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Improving the Impact of Experiential Learning Activities through the Assessment of Student Learning Styles

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Long a staple of engineering technology, experiential learning is becoming a topic of growing interest among the wider engineering educational community. Experiential learning theory imports practical experiences into the learning environment. While the putative benefits of experiential learning have been highlighted, the activities introduced into the learning environment are rarely systematically designed around the content of the course or the needs of the student population. There has been little work with respect to the effects of these activities on students and their learning. Given the growing interest in experiential learning and the significant costs associated with these activities as opposed to the traditional lecture model, a more robust analysis is needed.

This work examines the effects of experiential learning activities on student learning for different types of courses; namely, what effects the abstract or concrete nature of the topic being taught has on the impact of the experiential learning activities. A solid mechanics course is used to highlight an abstract topic, while a manufacturing course is used to evaluate a more concrete topic. Students' learning styles are also important to take into account when examining the effect of experiential learning activities. The Kolb Learning Style Inventory (KLSI) and the Felder and Soloman's Index of Learning Styles (ILS) are used to evaluate student learning styles.The final variable examined in this work is the timing of the experiential learning activities. Across a course type and student learning style, the timing of a practical activity either prior to or after a lecture might be an important factor for an efficient learning cycle. This work examines the type of course, a student's learning style, the effect of experiential activities, and the timing of those activities.

The sample of engineering technology students examined for this work is somewhat balanced in aggregate according to the KLSI. The ET group assessed has a higher percentage of active, sensing, visual, and sequential learners than previously reported engineering populations when assessed using the ILS. The effect of experiential learning activity timing is not shown to be a significant factor in student confidence, visualization ability, or competence. Students with moderate or strong preferences along the dimensions of the ILS are not shown to elicit higher confidence, visualization ability, or competence in the two courses. Limitations are detailed and opportunities for future work are highlighted.

Introduction

As experiential learning activities become more popular and widespread in engineering education, a better understanding of their effects on student learning is needed. While the benefits of experiential learning have been discussed in varying contexts from service learning [2-4], to research experiences [5], laboratory exercises [6, 7],and industry field trips [8]. Examinations of the impact on students have been somewhat cursory to date [3]. Very little work exists with respect to the effects of these activities on individual students in varying types of courses. These practical activities pursue active learning processes by transferring theoretical knowledge to pragmatic tasks and vice versa [9, 10]. Common among these activities is that they are often based on Kolb's experiential learning theory that indicates that experience can change learning status through interaction between learning and environment [1, 11]. Kolb's previous work explored alternative experiential learning styles and the effects of practice-based activities on academic performances [1, 12-14]. Little work has examined alternative types of academic content, the role of that content on these practical tasks' ability to improve student learning, and the interactions of students' learning styles.

Significant work has been done with respect to categorizing various learning styles [15-18]. Learning styles are defined as a model that "classifies students according to where they fit on a number of scales pertaining to the ways they receive and process information" [19]. Learning styles are viewed as part of a person's personality [20]. While previous research cautions against tailoring pedagogy to specific learning styles [20-22], taking those learning styles into account and ensuring that instruction is meeting the students' needs is important [23]. The understanding of learning styles is especially important when incorporating experiential learning [24]. When examining learning styles, it is important to use a valid and reliable instrument [15]; preferably one with significant history [25]. This work uses the Kolb Learning Style Inventory (KLSI) [26] and the Felder and Soloman's Inventory of Learning Styles (ILS) [27].

Svinicki and Dixon [28] noted almost 30 years ago that the standard lecture used to teach engineering has changed little. While the introduction of experimental learning activities have revolutionized some aspects of education, certain courses are still taught in a traditional manner. This type of teaching does not favor all students [29]. Even when experiential learning activities are incorporated, their timing is often arbitrary. Should they be incorporated prior to lecture materials or after the concept has been introduced through traditional lecture. While measures for assessing the concreteness or abstract nature or words or concepts have been developed [30], very little has been done to explicitly assess where certain academic topics fit on the abstract to concrete continuum. The presentation of problems as concrete or abstract has been shown to have significant effects [31]. Understanding what effect this level of abstract or concrete nature has on the impact of experiential learning activies could be used to impove pedagogy.

This work examines three aspects of experiential learning activities in two distinct Engineering Technology courses: 1) the relationship between student learning style and the timing of experiential learning activities related to a given topic; and 2) the role of course and topic type on the relationship between student learning style and the timing of experiential learning activities. The next section details the background research in these areas, this is followed by the methods, results, and conclusions of the work.

