Empowering Students to Self-Select Resources Befitting Their Individual Learning Styles in a Reactor Design Engineering Course

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Abstract

The Felder-Solomon Index of Learning Styles (ILS) is a validated tool to assess a student's preferred mode of learning and has been used to help engineering educators develop active learning pedagogy and focus course content delivery successfully for over two decades [1-12]. This Work-In-Progress paper focuses on an alternate application of the Index of Learning Styles: using it to empower students to make better choices of course resources to increase their likelihood of success in a course. Students in a senior-level reactor engineering course were given a series of graded and extra credit assignments involving taking the Index of Learning Styles, completing a short workshop to learn what their results mean and how to apply them, and completing two surveys (pre-survey at the beginning of the semester and post-survey at the end). Students seemed to be able to connect what they learned from their ILS results to resources available in the class that would work most effectively with their preferred learning styles. In the post-survey analysis, students still felt that their learning styles did affect the way they study and learn the material in class, but less than 50% of the class admitted that they used the resources available.

Introduction

The Felder-Soloman Index of Learning Styles is a validated and accepted tool for assessing where on the spectra (visual-verbal, sensing-intuitive, active-reflective, sequential-global) students fall with respect to the different stages in the learning process [1-3]. To date, the inventory has been used as a guide to help instructors vary their classroom instruction to use methods that will ultimately address all learning styles by cycling through instruction approaches [2, 4-9].

Over the last two decades, a group of educational psychologists have attempted to refute the validity of learning styles in the design of instruction, stating that doing so is a detriment to student outcomes, and even deny the existence of learning styles [13-16]. These studies tend to gravitate towards the view that evidence is lacking in (1) the belief that learning styles are invariant over time, even when instructional factors and challenges change, and (2) the validation meshing hypothesis of molding instruction strictly to individual students' learning styles [17].

Through the evolution of the definition of learning styles, the most current learning style models focus on a student's preference to learning and retaining information and do not strictly tie the student to one particular learning style. Further, a student's preferred learning style can change based on their experiences and maturity. With respect to instructional design, most engineering education experts recommend not tailoring course instruction to individual students' learning styles as the meshing hypothesis suggests. Rather, it is recommended to cycle through various pedagogical techniques that will favor a variety of learning styles [1,17-19]. Balancing instructional pedagogical techniques avoids unfairly discriminating those with learning styles opposite of how course materials are presented, and the exhaustion associated with simultaneously catering to all learning styles at once in university-sized engineering courses. Directly tailoring individual students learning styles to instruction is only truly effective on the small scale (fewer than 3 students at a time). If an instructor follows a learning-styles-balanced

approach, students are more likely to persist in engineering and hone skills necessary for successful careers [1,17]. A variety of engineering educators in varying disciplines have reported success in using the balanced learning style approach to course instruction design [2, 4-5, 10-12, 17].

Despite the proven effectiveness of incorporating learning styles into classroom instruction, the amount of time students spend in the classroom as a part of their study cycle is relatively small compared to the time they spend deciphering course content on their own [18]. Even highly effective instructors who use a plethora of well-established and validated pedagogical techniques and provide ample resources to foster success can find they have a subset of students who are working diligently yet continue to struggle with performing on course assessments. Could it be possible that students are experiencing resource overload? With so many choices of resources, could they be choosing poorly and still be struggling as a result? Could having a way to help them identify which course resources are most effective for them to employ when they are studying outside of class help them focus their study time more efficiently?

Learning styles have been shown to help students make the most of group interactions in engineering and computer science courses [12]. Student self-awareness of their learning styles has also been used to help students realize their study strengths and ways to improve their study process [17]. The primary researcher in this study has also employed the ILS in engineering education success programs to help promote more efficient study sessions with struggling students and students in academic-success-based scholarship programs [20]. This Work-in-Progress paper explores the effect of empowering students to use course resources with respect to their individual learning style to study outside class more effectively in a senior reactor design engineering. In this assessment (encompassing one course semester), the students in a senior reactor design course were given an assignment at the beginning of the semester to take the Index of Learning Styles, watch a lesson on learning styles with study tips and take a survey on their knowledge level and thoughts on learning styles. Students were also given the opportunity to take a post survey towards the end of the semester. This short report will focus on the assessment of their knowledge of the students' own learning style and report on the effectiveness of students self-selecting course resources based on their learning styles.

