Understanding First-Year Engineering Students' Perceived Ideal Learning Environments

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***Abstract*—** There is a growing interest by engineering education researchers to identify learning spaces that enhance student engagement and learning in higher education [1-3]. Yet seldom does the creation and design of these learning environments consider students' initial perceptions of these spaces. This exploratory study sought to understand what early engineering students perceive are their ideal learning environments. A rearrangeable, active, and mobile learning classroom space, containing 14 tables and 42 chairs, was used as part of an Introduction to Engineering Course.

Student teams hand-drew sketches of their ideal learning environment, pitched their designs to the class, and repositioned the existing lecture-style classroom arrangement. The top three classroom designs were voted by the students and furniture was arranged accordingly. After each arrangement, an open discussion took place amongst the students about the learning space. Audio recordings, sketches, images, and quotes of students' perceived ideal learning environments were collected. Pre- and post-surveys about perceived emotions and stress were collected as well as near-to-real-time engagement (via electrodermal activity sensors).

Preliminary findings suggested that students preferred moveable, open-spaced, and collaborative arrangements that face forward (e.g. U-shaped theater-style) over traditional learning spaces (e.g. stationary lecture-style). While electrodermal activity (EDA) was not significant, students' self-reported levels of self-efficacy increased marginally, but not statistically significantly over the duration of the class period.

***Keywords*—First-year Experiences, Research in Engineering Education, Active Learning, Sustainable Education Systems, Student-centered Teaching**

I. Introduction & Background

Many studies in education focus on innovative classroom pedagogy, but fewer studies focus on how actual seating arrangements effect student learning outcomes [4-5], especially in engineering. There is a need for research concerning the perceived ideal environment of students [6] to focus the classroom on improving student-centered learning. When students are the center of learning, their ideas and experiences are more valued, increasing motivation and engagement [5, 7-8]. Well-designed learning spaces need to provide the ability for collaboration, personalization, flexibility, and inclusion [7].

Harvey & Kenyon [9] stated the following:

> Learning environments symbolize an institution's vision of educational philosophy. Learning spaces should represent, too, the inclusivity of learners and educators in planned decision making to foster attainment of learning goals for all constituents, yet too often these decisions are made by those far removed from the classroom. (p. 1)

One of the major issues with classroom design is that different stakeholders have varying perceptions of the seating styles and arrangements needed in the classroom; these preferences can range from equitable use, flexibility, disability accommodation, or easy of clean-up [9].

By having mobile furniture and allowing users to adjust the seating styles accordingly, the space can be inclusive and functional in ways that account for various learning needs and pedagogies [9]. As stated by the Joint Information Systems Committee (JISC) [7]:

> Understanding what makes an effective [classroom] design is important. The best are likely to assist all within the institution to work more productively and produce learners who are confident, adaptable, independent, and inspired to learn. In short, the design of our learning spaces should become a physical representation of the institution's vision and strategy for learning – responsive, inclusive, and supportive of attainment by all. (p. 2)

In a study by Harvey & Kenyon [9], undergraduate students reported a preference for movable tables and chairs

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and while fixed, tiered seating and tablet arm chairs were rated the lowest. Students claim that modern learning spaces influence their motivation, psychological comfort, and satisfaction more than their actual learning [3, 5].

There is a need to turn away from traditional, outdated teaching techniques in engineering to alternative learning techniques [10], such as problem and project-based learning, in order to increase retention and encourage more students who can make important contributions to society [1, 10-11]. These changes in teaching techniques can be fostered by classroom design and flexibility. This was found at St. Edward's University where professors naturally used more active learning techniques simply by moving to a mobile classroom [12].

Students in engineering may initially have negative reactions and resistance to active learning methods being employed by the instructor [13]. This partly results because of typical, lecture-style classroom configurations limiting instructor access and student [13]. Students show less resistance and more engagement when a variety of active learning activities are employed [13], which can be better adapted to with flexible, mobile learning spaces. When an instructor and students are in a space that is adapted to active learning activities with enhanced technology, higher performance was measured among the students [14].

