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A survey of biological and agricultural engineering students and faculty learning preferences

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Introduction

While all individuals can learn using different modes of receiving and processing information [1]–[3] most learners exhibit preferences in the way they receive and process information [4]–[6], called learning preferences or learning styles. When information is presented in ways that frequently mismatch a student's learning preference, the student can become demotivated and disengaged with the learning process [7]. It is critical for instructors to realize that students in their classrooms exhibit various learning preferences so that they implement a teaching approach incorporating various ways of presenting new material to provide an optimal learning environment for all students in the class [8], [9]. Instructors have their own learning preferences too, which can impact the way they deliver information in the classroom [10]. Therefore, it is also important for instructors to become aware of their own learning preferences and potential bias towards one teaching style [11], especially since research shows that learning can be reinforced when students are presented with the same information through a variety of modalities (verbal, visual, practical) [12], [13]. Students also benefit from knowing their learning strengths and weaknesses so they can implement study strategies to improve their learning when the course presentation mismatched their style [14]. Some researchers even found a correlation between whether students were able to identify their learning preferences and their academic achievement [15]. Students can also train to become more comfortable learning from all teaching modalities so they are better prepared to face every learning situation they encounter in their lifetime [9], [10]. Knowing one's learning preference as well as teammates' preferences is also helpful for resolving conflict in teamwork [14].

There are a plethora of learning styles survey instruments available. Coffield [16] conducted a thorough review of the most commonly used instruments for use in education and concluded that learning styles models have variable quality, with some models exhibiting psychometric weaknesses including internal consistency, test-retest reliability, construct validity and/or predictive validity. The Felder and Soloman Index of Learning Styles (ILS) instrument was developed in 1996 primarily for use by college instructors and students in engineering and the sciences. It was validated in several studies and was proven to have good construct and predictive validity [17], [18]. The instrument assesses learning preferences on four scales with two dimensions each: Processing with the Active and Reflective dimensions; Perception with the Sensing and Intuitive dimensions; Input with the Visual and Verbal dimensions; and Understanding with the Sequential and Global dimensions. Ratings are represented by a degree of preference for each learning scale: balanced (no preference between dimensions), moderate preference for one dimension, or strong preference for one dimension.

In the processing scale, active learners prefer learning the material by applying it, discussing it or explaining it to others. Reflective learners prefer to think about and reflect on the material first. In the perception scale, sensing learners prefer to learn facts and concrete material that relate to the real work, doing hands-on work, and tend to be more practical. Intuitive learners prefer working with abstract concepts and mathematical formulations. In the input scale, visual learners prefer when the material is presented using pictures, diagrams, flowcharts. Verbal learners prefer written and spoken materials. In the understanding scale, sequential learners prefer material to be presented in linear steps that logically follow the previous one, from small parts to whole. Global learners prefer when the big picture is presented first and learn in large jumps, when they are able to connect the information to the big picture.

Several studies have reported US undergraduate engineering students' learning preferences according to the ILS (see [17] for a compilation of studies before 2005; [19], [20]). While some variability is observed between the different studies, they all report that a large majority of students have a preference for visual learning, and, to a lesser extent for active learning. A couple of studies also compared the learning preferences of engineering students with those of engineering faculty. For example, [21] found statistically significant differences in the mean scores of students and faculty on Active-Reflective, Sensing-Intuitive and Sequential-Global scales.

Only one study specifically focused on Biological and Agricultural Engineering undergraduate students and faculty learning styles at Pennsylvania State University [22]. However, this study used the Group Embedded Figures Test (GEFT) and Myers-Briggs Type Indicator (MBTI) instruments. They found no significant difference between the personality types of the Myers-Briggs Type Indicator (MBTI) test between engineering students and faculty.

In addition, most studies have been published several years or decades ago, but nowadays, most of the undergraduate students are from Generation Z, the first generation to be digital natives [23], [24]. They use technology to facilitate their lives, find relevant information, and solve their problems. They grew up with sophisticated visual imagery. They are known to be fast decision makers and rely on a trial and error approach [25]. To this date, there is a dearth of studies focused on exploring Generation Z learning preferences.

