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ABET Student Outcome 7: Using Learning and Study Strategies Inventory (LASSI) Data to Reveal Societal and Generational Effects on Student Learning Skills

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Trends in Freshman Engineering Student Learning Skills using Learning and Study Strategies Inventory (LASSI)

Abstract

Every semester, we get a new group of freshman engineering students. Are the new groups more prepared for learning? Are they getting weaker with time? Or do they bring in the same level of learning skills as their predecessors? This paper offers a tool to answer that question.

Since 2020, the Department of Mechanical Engineering has collected data from the Learning and Study Strategies Inventory (LASSI) to evaluate ABET Student Outcome 7: the ability to acquire and apply new knowledge using appropriate learning strategies.

LASSI evaluates student learning skills across ten scales of Information Processing, Selecting Main Ideas, Test Strategies, Anxiety, Attitude, Motivation, Concentration, Self Testing, Time Management, and Using Academic Resources. These scales provide a detailed picture of students' learning strengths and weaknesses and their evolution with time.

This paper presents a cumulative sum (CUSUM) analysis of freshman and senior LASSI scores for detecting significant shifts in student learning skills over time. The CUSUM approach was selected for its ability to identify persistent changes in the means of the data by plotting the cumulative differences as the mean changes with time.

Freshman CUSUM curves show that out of the ten basis scales of learning, all except two have kept stable means since the Fall of 2020. Information Processing shows a persistent drop; Using Academic Resources shows a persistent rise.

This paper provides the trends of incoming student learning skills over time. The trends also pinpoint the exact time the trends fall outside of stable 2 standard deviation bands, making it possible for future studies to investigate correlation with societal events such as COVID-19 and the introduction of generative artificial intelligence. Further, the paper provides the same trends for graduating seniors and suggests improvement strategies for weakening trends.

I. Introduction and related work

Every semester, we get a new group of freshman students. Are the new incoming students better prepared for learning than the previous groups? How are the learning skills of freshmen changing with time? This paper provides a method for answering this question.

The background and motivation for this work stems from two sources: First: The department's usage of Learning and Study Strategies Inventory (LASSI) for measuring ABET Student Outcome 7 (SO7) provided a large collection of student data that offered

great potential for digging for trends, and second: the need for quantifying the learning preparedness profiles of incoming freshmen to be able to design curricula that support the learning of new groups with changing skills.

A. ABET SO7 and its importance

SO7 is 'an ability to acquire and apply new knowledge as needed, using appropriate learning strategies' [1].

The field of Engineering is dynamic, with new techniques, paradigms, and advances, such as artificial intelligence constantly requiring practitioners to train anew. Further, the multidisciplinary nature of most Engineering practices requires continuous learning. Many Engineering problems also include a global aspect which needs collaboration with people of different cultures and backgrounds—another facet that benefits from strong independent learning skills. All these reasons make SO7 a key ingredient for the effectiveness of the future engineers.

For a detailed prior work review on available methods of measuring SO7 [3-6], including pros and cons of each, please see the authors' previous paper [2].

B. LASSI and its importance

LASSI is a standard inventory from Educational Psychology. It assesses student learning preparedness across ten scales and three components of Skill (Information Processing, Selecting Main Ideas, and Test Strategies), Will (Anxiety, Attitude, and Motivation), and Self-regulation (Concentration, Self Testing, Time Management and Using Academic Resources) [7]. For more details on the definition of each scale, please visit the Appendix.

1. The form of LASSI

The tool is in the form of an online questionnaire. It contains 60 questions and takes about 10 minutes to complete [7].

2. Validity and prior work

LASSI is a vastly and rigorously researched tool. Extensive studies spanning over more three decades establish LASSI's validity and reliability [8-10], its strong correlation with academic success [11, 12], and its efficacy in measuring the influence of program intervention on student independent learning development [13]. There is also research studying its race [14] and gender [15] biases.

LASSI's designers used the bulk of research mentioned above to refine the instrument. For example, the study of correlation between the scales allowed the elimination of dependent categories and reduced the original 16 scales to the current ten as independent basis vectors [7].

