Leveraging LASSI for Measuring ABET Student Outcome 7: Fostering Student Independence in Learning

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Abstract: Accurate assessment of ABET Student Outcome 7, Independent Learner Skills, presents a challenge due to its underlying psychological nature. In this study, the Learning and Study Strategies Inventory (LASSI) is used as a comprehensive tool for accurately quantifying this essential competency. LASSI is a well-researched and robust instrument whose ten scales (Anxiety, Attitude, Concentration, Information Processing, Motivation, Selecting Main Ideas, Self-testing, Testing Strategies, Time Management, and Using Academic Resources) are proven to correlate strongly with independent learning and academic success.

By implementing LASSI since the Fall of 2020, the department has successfully measured the degree of each relevant LASSI scale in students twice in the program: At the start and near the end. A comparison between the two provides a measure for the efficacy of the program's delivery of SO7.

The exposure to LASSI in the freshman year provides the students (and the department) with an image of their current level of skills compared with a national norm. It also teaches the students, indirectly, about the various learning skills that contribute to their academic success. This exposure, in combination with LASSI's individually tailored suggestions for improvement, acts as an effective intervention, while the department can add to it by providing targeted training and seminars for specific scales.

This paper highlights the efficacy of LASSI as a reliable and valid tool for measuring the crucial ABET SO7 and provides guidance on data analysis and designing interventions for enhancement of independent learner skills during the program.

I. Introduction: Founded in 1932, the engineering professional entity ABET has been regulating and accrediting college and university programs in applied and natural science, computing, engineering, and engineering technology at the associate, bachelor's, and master's degree levels [1].

ABET accredits programs based on the presence of a systematic improvement of educational quality, continuous improvement being a key for training professionals suited for a dynamic and competitive environment. ABET ensures the existence of this improvement system using a set of criteria measuring specific outcomes in students, faculty, curriculum, and the program in general.

This paper focuses on one of these ABET criteria: The Student Outcome 7 (SO7), the challenges of measuring it, and how to overcome them.

A. SO7 and its importance: ABET defines SO7 as an ability to acquire and apply new knowledge as needed, using appropriate learning strategies [1].

   The importance of this outcome is in the need for acquiring new knowledge. This need arises from different facets of the engineering field.

   First: The field is extremely dynamic, with fast advances that make available new tools and paradigms such as artificial intelligence, new techniques like additive manufacturing, and even new branches or combinations of existing branches as new fields such as neurobotics. The engineer, whose career spans over multiple decades, must be able to independently acquire knowledge needed to keep up with the trends.

   Second: Even in the short term, a successful engineer must study the best practices of their field and take charge of their professional development to keep contributing meaningfully to their field.

   Third: Most engineering projects are multidisciplinary. An effective engineer must be adaptable and, as the need arises, must be able to learn the basics of other disciplines for broadening their view and for communicating with a multidisciplinary team.

   Fourth: Engineers increasingly need to solve problems of a global nature. This cannot be done without collaborating with people of vastly different backgrounds, and navigating diverse cultures needs impeccable learning skills.

   For these reasons, SO7 is much more than a check box for accreditation. It is a key to the effectiveness of our future engineers.

B. The need: challenges in assessing SO7: Engineering departments face challenges in measuring SO7 due to its psychological nature. Measuring will need to include a subjective part—the student's perception of their learning, which relates with factors such as their perception of rate of retrieval of memory. This perception may not be the same as their real skill level [2].

   Another challenge is that independent learning is not one skill but a combination of different skills. Some of these skills include self-assessing, methods of processing information, time management, and adeptness in using knowledge resources. Further an individual's motivation, level of anxiety, and attitude have a tremendous influence on their independent learning. Researchers have studied and proven the correlation between these factors and learning since the nineties [3], and reviewed more recently in [4], with practical guidelines on how to use them in shaping their teaching. This multifaceted nature of independent learning requires a comprehensive tool that takes all the aspects into account.

The type of assessment is another challenge: A student with good learning skills will achieve high grades in traditional exams, but for students with lower skill levels, the lower grade fails to depict a detailed image of the student's learning profile. A simple low grade in a traditional exam cannot reveal which components of the learning skill set are lacking. Different types of assessments are needed to support self-improvement [5].

The department needed a comprehensive tool to measure the relevant skills and provide a map of improvement for the individual students and the program in general. Considering the nature of the need, the department sought the tool in the discipline of educational psychology.