The goal of this study was to survey and report on the learning preferences of current Biological and Agricultural Engineering undergraduate students and faculty at NC State University. Specifically, participants' learning preferences were surveyed using Felder and Soloman's ILS instrument. Distributions of scores within each group were determined. Statistical analyses were performed to determine if differences exist between learning preferences of students and faculty.

Methods

A specific survey instrument combining demographic questions and the ILS questionnaire was designed for each group (students and faculty). Distinct surveys were designed to limit fraudulent survey participation, for example, students identifying as faculty. The first demographic question asked participants to select their affiliation with the NC State University

Biological and Agricultural Engineering Department to filter out participants not affiliated with the department. Demographic questions for faculty asked about their rank, age group, teaching appointment, gender, whether they were first generation college students, whether they transferred from community college, whether English was their primary language, whether they completed some of their education outside of the US and what was their preferred method of classroom delivery. Students' demographic questions asked about their class rank, degree concentration, age group, gender, whether they were first generation college students, whether they transferred from community college, whether English was their primary language, and what was their preferred method of classroom delivery.

Felder and Soloman ILS instrument consists of 44 questions, more specifically eleven questions per scale of learning: Input, Processing, Understanding, Perception. Each question has two possible answers corresponding to the two dimensions of the scale, for example one response representing Active learning and one representing Reflective learning. For all the questions in a scale, the number of answers for each dimension is counted. The score for the scale is calculated as the difference between the numbers of answers between the two ends. Scores can range from -11 (all answers fell on one dimension of the scale, for example Reflective), to + 11 (all answers fell on the other dimension, for example Active). According to the scoring guide from Felder and Soloman, absolute scores of 1 and 3 represent a balanced learning profile, absolute scores of 5 and 7 represent a moderate preference for one dimension, and absolute scores of 9 and 11 represent a strong preference for one dimension.

After IRB approval, the surveys were implemented in Qualtrics. The surveys were completely anonymous and no personal identifier was collected. The Qualtrics tool was programmed to compute the participant score for each learning scale upon completion of the survey. The tool was set up to return the participant's degree of preference for each learning scale (balanced, moderate or strong preference) as well as some language written by Felder and Soloman in the "learning styles and strategies" document accompanying the questionnaire. Students and faculty were recruited via email (with the link to the survey), in-class announcements and flyers (with a QR code linking to the survey) during the last week of August 2022. Every faculty and student in the department was eligible to take the survey. The online survey stayed open for four weeks. Valid responses from 23 faculty members and 38 undergraduate students in the Biological Engineering program were received.

The survey data was downloaded from Qualtrics and analyzed using R [26]. For each group, the mean score, median score, standard deviation, and distribution of scores were computed for each of the four learning scales. A non-parametric Mann Whitney U test was used to determine whether there was a statistically significant difference between the distributions of scores in each group on each of the four learning scales, with a significance level $\alpha=0.05$.

Results

The purposes of this survey were to determine the distribution of learning preferences for faculty and undergraduate engineering students (BE) in the department of Biological and Agricultural Engineering at North Carolina State University, and to identify similarities and differences between the learning preferences of these two groups. The results of this study are listed in Table 1. Numerical values of the mean and median are indicative of the average learning preference of the population based on the scale provided by the scoring guide of Felder and Soloman. The standard deviation quantifies the spread of the scores within the population. In the following sections, results will be described for each learning scale.

Table 1: Statistical Results of Learning Preferences of the Faculty and BE Populations

	ACT/REF		**SEN/INT**		**VIS/VER**		**SEQ/GLO**	
	Faculty	BE	Faculty	BE	Faculty	BE	Faculty	BE
Mean	0.043	2.47	1.26	3.42	7.26	6.11	-0.043	1.47
Median	-1	3	1	3	9	7	-1	2
standard deviation	4.59	4.85	6.45	4.00	3.58	4.02	4.43	3.37
p-value Mann Whitney test	0.030		0.258		0.239		0.170	

Active/Reflective Scale

Overall, both faculty and BE student populations exhibit a balanced learning preference for the active/reflective scale based on the mean and median data shown in Table 1. The faculty population had an average score of 0.043 with a median of -1 which indicates an overall balanced learning preference for this scale. The distribution of the faculty data for the active/reflective scale is shown in Figure 1. Of the 23 faculty surveyed, results ranging from moderately reflective to strong active learning preferences and the standard deviation of 4.59 indicate that there is a wide distribution of learning preferences within this scale for the faculty population.