3. Advantages and disadvantages

LASSI's great advantage is in breaking down learning into its basis vectors and providing a detailed profile for each student. This feature allows the educators to pinpoint the weak areas and provide targeted interventions. Another advantage is creating the potential for broad study of trends over long periods of time. A disadvantage mentioned for LASSI is that it does not relate to the contents of any specific engineering course. For more details on LASSI's scope and usage please see [2].

LASSI's advantages mentioned above make it an excellent tool for monitoring the detailed learning preparedness profiles of freshmen over time, gaining insight into generational changes in learning skills, for designing curricula that supports the evolving needs of incoming groups.

This paper presents our methodology of implementation of LASSI and data analyses as well as detailed trends observed in our freshmen and seniors from the Fall of 2020 to the Fall of 2024. A discussion of trends, possible reasons behind it, possible strategies of intervention, and suggestions for future work are also provided.

II. Methodology

The following sections detail methods of implementing LASSI and collecting data.

A. LASSI implementation

All freshmen take LASSI in their first semester as an assignment in Introduction to Mechanical Engineering course. The assignment is required and has a high point value for completion. The instructors teach students about the ten scales of independent learning, which acts as an intervention in itself by making students aware of what contributes to their learning.

All seniors take LASSI in their last semester as a required assignment in Senior Design II course. Students use the same code assigned by LASSI in their first semester. The senior assignment will act as a post-test for comparison and establishing improvement in each scale.

While each student receives their detailed profile directly from LASSI, the department analyses data anonymously. This is made possible by LASSI assigning codes to students and pairing pre- and post-tests.

For more details on LASSI's student interface, licensing prices (paid by the department), and continuous improvement feedback loop please see the author's previous paper [2].

B. Data collection and sample size

The department collects data every semester for all freshmen and seniors. Dataset sizes vary with semesters. Introduction to Mechanical Engineering course has more students in Falls semesters compared with the Spring semesters; Senior Design II has more students in Spring semesters compared with Fall semesters. Yearly averages since the Fall of 2020 are: 357 ± 23 freshman students and 153 ± 12 senior students.

Freshmen comprise multiple Engineering majors, including Mechanical, Aerospace, Computer, Biosystems, Civil, and Industrial with a small number of undeclared majors. Seniors are exclusively Mechanical Engineering majors.

The percentage of ME majors in the freshman classes changes with semesters. As an example, in the Fall of 2024, one of the two freshman classes had 65% ME majors. There is also attrition and students who change majors, which accounts for the smaller senior population size.

III. Data analysis and results

The following sections present the analysis methods and trends observed in freshmen and seniors from the Fall of 2020 to the Fall of 2024.

A. Usage of LASSI data for evaluating ABET SO7

This was presented in detail in a previous work of the authors [2] This section offers a summarized review of the parts that are needed in the current study.

1. LASSI provides both a raw score and the percentiles that each student falls in for each scale compared with LASSI's national norm. (For a detailed description of the national norm, please see [7].) The percentile data can be used to create a big-picture view of freshmen and seniors in each semester.

   Histogram plots are a good tool to show the percentiles. One such plot for the scale of Concentration in the Fall of 2022 is provided in Fig.1 as an