This research study focused on engineering students' perceptions of their ideal learning environment as recent research is calling for more inclusive and active spaces that allow active pedagogy in engineering education [1, 10-11]. In addition, we incorporated biometric approaches in an attempt to assess student's nearer-to-real-time engagement in these learning spaces [15-16]. Self-efficacy was also assessed.

A commonly measured biosignal is electrodermal activity (EDA), which is a measure of electrical conductivity from sweat on the skin, evidencing activation of the sympathetic (fight/flight system) autonomic nervous system caused by responses such as high levels of stress, cognition, or emotion [17-19]. The EDA signal includes both a baseline (tonic) form as well as a stimulus-specific form (phasic) [17]. Mental activity or emotional strain can be evidenced by a change in phasic responses, which is a response to affective or emotional arousal [17].

Self-efficacy is the belief the student has about his or her ability to perform to a specific level [20]. Students with high self-efficacy feel they have the ability to control situations and exercise influence over them [20]. Self-efficacy was used to determine if the students felt that the moveable furniture and its arrangements would increase their confidence in their ability to learn in different classroom arrangements.

II. Methods

This mixed-methods exploratory study was held in two sections of a 50-minute Introduction to Engineering course at a western institution of higher education in the United States, which had 38 total students across both sections. Sixteen of these students volunteered to participate in the research study. Primary emphasis of the findings were placed on the qualitative results.

All 16 participants had 62 or less college credit hours with an average GPA of 3.37. Females made up 12.5% of the population. The average age of the participants was 21.7 years. Ten of the participants were declared engineering majors. During the study, all 16 participants wore electrodermal activity (EDA) sensors, although due to sensor malfunction, 12 of these students' biometric data could be utilized. While the population for EDA may appear small, this is an adequate size due to the complexity and high volume of data obtained (~18,000 data points per participant) [15].

For the first five weeks of the course, the instructor conducted classes in lecture-style format (e.g. straight rows and tables in a classroom setting) to mitigate any pre-conceived notions of ideal learning environments prior to the study and to keep consistent with the common arrangement of other classrooms on campus. During the sixth week of class, the instructor introduced a lesson in lecture-style and then transitioned into an open discussion about ideal learning environments. Students provided a handwritten and hand-drawn description of their ideal learning environment.

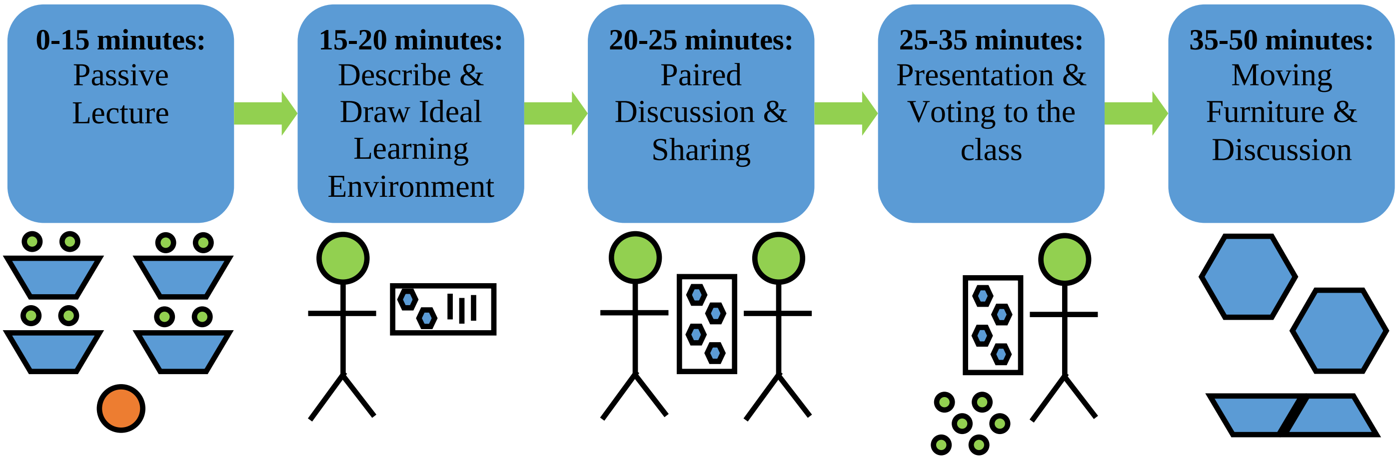

Fig. 1 Timeline of the events that occurred during the class session. Green dots indicate students and an orange dot represents an instructor.