Background

Experiential Learning

Experiential learning attempts to rectify what Kolb characterized as the "rejection" of the "real-world" by the educational establishment [1]. The key to experiential learning is the creation of knowledge "through the transformation of experience" [1]. To understand the cycle, an understanding of the four basic kinds of experience modes is needed: concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), and active experimentation (AE). A different learning process is conducted depending on which aspect of experiences affect individuals [12]. The ideal experiential learning cycle will have a learner "touch all the bases" [12] of the cycle seen in Figure 1.

In diverse fields, several positive effects of experiential learning have been proven. Experiential learning benefits learners with proper exercises. For example, research experiences increased effective performances of underrepresented groups in science, technology, engineering, and math graduate programs [5]. Industry field trips have been shown to increase students' engagement and affective learning [8]. Wong *et al.* [32] also reported the effectiveness of experiential learning in the Project Haiti program. Exeriential learning activities are used by several engineering educators. For instance, recent course activities have required interactive exercises based on group, web, or mobile activities [33-35]. Game-based learning and the related activies have also been used for engineering education [36-39]. Zhan *et al.* [40] introduced numerous application cases of LabVIEW in engineering and discussed the effectiveness of this tool; LabVIEW is the simulation software used for learning activities. These games are not in a real situation, but the purpose of "learn by doing" [38] is parallel to experiential learning. Numerous studies based on experiential learning have combined actual or simulated (concrete) experiences with the traditional (abstract) lecture. Because the experiential learning model is based on a frame of the successive cycles between concrete and abstract concepts, a transfer from a theoretical lecture to the experiential activity or vice versa is claimed to be the sequential cycle for learning [1, 41]. In combined learning activities both the abstract and the concrete have a superior effect than only a conceptual lecture or an experiential exercise [42-44].

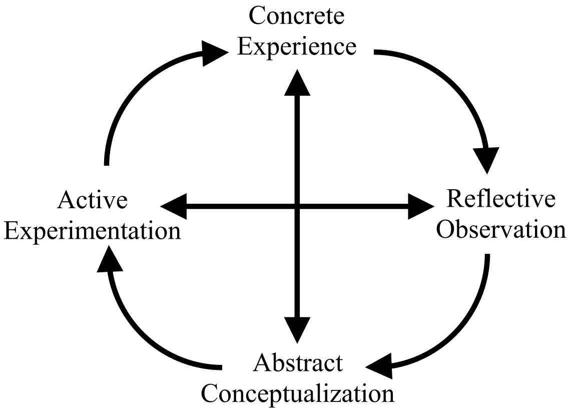

Figure 1. Kolb [1] Model of Experiential

Learning Styles

Learning style classification and assessment has a significant history in educational psychology. The encompassing review of Cassidy [15] notes the major dimensions of learning style classifications and categorizes over 20 different models. These major categories include those of Curry [45]: instructional preference, social interaction, information processing, and cognitive personality. Also included are the dimensions of Riding and Cheema [18] which include wholist versus analytic and verbalizer versus imager. In the Riding and Cheema [18] classifications, wholist process information in total, while analytic people break it into smaller components; verbalizers represent information as works, while imagers use images. Rayner and Riding [17] categorize models as centered on: personality, cognitive processing, or learner processing and preferences.

Hawk and Shah [20] also categorize several learning style models along various dimensions; these include concrete versus abstract, active versus reflective, sequential versus global, visual versus verbal, intuitive versus sensing, sociological elements, environmental elements, emotional elements, physical elements, and psychological elements. The models categorized by Hawk and Shah [20] include: Kolb [1], Gregorc [46], Felder and Silverman [19], the VARK model by Fleming [47], and the Dunn and Dunn [48] model. While the Dunn and Dunn [48] model is the most comprehensive and covers the environmental, emotional, physical and psychological elements. However, some of these dimensions are not of interest for the pedagogy under consideration in this work. The VARK [47] and Gregorc [46] models contain elements comprised in the Felder and Silverman [19] and

Kolb [1] models. The Felder and Silverman [19] and Kolb [1] models are used in this work given their focus on engineering in general and experiential learning in particular, respectively.