The BE students had an average score of 2.47 and a median of 3 which suggests that this population on average exhibits a balanced learning preference for the Active/Reflective scale. The distribution of the BE population data is shown in Figure 2. Of the 38 students surveyed, the students' preferences ranged from strong reflective to strong active and the standard deviation was 4.85 which indicates that this population, similar to that of faculty, exhibit a wide distribution of learning preferences for the active/reflective scale. The BE student population did exhibit a stronger trend for active learning preference with 42% of the sample population exhibiting a moderate to strong preference compared to 21% of faculty. This difference between the two populations was found to be significant by the Mann Whitney U test.

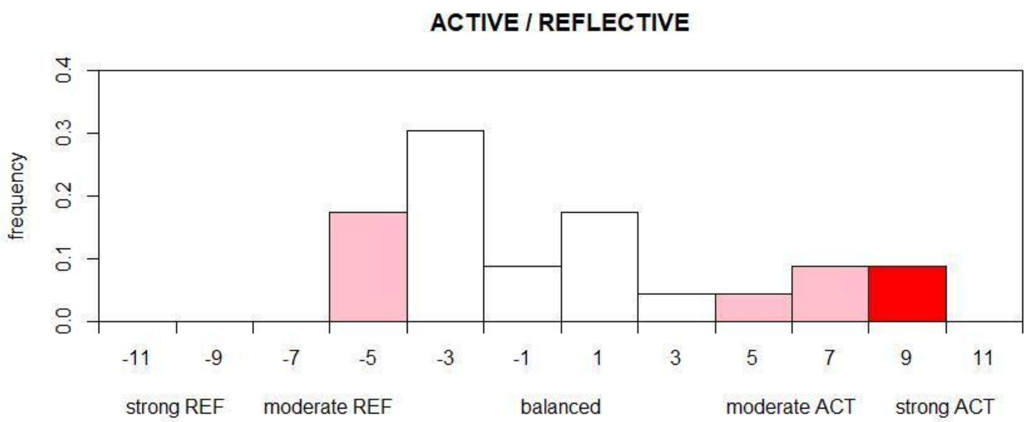

Figure 1. Faculty Population Distribution for Active/Reflective Scale

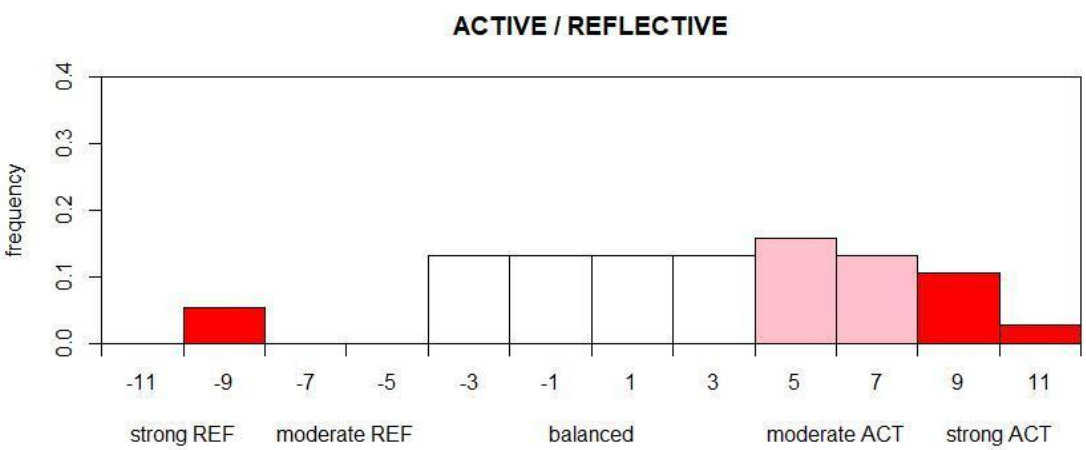

Figure 2. BE Student Population Distribution for Active/Reflective Scale

Sensing/Intuitive Scale

According to the mean and median data shown in Table 1 both faculty and BE student populations exhibit a balanced learning preference for the sensing/intuitive scale of the ILS. The faculty population had an average score of 1.26 with a median of 1 which indicates an overall balanced learning preference for this scale. The distribution of the faculty data for the sensing/intuitive scale is shown in Figure 3. Of the 23 faculty surveyed, results ranging from strong intuitive to strong sensing learning preferences and the large standard deviation value of 6.45 indicate that there is a large distribution of learning preferences within this scale for the faculty population.