Students were then asked to discuss their ideal learning environments in pairs and to sketch a visual representation of such on a handheld white board. A member of the research team took pictures of these drawings with permission from the students. A total of 15 sketches and descriptions were analyzed as one of the participants opted to not provide a drawing and description.

A designated spokesperson from the pair presented the idea to the class. The top three ideas were then chosen by the class. Then, students rearranged the classroom furniture into the voted-upon arrangements. After each arrangement, an open and verbal classroom discussion was held to talk about the positive and negative aspects of each classroom arrangement. See Fig. 1 for an overview of this timeline and research design of this learning environment.

Pre-approved Institutional Review Board (IRB) surveys were administered to the students before class began and right after it finished. The pre-survey included questions about demographics, academics (grade point average, year in college, total credits, etc.), preferred learning environment, and classroom environment impact. We also collected health, academic emotions, and stress data, although this will not be the focus of this work.

III. Results

To determine student self-efficacy, students were asked both before and after the session, "How confident are you that this furniture arrangement will ensure your learning is enhanced?" The answer was on a Likert scale from '1' to '5' with ‘1’ meaning not confident at all, ‘3’ meaning somewhat confident, and ‘5’ meaning very confident. A paired t-test revealed that there was a marginal, not statistically significant increase in self-efficacy ($p = 0.11$) during the session.

Fifteen descriptions of the students’ ideal learning environment were coded using descriptive and in-vivo coding followed by magnitude coding. Intercoder agreement was 85% and discussions occurred until consensus was achieved. Themes were categorized as (a) instructor-centered, meaning that students showed a preference for a focus on and equal access to the instructor from their seating position; (b) student-centered, meaning the students showed a preference for group-based arrangements to provide access to discussion with other students; or (c) blended, meaning the student mentioned both a student-centered and instructor-centered arrangement depending on the teaching style and activities happening in the classroom.

A common overall idea that appeared in the ideal learning environment descriptions was that of connectedness (e.g. Participant 7) and visibility of classmates (e.g. Participants 1 & 5), visibility and access to the instructor (e.g. Participants 4 & 13), and the course content (e.g Participant 12).

Approximately 40% of participants (e.g. Participants 1, 3, 5, 8, 11, & 14) mentioned the classroom being arranged in a way that brought psychological comfort in interaction, meaning the set up was arranged in such a way that they were comfortable and able to engage with those around them. Natural light was also mentioned by one participant (e.g. Participant 13) in order to help them.

One of the participants strictly wanted to work alone have their own space, and keep a typical, individualized, lecture set-up (Participant 9).

Magnitude coding revealed that student-centered environments were mentioned 17 times while instructor-centered were only mentioned 9 times. In Table 1, the three different types of responses received are summarized.

Each of the 15 students were only placed in one of the three categories. The post-survey average self-efficacy of students in each of the categories was calculated. The self-efficacy value was available for 11 of the participants. Two participants’ responses were categorized as instructor-centered, four were student-centered, and five were blended.

The mean phasic EDA was also compared for the students in each of the categories. The EDA data was available for 11 of the participants. Two students’ responses were categorized as instructor-centered, six were student-centered, and three were blended.

The three different types of responses received, examples, self-efficacy averages, and mean phasic EDA values are provided in Table I. Representative images are provided in Fig. 2.