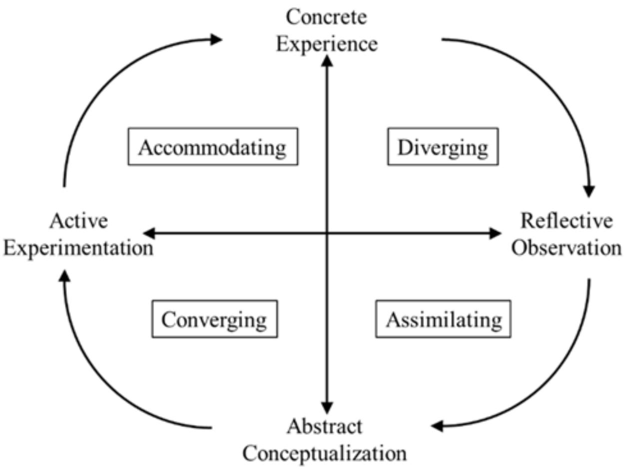

Figure 2. Kolb [1] Model of Experiential

The ideal experiential learning cycle will have a learner "touch all the bases" [12] of the cycle. Kolb also explains that learners can be classified with different learning styles, and they would have dominant learning abilities corresponding to their learning styles. There are four learning styles: diverging, assimilating, converging, and accommodating; assimilating and converging are included in the abstract style and accommodating and diverging are in the concrete style [1, 12]. Diverging learners work with concrete examples that cue their broad ideas; assimilating learners are best at organizing information, so they can make their idea concise based on massive information from experiences, and converging learners find applications for theories because they are skilled at problem solving process with their subjective theory; accommodating learners are familiar with acting, so they gain from "hands-on" experiences [12]. Kolb's model with the various learning styles is shown in Figure 2.

The specific learning styles are shown to be more prevalent in certain fields and they are associated with better performances in such areas. Kolb and Kolb [12] conduct research about how students' learning styles would be different depending on their field using the Kolb Learning Style Inventory (KLSI). Kolb [49] finds that certain undergraduate backgrounds cluster in certain areas of the plot of the Kolb learning styles; he also cites the work of another researcher that found management styles to correlate with their Kolb learning style. In general, students in an art field had diverse learning styles and people who were in the management education tended to have the abstract learning styles. Among surgical residents, converging and accommodating learners were more prevalent; the convergers scored significantly higher on a standardized medical examination than the accommodators [13]. Students of business information systems were found to have converging or assimilating learning styles; their abstract conceptualization was positively correlated with performance [50]. Manolis *et al.* [24] highlight as a weakness that early KLSI did not report the strength of a style. This has been rectified in KLSI version 4 used in this work [26].

The Felder and Soloman's Index of Learning Styles (ILS) is a learning style model with four axes: active-reflective, sensing-intuitive, visual-verbal, and sequential-global [19, 29]. Unlike the KLSI, the ILS axes are not orthogonal in nature. They are number lines ranging from -11 to +11; a very strong active preference would be at the far left end of the number line. The ILS has its genesis in engineering education and has been used to evaluate engineering student learning styles. Felder and Brent [29] note that most engineering lectures are theory based and favor reflective, verbal, and intuitive learners (as opposed to active, visual, and sensing learners). In the same work, they summarize ILS findings and report that a majority of engineering students are active, sensing, visual, and sequential learners. Felder and Silverman [19] point out that laboratories, often a major component of engineering technology education, are more aimed at sensing learners. Montgomery [51] uses the ILS to inform and guide the use of multimedia in a chemical engineering course. Seery *et al.* [52] use a web-based tutorial intervention to target active, sensing, visual, and sequential students. This resulted in improved performance in a Manufacturing and Operations Engineering program. Even outside of engineering, hospitality students took the ILS and were found to prefer active, sensing, visual, and sequential instruction [53]. Green and Sammons [53] also highlight the importance of experiential learning in hospitality education. The KLSI and ILS are summarized in Table 1.

Table 1. Comparison of Kolb [1] LSI and Felder and Soloman [19] ILS

	KLSI	**ILS**
Theory and Background	• Based on experiential learning model	• Parts of experiential, phenomenological, and sensory learning theory
Scale Axes	• Orthogonal axes of concrete experience vs. abstract conceptualization and reflective observation vs. active experimentation	• Non-orthogonal axes of active vs. reflective; sensing vs. intuitive; visual vs. verbal; and sequential vs. global
Focus	• Transformation experience (experiential learning) can be helpful for making total learning cycle	• It is important to implement balanced instruction, not to target pedagogy only to preferred learning styles
Weakness	• Construct validity for dimensions [22]	• Somewhat low internal consistency reliability [21, 22, 25]
Key Findings	• Several studies support measurement and highlight its use for differentiating students • Lack of research about combinations of style differences and individual differences	• Overall short history and limited usage compared to Kolb • Tendency to classify students as balanced (lacking strong preference on any scale)

Methods

This work examined the learning styles and experiential learning activities of students in two courses. These courses were in the Manufacturing and Mechanical Engineering Technology program at Texas A&M University. One couse was a manufacturing course; in this sophmore-level course, MMET 281, students are introduced to polymer manufacturing and assembly processes. The course has a laboratory component where students manufacture artifacts using the various non-metalic manufacturing processes discussed in lecture and examine the effects of materials and process parameters (e.g., injection pressure, temperature) on product attributes (e.g., quality, cycle time). In this course the lecture is common and had approximately 60 students. There were four labororatory sections with aproximately 15 students in each section. The other course was a solid mechanics course; in this junior-level course, MMET 376 , students learn about the mechanics of materials in the lecture. In the laboratory, they get hands on experience loading components in various configurations and tabulating deformation and resulting stresses. This course again had a common lecture with approximately 60 students overall and 15 in each of the laboratory sections. These two courses were selected given their differing content. Solid mechanics is typically viewed as a very theoretical and abstract course; manufacturing is highly practical and concrete in nature.