C. Prior work and introduction to the Learning and Study Strategies Inventory (LASSI):
    1. Prior work on methods of measuring SO7: ASEE Paper [6] reviews the existing methods of measuring SO7. The reported methods fall into one of these categories: Qualitative rubric used for assessing student performance in laboratory projects or in capstone design [7], and usage of American Association of Colleges and Universities (AAC&U) rubric on Lifelong Learning [8] outside of a course context.

        These tend to be limited and qualitative, for example [9] splits the learning profile into only 2 sub-outcomes and measures student performance in each outcome in projects using rubrics with qualitative levels of Unsatisfactory, Minimal, Adequate, or Exemplary.

        The paper [6] offers a rubric that breaks down the learning into three sub-components of identifying the needed knowledge, developing a learning plan, and applying the knowledge to an engineering goal. Their rubric contains qualitative measures: beginning, developing, accomplished, and exemplary.

        The lacking components in these assessment methods are fourfold: 1) They do not break down learning into a research-proven sufficient number of independent sub-components. 2) They do not paint a detailed learning profile for each student that can be consistently updated at intervals to reveal improvement. 3) They do not provide clear paths for interventions. 4) They do not compare the students with a national norm as LASSI does.

    2. What is LASSI? LASSI is an online multiple choice test. It contains 60 questions and takes about 10 minutes to complete. It measures students' skill level and their awareness of it in ten scales that cover three broad areas of skill, will, and self regulation [10].

The ten scales are: Skill (Information Processing, Selecting Main Ideas, and Test Strategies), Will (Anxiety, Attitude, and Motivation), Self regulation (Concentration, Self Testing, Time Management and Using Academic Resources). The Appendix contains the description of each scale from [10].

Weinstein, Palmer, and Acee developed the first edition of LASSI in 1982 as part of the Cognitive Learning Strategies Project at the University of Texas at Austin. This project was devised in response to an observed problem: the number of academically unprepared students that entered post-secondary education was increasing, and to address this problem, an accurate and reliable measure of learning was needed [10].

Over the past decades, researchers have performed extensive studies on validity and reliability of the test [11], [12], [13], correlation with academic success [14], [15], efficacy in measuring the influence of program intervention on student independent learning development [16], and biases based on race [17], and gender [18].

LASSI's designers used the research to refine the instrument in its 2nd and 3rd editions. They reduced the number of the basic scales from its original 14 to 10, eliminating overlapping categories. They also limited the number of questions to an efficient 60 items [10].

II. Methodology: Implementation of LASSI in the department

A. The decision: The Assessment Committee in the department of mechanical engineering oversees evaluating each ABET student outcome. The committee accomplishes this task by assigning one or more outcomes to its members who in turn devise appropriate evaluation methods, coordinate integration of the methods in the curriculum, analyze the data, and provide feedback based on the results.

The decision to use LASSI was based on research performed in this committee and the approval of the department's head. The department provides funds for the purchase of LASSI licenses each year.

B. Process and participants: LASSI breaks down learning into ten scales (see section I.C.2. above). Once students are aware of these ten scales, this conscious awareness can act as an intervention in itself, leading them to improve their weak areas. For this reason, the Assessment Committee decided to offer LASSI to every student rather than using a limited sample.

Students take LASSI twice during the curriculum. First as freshmen in the Introduction to Mechanical Engineering course, and the second time as seniors in the

Senior Design course. This provides an accurate before/after measurement of their learning profile as they complete the curriculum.

Instructors in both courses assign LASSI as a required assessment with a high point value. Instructors for the freshman course also devote time to teach students about LASSI scales, their meaning, correlation with academic success, and ways to use their LASSI results to become excellent independent learners.

Instructors also let students know that the department uses their results anonymously and/or as an aggregate to monitor and enhance the curriculum's effectiveness in training lifelong learners.

The department offers LASSI every semester, including summers, to all freshman and senior students. As of March 2024, the price for each LASSI 3rd edition administration per student has been 4$ for groups containing more than 200 students. Students receive a username and password to access and take the test online.