TABLE I. Summary of the coded responses from the study participants. All representative quotes come from the written description students gave of their ideal learning environment

Theme	**Representative Quote(s)**	**Average Self-Efficacy**	**Mean Phasic EDA (µS)**
Instructor-Centered	• I like to work alone & don't work well with others (Participant 9, Line 3). • Seating would be arranged in a big circle with the professor in the center (Participant 13, Line 1).	3.5 ± 0.7	0.185 ± 1.967
Student-Centered	• I like larger classrooms to be split up into smaller groups so I can be more willing to speak up in a small group instead of the whole class (Participant 8, Line 2).	3.5 ± 0.6	0.009 ± 0.733
Blended	• I would rearrange the desks, so that students can work together in groups of 3-4. However, I would make sure that all desks are facing towards the instructor (Participant 4, Lines 1-2).	3.8 ± 0.8	-0.019 ± 0.658

The average self-efficacy values between the three theme groups were not statistically different ($p > 0.05$), though the blended group had a slightly higher value (3.8) than instructor (3.5) or student-centered (3.5) groups. This was likely due to

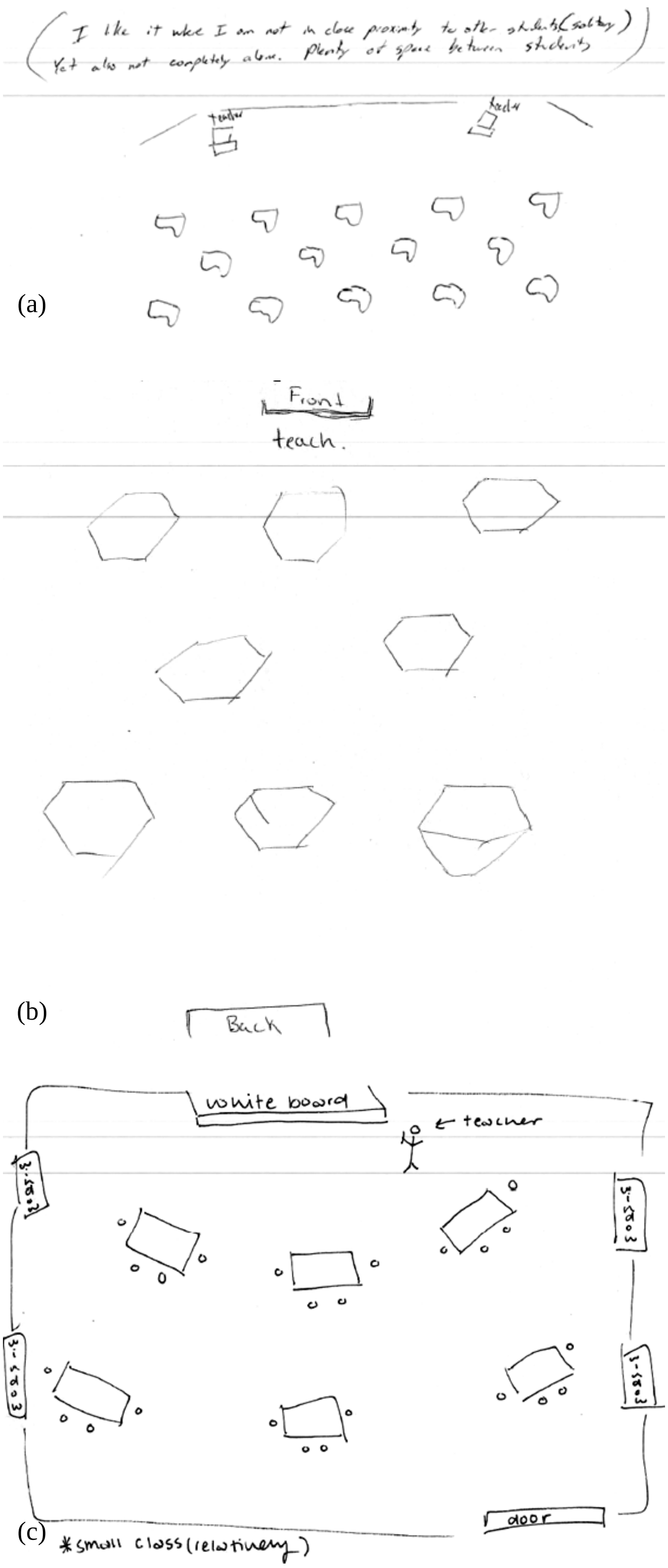

Fig. 2 Representative images of the three themes found during coding. Individual students drew these depictions after being prompted to draw their ideal learning environment. Panel (a) is an instructor-centered arrangement. Panel (b) is a student-centered arrangement. Panel (c) is a blended arrangement.

the small number of participants who had given post-survey self-efficacy values. Additional participants would help uncover more detailed statistical relationships among participant responses.

