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Differences in Learning and Study Strategies between Home and International Students on a Foundation Year in Science and Engineering

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This study considers the diagnostic potential of the Learning and Study Strategies Inventory (LASSI) for a mixed cohort of British and International students on a Foundation year Engineering and Physical Sciences course at a British university. A LASSI questionnaire was completed by the cohort (n = 195, 99/96 - British/International) at the commencement of their studies. Correlations between the constructs measured by this psychometric instrument and the academic results of the dual cohort were examined to determine any diagnostic potential of the instrument and to elucidate any differences between the British and the International students that might inform future practice. Significantly different correlations between academic performance and some of LASSI subscale were found between the two groups, which analysis suggests did not stem from differences in the function of the instrument. The results suggest that university students are likely to benefit from training in strategic studying and learning skills in order to improve academic outcomes and develop more successful life-long learners by supplementing their innate intellectual talents. However, the strengths of the correlations between the aspects of strategic learning measured by the LASSI and academic outcomes suggest that the LASSI alone is not sufficiently discriminating to identify those individual students most in need of intervention.

Introduction

Weinstein (2010) defines a learning strategy as “any behavioural, cognitive, metacognitive, motivational, or affective process or action that facilitates understanding, learning, and meaningful encoding into memory”.

The human mind is generally classified into three modes of mental functioning: cognitive, conative and affective (Snow, 1996). The cognitive domain encompasses any process where the learner becomes aware of, or obtains knowledge of, an object or idea. It is described by words such as perceiving, recognising, conceiving, sensing, judging, and reasoning. The affective

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domain refers to temperament, mood, and emotions. The conative domain encompasses motivation, desire and volition (Snow, 1996; Kupermintz, 2002). Cognition and conation have also been related: cognition is the process of gaining knowledge, whereas conation is the desire to know (Maslow 1943). Students with similar levels of cognitive skills have a range of outcomes academically because many important differences in achievement and aptitude are affective or conative, rather than cognitive; Kupermintz (2002) found that both affective and conative variables were important predictors of individual differences in science achievement. Although strong cognitive skills are an important component of ultimate academic outcomes students' academic performance is affected by their repertoire of aptitude resources, which has been developed and structured throughout their learning histories, and which are not all cognitive (Kupermintz, 2002), plus a range of personal factors. The three domains have also been linked together by Fishbein and Ajzen's (1975) Theory of Reasoned Action, which related the successful achievement of an action to a path through the cognitive domain (represented by beliefs) to the affective domain (attitude) to the conative domain (intention). Teachers therefore need to understand variations in learners' motivation, attitude and style as well as in their cognitive ability (Snow, 1996).

A subset of study and learning strategies involves self-regulation (Weinstein, 2010) and the self-regulated application of learning and study strategies. Requiring students to accept greater responsibility for the success of their learning enables students to become lifelong learners (Weinstein 2011), which is a requirement of ever-changing demands of the modern workplace (Cornford, 2002).

The Learning and Study Strategies Inventory (LASSI)

The Learning and Study Strategies Inventory or LASSI (Weinstein et al., 1987) is a widely used psychometric instrument that was developed to measure ten learning characteristics of adults, which were believed to be essential components for academic success, in response to a perceived increase in academically underprepared students entering post-secondary education (Weinstein, 1987). The LASSI is purported to be "a diagnostic and prescriptive measure that assesses student thought processes and behaviours that impact studying and learning", which provides measures of students' capabilities against normative samples, enabling the self-diagnosis, or a framework for subsequent intervention (Weinstein et al., 1987). The ten LASSI subscales (each subscale covering one learning characteristic) identify strengths and weaknesses in cognitive, conative, and affective readiness for academic success and ability to manage academic demands (Finch, 2016; Weinstein and Palmer, 2002). The LASSI has been used in thousands of colleges and universities over the last thirty years, including in translation.

The original LASSI, used in this study, comprises seventy-seven items. Each item is a descriptive statement. Students were required to use the following five-point Likert-type scale to compare themselves against each description:

> 5 - "Very much typical of me". The statement would always describe you or it would be true of you almost all the time.
> 4 - "Fairly typical of me". The statement generally would be true of you.
> 3 - "Somewhat typical of me". The statement would be true of you about half of the time.
> 2 - "Not very typical of me". The statement generally would not be true of you.
> 1 - "Not at all typical of me". The statement would never describe you, or it would be true of you only rarely.

Each item on the LASSI questionnaire is associated with one of ten subscales: Anxiety (ANX), Attitude (ATT), Concentration (CON), Information-processing (INP), Motivation (MOT), Selecting Main Ideas (SMI), Self-testing (SFT), Test Strategies (TST), Time Management (TMT) and Study Aids (STA). Nine of the ten subscales have eight items; the SMI subscale has five items.

A detailed description of what is assessed by each subscale can be found in Weinstein and Palmer (1987 and 2002). For example: "The Anxiety Subcale assesses the degree to which students worry about school and their academic performance. Do students worry so much that it is hard for them to concentrate? Are they easily discouraged by low grades?"