C. Continuous improvement feedback loop
   1. The department performs data analysis on LASSI results from each semester (see the sections below) to measure the change between scores of freshmen and seniors in each scale. This measure reveals possible areas of improvement and suggests interventions. For example, if the scale of Anxiety shows low improvement from freshman to senior, the assessment committee devises seminars and interventions placed in laboratory courses to help students in that specific area.
   2. The freshman scores also provide a profile of learning skills for students entering the program. The assessment committee shares this information in yearly faculty retreats to help the faculty plan their lessons, emphasizing methods of improving the weak scales.

III. Data analysis, results, and discussion

A. Comparison of before and after scores for each student

Analysis: Once a student completes the curriculum and takes the after-test LASSI, his or her raw scores can be compared for an accurate individual measurement of learning skill improvement. Each student receives this data directly from LASSI and is able to make the assessment individually. The department too can make this analysis on the individual raw scores, anonymously, using the codes assigned to pre- and post-tests for each student.

Application: The department began collecting the data in the Fall of 2020, and this individual analysis will be possible at the end of Fall 2024 when the first freshman class that took LASSI reaches graduation.

In the meantime, a big-picture aggregate analysis (see the sections below) was performed on the data.

B. Comparison of LASSI scores between freshmen and seniors as an aggregate

1. Measure design and histogram plots: For each student, LASSI results provide both the raw score in each of the ten scales and the percentiles the student falls in compared to LASSI's national norm. The national norm contains data from 820 first time college students and 566 students who were previously enrolled in college, a composition that must be taken into account when interpreting the scores.

   To generate a big-picture image of student learning improvement through the curriculum, a GPA-like measure was designed:

   The score for each scale was calculated as
   [(Number of students in the 75-100 percentile)*4 +
   (Number of students in the 50-75 percentile)*3 +
   (Number of students in the 25-75 percentile)*2 +
   (Number of students in the 0-25 percentile)*1] / Total number of students

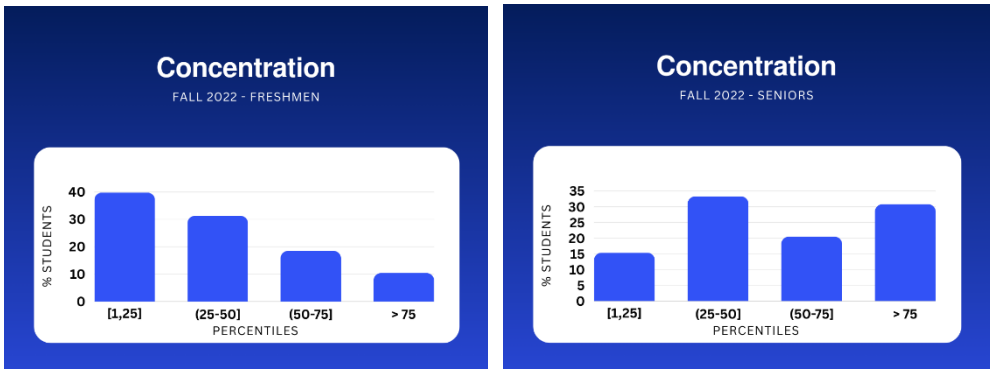

Figure 1: The Scale of Concentration percentiles for freshmen and seniors of Fall 2022.

Application: Figure 1 shows an example of such histogram plots for the scale of Concentration from the Self-regulation component. The figure compares the big picture image for this scale between freshmen and seniors of Fall 2022. The graphs provide data for the calculation of concentration score: 2 for freshmen and 2.7 for seniors, about 30% score difference in this case.