The BE student population had an average score of 3.42 and a median of 3 which suggests that this population on average exhibits a balanced learning preference for the Sensing/Intuitive scale. The distribution of the BE student population data is shown in Figure 4. Of the 38 students surveyed, the students' preferences ranged from moderately intuitive to strong sensing and the standard deviation was 4.00 which indicates that this population exhibits a wide distribution of learning preferences for the Sensing/Intuitive scale, although not as large of a distribution as that of the faculty population. The BE student population did exhibit a stronger trend for sensing learning with 47% of the sample population exhibiting a moderate to strong preference compared to 39% of faculty, although this trend was not found to be significant based on the statistical analysis.

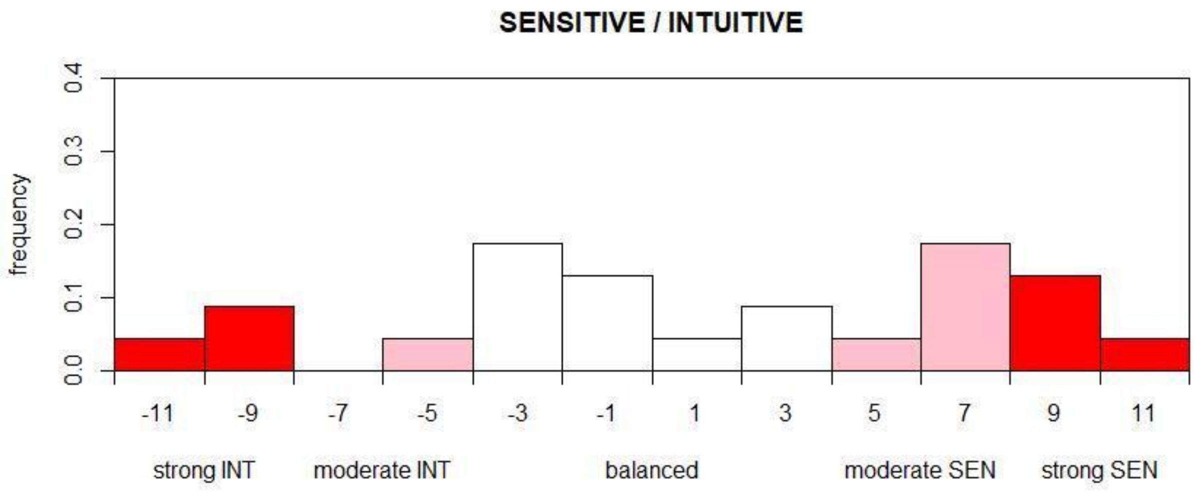

Figure 3: Faculty Population Distribution for Sensing/Intuitive Scale

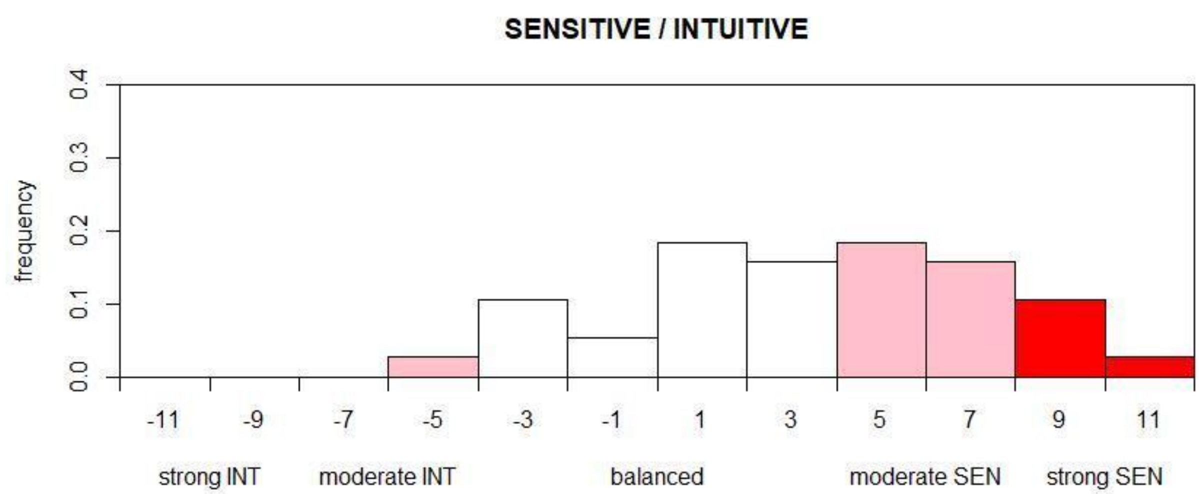

Figure 4: BE Student Population Distribution for Sensing/Intuitive Scale

Visual/Verbal Scale

According to the mean and median data shown in Table 1 both faculty and BE student populations exhibit a moderate visual learning preference for the visual/verbal scale of the ILS. The faculty population had an average score of 7.26 with a median of 9 which indicates an overall moderate to strong learning preference for this scale. The distribution of the faculty data for the visual/verbal scale is shown in Figure 5. Of the 23 faculty surveyed, results ranging from balanced to strong visual learning preferences and the standard deviation value of 3.45 indicate that while there was a wide distribution of learning preferences within this scale, the distribution was more concentrated around one area of the scale than what was observed with the other three scales that were analyzed.

The BE student population had an average score of 6.11 and a median of 7 which suggests that this population on average exhibits a moderate learning preference for the visual/verbal scale. The distribution of the BE student population data is shown in Figure 6. Of the 38 students surveyed, the students' preferences ranged from balanced to strong visual and the standard deviation was 4.02 which indicates that this population exhibits a large distribution of learning preferences for the visual/verbal scale. Both the faculty and the BE student population show a moderate preference for visual learning styles. There were no significant differences found between the preferences between the two populations for the visual/verbal scale. From the analysis, it can be concluded that both the faculty and the BE student populations which were sampled show a moderate preference for visual learning.