The limitations of self-reporting instruments are well documented; however Weinstein states that "it remains the best method for providing a window on the mind" (Weinstein, 2010). The LASSI has been updated twice, but the greater amount of research remains focussed on the original version, providing this study with more potential for comparison and confirmation of results. Although some authors have made use of research conducted using the original LASSI as the basis of analysis of later editions, despite the fact that the ten subscales remained the same in name and stated purpose in the second edition, it is unclear whether the interrelatedness of the subscales could be expected to remain sufficiently similar to warrant these cross comparisons considering that only 38 items (Prevatt, 2006) from the original LASSI were unchanged in the new 80 item second edition.

With the release of the second edition of LASSI, Weinstein et al. (2002) identified that each of the LASSI subscales was primarily related to one of the three components of strategic learning: skill, will and self-regulation, following on from Weinstein's Theory of Strategic Learning. All three components are thought to interact with each other to create effective and efficient learning (Weinstein et al., 2011)

'Skill' examines students' strategies and cognitive processes in identifying, acquiring and constructing meaning of new information and in test preparation (Information Processing, Selecting Main Ideas, and Test Strategies). 'Will' examines students' attitudes towards learning, their interest, diligence and self-discipline and ability to manage worry about academic performance (Anxiety, Attitude, and Motivation). 'Self-regulation' examines students' ability to manage the whole learning process by effective use of time, maintenance of concentration over time, self-assessment against and use of study support materials (Concentration, Self-Testing, Study Aids, and Time Management) (Weinstein, 2002). These combinations of LASSI subscales were not deduced empirically, and given that the description of the LASSI subscales did not change, it has been assumed to apply also to the original LASSI (Prevatt, 2006).

Predictive Value of the LASSI

If the LASSI is a valid instrument, and those aspects of strategic learning purportedly measured by the LASSI are actually required for academic success, then it should be expected that correlations between the LASSI subscales scores and measures of academic achievement would be found. Such correlations have been reported against some, or all, of the LASSI subscales.

Haynes (1988) found the LASSI discriminated between the upper and lower tertiles of student ability. However, there was less difference in subscale scores between higher ability and average students, where only ANX, TST, MOT and ATT subscales were higher in the upper tertile, compared to the middle, and by a much smaller margin than between upper and lower tertiles. Albaili (1997) found, using an Arabic translation of the original LASSI, that lower performing students had significantly lower scores on all LASSI subscales than average or higher performing students but found no significant differences between the average and higher performing groups. Both Haynes (1988) and Albaili (1991) found MOT to be the greatest discriminating factor between highest and lowest achieving tertiles, whilst Yip (2007) found MOT to be the second most discriminating subscale after ATT. Hulick and Higgson (1989) found all subscales, except TMT, differentiated between high and low GPA college freshmen; however, the difference was only significant on ANX, MOT, ANX, CON, INP and TST subscales.

Haynes (1998) also found that female students scored significantly higher on all subscales than an approximately equal number of male students, with no correlation between gender and academic performance. Olaussen and Braten (1998) found female students only scored higher on the MOT, TMT and STA with male students scoring higher on ANX and INP.

A South African study found statistically different scores between students having English as a first vs a second language; consideration of confounding variables aside, the subscales TMT, INP and SFT were found to be significantly higher for the African students with English as a second language compared to the group of white and Indian students whose first language was English (Agar, 1995). Yip (2007), using a Chinese version of LASSI, found all ten LASSI subscales differentiated between low and high performing students. Sizoo et al. (2002) found no statistical differences for male students on any subscale, between the learning strategies of International students compared to American students in an American business school, but differences on the ANX INP and STA subscales for female students. Olaussen and Braten (1999) validated the cross-cultural application of the LASSI comparing American and Norwegian groups and finding differences only on the MOT and ATT subscales. This was interpreted as suggesting Norwegians value education more highly but have less faith in the value of effort compared with the American group.

The variety of results that have been reported make it unclear how reliably a score on any LASSI subscale can be expected to predict academic performance, but still suggests that there is useful information to be found from the LASSI, and that the instrument has utility even when only a subset of the subscales indicate students at risk of underperformance.

Reliability and Validity of the LASSI

Validity, the degree to which an instrument measures what it purports to measure, and reliability, the degree to which an instrument measures consistently, are closely associated. An instrument cannot be valid unless it is also reliable; however reliability is independent of validity (Nunnally, 1994).

The importance of providing reliability coefficients of the subscale score was emphasised by Wilkinson (1999). Cronbach (1951) developed the alpha coefficient to measure the internal consistency of a test, where multiple items are expected to measure the same construct; it is probably the most widely used objective measure of reliability, possibly because of its simplicity of application (Tavakol, 2011; Streiner 2003). The higher the alpha coefficient for a test instrument the lower the fraction of the test score attributable to measurement (random) error. Specifically, $1 - \alpha^2$ = the error variance; the fraction of the test score attributable to random error (Nunnally, 1994; Tavakol, 2011).

A test cannot simply be said to be reliable or unreliable. As Wilkinson (1999) put it, "Reliability is a property of the scores on a test for a particular population of examinees"; so published values of alpha should not be relied upon (Feldt and Brennan, 1989; Streiner, 2003). A group with greater homogeneity will have a higher alpha coefficient, and vice versa (Streiner, 2003).

Nunnally (1978) advised that in basic research a reliability of 0.7 was sufficient; but in an applied setting, where decisions would be based on test scores, 0.9 must be the minimum accepted. However, Streiner (2003) recommends 0.9 as the limit beyond which item redundancy is highly likely contributing to the higher value.