Both courses have lecture and laboratory sections throughout the week. In the case of MMET 281, the lectures were on Monday and Wednesday morning; the laboratories were on Monday, Tuesday, Wednesday, and Thursday evenings. In the case of MMET 376, lectures were on Tuesday and Thursday and the laboratories were on Monday and Wedesday in the mornings and early afternoons. This scheduling allowed for the timing of the experiential learning activities to be evaluated. Previous work by Wang *et al.* [54] attempted to evaluate the effects of timing, but this work adds an additional course, a more discrete evaluation method (as opposed to course grades), and takes into account learning styles.

As part of this work, student learning styles were evaluated using two instruments: the Kolb Learning Style Inventory (KLSI) version 4 used in this work [26] and the Felder and Soloman's Index of Learning Styles (ILS) [19, 29]. As recommended [20] these learning style assessments were done at the beginning of a semester. The KLSI is based on the experiential learning model of Kolb [1]. Participants take the KLSI online answering a series of questions regarding their preferences about certain activities and view. Participants receive 5 scores as part of the KLSI. These include their percentiles among the population on the four dimensions of the Kolb model: Concrete Experience, Reflective Observation, Abstract Conceptualization, and Active Experimentation. These percentiles are used to determine an overall learning style based on the amount of area in a particular part of a 3 by 3 grid. As seen in Figure 3, this example has a downward projection towards the middle; as seen in Figure 4, this would equate to a Thinking learning style. A person with equal scores on all four axes would be Balancing; those skewed to the upper right would be Imagining. Also given is a Learning Flexibility Score, this measures how much a person's learning style varies situationally.

The Felder and Soloman's Index of Learning Styles (ILS) [19, 29]is a learning style model with four axes: active-reflective, sensing-intuitive, visual-verbal, and sequential-global. Participants answer 44 questions which are scored as +1 or -1. Scores on this inventory scale range from -11 (heavily active, sensing, visual, or sequential) to +11 (heavily reflective, intuitive, verbal, or global). Depending on the sign of the score, participants are placed into one of the two categories across the four dimensions.

Three experiential learning activities (laboratories) were selected from each of the two courses evaluated. These were spaced throughout the semester. In the case of the manufacturing course, laboratories in extrusion, thermoforming, and injection molding were selected. In the manufacturing course, students were incentivized with a 10% bonus on their lab if they completed all aspects of the data collection process; students who chose not to consent could earn these extra credit points through an additional exercise. In the case of the solid mechanics course, laboratories in torsion, bending, and combined loading were selected. No incentive was provided for participation in the solid mechanics course. A survey instrument along with a Preand Post- framework are used. An example survey instrument is shown in Appendix A. Section I asks questions regarding participant confidence with respect to the topic under consideration. These are scored on a 5-point Likert [55] scale . Section II asks about the participant's ability to visualize certain aspects of the topic under consideration. These are also scored on a 5-point scale. Section III asks a series of true or false questions; correct answers are scored as one point, incorrect answers are scored as zero. The Pre-survey is the same as the Post-Survey, only the Pre-Survey does not include Section III (the competence questions). The true or false questions were omitted from the Pre-Survey as not to bias the respondents and to allow for more reliable data to be obtained about competency in the Post-Survey. The Pre-Survey Section I and Section II questions are summed to give an Initial Confidence and Initial Visualization Score, respectively. The Post-Survey questions are summed the same way along with a Competence Score based on total number of correct answers. To examine if the timing of the experiential learning activity had an effect on student confidence, visualization, or competence, the order of the lecture with respect to the lab was examined. The Pre-Survey was administered after the first educational activity associated with that topic for a particular course and topic. For example, if a student had the laboratory first, they would receive the Pre-Survey at the end of the laboratory; this is denoted as Laboratory First. If a student had the lecture prior to the laboratory, the Pre-Survey would be taken prior to the laboratory; this is denoted as Lecture First. Results are shown in the sections below.