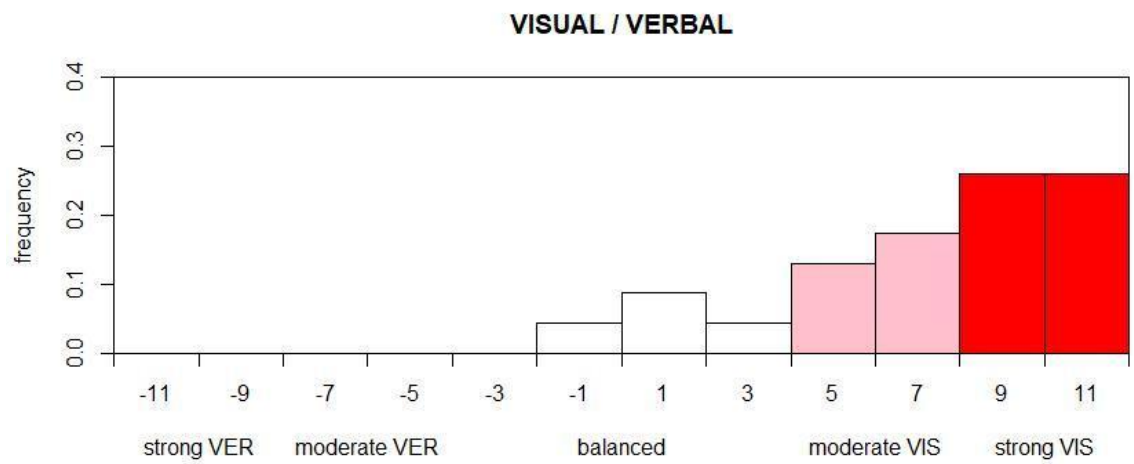

Figure 5: Faculty Population Distribution for Visual/Verbal Scale

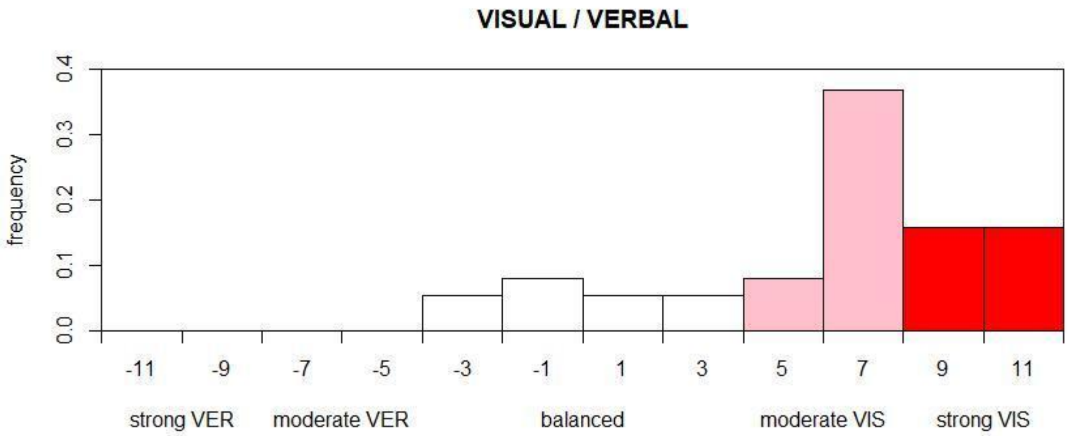

Figure 6: BE Student Population Distribution for Visual/Verbal Scale

Sequential/Global Scale

Overall, based on the mean and median data shown in Table 1 both faculty and BE student populations exhibit a balanced learning preference for the sequential/global scale of the ILS. The faculty population had an average score of -0.043 with a median of -1 which indicates a balanced learning preference for this scale. The distribution of the faculty data for the sequential/global scale is shown in Figure 7. Of the 23 faculty surveyed, results ranging from moderate global to moderate sequential learning preferences and the standard deviation value of 4.43 indicate that while there was a wide distribution of learning preferences within this scale. While the distribution for this scale was similar to the other scales evaluated, it is interesting to note that no strong preference was recorded for either end of the scale, which reinforced the fact that this population is balanced for this scale of the index as indicated by the mean and the median.

The BE student population had an average score of 1.47 and a median of 2 which suggests that this population on average exhibits a balanced learning preference for the sequential/global scale. The distribution of the BE student population data is shown in Figure 8. Of the 38 students surveyed, the students' preferences ranged from moderate global to moderate sequential and the standard deviation was 3.37 which indicates that this population exhibited a distribution similar to that of other scales evaluated within in this survey for this particular population. Unlike other scales evaluated, no strong preference was recorded for either end of the scale, indicating that the distribution of the data was centered near the balanced preference for this scale. Both the faculty and the BE student populations show a balanced preference for this scale of learning styles given that there were no significant differences found between the preferences between the two populations for the sequential/global scale. From the analysis of the sample populations, it can be concluded that both the faculty and the BE populations that were sampled show a balanced preference for sequential/global learning styles.