Validity is not a property of the test or assessment as such, but rather of the meaning of the test scores (Messick, 1995). Assessment of validity requires a reasoned judgement of the extent to which an interpretation of the test scores is supported by empirical evidence and theoretical rationales (Messick, 1989).

Latent Structure of the LASSI: Factor Analysis

Concerns have been raised over the psychometric properties of the LASSI, and whether the seventy-seven items chosen by its authors actually measure the ten aspects of strategic learning described, and whether each of the ten subscales was primarily related to the specific one of the three components of Weinstein's model of strategic learning (Melancon, 2003; Olaussen and Braten, 1998; Olejnick and Nist, 1992; Cano, 2006). This is in part because Weinstein et al. did not use factor analysis when composing the LASSI, and compiled the items used from a larger list grouped together by a teams of experts, and refined after trials using the Cronbach's alpha to select the final item list (Weinstein et al. 1988).

A number of studies have conducted exploratory factor analyses on LASSI data sets performing a principal components analysis on the correlation matrix of the ten subscales to extract the factors using an oblique rotation to determine the factor structure (Olejnik and Nist, 1992; Olaussen and Braten, 1998; Cano, 2006). The analysis of latent structure has been used by other researchers to confirm the similarity in psychometric behaviour of the instrument with different language versions and across cultures (Olaussen and Braten, 1998).

Olejnik and Nist (1992), using the Promax method of oblique rotation, reported finding three latent variables were measured by the LASSI; their choice of three factors relied on consideration of the scree plot, with the third eigenvalue having been 0.933. The three latent constructs were named 'effort-related activities', 'goal orientation' and 'cognitive activities'. The 9 LASSI subscales composing the three factors were: MOT, TMT and CON; ANX, SMI and TST; INP, STA and SFT. The ATT was most strongly correlated to the effort-related activity factor, but less strongly than other subscales were to one of the latent factors, and Olejnick and Nist (1992) considered it too low for inclusion. These three latent constructs did not match those proposed by Weinstein (2002). Olejnik and Nist (1992) also calculated Cronbach's alpha for the two groups used in their study and found results similar but a little lower than those reported by Weinstein (2002).

Olaussen and Braten (1998) also concluded that three latent factors were measured by the LASSI using the Kaiser-Gutman rule of 1.0 as the minimum eigenvalue for two separate samples of Norwegian students; the scree plots also indicated three factors. They then used the Direct Oblimin method of oblique rotation to determine which subscales constituted each factor. Olausen and Braten (1998) found a similar structure to Olejnick and Nist (1992) except that ATT was now more strongly correlated. Olausen and Braten (1998) kept the names assigned by Olejnick and Nist (1992) and found the latent factors composed as follows: 'effort-related activities' - ATT, MOT, TMT ,and CON subscales; 'goal orientation' - ANX, SMI, and TST; 'cognitive activities' - INP, STA, and SFT. Olausen and Braten (1998) found the factor structure to be similar between the two cohorts they studied, with only the CON subscale having a high pattern coefficient on both the first and second factor for their second-year sample.

Cano (2006) also used the Direct Oblimin method of oblique rotation, with delta set to zero, to determine the pattern structure, after factor extraction using the Kaiser-Gutman rule and Catell's scree plot test. Cano (2006) named his three factors Affective Strategies, Goal Strategies and Comprehension Monitoring Strategies. Cano's three factor structure only accounted for 66.24% of variance before rotation. Considering only the highest pattern coefficients, the composition of the three factors were identical to those found by Olausen and

Braten (1998). Cano (2006) also demonstrated that this solution was stable across three sub-cohorts, grouping students by faculty, and determined the correlations between the academic performance of first and last year students in the study and the three latent structures.

Participants

195 students completed both the LASSI and the required assessments across four engineering and science modules and two mathematics modules. Ninety-nine students (84 male, 15 female) were classed as British Students by their fee status, which has residency and citizenship requirements. All had English language ability sufficient to meet university entrance standards. Ninety-six students (75 male, 22 female) were International, and had a variety of experience levels with English as a second language. Forty-nine of the international students had Arabic as their first language; originating from seven countries.

Procedure

The questionnaire was completed using the institution's online test platform during the first week of teaching. No feedback was given during the academic year that might influence possible correlations between LASSI subscale results and academic performance. Although students did receive instruction in some aspects of study skills covered by the LASSI the instructors did not have sight of the students LASSI results. At the end of the year, those students who completed all components of the course had their average percentage scores in the four engineering and science modules and in the two mathematics modules calculated and matched to their LASSI scores. All personal information was deleted to ensure confidentiality and the anonymised data set was then analysed using MS Excel and IBM DPSS programmes.

Results

Table 1 presents Cronbach's coefficient alpha for the scores on each of the ten LASSI subscales for the British and International students and a range of alpha coefficient values from the published data in a selection of similar and commonly cited studies. All but two of the alpha coefficient values are greater than or equal to 0.7; the level required for an acceptable level of reliability in a research instrument (Nunnally, 1978). No alpha is above 0.9; the level that would suggest items are redundant (Streiner, 2003).