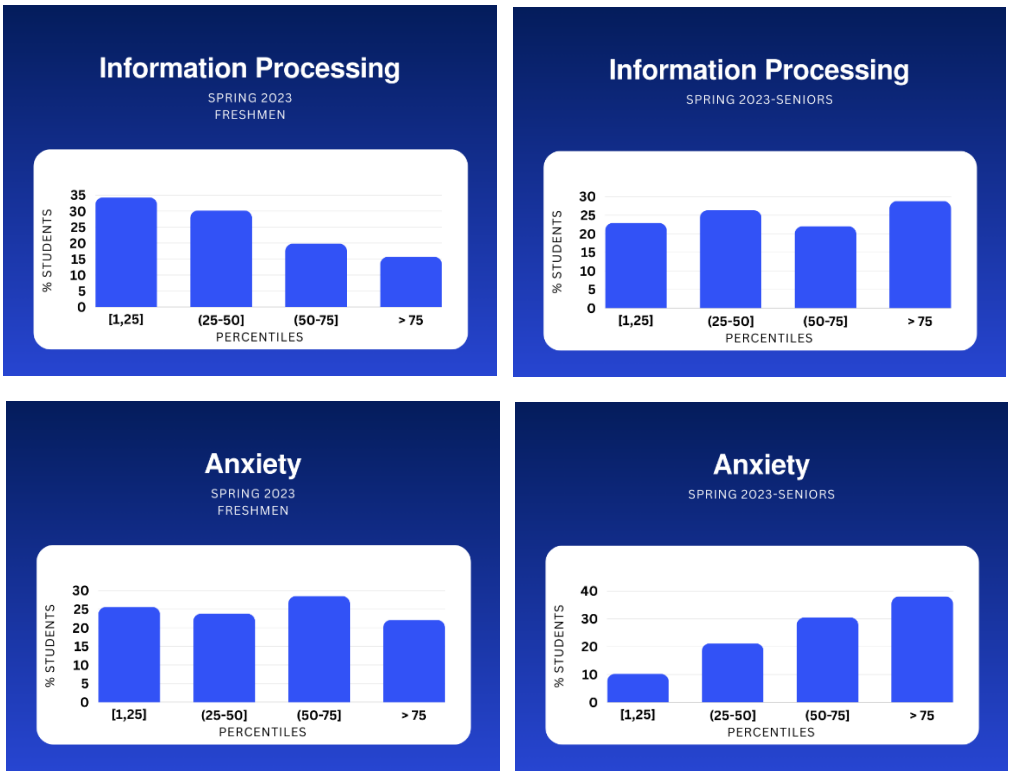

Figure 2: Information and Anxiety percentiles for freshmen and seniors of Spring 2023.

Other scales also show shifts from more freshmen in the lower percentile toward more seniors in the higher percentiles. Figure 2 shows two such comparisons representative of the components of Skill (Information Processing) and Will (Anxiety).

2. Significance of the observed aggregate differences between freshmen and seniors

   Analysis: Microsoft Excel's data analysis package was used for all statistical analysis in this study. The T-test Paired Two Sample for Means was used to determine the significance of changes observed between overall score averages of freshmen and seniors in each LASSI scale.

   Each scale's overall average was used as a data point for the t-test and calculation of p-values. p-value determines the probability of the observed change being due to chance [19]. A common threshold for the p-value is 0.05 which can be considered as the significant level (α) of the test [20]. The difference between two measured values is significant if the p-value is smaller than that defined significant level (usually at $\alpha = 0.05$).

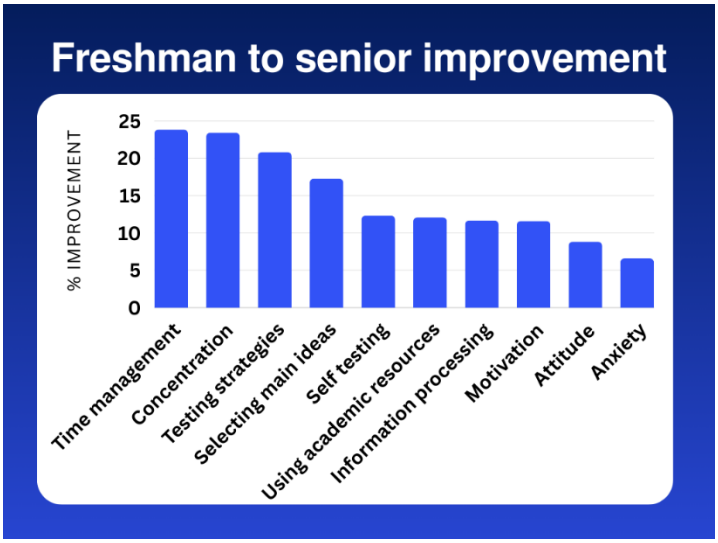

Figure 3: Senior to freshman improvement based on aggregate averages

Application: Figure 3 shows the aggregate overall improvement from freshman to senior for each scale.

The top three most improved scales are among skill and self-regulation components: Time management, Concentration, and Testing strategies. This was to be expected since the curriculum explicitly works on these skills through problem-solving and homework assignments.

The bottom three least improved scales are the will components: Anxiety, Attitude, and Motivation. This, although expected since the curriculum does not explicitly provide improving practices in these areas, still provides a path for the department to devise training, seminars, and other interventions to help these scales.