Course, Demographics and Methods

This senior-level reactor design course was offered in the Fall of 2023 at Clemson University. The students were 63% males and 37% females with an ethnic breakdown of 78.3% white, 8.7% Asian, 4.3% black and 8.7% Hispanic. The text used in the course was "Elements of Chemical Reaction Engineering. Sixth Edition" by H.S. Fogler. In the text, Fogler has developed many excellent resources to help students understand reactor design concepts and practice complex applications [21]. These resources included interactive examples, Polymath and MATLAB coding examples, industry-based examples, references to outside literature sources and example solutions.

At the beginning of the semester, as a part of their first homework assignment, students were asked to complete the ILS (100% response rate) [22]. Screenshots of the ILS results were

submitted to the university-supplied course management system, CANVAS. After receiving their ILS results, students were required to complete a 50-minute learning module on learning styles that included instruction on what their score meant, how their brain processes information, the biology of learning, what the learning styles are, advice on what kinds of resources might be best to fit their learning style and how to work with others who might have a different learning styles than theirs [1-3, 17-19, 23]. Then, students were asked to complete a survey including Likert-based questions regarding their level of understanding of learning styles (Appendix) and the following open-ended questions (87% response rate):

- From the Learning Styles Assessment presentation and advice, what are you already doing now in your study cycle that seems to work well?
- What are some areas you could improve and how would you propose implementing changes? Are there any ideas that came to mind that weren't in the advice in the video?
- Pick two resources listed in Appendix I from the reactor design text [Fogler] that you think would help you when you are studying or doing homework for this class. For each resource, write a short (1-2 sentences) on how you think it would help you with respect to your learning style.

Throughout the semester, students were encouraged to use Fogler resources, and were pointed to various resources that emphasized the subjects covered in class, particularly after in-class, low stakes assessments. Students were also given insights as to how they would be assessed on exams with ideas as to how to study for exams. The course has two midterm exams and one final exam. At the end of the semester, students were offered an extra credit opportunity to complete a post-survey on their knowledge of learning styles and how they feel knowing them helped their study sessions (67% response rate). They were asked a combination of Likert based questions (Appendix) and the following open-ended questions:

- From the ILS presentation and advice, what new things did you try while studying and how did you feel it worked?
- Now that the semester is nearly over, what are some areas you could improve and how would you propose implementing those changes?
- If you used resources from this course (either provided by the instructor or Fogler), which ones do you feel worked best with your learning style?

Results and Discussion

Learning Styles Distribution

The ILS uses a set of questions about learning, study and personal preferences to help determine where the student falls in four ranges: visual/verbal, sensing/intuitive, active/reflective and sequential/global. Each of these ranges is linked to a specific step in the learning process: information presentation, perception, information processing and long-term storage [1-3]. Students who score a 1-3 may only have a slight affinity for one learning style type in the range and might also be able to easily adapt their learning style for either type in that category. A score of 5 to 7 indicates a moderate affinity for a particular learning style category while a score of 9 to 11 is indicative of a strong affinity for a learning style category [22].

The reactor design students' Learning Styles Inventory profile distribution appears to fit the trends seen by other engineering educators in that the majority of their students tended to be stronger visual learners as opposed to verbal learners [3] (Figure 1a). This class also showed an affinity to be sensing learners (73%) rather than intuitive learners (27%) (Figure 1b). At midterm, the students were asked for feedback with respect to course improvements. The learning style preference distribution was evident in the general feedback on course as the most requested improvements included clearer visuals, more in-depth application-based examples and a reduced focus on theoretical concepts. While the active / reflective and sequential/global preferences seem to be more evenly distributed, the class also tended to have a relatively low affinity for either category's learning style and are well balanced or adaptive in their learning styles (Figure 1c-d). Again, in the midterm feedback of the course students generally requested more opportunities to physically participate in course activities (iClicker questions, group work).