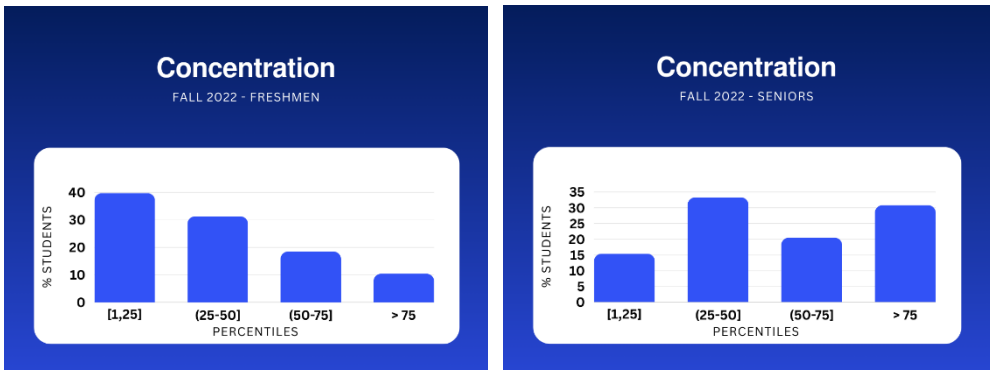

Figure 1: Concentration percentiles for freshmen and seniors of Fall 2022 [2]

example. All scales show a similar pattern—leaning toward the lower percentiles for freshmen (left) and leaning toward the higher percentiles for seniors (right.)

2. A GPA-like measure was designed to use the percentile data and assign a score to each learning scale for freshmen and seniors each semester. This score is calculated as follows:

   [(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

   This score is used to calculate percentages of improvement from freshman to senior in the aggregate analysis. (Individual student comparisons will also be possible in the future when the freshmen that took the pre-test reach the senior level.) Figure 2 shows the improvement percentages in each scale, with Skill and Self-regulation components showing the highest improvements. Changes are proven to be significant using p-value [16, 17] calculations. For details of these results please see [2]

B. Usage of LASSI data for freshman and senior trends

To study trends, moving averages of the scores for each scale were monitored using a cumulative sum (CUSUM) analysis.

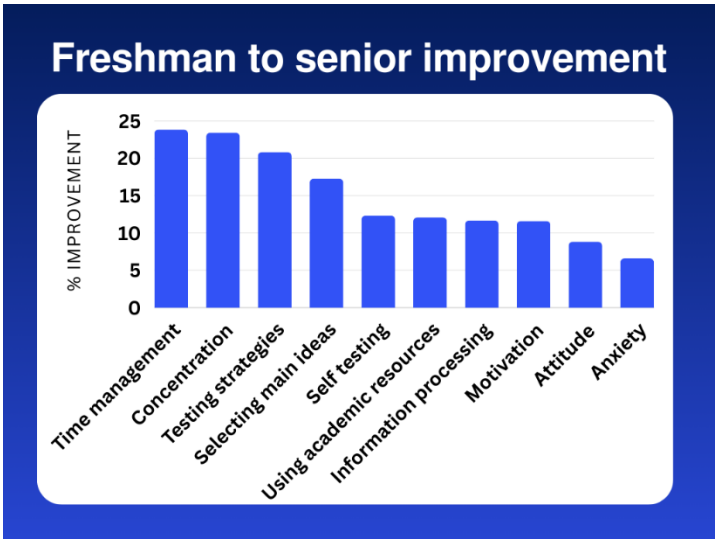

Figure 2: Senior to freshman improvement based on aggregate averages from Spring 2021 to Summer 2023 [2]

1. CUSUM curves

   A CUSUM analysis [18] is a good tool for observing persistent changes in data with time. CUSUM calculates a cumulative difference between the historical mean and the new data. The cumulative nature of this plot acts as a magnifier to make the persistent change more visible. It also allows the observer to pinpoint exactly when the cumulative differences become significant based on the historical standard deviation. Figure 4 shows one such curve for the scale of Anxiety in freshmen.

   The upper and lower CUSUM limits (UC and LC) are usually determined based on an appropriate multiple of the historical standard deviation, usually between 1 to 3 standard deviations. In this study the bands are of the width 2 sigma with sigma being the historical standard deviation. For more details and an example with different sigma bands see [2]. The first three semesters of data collection were used to calculate historical mean and standard deviation.

2. Freshman trends

   Out of ten LASSI scales of learning, all but two are keeping stable means over time. Figures 3 provides the CUSUM plots for two of the stable scales: Anxiety (left) and Attitude (right.) The rest of the stable scales show similar trends.