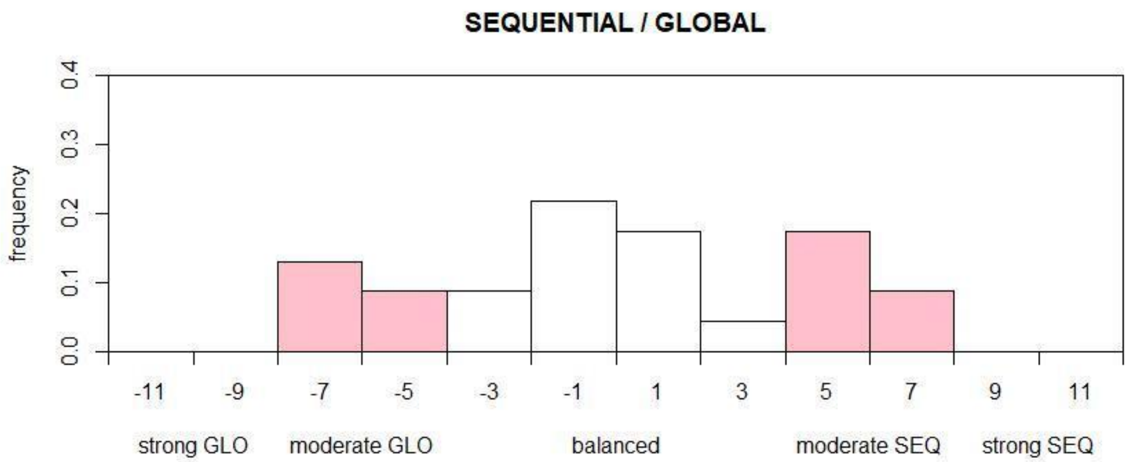

Figure 7: Faculty Population Distribution for Sequential/Global Scale

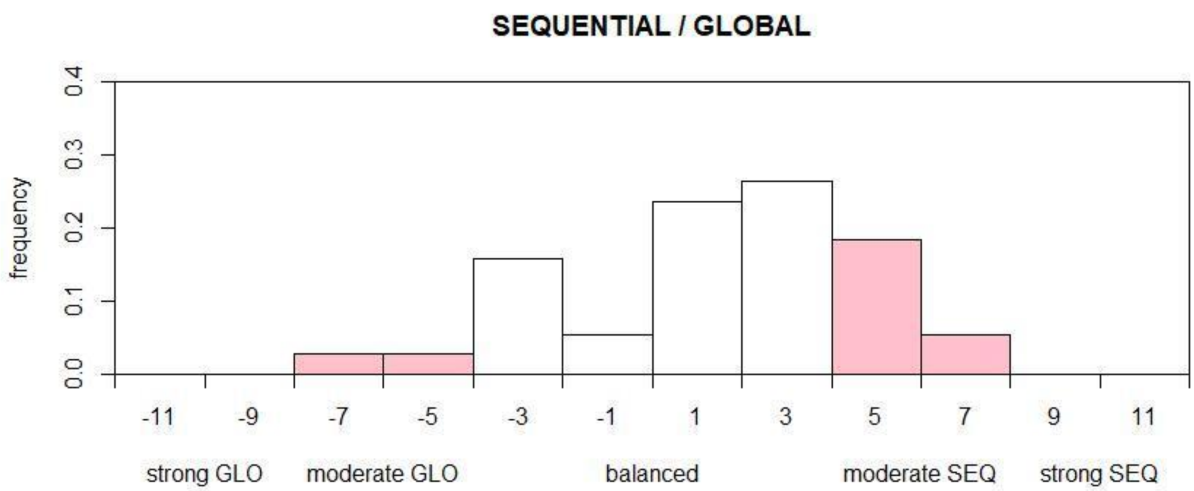

Figure 8: BE Student Population Distribution for Sequential/Global Scale

Discussion

Comparison with Other Engineering Programs

For the first time ever, this article reports learning preferences for undergraduate students and faculty members in a Biological Engineering program assessed by the ILS. The distributions of preferences can be compared with previous studies using the ILS. Most studies report the percentage of respondents falling in each dimension of a learning scale (Active vs Reflective for example). This means that a student with a score of 1 on the Active - Reflective scale would be categorized in the same group as a student with a score of 11 on the scale. A comparison of students' preferred dimension for each learning scale is shown in Table 2. Only studies involving engineering students in English-speaking countries and carried out after 2000 were reported. Generally, learning preferences of Biological Engineering students at NC State University align well with other engineering disciplines. Biological Engineering students display the largest preference for the sensitive and sequential dimensions of all the populations reported in Table 2. The strong score of Biological Engineering students on the sensitive dimension aligns well with the practical and hands-on aspect that characterizes the discipline [28].

Table 2. Percentage of students with a preference for Active, Sensing, Visual and Sequential learning dimensions.

