Putting Theory into Practice: Supplemental Learning Opportunities That Match Student Learning Styles

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Abstract

The "matching hypothesis," or the idea that learning is maximized when key aspects of the learning environment matches the preferred style of the learner, is a well-known theory. To best put this theory into practice, however, a number of questions have yet to be answered. For example, what critical aspects of the learning environment and a student's learning style should be matched, and how best could this matching occur? We are investigating these questions by comparing effects of Supplemental Learning Opportunities (SLOs) which engage different learning styles. The first type of SLO consists of a well-structured classroom lecture environment with on-paper, engineering problem-solving exercises. The second type of SLO is a hands-on laboratory environment with integrated on-paper, engineering problem-solving exercises. The structures of both SLOs are strongly aligned with well-accepted (but different) theories of how to help students learn. Both SLOs are designed to reinforce material from the foundational course of a multidisciplinary sophomore engineering curriculum, which emphasizes both mathematical skills and physical insight. Two groups of engineering students (n = 50), well-matched in mean and median grade point averages, gender proportions, course instructors, intended majors, and learning styles (as assessed by the Index of Learning Styles and the VARK instrument) participated in the SLOs one hour each week for at least four weeks. Neither SLO group consistently outperformed the other group on the assessments, and assessment scores were generally similar across both sections. Assessments that were administered before and after SLO sessions showed improved post-session scores, indicating that students learned from both types of SLOs. Students classified as active learners by the Index of Learning Styles appeared to benefit from both environments. Our preliminary results indicate that matching student preference for sensory/intuitive learning with the SLO teaching environment may have benefited student learning (*i.e.,* sensory learners generally performed better in the hands-on active SLOs, and intuitive learners generally performed better in the classroom-active SLOs). Further investigation is currently ongoing, but these results support the general idea of using varied teaching styles/approaches within a given course to help students with a broad range of learning styles.

Key Words

Education Methods

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Introduction

The theory that people learn more when their learning style matches an instructor's teaching style has a long history in the educational literature [1, 2]. The style of a traditional lecture environment, in which a professor talks and writes on a blackboard while students listen quietly and take notes, is an extreme mismatch with the learning style of someone who learns best from physically doing real-world things. This learning style is called Kinesthetic learning in the "VARK" learning style system [3, 4], a system which describes people's preferences for receiving and recalling information in terms of their Visual, Aural, Reading/writing, and Kinesthetic preferences. An alternative learning style system, the Index of Learning Styles (ILS) [5, 6], separately considers two aspects of the learning style of someone who learns best by physically doing real-world things. First, the ILS considers the degree of preference for Active learning, or learning by actively doing things (as opposed to Reflective learning, in which someone prefers to learn through quiet and individual reflection). Second, the ILS considers the degree of preference for Sensory learning, in which someone best focuses on and recalls information gained from their senses through real-world experiences (as opposed to Intuitive learning, in which someone best focuses on and recalls theories, concepts and ideas that are not necessarily grounded in real experience). Other dimensions of the ILS describe people's preferences for Visual versus Verbal, and Sequential versus Global learning. Because individuals with Kinesthetic VARK and/or Active and Sensory ILS learning styles are, in theory, poorly served by traditional classroom lecture environments, we are exploring ways to better engage these learning styles in an engineering course. We are also seeking evidence that matching instructional style with student learning style – *i.e.*, putting theory into practice – results in better learning.

The engineering course we have chosen to work with is ES201, Conservation and Accounting Principles, the foundational course of the Rose-Hulman Sophomore Engineering Curriculum. This course, taken by a large multidisciplinary student population, teaches a systems, modeling, and accounting approach to engineering problem-solving, emphasizing both mathematical skills and physical insight. We provided supplemental learning opportunities (as described in the Methods section below) to students enrolled in the ES201 course during the Fall of the 2007/2008 academic year, and are currently analyzing a number of types of assessment data. Due to the large size and ongoing nature of this project overall, this paper will focus on one aspect of the project: assessment results from the supplemental learning opportunities. Analyses of course exam scores, overall course grades, and student performance in courses prior to and following the ES201 course are currently ongoing and will be reported elsewhere.