The scale of Information processing shows a persistent drop. See Fig. 4 (left.) The scale of Using academic resources shows a persistent rise. See Fig. 5 (left.) Because of the magnifying effect of CUSUM curves, the non-cumulative moving averages are also provided for comparison, so that the real range of the changes can also be seen (Figs. 4 and 5 (right).)

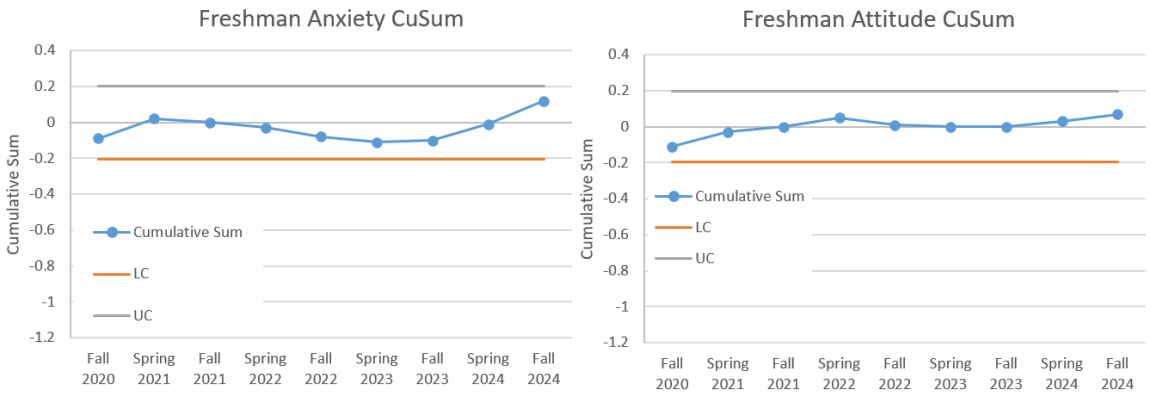

Figure 3: Examples of freshman trends with stable means

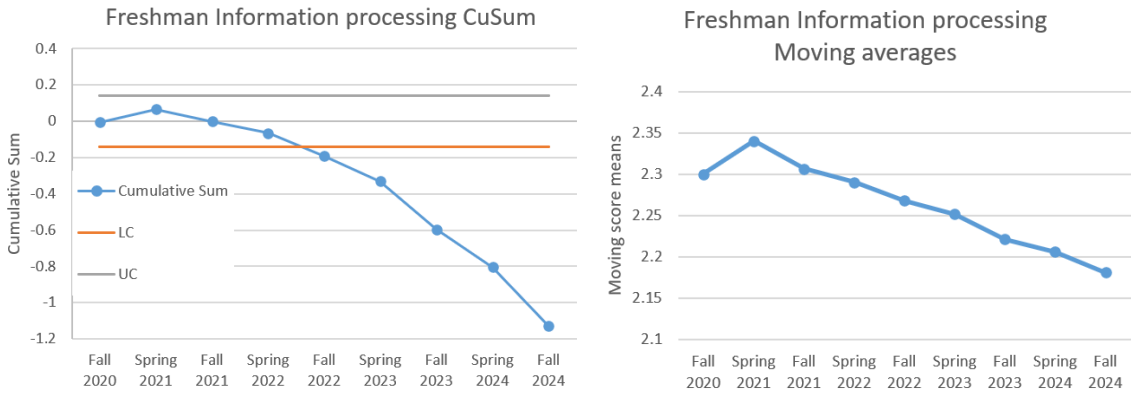

Figure 4: Trends in freshman Information Processing

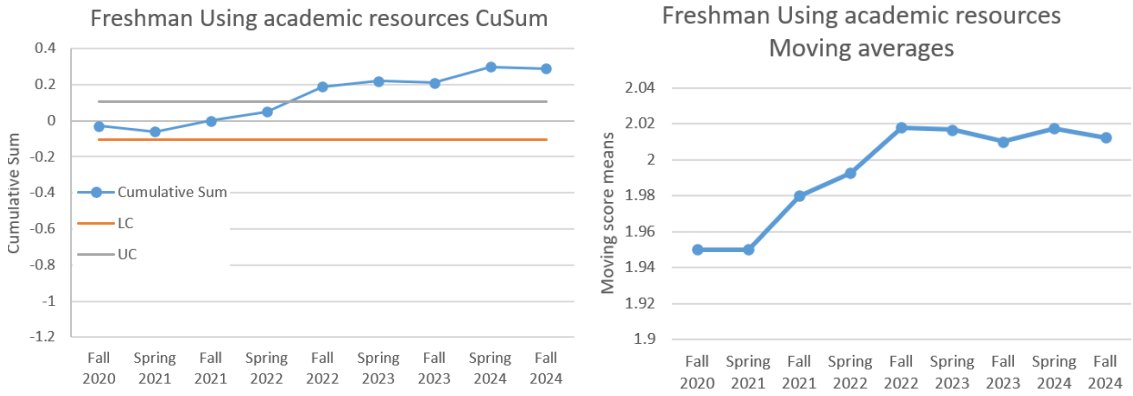

Figure 5: Trends in freshman Using Academic Resources

3. Senior trends