The mean phasic EDA values between the three theme groups were not statistically different ($p > 0.05$), though the mean phasic value for the instructor-centered arrangement was nearly 9.5 times larger in magnitude than the blended and the standard deviation from the instructor-centered is nearly three times the magnitude of the other standard deviations. This was likely due to the small number of participants for whom usable EDA data was obtained. Additional participants and better filtering methods could uncover additional insight into relationships between the groups.

IV. Discussion

Student engagement increases in the classroom when the teaching activities align with the physical layout [13], which was something recognized by the students. Steelcase has also recognized this importance from research that a mobile classroom plus active pedagogy equals positive student and teacher outcomes [12]. This was alluded to in the results mentioned above with the blended theme comments. Students recognize a need for flexible spaces to adapt to various teaching styles and activities. For example, a small group style classroom setup is more effective at increasing student engagement during active learning activities than in a lecture-style, straight row setup [1]. It seems that students appreciated moveable furniture that could be arranged according to the activities, which aligned with Harvey & Kenyon's findings [9].

Seating configurations can influence what types of active learning activities can be implemented well in a classroom [13]. Students commented about their accessibility to the instructor as well as where their focus was turned. Flexible learning environments can be adapted to meet these accessibility needs. For example, if a lecture-style is needed at the beginning, the classroom can be arranged to have the focus on the instructor. Therefore, if a group activity with four people follows, moveable furniture can allow a quick change from the lecture-style to a cluster format.

Byrne, Hattie, and Fraser [6] found in a study of 7th, 9th, and 11th graders that age made a difference in preferences of classroom learning environments. Since this was a primarily freshman and sophomore class, these perceptions may also change in an upper-level class. It is known that freshman are searching for a higher sense of belonging, which has been found to come most successfully from instructor encouragement, well designed course instruction, student participation, and interaction [21]. The seating arrangement in classrooms can govern the accessibility of the instructor to effectively facilitate learning, which can influence student engagement [13].

The mention of psychological comfort of 40% of the participants aligned with the findings of Adedokun, Parker, Henke, an Burgess [5], who found that over half of the undergraduate students said that 21st century learning spaces increased their psychological comfort with the space's flexibility. Natural light can help with psychological comfort, not to mention the health and productivity benefits that have been found to accompany higher amounts of natural light [22].

Students perceiving different ideal learning environments calls for a flexibility in sub-spaces, allowing students to adapt the classroom arrangement to their own individual needs and preferences. This was evidenced by Harvey & Kenyon [9] in the following statement:

> Embedding choice into the classroom is essential given the diversity of learners, instructors, and instructional modalities, and seating styles in classrooms are easily changeable environmental variables that impact choice, purpose, inclusivity, and functionality. (p. 2)

V. Conclusions

There is an overall preference revealed in the student responses that flexibility in classroom spaces are needed. Some prefer isolation, some prefer collaboration, some prefer a focus on the instructor, and some prefer to focus on interaction with other students. Classrooms with ample space, lighting, and choice available that can be adjusted according to student preferences and learning activities will hopefully increase the comfort, motivation, learning, and satisfaction of students in the classroom.

VI. Limitations & Future Research

The EDA data from this study was used, but further analysis is being conducted on the filtering of the data [19]. Better filtering methods of the EDA data could give valuable insight into the real-time biological responses of students in the classroom. The small, narrow population also contributed to the inability to validly draw correlations in the data. Future research will consist of collecting more data and surveys from an increased number of participants. Filtering methods are being developed to better understand and draw conclusions from the EDA data.

VII. Relevance to Peace Engineering

This study provided first-year Introduction to Engineering students an opportunity to design and arrange their own learning space. Through self-reports, sketches, and engagement measurement (via electrodermal activity sensors), learning enhancement was assessed. Determining students' perceived ideal learning environments can help in focusing teaching to be more student-centered.

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