	ANX	ATT	CON	INP	MOT	SMI	SFT	TST	TMT	STA
British	0.88	0.73	0.82	0.74	0.80	0.74	0.71	0.77	0.81	0.36
International	0.85	0.70	0.86	0.76	0.71	0.53	0.75	0.76	0.72	0.72
LASSI Manual*	0.81	0.72	0.84	0.83	0.81	0.74	0.75	0.83	0.86	0.68
Literature range**	0.76 - 0.86	0.66 - 0.77	0.78 - 0.85	0.72 - 0.82	0.68 - 0.83	0.67 - 0.81	0.63 - 0.85	0.72 - 0.79	0.81 - 0.87	0.57 - 0.74

*Weinstein et al (1987); ** (Olejnick & Nist (1992), Olaussen & Braten (1998), Flowers (2012), Chacko (1991), Cano (2006), Flowers (2003))

Table 1: Cronbach's Alpha Results

For British students the alpha coefficient was unusually low on the STA subscale, whereas the International cohort had an unusually low score on the SMI subscale. Low values of Cronbach's alpha can arise from there being too few items on a scale, a low level of inter-relatedness of items, or items that are not homogeneous.

Another measure of the internal consistency of a test scale is the average inter-item correlation. Clark and Watson (1995) recommend that the average inter-item correlation fall in the range of .15—.50 with the lower part of the range being appropriate for broader constructs such as extraversion and the high part of the range being required for very narrow constructs. An item level analysis was performed on the subscales, calculating the inter-item correlations within each subscale. The average value of each item's correlations with the other seven items (four for SMI) is shown in table 2.

Item	1		2		3		4		5		6		7		8	
	BRIT	INTL	BRIT	INTL	BRIT	INTL	BRIT	INTL	BRIT	INTL	BRIT	INTL	BRIT	INTL	BRIT	INTL
ANX	0.39	0.41	0.35	0.33	0.43	0.42	0.54	0.50	0.53	0.35	0.52	0.51	0.59	0.53	0.57	0.47
ATT	0.19	0.14	0.24	0.23	0.29	0.16	0.15	0.23	0.22	0.24	0.15	0.14	0.32	0.30	0.33	0.19
CON	0.39	0.45	0.27	0.43	0.34	0.42	0.41	0.52	0.44	0.50	0.33	0.44	0.40	0.30	0.48	0.44
INP	0.29	0.24	0.19	0.28	0.24	0.23	0.34	0.27	0.35	0.32	0.31	0.39	0.19	0.28	0.24	0.28
MOT	0.33	0.24	0.37	0.30	0.20	0.19	0.34	0.25	0.38	0.16	0.36	0.19	0.31	0.22	0.28	0.21
SMI	0.37	0.09	0.23	0.13	0.37	0.28	0.27	0.12	0.41	0.29						
SFT	0.22	0.26	0.20	0.32	0.23	0.23	0.16	0.29	0.19	0.23	0.15	0.26	0.26	0.36	0.25	0.25
TST	0.29	0.24	0.23	0.24	0.34	0.32	0.03	-0.09	0.28	0.22	0.18	0.14	0.26	0.28	0.32	0.27
TMT	0.28	0.28	0.44	0.26	0.41	0.36	0.38	0.30	0.29	0.17	0.31	0.08	0.43	0.29	0.26	0.20
STA	0.09	0.21	0.19	0.29	0.01	0.21	0.03	0.14	0.05	0.29	0.12	0.27	0.09	0.19	0.03	0.20

Table 2: Mean of the correlations between each item and all other items on each subscale

For the SMI subscale the low alpha coefficient for International students can be attributed to the lower inter-item correlations; one of the items had negative correlation with some (not all) other items. On the STA subscale it was found that several inter-item correlations were negative, resulting in the majority of the average inter-items correlations falling close to 0; two items had negative correlations against three other items each, one of the items had a correlation r = - 0.22 against the average value, suggesting the item was being interpreted in the opposite sense to the other items on that subscale; the correlation was also negative, but weaker, r = - 0.13, for the same item for the International cohort. The low values of coefficient alpha on these two subscales suggest variations in interpretation of some of the items used on those subscales between the cohorts. The low inter-item correlation of item 4 on the TST subscale has not resulted in any apparent issues.

	Mean			SD		
	BRIT	INTL	Range*	BRIT	INTL	Range*
ANX	22.7	22.4	23.2 - 29.2	7.4	6.8	5.4 - 6.5
ATT	32.2	32.4	31.5 - 33.4	4.5	4.3	3.8 - 4.9
CON	26.3	26.8	24.9 - 27.5	5.8	6.1	5.0 - 6.1
INP	29.3	29.3	25.4 - 28.6	4.7	4.9	4.4 - 6.1
MOT	30.4	30.2	25.5 - 33.2	5.3	4.6	4.9 - 5.4
SMI	18.3	18.2	17.3 - 19.3	3.6	2.9	2.7 - 3.9
SFT	26.9	28.0	23.1 - 26.6	4.8	5.2	4.2 - 5.5
TST	27.9	28.0	27.3 - 31.2	5.6	5.0	4.0 - 5.9
TMT	25.0	26.2	22.4 - 26.2	5.9	5.0	6.0 - 6.8
STA	25.4	25.8	24.1 - 26.6	3.9	5.1	4.3 - 5.3
Mean	26.4	26.7	25.6 - 27.7			

Table 3: Mean and Standard Deviation (SD) of LASSI subscale scores for British and International Cohorts in present study, compared to collated range of reported scores (Olejnick and Nist, 1992; Olaussen and Braten, 1998 ; Flowers, 2012; Chacko,1991; Cano,2006; Flowers 2003)

The majority of mean scores on each LASSI subscale and standard deviations found in the present study lie within the ranges collated from the literature (see Table 3 description). The mean and total scores from the ten subscales were very similar between the British and International cohorts and fell in the middle of the range of means and totals found in the literature sample cited. The ANX scores for both British and International students are lower than others reported and have higher standard deviations, but are similar between cohorts. The INP scores were identical for the cohorts but were higher than the literature range, with standard deviations at the lower end of the published range. The SFT scores were both also higher than the published range, with standard deviations within the published range. The TMT scores were both within the published range but had standard deviations lower than typical. The SMI and STA means were within the published ranges, but the International cohort on the SMI subscale and the British cohort on the STA subscale had lower than typical standard deviations.