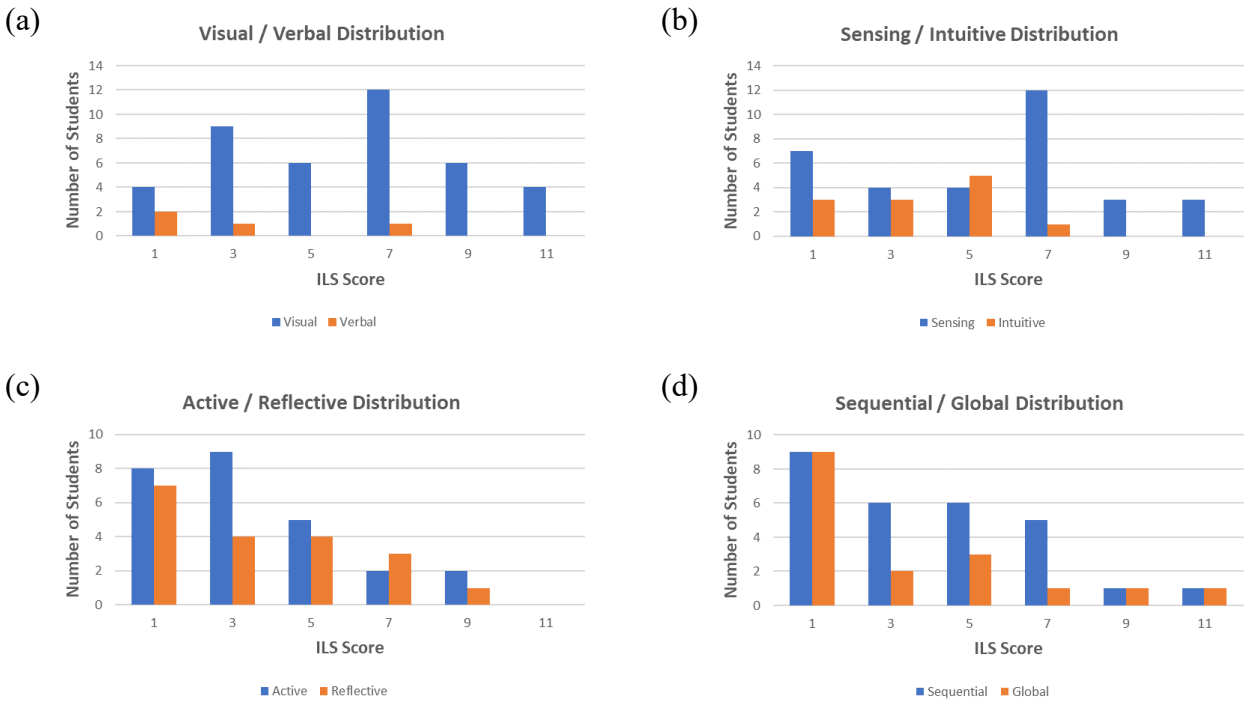

Figure 1: Learning Styles Inventory Distribution for students in the senior reactor design course. Scores

Pre-Survey

Evaluation of the pre-survey results suggests being able to identify their learning styles helped students to choose more effective resources for their study time and to explain why certain study methods worked while other methods didn't work for them. Students with well-balanced learning styles profiles admitted in their open-ended questions that they were often frustrated while studying. Students also noted past frustration with study modes that do not effectively coincide with their preferred learning style.

Most students were able to identify key areas of improvement for their study time and tended to choose course resources that best fit their learning styles. Of the 87% of the class that responded to the pre-survey, 47.5% of them indicated that their learning styles results did not surprise them. After watching the learning styles video, 95% of the respondents rated their understanding of how their learning styles affected their study habits at a 4 or higher. This is further supported by the types of resources that the students tended to choose in the open-ended question about which course resources appealed to them. Of all the resources listed in Appendix I of Fogler's text [21], video-based resources (LearnChemE, Living Example Problems) were chosen by the most students (58.7%) all of whom were visual learners. Verbal learners tended to choose text-based resources like the chapter objectives and Professional Reference Shelf. Just over half of the strong sensing learners (scoring a 7 or higher) chose resources like iClicker questions, Interactive Computer Games and Self Tests. This result was not anticipated as the questions in these resources vary between fact/application questions and concept/theory questions. Casual conversations with several of these students revealed that the students sought to challenge themselves in an area of weakness to better prepare for conceptual questions on exams. This was not formally addressed in the pre- and post- surveys and will have to be examined further in future studies.