Figure 3. Example KLSI Percentile Score

Figure 4. Learning Styles of Kolb LSI

Active Experimentation	Concrete Experience			Reflective Observation
	Initiating	Experiencing	Imagining	
	Acting	Balancing	Reflecting	
	Deciding	Thinking	Analyzing	
	Abstract Conceptualization			

Results

The results for the participants in the two courses on the ILS are shown in Table 2. Across the two courses 81 participants completed the ILS; not all students enrolled in the two courses consented or participated in the various aspect of the study. The results show that the assessed ET students are slightly active, sensing, and sequential. They are significantly visual, as opposed to verbal. The percentage breakdown of the various categories shows the group to be more active, sensing, visual, and sequential than the wider engineering student community as reported by Felder and Brent [29]. ET students may be self-selecting into a more experiential learning focused program based on their assessment of their learning style.

Table 2. ILS Response Results

	Average Score	St. Dev	
Active/Reflective	-2.69	4.04	72.8% Active
Sensing/Intuitive	-2.23	5.26	71.6% Sensing
Visual/Verbal	-6.67	3.80	95.1% Visual
Sequential/Global	-1.02	3.72	63.0% Sequential

Figure 3. KLSI Category Results

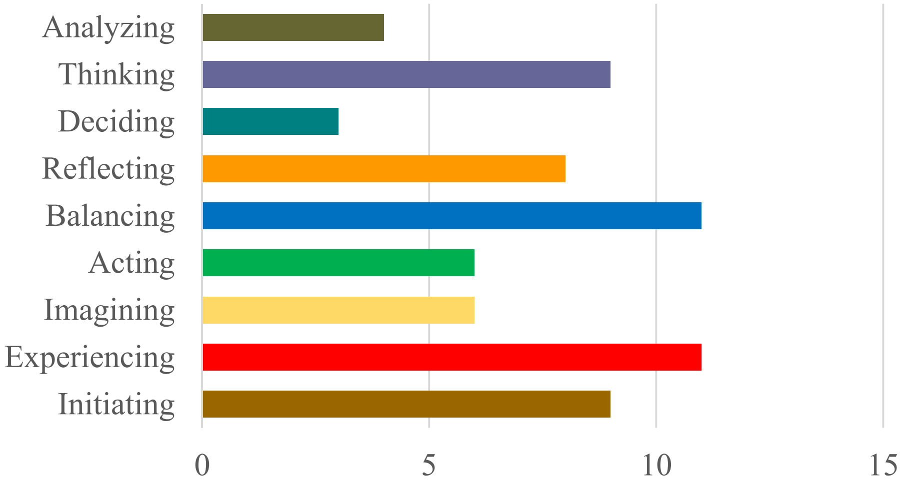

Table 3. KLSI Response Results

	Average Percentile	St. Dev.
Concrete Experience (CE)	48.75	24.14
Reflective Observation (RO)	59.52	25.41
Abstract Conceptualization (AC)	46.01	26.11
Active Experimentation (AE)	63.45	28.87
Learning Flexibility (Flex)	0.75	0.18

The results for the 67 participant that completed the KLSI are shown in Table 3. These results show a slight skew towards Reflective Observation and Active Experimentation. Overall, the composite group tends to have a more Balancing profile. The Learning Flexibility Score for the group is relatively high at 0.75. The categorizations for these participants are shown in Figure 3. The participant categories tend to be skewed towards the top of Figure 4 with Experiencing being the largest category (along with Balancing).

Table 4. Correlations among Learning Style Variables

	Act-Refl	Sens-Intu	Vis-Verb	Seq-Glob	CE	RO	AC	AE	Flex
Act-Refl	1	-.255* .022	.167 .135	-.014 .898	-.201 .105	.414** .001	.140 .264	-.180 .149	-.323** .008
Sens-Intu		1	-.012 .918	.185 .098	.200 .108	-.297* .015	.145 .246	-.090 .471	.216 .082
Vis-Verb			1	-.084 .454	-.082 .513	.314* .010	.178 .154	-.287* .019	-.004 .975
Seq-Glob				1	.082 .514	-.146 .243	.075 .550	.017 .893	-.007 .955
CE					1	-.232 .059	-.158 .202	-.057 .649	.501** .000
RO						1	-.134 .281	-.300* .014	.027 .829
AC							1	-.692** .000	-.091 .462
AE								1	-.157 .205