Based on p-value calculations, the department's senior LASSI scores (average = 2.57 ± 0.06) were significantly higher (p = 4.4E-06) than its freshman scores (average = 2.16 ± 0.04).

At the end of Fall 2024, when the first group of freshmen who took LASSI reaches graduation, this kind of significance analysis can also be done using individual students as data points.

C. Identification of trends and patterns in LASSI scales: LASSI data provides a valuable resource for longitudinal studies, examining trends, effects of changes in curriculum, and even societal change factors, such as the COVID 19 pandemic. An example of such an investigation is provided in the case study below.

Analysis: For each scale, monitoring the moving mean and standard deviation allows for observation of any possible shift toward higher or lower skills. A cumulative sum (CUSUM) chart [21] is a good tool for detecting small shifts in the data. CUSUM charts plot a cumulative difference between the historical mean and the new data. Due to the cumulative nature, this chart is more sensitive to small changes compared with a moving average chart while at the same time it provides a less noisy visual representation for the trends.

Application case study: In the Fall of 2022, LASSI data showed an anomaly prompting the department to investigate deeper. In that semester, the data was suddenly showing a surge in the aggregate freshman to senior improvement in the scale of Information Processing. While this could be good news, a study was needed to reveal the cause, since the department had not implemented any particular change in the curriculum.

Figure 4 provides an example of the CUSUM control chart for the scale of Information Processing. From the Fall of 2020 till the Fall of 2022, the data showed a stable mean and standard deviation of 2.3 ± 0.02 for the freshman Information Processing scale. Using these values as historical reference, the upper and lower CUSUM limits (UC and LC) were set to 4σ, where σ is the historical standard deviation. This allows the trend to show exactly at what time the shift in mean passes the sensitivity limit of $4\ \sigma$. In this case, it is seen that the freshman Information processing skill dropped significantly in the Fall of 2022.

A similar chart for seniors showed no such drop, even when plotted for a higher sensitivity of $1\ \sigma$ rather the $4\ \sigma$. This comparison pinpointed that the observed surge in improvement had been due to a drop in freshman skills rather than a rise in senior skills, an effect that, considering the timing, can be due to the COVID-19 pandemic. The true underlying cause needs further future research.

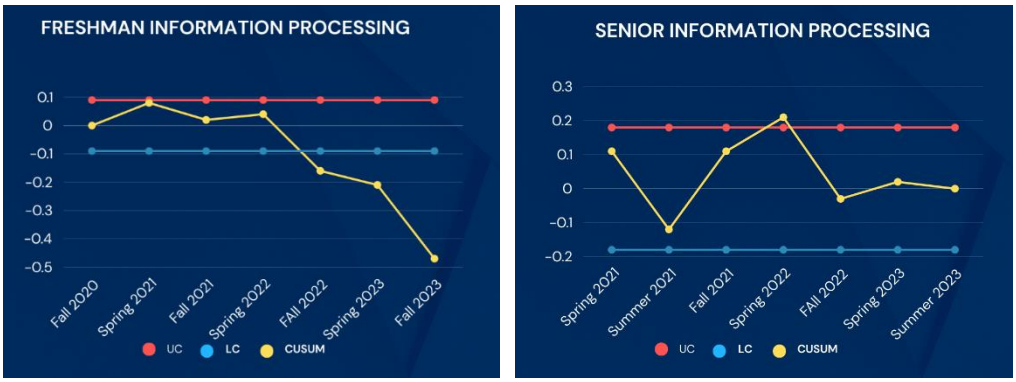

Figure 4: CUSUM charts for the scale of Information processing

The dramatic drop in the scale of Information Processing was not seen in all of the scales. For example, freshman skill of Selecting Main Ideas remained quite stable in mean and standard deviation over the observed semesters. Figure 5 shows the CUSUM curve for this scale, drawn with the sensitivity level of 3 σ.

To understand the underlying causes of such trends in different scales needs broader future research.