Out of ten LASSI scales of learning, three are keeping a stable mean. The three are: Testing Strategies, Selecting Main Ideas, and Motivation. Figure 6 shows these stable trends for the scales of Testing Strategies and Motivation. All other scales show a persistent rise. Examples of such rising trends are provided in Figs. 7-9.

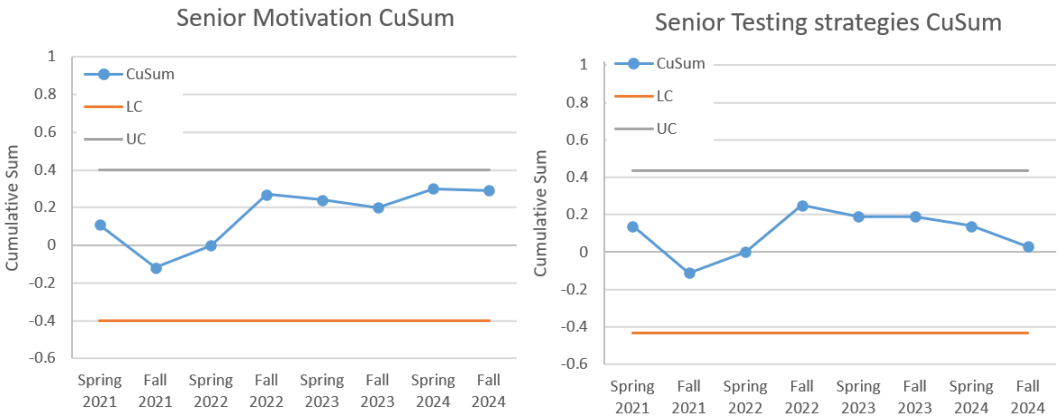

Figure 6: Examples of stable senior trends

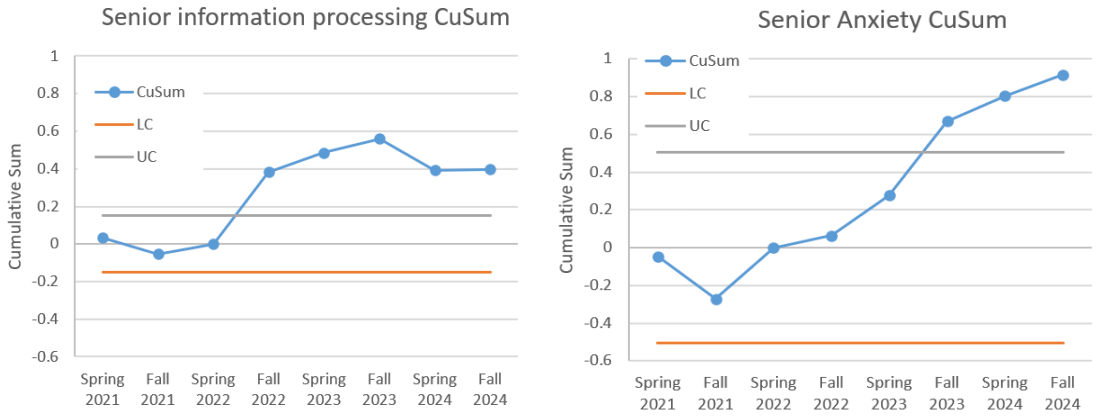

Figure 7: Positive senior trends for Information Processing and Anxiety scores

IV. Discussion of results

A. Alignment with other national trends: There are two other trends that seem aligned with the observed drop in Information processing skills of freshmen.