The greatest difference between British and International subscale scores was found on the TMT subscale followed by SFT, which were 4.6% and 4.1% higher respectively for the International cohort. The differences between British and International scores were less than 2.1% on the remaining subscales. These differences cannot be considered significant between two very different cohorts, given that Olaussen and Braten (1998) found three mean subscale scores that differed between two different cohorts of Norwegian college students (first-year compared with second-year) in the range 6.3% to 8.7%, with a further mean subscale difference greater than 3%.

Tables 4 and 5 present the average scores on each of the ten LASSI subscales for students with different levels of achievement.

	BRIT E&P			INTL E&P			BRIT MATH			INTL MATH		
	Highest Quartile	Lowest Quartile	Δ (%)	Highest Quartile	Lowest Quartile	Δ (%)	Highest Quartile	Lowest Quartile	Δ (%)	Highest Quartile	Lowest Quartile	Δ (%)
ANX	24.2	24.3	-0.4	22.8	22.8	-0.1	24.4	23.4	4.1	21.9	22.8	-3.9
ATT	33.2	30.4	9.2	34.3	32.0	7.2	32.2	30.4	5.8	33.3	33.1	0.8
CON	28.9	26.1	10.6	28.4	26.9	5.6	28.0	25.7	8.8	27.4	25.0	9.5
INP	28.8	29.8	-3.2	29.8	29.1	2.3	29.3	29.7	-1.3	30.4	29.7	2.2
MOT	30.6	29.3	4.4	32.3	29.8	8.2	31.0	29.3	5.9	31.6	30.0	5.1
SMI	19.1	18.9	1.1	18.9	17.8	6.3	18.5	18.2	1.5	18.7	18.3	2.5
SFT	27.4	25.7	6.4	29.7	27.3	8.9	27.6	24.9	10.6	29.7	27.4	8.6
TST	29.6	28.0	5.5	28.6	27.6	3.4	29.3	28.1	4.4	28.2	28.3	-0.6
TMT	26.3	23.6	11.6	28.2	25.0	13.0	26.6	23.9	11.2	28.3	23.6	20.0
STA	25.3	24.2	4.3	26.2	26.0	1.0	25.3	23.9	5.9	26.4	25.3	4.6
MEAN	27.3	26.0	5.0	27.9	26.4	5.6	27.2	25.8	5.6	27.6	26.3	4.7

Table 4: Comparison of LASSI subscales average scores vs level of academic achievement for highest and lowest quartiles.

Seven subscales differentiated between the highest and lowest quartiles for both British and International students in both Engineering and Physical Science (E&P) modules and Mathematics (MATH) modules. The subscale that discriminated between highest and lowest quartiles most, across both cohorts and both subjects, was TMT; but the second and third most discriminating subscales varied between cohorts and subjects. The three most discriminating subscales for each cohort subject combination were statistically significant: $p < 0.05$, using t-test assuming unequal variances. For British students TMT followed by CON then ATT were the most discriminating subscales for E&P while for MATHS they were TMT followed by SFT then CON. For the International students the most discriminating subscales were TMT followed by SFT then CON for E&P, and TMT followed by CON then SFT for MATH.

Table 5 compares the mean LASSI subscale scores for students in the highest, middle and lowest tertiles of academic performance in each of E&P (mean of 4 modules) and MATH (mean of 2 modules). For both E&P and MATH for both cohorts the mean LASSI subscale score was greater for the highest performing tertile compared to both middle and lowest tertiles; however the mean scores did not differentiate between middle and lowest tertiles. No individual subscale differentiated sequentially between highest, middle and lowest subscales for both cohorts and both subjects.

For E&P, TMT differentiated sequentially between the three tertiles for both British and International students; ATT, CON. MOT and SFT differentiated highest from middle/lowest.

