lectures with an outline of what they will cover. Such outlines are
    (a) somewhat helpful to me.
    (b) very helpful to me.
41. The idea of doing homework in groups, with one grade for the entire group,
    (a) appeals to me.
    (b) does not appeal to me.
42. When I am doing long calculations,
    (a) I tend to repeat all my steps and check my work carefully.
    (b) I find checking my work tiresome and have to force myself to do it.
43. I tend to picture places I have been
    (a) easily and fairly accurately.
    (b) with difficulty and without much detail.
44. When solving problems in a group, I would be more likely to
    (a) think of the steps in the solution process.
    (b) think of possible consequences or applications of the solution in a wide range of areas.