*Signifies p <0.05; **Signifies p < 0.01

Table 4 shows the correlations among the learning style variables for the two inventories. As expected, the Active/Reflective score on the ILS is significantly positively correlated with the Reflective Observation score on the KLSI. These two scales are viewed as "identical" [29]. The correlation with Active Experimentation has the right sign, but does not meet the criterion for statistical significance ($\alpha = 0.05$). The Active-Reflective score on the ILS is also negatively correlated with Learning Flexibility; this would imply that more Active learners on the ILS are less flexible. The Sensing/Intuitive score is negatively correlated with the Reflective Observation score. This implies that Sensing students are less likely to be in the upper percentile on the Reflective Observation scale. This aligns with the theory which states that Sensing individuals are more likely to prefer concrete experiences. The Visual/Verbal is negatively correlated with both the Reflective Observation and Active Experimentation percentiles; Visual learners are less likely to score highly on those two scales. The Sequential/Global score did not have any significant correlations with the KLSI variables. The Concrete Experience score and Learning Flexibility are significantly positively correlated. Both Reflective Observation and Abstract Conceptualization have significant negative correlations with Active Experimentation. In the case of Reflective Observation and Active Experimentation, this is to be expected as they are on the opposite ends of the same scale; this is not the case with Abstract Conceptualization and Active Experimentation.

Table 5 shows the results of the Pre- and Post-survey responses for the three manufacturing course laboratories. It should be noted that due to a scheduling issue, all participants had the laboratory prior to the lecture for the extrusion module. Both confidence and visualization and confidence scores rose after the lecture. This was also the case for the thermoforming module for both timing groups; after all instruction had been completed, the scores rose. In the case of injection molding, both the confidence and visualization scores decreased at the end of instruction. The role of timing (if the experiential exercise was before or after the lecture) was not seen to have significant effects on confidence, visualization, or competence. In each case of the manufacturing course, the laboratory first group scored higher in both initial and final confidence and visualization. However, only the initial confidence was statistically significantly higher for the laboratory first group in the thermoforming module.

Table 5. Manufacturing Course Results by Timing

	Lecture First			Lab First			t	Sig. (2-tailed)
	N	Mean	SD	N	Mean	SD		
Extrusion								
Initial Confidence	N/A	N/A	N/A	59	14.29	2.59	N/A	N/A
Initial Visualization	N/A	N/A	N/A	57	16.70	1.90	N/A	N/A
Final Confidence	N/A	N/A	N/A	55	15.93	2.36	N/A	N/A
Final Visualization	N/A	N/A	N/A	55	16.96	1.89	N/A	N/A
Competence Score	N/A	N/A	N/A	55	2.62	0.97	N/A	N/A
Thermoforming								
Initial Confidence	24	14.50	3.32	27	16.67	2.20	-2.17	**0.01**
Initial Visualization	24	14.25	2.75	28	15.21	2.82	-0.96	0.22
Final Confidence	17	16.47	1.87	22	17.00	1.90	-0.53	0.39
Final Visualization	17	15.18	2.21	22	15.73	2.00	-0.55	0.42
Competence Score	17	2.65	1.17	22	2.59	0.91	0.06	0.87
Injection Molding								
Initial Confidence	21	16.10	2.30	23	16.61	2.10	-0.51	0.44
Initial Visualization	21	16.71	1.82	23	17.22	1.70	-0.50	0.35
Final Confidence	22	15.27	3.30	22	16.09	2.56	-0.82	0.36
Final Visualization	22	15.68	2.64	22	16.45	2.13	-0.77	0.29
Competence Score	21	2.10	0.62	22	1.86	0.71	0.23	0.26

Data for the solid mechanics course is shown in Table 6; it should be noted that in some cases, participation is somewhat low. Confidence increases for the laboratory first group of the torsion model. In all other torsion cases, the variables decrease from Pre- to Post-Survey. In the case of the bending module, both confidence and visualization increase for both lecture first and lab first configurations. Overall, there were no widespread patterns with respect to Pre- and Post-Survey timing. The low number of Post-Survey participants should be noted for this data set. Several students chose not to participate in some of the Post-Surveys. In the case of laboratory first or lecture first, there were no conclusive results. Only the initial confidence for torsion was statistically significantly higher for the lecture first group.

Table 6. Solid Mechanics Course Results by Timing

	Lecture First			Lab First			t	Sig. (2-tailed)
	N	Mean	SD	N	Mean	SD		
Torsion								
Initial Confidence	16	15.94	1.436	23	13.09	2.43	2.85	**0.00**
Initial Visualization	16	14.69	1.662	23	14.83	1.80	-0.14	0.81
Final Confidence	8	15.13	1.356	9	14.11	2.93	1.01	0.39
Final Visualization	8	15.5	1.927	9	14.33	2.35	1.17	0.28
Competence Score	16	2.313	0.873	9	1.56	1.24	0.76	0.09
Bending								
Initial Confidence	14	15.50	1.65	23	13.78	3.33	1.72	0.08
Initial Visualization	14	14.86	1.66	23	15.17	2.84	-0.32	0.71
Final Confidence	11	15.64	1.96	20	15.55	2.39	0.09	0.92
Final Visualization	11	15.64	2.06	20	15.55	2.09	0.09	0.91
Competence Score	11	2.18	1.25	20	2.35	0.88	-0.17	0.66
Combined Loading								
Initial Confidence	7	14.86	1.77	22	15.68	2.06	-0.82	0.35
Initial Visualization	7	14.71	1.60	22	15.27	2.19	-0.56	0.54
Final Confidence	9	15.00	1.87	18	15.33	3.11	-0.33	0.77
Final Visualization	9	14.89	1.96	18	15.28	2.42	-0.39	0.68
Competence Score	9	2.67	1.41	18	2.83	1.10	-0.17	0.74