1. The Trends in International Mathematics and Science Study (TIMSS) provides reliable data on mathematics and science achievements of students

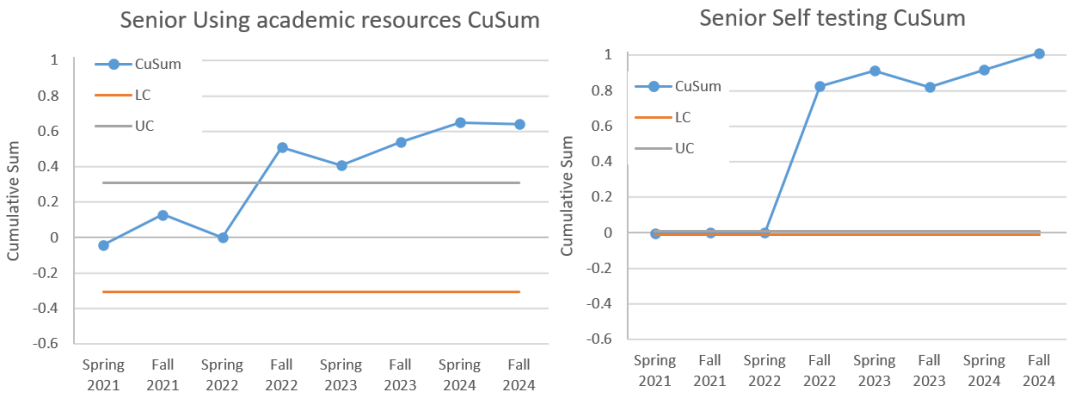

Figure 8: Positive senior trends for Using Academic Resources and Self Testing scales

internationally. United States have been participating in this test since 1995. The test is administered every 4 years to 4th grade and 8th grade students. For more details on this standard test, please see [19].

From 2019 to 2023, TIMSS mathematics achievement data shows an 18 point drop in score (535 to 517) for 4th grade and a 27 point drop in score (515 to 488) for 8th grade.

While establishing a definite connection between this trend and the freshman drop in Information processing skill needs further research, the relation between math skills and Information Processing is an established fact [20, 21]

2. 'The National Assessment of Educational Progress (NAEP) assessment in reading comprehension is given every two years to students at grades 4 and 8, and approximately every four years at grade 12. The assessment measures reading comprehension by asking students to read selected grade-appropriate materials and answer questions based on what they have read.' [22] These results reflect in Nation's Report Cards which show significant decrease in 2022 compared with 2019 in both math and reading for 4th and 8th grade students. [23]

   While establishing a definite connection between this trend and the freshman drop in Information processing skill needs further research, the relation between reading comprehension and Information Processing has been researched and established [24].

These two national results suggest that the trends we see in the department may be part of a larger phenomenon at the national level.