For the active/reflective and sequential/global categories, students tended to score in the well-balanced learning styles range. The few students who had a stronger affinity towards one or the other in the active/reflective categories did tend to gravitate towards resources that matched their preferred learning styles. Active learners seemed to prefer resources that promoted interactive learning while the strong reflective learners preferred resources that allowed them time to think about what they learned before working.

Post-Survey

Students were offered extra credit to complete the post-survey comprised of Likert-based questions (Appendix) and open-ended questions. Despite being given time through finals week, only 67.4% of the students completed the survey. Students were asked if they still felt that their learning styles accurately depicted their learning style, 64% of respondents agreed or strongly agreed while 13% disagreed. Similarly, students also generally still felt that their learning styles affected their ability to learn the material and shaped their study habits (64% and 55% respectively agreed or strongly agreed). At the end of the semester, 48% of students felt that there were enough resources provided that fit with their learning style while 38.7% were neutral and 9.6% disagreed or strongly disagreed.

Students were also asked if they consistently employed resources during the semester, particularly from Appendix I [21]. The results were mixed with approximately 30% agreeing, 30% being neutral, and 30% disagreeing. Students who did employ Fogler and course resources gravitated towards interactive, visual resources and tended to feel more comfortable with course material as the midterms and finals approached. Students admitted that they altered the way they studied more by incorporating the study cycle [18], rather than consciously focusing on their learning style. For the students that did use course and Fogler resources, students also tended to gravitate towards resources that matched their learning style.

Conclusions and Future Work

Even though the results of this study were mixed, there is some evidence that introducing students to what their learning style is and how to use that knowledge does help them to be able to identify resources that might be most beneficial to them. However, there is also evidence that students might not use the resources, even if they have a high likelihood of being helpful. The students in this study were seniors who may already be quite set in their study habits and changing those habits this late in their education may be difficult. Anecdotal conversations with a few of the students seemed to indicate that they tended to use out-of-class resources more at the beginning of the semester, but continuing to use them became difficult as the semester progressed. Seniors are typically interviewing for jobs both on campus and off campus and taking senior design, in which the workload becomes progressively more intense. Future study will include students in varying class levels of students (freshmen – seniors).

Moving forward, the questions in the surveys will be updated to provide more information on why students tend to shy away from using resources in the course and if knowing their learning style makes them more apt to use a resource that would work effectively with their learning style. Questions will also be updated to attempt to gather more information on why certain resources were chosen over others. The learning styles workshop module is long. While it appears that students can glean what was intended for them to learn from the workshop, future studies will include a set of shorter videos that breaks the information into shorter sections. The first 10-minute video will cover the learning process, the study cycle, the biology of learning and an overview of learning styles. The remaining 40 minutes will be split into eight, 5-minute videos focusing on each of the learning dimensions individually. Students wishing to receive full credit for the assignment will be required to watch the first 10-minute video and at least four of the eight, 5-minute videos.

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Appendix

Pre-Survey Likert Questions

Possible responses ranged from 1 – 5, where 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree or Disagree, 4 = Agree, 5 = Strongly Agree.

1. I was surprised by my results.
2. I understand how the different learning styles can affect the study cycle.
3. I feel that knowing more about my learning styles can help improve my study time.
4. I would recommend the Learning Styles Assessment to a friend who was struggling in a class.
5. I feel confident that I will be able to implement changes to my study habits.
6. I feel confident using or trying resources in the Fogler text.
7. I feel that the results of the Learning Styles Assessment adequately describe the type of learner I am.

Post-Survey Likert Questions

Possible responses ranged from 1 – 5, where 1 = Strongly Disagree, 2 = Disagree, 3 = Neither Agree or Disagree, 4 = Agree, 5 = Strongly Agree.

1. I noticed ways that my learning style affected my ability to learn material in the course.
2. I noticed ways that my learning style affected my study habits this semester.
3. I feel that knowing more about my learning styles did help improve my study time.
4. I would recommend the Learning Styles Assessment to a friend who was struggling in class.
5. I implemented changes to my study habits as a result of knowing my learning style.
6. I used resources provided by the instructor that matched my learning style.
7. After going through the material in tis course, I feel that the results of my Learning Styles Assessment adequately describe the tyle of learner I am.
8. The instructor provided course resources that matched my learning style.
9. I used Fogler resources that matched my learning style.