Table 7. Manufacturing Course Results by ILS Active - Reflective

	Active-Reflective > -5			Active-Reflective ≤ -5			t	Sig. (2-tailed)
	N	Mean	SD	N	Mean	SD		
Extrusion								
Initial Confidence	38	14.45	2.479	21	14.00	2.83	0.45	0.53
Initial Visualization	37	16.84	1.834	20	16.45	2.04	0.39	0.47
Final Confidence	34	15.85	2.35	21	16.05	2.42	-0.19	0.77
Final Visualization	34	17.15	1.925	21	16.67	1.83	0.48	0.36
Competence Score	34	2.588	1.104	21	2.67	0.73	-0.08	0.77
Thermoforming								
Initial Confidence	32	15.72	2.99	19	15.53	3.01	0.19	0.83
Initial Visualization	32	14.88	2.30	19	15.16	2.57	-0.28	0.69
Final Confidence	25	17.12	1.81	14	16.14	1.92	0.98	0.12
Final Visualization	25	15.64	2.06	14	15.21	2.19	0.43	0.55
Competence Score	25	2.68	1.07	14	2.50	0.94	0.18	0.60
Injection Molding								
Initial Confidence	28	16.21	2.15	16	16.63	2.31	-0.41	0.56
Initial Visualization	28	16.93	1.63	16	17.06	2.02	-0.13	0.81
Final Confidence	27	15.22	3.20	17	16.41	2.40	-1.19	0.20
Final Visualization	27	16.07	2.64	17	16.06	2.05	0.02	0.98
Competence Score	28	2.11	0.57	15	1.73	0.80	0.37	0.08

To take into account the learning style of the participants, the means for the Pre- and Post-Surveys were compared for both courses. Using the suggestion of Felder and Brent [29], students with a strong or moderate preference were compared with those who did not. Litzinger *et al.* [25] define those with a moderate preference on the ILS as those with a score that has an absolute value of greater than or equal to 5. Table 7 shows a comparison of those with an Active/Reflective score of greater than -5 and those with an Active/Reflective score of less than or equal to -5 for the manufacturing course modules. There were not any significant, conclusive, and consistent differences for these two groups in the manufacturing course.

A comparison of these two ILS groupings for the solid mechanics course is shown in Table 8. Again, there were not any significant, conclusive, and consistent differences for these two groups in the solid mechanics course. Similar analyses were carried out for the Sensing/Intuitive, Visual/Verbal, and Sequential/Global dimensions. These were all done using less than or equal to -5 as a break point. None of these comparisons yielded consistent statistically significant differences for either course.

Table 8. Solid Mechanics Course Results by ILS Active - Reflective

	Active-Reflective > -5			Active-Reflective ≤ -5			t	Sig. (2-tailed)
	N	Mean	SD	N	Mean	SD		
Torsion								
Initial Confidence	18	14.44	1.723	22	14.14	2.98	0.31	0.70
Initial Visualization	18	14.72	1.364	22	14.86	1.98	-0.14	0.80
Final Confidence	8	15.75	1.669	9	13.56	2.40	2.19	**0.05**
Final Visualization	8	14.75	2.493	9	15.00	2.00	-0.25	0.82
Competence Score	13	2.00	0.913	13	2.15	1.21	-0.15	0.72
Bending								
Initial Confidence	17	14.18	2.81	21	14.67	2.97	-0.49	0.61
Initial Visualization	17	15.65	1.87	21	14.76	2.88	0.89	0.28
Final Confidence	15	15.53	2.13	16	15.63	2.36	-0.09	0.91
Final Visualization	15	15.20	1.57	16	15.94	2.41	-0.74	0.32
Competence Score	15	2.27	0.96	16	2.31	1.08	-0.05	0.90
Combined Loading								
Initial Confidence	13	15.31	1.65	16	15.63	2.28	-0.32	0.68
Initial Visualization	13	14.62	1.45	16	15.56	2.39	-0.95	0.22
Final Confidence	13	15.15	2.48	14	15.29	3.02	-0.13	0.90
Final Visualization	13	14.69	2.10	14	15.57	2.38	-0.88	0.32
Competence Score	13	2.69	1.18	14	2.86	1.23	-0.16	0.73