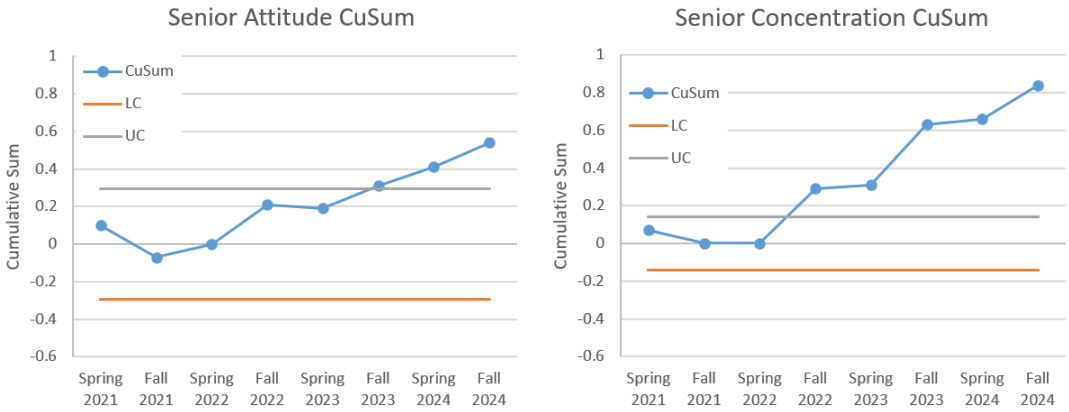

Figure 9: Positive senior trends for Attitude and Concentration scales

B. Speculation on causes

1. Freshman trends

The drop in freshman information processing and the rise in Using academic resources both fall outside of the 2 sigma bands starting the Fall of 2022. Since ChatGPT was introduced in November 2022, this decrease is likely not due to AI usage. The COVID-19 pandemic effect, on the other hand, matches the timing. The national trends mentioned in sections IV.A.1 and 2 above support this theory. However, whether this is the true cause needs further research.

Further, the rise in Using academic resources may be happening in compensation for the dropping Information Processing skill. Again, to establish if this is the case, will need further research.

2. Senior trends

Since the reported senior data is not for the same freshmen who experienced the drop in Information Processing, one possibility is that the rise may be due to a rise in freshman skills in the years before the start of our data collection. The Nation's Report Cards do show a slight rise in the relevant skills from 2009 to 2015 [25], which would include some of the years in questions. Students who were seniors in 2021 where in 8th grade in 2016 and in 4th grade in 2012. A comparison between LASSI skills from 2017 to 2021 which would observe the freshmen for whom we have the senior data is not available for our institution. If LASSI data remains aligned with the Nation's Report Cards, a drop in senior information processing must be expected in the coming years.

Further limitation in comparing senior trends against freshman trends: since the freshman class has a mixed-major composition, a more accurate interpretation would need separating the majors and performing a same-student freshman-to-senior comparison to avoid the major bias effect. This will be possible in the coming years when the relevant data becomes available.

C. Suggested strategies for supporting students with lower Information Processing skill

1. Professors can provide assignments that build the Information processing skill. These assignments can contain: Synthesizing information from multiple sources, visualizing and mapping concepts, connecting new concepts with prior knowledge.
2. The department can provide regular workshops and seminars that train students for: Critical thinking, breaking down complex engineering problems into their basic part, and data interpretation.
3. The department can make available easy-to-use guides supporting skills such as: Notes taking, summarizing, and annotating.
4. Since the usage of academic resources is on the rise, with the possibility of it being a compensation for the drop in Information processing, making more and better resources available to students, in collaboration with libraries, can also help.

V. 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.

VI. Conclusion: This paper presented trends in the department of Mechanical engineering's freshman and senior learning skills from the Fall of 2020 to the Fall of 2024. The Learning and Studies Strategies Inventory was used as a tool for collecting student learning profiles across ten basis scales. A significant drop was seen in the scale of Information Processing for freshmen with an accompanying rise in the scale of Using Academic Resources. The rest of the ten scales of learning kept a stable mean. Senior trends showed a stable mean in three scales of Selecting Main Ideas, Testing Strategies, and Motivation. The rest of the ten scales showed a persistent rise in mean. The paper also provided discussions on alignment with other national trends, speculations on causes, and suggested intervention strategies.

Overall, the trends show that incoming freshmen has been less skilled in information processing in past few years. Further, even though this drop is not currently seen in seniors, if no intervention takes place, a drop may be expected once the freshmen with lower skills reach the senior year.

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Appendix: The 10 scales of LASSI

The following is an excerpt of LASSI user manual [7].

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?