	BRIT E&P			INTL E&P			BRIT MATH			INTL MATH		
	Highest Tertile	Middle Tertile	Lowest Tertile	Highest Tertile	Middle Tertile	Lowest Tertile	Highest Tertile	Middle Tertile	Lowest Tertile	Highest Tertile	Middle Tertile	Lowest Tertile
ANX	24.3	20.3	23.4	21.6	23.0	22.7	24.0	21.2	22.8	22.1	23.0	22.1
ATT	33.6	32.0	31.0	33.5	31.8	31.8	32.7	32.9	30.9	32.7	31.4	33.0
CON	28.6	24.8	25.5	28.3	26.3	25.9	27.9	25.3	25.7	27.4	26.9	26.2
INP	29.0	29.3	29.6	29.0	29.9	29.0	29.2	29.3	29.5	29.7	28.3	29.9
MOT	31.5	29.9	29.8	31.7	29.2	29.7	31.2	30.4	29.6	31.2	29.0	30.4
SMI	18.9	17.4	18.5	18.8	18.3	17.5	18.6	18.2	18.1	18.5	17.8	18.2
SFT	27.8	26.7	26.2	28.8	27.2	28.0	27.7	27.3	25.7	29.4	27.0	27.5
TST	29.6	25.8	28.2	28.4	28.2	27.4	29.3	26.8	27.6	27.9	28.3	27.9
TMT	26.2	25.2	23.8	27.7	26.1	24.8	26.5	24.2	24.4	27.5	26.1	25.0
STA	25.0	26.3	25.0	25.7	25.5	26.2	26.0	26.3	24.0	26.3	24.9	26.2
MEAN	27.5	25.8	26.1	27.3	26.5	26.3	27.3	26.2	25.8	27.3	26.3	26.6

Table 5: Comparison of LASSI subscales average scores vs level of academic achievement in tertiles

For MATHS only TMT differentiated between all three tertiles sequentially for the International students; CON and MOT differentiated highest from middle/lowest tertiles for both cohorts. Generally, on seven subscales the highest tertile had the highest scores; but across all subscales the lowest tertile scores were almost as likely to be higher than the middle tertile scores as vice versa.

Factor Analysis

An exploratory principal component analysis using the correlation matrix of the ten LASSI subscales was performed to determine the number of factors measured by the instrument.

	Pattern Matrix Component			**Structure Matrix Component**				**Pattern Matrix Component**			**Structure Matrix Component**		
BRIT	**1**	**2**	**3**	**1**	**2**	**3**	**INTL**	**1**	**2**	**3**	**1**	**2**	**3**
ANX	0.019	-0.291	**0.803**	0.238	-0.285	**0.809**	**ANX**	-0.103	0.037	**0.882**	0.137	-0.115	**0.850**
ATT	**0.659**	0.101	0.140	**0.739**	0.283	0.386	**ATT**	**0.678**	-0.118	0.228	**0.712**	-0.001	0.423
CON	**0.854**	-0.314	0.169	**0.830**	-0.078	0.487	**CON**	**0.823**	-0.202	0.179	**0.825**	-0.045	0.425
INP	-0.059	**0.825**	0.276	0.271	**0.809**	0.255	**INP**	-0.142	**0.910**	0.210	0.115	**0.847**	0.040
MOT	**0.739**	0.285	-0.028	**0.807**	0.489	0.248	**MOT**	**0.704**	0.270	-0.100	**0.738**	0.441	0.045
SMI	0.037	0.327	**0.799**	0.425	0.339	**0.813**	**SMI**	0.419	0.200	**0.580**	0.616	0.208	**0.661**
SFT	0.528	**0.567**	-0.052	0.665	**0.712**	0.146	**SFT**	0.517	**0.559**	-0.304	0.561	**0.719**	-0.250
TST	0.214	0.061	**0.810**	0.533	0.122	**0.890**	**TST**	0.332	-0.070	**0.763**	0.517	-0.107	**0.860**
TMT	**0.866**	-0.030	-0.033	**0.845**	0.209	0.290	**TMT**	**0.805**	0.022	-0.046	**0.798**	0.208	0.163
STA	0.089	**0.733**	-0.202	0.215	**0.757**	-0.168	**STA**	0.060	**0.799**	-0.105	0.210	**0.828**	-0.206

Component Correlation Matrix (BRIT)

	1	**2**	**3**
1	1.000	0.276	0.373
2	0.276	1.000	0.002
3	0.373	0.002	1.000

Component Correlation Matrix (INTL)

	1	**2**	**3**
1	1.000	0.222	0.263
2	0.222	1.000	-0.146
3	0.263	-0.146	1.000

Extraction Method: Principal Component Analysis. Rotation Method: Direct Oblimin with Kaiser Normalisation.

Table 6: Pattern and Structure matrices for British and International Cohorts

The first four eigenvalues were found to be 4.145, 2.035, 1.102 and 0.685 for British students and 3.977, 2.222, 1.067 and 0.727 for International students. Therefore, using the Kaiser-Guttman rule of 1.0 as the maximum eigenvalue for factor extraction, both the British and the International cohorts presented three factors. The scree plots also indicated three factors. This suggests that only three latent variables were measured in this implementation of the LASSI instrument with these cohorts. The grouping of subscales into factors was identical between the British and International groups, and although the correlations and secondary loadings varied, as would be expected between any two cohorts, the similarity in the factor analysis supports the assumption that the test instrument behaved sufficiently similarly between the study cohorts that the differences found cannot be attributed solely or significantly to the test instrument. Taking only the factors most strongly correlated with each of the LASSI subscales, the three factors grouped the LASSI subscales as follows: ATT, CON, MOT and TMT; ANX, SMI and TST; INP, STA and SFT. This matches those found in previous studies (Cano, 2006; Olejnick, 1992; Olaussen, 1998). The majority of the loadings were in the 'excellent' range suggested by Comrey and Lee (1992) at greater than 0.71 (indicating 50% overlapping variance); The exceptions were the SFT subscale for British and International students and the SMI subscale for International students. The loading of the SMI variable onto the second and third factors was less differentiated in the International cohort, compared to the British cohort, falling from 0.78:0.34 to 0.59:0.36 for the International cohort, which remains in keeping with the literature, where the ratio of loadings for SMI was 0.61:0.3 (Olejnick, 1992), 0.65:0.4 (Cano, 2006 - science cohort) and 0.67:032 (Olaussen, 1998). The difference in loading of the SFT subscale on the first and second factor (or first and third for International students) was 0.03 for British students and 0.04 for International students, which was low compared to that reported for other groups, although Cano (2006) did have a difference of only 0.09 in his social science subset.