Conclusion

This work examined the role of experiential learning activities on the confidence, visualization ability, and competence of engineering technology students at a large Southern US university. Students' learning styles were assessed using the KLSI and the ILS to determine if those preferences had an effect on the confidence, visualization ability, and competence variables in two disparate courses. These courses included a solid mechanics course whose material is often viewed as somewhat abstract in nature. The other course was a manufacturing course that was deemed more concrete in its content. Both courses included laboratory components that provided significant experiential learning opportunities. Three modules were assessed in each course. Pre- and Post-Surveys were used to examine the variables of interest. Scheduling allowed for lecture first and lab first scenarios to be evaluated.

The ET student population was assessed using the ILS and found to be slightly active, sensing, and sequential. They are significantly visual, as opposed to verbal. By percentage, the group was found to be more active, sensing, visual, and sequential than the wider engineering student community as reported by Felder and Brent [29]. When assessed by the KLSI, this population was broadly balanced in aggregate and had a relatively high Learning Flexibility score. The effect of experiential learning activity timing was not a significant factor in student confidence, visualization ability, or competence. Students with moderate or strong preferences along the dimensions of the ILS were not shown to elicit higher confidence, visualization ability, or competence in the two courses. One reason for this lack of significant findings could be the limited number of data points. Given the skewed nature of the population under consideration, more active, sensing, visual, and sequential, the large group of balancing individuals was likely not significantly different enough. This is one of several limitations that affected the work.

In addition to the small number of reflective, intuitive, verbal, and global learners, there was also a limited number of participants in some of the groupings. This could have affected the overall quality of the analysis. While in the manufacturing course, students were incentivized to participate, in the solid mechanics course, they were not. The competence questions were also not graded; students may not take such questions as seriously as they might had their answers affected their course grades. Future work will attempt to rectify some of these limitations. In addition to better incentivizing students to participate and try their best, additional data will be collected to expand the sample population. These additional data will allow for the more participants with strong or moderate preferences to be analyzed. This would improve the findings and help determine the role of learning style preference on the impact of experiential learning activities. Additional statistical analyses will also attempt to better examine the interaction of experiential learning exercise timing and learning style. Given the growing interest in the wider engineering education community for experiential learning and the ET community's long history with this topic, this will likely be an interesting and fruitful future research area.

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Appendix A. Example Post Survey

Name____________________

Section____________________

Strength of Materials
Topic - Torsion

Please circle your response.

Section I

1. I can explain what *torque* is.

Not Confident at All 1	Not Confident 2	Neither confident nor not confident 3	Confident 4	Very Confident 5

2. I know how torque is related to the *torsional stress* in a shaft.

Not Confident at All 1	Not Confident 2	Neither confident nor not confident 3	Confident 4	Very Confident 5

3. I understand the effect of cross section property on the stress in a shaft under torsional load.

Not Confident at All 1	Not Confident 2	Neither confident nor not confident 3	Confident 4	Very Confident 5

4. I can explain how torque is transmitted in a gear box/power transmission system.

Not Confident at All 1	Not Confident 2	Neither confident nor not confident 3	Confident 4	Very Confident 5

Section II

1. When looking at a physical (real world) example and given a force and a reference coordinate system, I can visualize the torque about the axes of the coordinate system.

Strongly Disagree 1	Disagree 2	Neither agree nor disagree 3	Agree 4	Strongly Agree 5

2. Visual illustrations were (or would be) necessary to understand the stress state of an object in torsion.

Strongly Disagree 1	Disagree 2	Neither agree nor disagree 3	Agree 4	Strongly Agree 5

3. Given a shaft with circular cross section, I can see how easy/difficult the cross section can rotate about its axis.

Strongly Disagree 1	Disagree 2	Neither agree nor disagree 3	Agree 4	Strongly Agree 5

4. I can envision stress distribution in a torque loaded object such as a shaft.

Strongly Disagree 1	Disagree 2	Neither agree nor disagree 3	Agree 4	Strongly Agree 5

Section III

1. If a shaft is fixed at one end and a torque is applied to its other end, the internal torque at any position along the axis is constant.

True False

2. Under torsion, the shear stress at the center line of a shaft is zero.

True False

3. If the diameter of a solid shaft is the same as the outer diameter of a hollow shaft, with the same applied torque the stresses experienced on the outer surfaces of the two shafts are the same.

True False

4. The amount of power transmitted by a shaft is directly proportional to the applied torque and inversely proportional to the rotational speed of the shaft.

True False