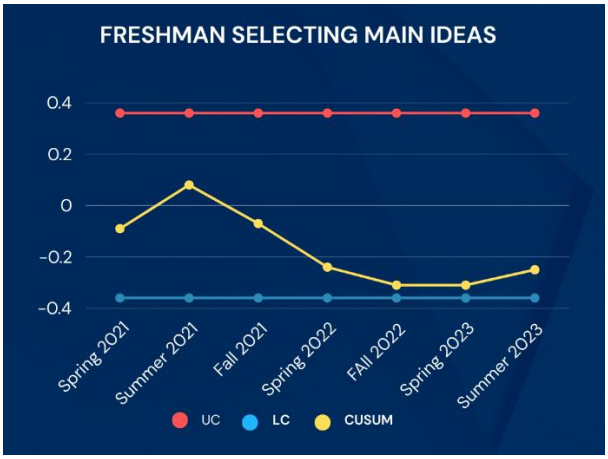

Figure 5: Freshman CUSUM chart for the scale of Selecting Main Ideas

As such, LASSI data provides an excellent tool for longitudinal studies of student skills and the effect of interventions as well as external factors.

IV. Acknowledgements: The authors are extremely grateful to the department of mechanical engineering of Auburn University for supporting the sustained collection of LASSI data for students.

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V. Conclusion: The implementation of the Learning and Study Strategies Inventory (LASSI) has proven successful in measuring ABET Student Outcome 7 (SO7). This paper described the advantages, methodology, and detailed data analysis that underscore the effectiveness of LASSI in assessing the crucial skills associated with independent learning.

The comprehensive feedback loops incorporated into the process ensure that the benefits of LASSI are not confined to measurement alone but extend to actionable insights. By hinting at areas of improvement, LASSI becomes a dynamic tool, empowering students to actively enhance their independent learner skills.

Further, exposing freshmen to the scales of LASSI not only measures their current levels of essential skills but also provides a strategic intervention, leading the students to self-awareness and self-regulation.

The findings confirm the successful integration of LASSI into the curriculum both for measuring ABET SO7 and for guiding students to improve their learning skills.

References

[1] ABET Home: https://www.abet.org/

[2] R. A. Bjork, J. Dunlosky, and N. Kornell, "Self-Regulated Learning: Beliefs, Techniques, and Illusions," *Annual Review of Psychology*, vol. 64, pp. 417–444, Jan. 2013

[3] P. R. Pintrich and E. V. De Groot, "Motivational and self-regulated learning components of classroom academic performance," *Journal of Educational Psychology*, vol. 82, no. 1, pp. 33–40, Jan. 1990.

[4] S. A. Ambrose, M. W. Bridges, M. DiPietro, M. C. Lovett, and M. K. Norman, *How Learning Works: Seven Research-Based Principles for Smart Teaching*, Jossey-Bass, 2010.

[5] M. Boekaerts, M. Zeidner, and P. R. Pintrich, Eds., *Handbook of Self-Regulation*. Elsevier, 1999, ISBN: 0080533205, 9780080533209.

[6] A. C. Szatmary, "Tools for Comprehensive Assessment of the 7 ABET Student Outcomes in Mechanical Engineering, with Application to Capstone Design," Paper presented at the *2023 ASEE Annual Conference & Exposition*, Baltimore, Maryland, Jun. 2023.

[7] J. McCormack, S. Beyerlein, P. Brackin, D. Davis, M. Trevisan, H. Davis, J. Lebeau, R. Gerlick, P. Thompson, M. J. Khan et al., "Assessing professional skill development in capstone design courses," *International Journal of Engineering Education*, vol. 27, no. 6, pp. 1308–1323, 2011.

[8] Association of American Colleges & Universities, "VALUE rubric development project," *Association of American Colleges & Universities*, Tech. Rep., 2017.

[9] J. Mynderse, "Assessing ABET student outcome 7 (new knowledge) with measurement systems," in 2022, *ASEE Annual Conference & Exposition,* 2022.

[10] C. E. Weinstein, D. R. Palmer, and T. W. Acee, *User's Manual, Learning and Study Strategies Inventory*, 3rd Edition, H&H Publishing, 202412. Access link: https://www.hhpublishing.com/LASSImanual.pdf

[11] M. P. Deming, M. Valeri-Gold, and L. S. Idleman, "The reliability and validity of Learning and Study Strategies Inventory (LASSI) with college developmental students," *Reading Research and Instruction*, vol. 33, no. 4, pp. 309–318, Jan. 199412. Access link: https://doi.org/10.1080/19388079409558163

[12] S. Dollar, “The Class of 1990: A Longitudinal Study of a Freshman Cohort at Texas A&M University-Kingsville,” Doctoral dissertation, Texas A&M University, Kingsville, TX, USA, 2005.