The Direct Oblimin oblique rotation method was selected to enable closer comparison with published work. Use of an oblique method, on the basis that the factors might have been correlated, did yield increased inter-factor correlations and beta loading coefficients (compared to orthogonal methods; results not presented). However, the factor correlation matrix only weakly supported the use of oblique rotation. The decision whether to use an oblique or an orthogonal rotation depends upon the degree of correlation of the factors. Tabachnick and Fidell (2018) suggest that best way to decide between the two is to first assume that the factors are correlated, and use an oblique rotation option, then consider the factor correlation matrix: if the inter-factor correlations are lower than $|0.32|$ then there is less than 10% overlap in variance among factors and the solution is nearly orthogonal, and an orthogonal rotation option such as Varimax should be used. However, where the inter-factor correlations exceed .32, then there is enough variance to warrant oblique rotation. One pair of factors for the British cohort and none of the pairs of factors in the International cohort exceeded .32 inter-factor correlation.

Correlations between LASSI Subscales and Academic Outcomes

Table 7 shows the correlations between LASSI subscales and the students' performance on average across the engineering and science (E&S) modules and the mathematics (MATH) modules. For British students there was a significant positive correlation between academic performance in E&S and five of the LASSI subscales (CON, MOT, SFT, TST and TMT), and between average performance in MATHS and three of the subscales (ATT, TST and TFT). The ATT subscale showed the strongest correlation to academic performance in both subject areas. For British students there was also a significant positive correlation between the mean (or total) score across the ten LASSI subscales and performance in both E&S and MATHS. For the International cohort only one significant correlation was found, which was on the TMT (time management) subscale; the correlation was stronger with MATHS. Some correlations became stronger, without loss of statistical significance, when only male students were considered. There were no significant correlations found for the female students.

	BRIT E&S	INTL E&S	BRIT MATHS	INTL MATHS	BRIT MALE E&S	INTL MALE E&S	BRIT MALE MATHS	INTL MALE MATHS
ANX	NC	NC	0.102 (NS)	NC	NC	NC	0.149 (NS)	NC
ATT	0.330 (0.001)	0.152 (NS)	0.261 (0.005)	NC	0.363 (0.001)	0.120 (NS)	0.278 (0.005)	NC
CON	0.180 (0.037)	NC	0.139 (NS)	NC	0.153 (NS)	NC	0.101 (NS)	NC
INP	NC	NC	NC	NC	NC	NC	NC	NC
MOT	0.173 (0.043)	0.141 (NS)	NC	NC	0.143 (NS)	0.148 (NS)	NC	NC
SMI	0.103 (NS)	0.120 (NS)	0.155 (NS)	NC	0.106 (NS)	NC	0.159 (NS)	NC
SFT	0.231 (0.011)	0.116 (NS)	0.236 (0.009)	0.169 (NS)	0.197 (0.035)	NC	0.225 (0.020)	0.134 (NS)
TST	0.167 (0.049)	NC	0.249 (0.006)	NC	0.175 (0.055)	NC	0.270 (0.006)	NC
TMT	0.190 (0.029)	0.271 (0.004)	0.153 (NS)	0.326 (0.001)	0.200 (0.034)	0.263 (0.011)	0.164 (NS)	0.322 (0.002)
STA	NC	NC	0.120 (NS)	NC	0.111 (NS)	NC	0.159 (NS)	NC
Mean	0.218 (0.015)	0.154 (NS)	0.234 (0.010)	0.141 (NS)	0.213 (0.026)	0.116 (NS)	0.239 (0.014)	NC

NC (No Correlation) = Pearson's $r < 0.1$, NS (Not Statistically Significant) = $p > 0.05$; E&S = Engineering and Science Modules

Table 7: Correlation of the LASSI subscale with final grades in Engineering and Science or Mathematics

The size of the sample required that correlations coefficients of $r = 0.44$ for British female students ($n = 15$) and $r = 0.37$ for International female students ($n = 22$) be achieved before statistical significance ($p \leq 0.05$) would be reached. However, a couple of interesting less significant correlations did appear for the British female students for Concentration ($r = 0.354$, $p = 0.098$) and Self-testing ($r = 0.405$, $p = 0.067$) against performance in the Engineering and Science Modules.

Discussion

The results of the LASSI indicate correlations between student performance and aspects of strategic learning that differ between British and International students. These differences do not appear to result from the test instrument itself, or from this instance of its implementation, because strong similarities in Cronbach's alpha coefficients and in the latent structure revealed by exploratory factor analysis suggest that the overall interpretation of the instrument by the two groups was not significantly different between the cohorts, and was similar to that of previous users of the LASSI based on the published results (Olejnick and Nist, 1992; Olaussen and Braten, 1998; Flowers, 2012; Chacko, 1991; Cano, 2006; Flowers, 2003).