Student population	**ACT**	**SEN**	**VIS**	**SEQ**	**number**	**Source**
Univ. of Puerto Rico-Mayaguez, Elect. & Comp. Eng (2000)	47%	61%	82%	67%		[17]
Ryerson Univ., Elec. Eng (2000)	53%	66%	86%	72%	87	
Ryerson Univ., Elec. Eng(2001)	60%	66%	89%	59%	119	
Univ. of Technology Kingston, Jamaica (2001)	55%	60%	70%	55%		
Tulane, Engr. Second-Year Eng (2001)	62%	60%	88%	48%	245	
Tulane, Engr. First-Year (2002)	56%	46%	83%	56%	192	
Univ. of Limerick, Mfg. Eng (2002)	70%	78%	91%	58%	167	
Ryerson Univ., Elec. Eng (2002)	63%	63%	89%	58%	132	
Ohio State University First year Eng (2015)	65%	54%	81%	64%	223	[20]
North Carolina State University, Biological Eng. (2022)	68%	82%	87%	74%	38	

A similar table was created for the comparison of faculty learning preferences (Table 3). Very few engineering faculty learning preferences have been gathered in the past. Similarly to students, Biological and Agricultural Engineering faculty display the largest preference for the sensitive dimensions of all the populations reported in Table 3.

Table 3. Percentage of faculty with a preference for Active, Sensing, Visual and Sequential learning dimensions.

Faculty population	ACT	SEN	VIS	SEQ	number	Source
Univ. of Western Ontario Eng. faculty (1997)	51%	40%	94%	53%	53	[17]
Ryerson Univ., Elec. Eng. Faculty (2002)	38%	42%	94%	35%	48	
North Carolina State University, Biological and Agricultural Eng.(2022)	44%	52%	96%	48%	23	

Comparison with Another BAE Program Surveyed with the MBTI

Past research shows that the sensing/intuitive learning scale from the ILS correlates with the sensing/intuitive dimension from the MBTI instrument [5], [29]. This suggests that it is possible to compare sensing/intuitive preferences between Biological and Agricultural engineering students and faculty at NC State University measured using the ILS and those of Biological and Agricultural engineering students and faculty at Pennsylvania State University measured using the MBTI instrument [22]. At Pennsylvania State University, they found that 50% of students were classified as Sensing and 50% were classified as Intuitive based on the MBTI instrument. This result does not align with the ILS results for NC State University students that show that 82 % of students classify as sensing. Looking at Figure 4, we notice that only 47% of NC State University students exhibit a strong or moderate preference for sensing, and that the remaining 35% only display a mild or balanced preference. This large proportion of students with a balanced preference could explain the discrepancy in preferences observed between the two groups. At Pennsylvania State University, 60% of faculty were classified as Sensing and 40% were classified as Intuitive based on the MBTI instrument, which is in agreement with the ILS results for NC State University faculty of 52% Sensing and 48% Intuitive.

Takeaways for Effective Instruction

One of the tenets of learning theory is that students learn and retain material better when they are presented with and process information using multiple modes. Therefore, the key takeaway for effective instruction is that professors must present information in various ways. This strategy is helpful to reduce instructors' bias towards one teaching modality, ensure information is delivered in a way that appeals to every student’s preference, and expose students to receiving information in a different modality and deepen their learning. Verbal and reflective teaching methods, including lectures and prints are most traditionally used in US engineering classrooms [30].

Effective instruction strategies include supplementing lectures and prints with visual learning opportunities such as sketching problems and showing videos, pictures and diagrams and incorporating a combination of active learning activities such as problem solving and reflective activities such as discussions.

Conclusion

Data collected by this study has provided our department with a valuable perspective on the learning preferences of the undergraduate engineering student and faculty populations. While we realize that this was a small sample size, based on the data collected we can conclude from this data set that students and faculty exhibit a large variety of learning preferences. A statistically significant difference in the learning preference distributions of faculty and BE students was found for the Active/Reflective scale. For the other scales, the populations exhibit similar preference distributions. Future plans for this study include scaling this study to include Biological Engineering students, Engineering Technology or Agricultural Systems Management students and faculty from other institutions across the US in an attempt to receive a larger sample size for evaluation, and evaluate whether learning preferences vary based on class rank or degree concentration. There are also plans to repeat this study at the department level on an annual basis to track the learning preferences of the student population as a cohort.

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