[13] A. W. Perkins, “Learning and Study Strategies Inventory (LASSI): A validity study,” Dissertations, Theses, and Masters Projects Theses, Dissertations, & Master Projects, College of William & Mary - School of Education, 1991.

[14] M. K. Khalil, H. G. Hawkins, L. M. Crespo, et al., “The Relationship Between Learning and Study Strategies Inventory (LASSI) and Academic Performance in Medical Schools,” *Med.Sci.Educ*., vol. 27, pp. 315–320, 2017. Access link: https://doi.org/10.1007/s40670-017-0400-x

[15] A. D. Carson, “Predicting student success from the LASSI for Learning Online (LLO),” *J. Educational Computing Research*, vol. 45, no. 4, pp. 399–414, 2011.

[16] L. Barnes, “Evaluating Independent Learning Development in a University Program,” *International Journal of Academic Research in Progressive Education and Development*, vol. 2, no. 1, pp. 152-159, 2013.

[17] L. A. Flowers, B. K. Bridges, and J. L. Moore, “Concurrent Validity of the Learning and Study Strategies Inventory (LASSI): A Study of African American Precollege Students,” *Journal of Black Studies*, vol. 43, no. 2, pp. 146-160, 2012, Access link: https://doi.org/10.1177/0021934711410881

[18] D. S. Bender and J. K. Garner, “Using the LASSI to predict first year college achievement: Is a gender-specific approach necessary?” in *Annual Meeting of the American Educational Research Association*, 2010. Access link: https://files.eric.ed.gov/fulltext/ED509393.pdf1

[19] B. Everitt, *The Cambridge Dictionary of Statistics*, Cambridge University Press, Cambridge, UK, New York, 1998.

[20] R. Nuzzo, “Scientific method: Statistical errors,” *Nature*, vol. 506, issue 7487, pp. 150–152, 2014.

[21] J. Murdoch, “Introduction to Cumulative Sum Charts,” in *Control Charts, M. Lovric (Ed.)*, pp. 329-330, Palgrave, 1979. Access link: https://doi.org/10.1007/978-1-349-16238-3_6

Appendix: The 10 scales of LASSI

The following is an excerpt of LASSI user manual [10].

The Skill Component of Strategic Learning

1. The Information Processing Scale assesses students' use of imagery, verbal elaboration, organization strategies, and reasoning skills as learning strategies to help learn new information and skills. These strategies are also used to build bridges between what students already know or believe and what they are trying to learn and remember. Do students try to summarize or paraphrase their class reading assignments?
   Do they try to relate what is being presented in class to their prior knowledge?

2. The Selecting Main Ideas Scale assesses students' thinking skills for identifying important information for further study from less important information and supporting details.
   Can students identify the key points in a lecture?
   Can they decide what is important to underline in a textbook?

3. The Test Strategies Scale assesses students' use of both test preparation and test taking strategies.
   Do students know how to study for tests in different types of courses?
   Do they review their answers to essay questions?

The Will Component of Strategic Learning

4. The Anxiety Scale 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 anxious even when they are well-prepared?

5. The Attitude Scale assesses students' attitudes and interests in college and achieving academic success.
   Do students only study for the courses they like?
   Is college really important or worthwhile to them?

6. The Motivation Scale assesses students' diligence, self-discipline, and willingness to exert the effort necessary to successfully complete academic requirements.
   Are students willing to put in the effort necessary to succeed on academic assignments?
   Do they easily "give up" in difficult classes?

The Self-Regulation Component of Strategic Learning

7. The Concentration Scale assesses students' ability to direct and maintain their attention on academic tasks.
   Are students easily distracted?
   Can they direct their attention to academic tasks?

8. The Self Testing Scale assesses students' use of comprehension monitoring techniques, such as reviewing or paraphrasing, to determine their level of understanding of the information or skill to be learned.
   Do students create and respond to questions that might be asked on a test?
   Do they stop periodically while reading to review the content?

9. The Time Management Scale assesses students' use of time management principles and practices for academic tasks.
   Do students procrastinate about completing academic tasks?
   Do they strategically manage their time for studying?

10. The Using Academic Resources Scale assesses students' willingness to use different academic resources such as writing centers, tutoring centers and learning or academic support centers, when they encounter problems with their coursework or performance.
    Do students go to a resource center for guidance?
    Do they avoid going for help?