Based on the strongest correlation to academic performance being found with the TMT subscale for the International cohort, the implication is that teaching of time management skills and strategies would have the biggest impact. The Time Management subscale is describe as assessing "students' use of time management principles for academic tasks. Are students well organized? Do they anticipate scheduling problems?" (Weinstein, 2002).

For British students the strongest correlation to academic performance was on the ATT subscale. Weinstein (2002) describes the Attitude subscale as assessing "students' attitudes and interests in college and achieving academic success. How clear are students about their own educational goals? Is school really important or worthwhile to them?" It may, therefore, be beneficial to consider methods for instillingand enhancingintrinsic motivators for this group, such as through early exposure to detailed information on career pathways and research opportunities, to help students develop a greater appreciation of the benefits of their education.

Although some dissimilarities have been found in the operation of the instrument across the two groups, the overall effect of these appears to be minor. The similarity in average scores on all the LASSI subscales between British and International students, supports this conclusion, particularly when compared to differences found in the LASSI scores between more closely similar groups (Olaussen and Braten,1998). It is therefore concluded that differences between the cohorts' LASSI scores are likely to reflect real differences in their strategic learning attributes.

Where significant differences that remain unexplained were found in the Cronbach's alpha coefficient between the two cohorts, the two affected subscales had no bearing on the subsequent analysis of the correlations between the LASSI subscale and academic performance, because neither cohort showed statistically significant correlation on either subscale, and therefore the impact on this study is assumed to be negligible.

Analysis of the average inter-item correlations identified LASSI items that were interpreted differently between the cohorts. For the International students, English language ability varied across the cohort, and therefore would not have been a constant detractor from the International cohort's interpretation of the SMI subscale, and because language is unlikely to have been a factor in the more significant variation of Cronbach's alpha on the STA subscale for the British cohort, it is likely that language-based issues of interpretation were not the sole contributor to the International cohort's lower SMI subscale alpha coefficient. The SMI subscale was based on only five items, and is therefore more sensitive to individual items being interpreted inconsistently than the other subscales. The deviation of the International cohort's SMI alpha coefficient was significantly less than that of the British group on STA. On the STA subscale the British cohort had more than half of the average inter-item correlation close to zero, which suggests a large part of the cohort interpreted the meaning of some items oppositely to the remainder of the cohort. The reasons for these differences in interpretation need to be explored to improve future applications of the LASSI. This will be a focus of a subsequent investigation – when students will be surveyed to gain an understanding of their respective interpretations of the meaning of each of the items.

Some correlations between student performance and LASSI subscales were more pronounced when only the male students were included; however the sample was too small to determine whether apparent gender differences were biased by the interpretation of the LASSI, or represented real gender differences in aspects of strategic learning. Future studies will attempt to combine data from students in successive years, to increase the sample size sufficiently to resolve this question, by increasing the statistical significance of any correlation discovered for female students.

The diagnostic value of the LASSI as a general tool for identification of students who might benefit from some intervention to improve their learning and study skills is unclear, as it is difficult to conclude based on these results, and those presented in the literature, that a reliable group requiring intervention could be identified simply by running the LASSI. The correlations found were low. Although there is certainly an indication that weaknesses in aspects of strategic learning are correlated to lower academic outcomes, many of the students assessed as having such weaknesses also achieved high scores academically. The trends found were also inconsistent and did not differentiate between lower and average performing students. The inconsistent trends comparing LASSI scores to academic performance reported in the literature may be attributed to several causes. First, as Kruger (1999) reports, there is evidence in the literature that the less competent are less able than their more skilled peers to gauge their own level of competence. This is likely to be a liability in any self-reporting instrument comparing students of different academic ability. Secondly, academic performance depends not solely on the strategic learning skills possessed by the students, but also on a range of cognitive skills not assessed by the LASSI. A serious limitation to the current study (and comparable studies) may be that the correlations we are looking for are significantly affected by the variation in these factors across the cohort. We could expect a student with stronger cognitive skills, who also has a strong set of learning and study strategies, to outperform those equipped with similar levels of learning and study strategies but with weaker cognitive skills. This suggests a number of additional factors would reduce the correlations found between performance and aspects of strategic learning measured by the LASSI. The LASSI score might therefore be a better predictor of academic outcomes when combined with tests of cognitive ability, which might need to be subject specific, to reduce the number of latent variables affecting academic performance.

Where the LASSI indicates a correlation between a particular aspect of strategic learning and academic performance, intervention could be applied to all students. However, there is not evidence that all students receiving intervention for a specific weakness in learning or study skills would benefit, or that the benefit would be equally distributed. The preference would be to more closely identify the individuals who would most benefit, by finding a more accurate diagnostic tool.

Conclusion

The LASSI has demonstrated statistically significant correlations between aspects of students' strategic learning and study skills and their academic performance. Differences were found between the between British and International cohorts that were not the result of difference in interpretation or implementation of the LASSI. Time management skills were most strongly correlated with academic success for International students. For British students, their belief in the value of education showed the strongest correlation. The diagnostic potential of the LASSI is limited to indicating general trends amongst groups of students which suggests it cannot be used to reliably identify individual students who would most benefit from intervention; correlations between academic performance and the LASSI subscales are low, which at least in part is due to academic performance being dependent on other factors, not accounted for in this study, such as prior cognitive skills, which are independent of the LASSI subscales.

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