Methods

All students enrolled in the Fall 2007 offering of ES201 (Conservation and Accounting Principles) at Rose-Hulman Institute of Technology [7] were asked via email to participate in this research project by attending and participating in at least four of five Supplemental Learning Opportunities (SLOs). Students gave their informed consent to participate in the project and submitted contact information on a protected internal web page (Institutional Review Board approval # RHS0068) on Rose-Hulman's institutionally-supported web-based course management system (the "ANGEL" system [8]). Volunteers then completed the Index of Learning Styles [6] (ILS; Copyright © 1991, 1994 by North Carolina State University; authored by Richard M. Felder and Barbara A. Soloman) and the VARK questionnaire [4] (VARK copyright version 7.0 (2006) held by Neil D. Fleming, Christchurch, New Zealand and Charles C. Bonwell, Green Mountain Falls, Colorado 80819 U.S.A.) using the protected website on the institutional course management system. The ILS and the VARK instruments are questionnaires that provide information about different ways in which individuals prefer to intake and process information. For this project, each student's score in the ILS Active/Reflective domain, the ILS Sensor/Intuitor domain, and the VARK Kinesthetic domain were recorded, along with each student's cumulative grade point average, their gender, their primary academic major, and their ES201 course instructor. This information was used to create two experimental groups of students, with similar demographics. Each group contained 30 students. Students who volunteered to participate in the study but who were not selected for one of the two experimental groups (classroom/teaching laboratory space limited participation to 30 students/group) received a thank-you note and a bag of assorted candy in their campus mailbox.

One group of students attended "classroom-active" SLOs, or SLOs taught in a well-structured classroom environment consisting of on-paper, problem-solving exercises led by a faculty member. This faculty member routinely called on students by name and supplemented lectures with active learning exercises so that students in the classroom-active SLOs were active participants in the classroom environment. The other group of students attended "kinesthetic-active" SLOs, or SLOs taught as hands-on laboratory exercises with short lecture explanations and integrated on-paper problem-solving, led by two faculty members. These faculty members interacted with students as they worked in teams to complete activities and on-paper problems, so students in the kinesthetic-active SLOs were active participants in a classroom environment and were also physically active, doing things with their hands. All three of the faculty members who taught the SLOs for this study routinely teach the ES201 course, and receive excellent teaching evaluations. Both types of SLOs were held on campus on Tuesday evenings from 6:00 - 7:00 p.m.; the classroom-active SLO was held in a traditional classroom setting (students sitting in rows, facing the instructor) and the kinesthetic-active SLO was held in a teaching laboratory setting (students sitting around tables, moving to use equipment and to occasionally face the instructors). The kinesthetic-active SLOs will be described in detail elsewhere [9].

Five one-hour SLOs of each type were held during the 10-week Fall 2007/2008 quarter: the first two SLOs occurred before the first ES201 course exam, the next two SLOs occurred between the first and second ES201 course exam, and the last SLO occurred before the third ES201 course exam. Students who attended four of the five SLOs received $65 for their time. Students who attended all five SLOs received $100 for their time. Students who attended three or fewer SLOs received no monetary compensation. Students were informed of the compensation rules prior to giving their informed consent to participate in the study, and were informed that they could withdraw from the study at any time (specifically, that a student who attended four SLOs and who then decided to withdraw from the study would still be compensated, even though their information would not be used in the study).

All SLO instructors worked from the same general learning objectives and coordinated the SLO activities/examples so that both groups of students were exposed to similar terminology (for example, if the kinesthetic-active SLO group was using skateboards in a hands-on exercise to illustrate static and kinetic friction, the classroom-active SLO group would solve a problem on paper that involved skateboards and static and kinetic friction). Examples and terminology were chosen in an attempt to maximize accessibility across genders and ethnicities (so, for example, skateboards which came pre-equipped with stickers of young white male 'skater dudes' were covered over with Rose-Hulman stickers; the spring trigger mechanism of a foam dart gun was explained in terms of breast cancer biopsy devices; etc.).

Students in both SLO groups completed a short assessment quiz/survey (for some sessions, pre- and post-session assessments were administered) after each SLO. Students in both SLO groups completed the same assessments. The SLO instructors did not see the assessments prior to the sessions; another faculty member (who also routinely teaches the ES201 course) met with the SLO instructors to confirm their learning objectives and examples/activities prior to the sessions, and created and scored the assessments.

Data from students who completed fewer than four SLOs were not used for this study. For analysis purposes, assessment performance information was first grouped by SLO type (classroom active versus kinesthetic-active). Second, data were grouped by the degree of kinesthetic learning preference (strongest kinesthetic preference: VARK Kinesthetic (K) domain score of 5 or higher; least kinesthetic: K domain score of 2 or less; or moderately kinesthetic: all other K scores). Third, data were grouped by preference for active learning (strongest active preference: ILS Active/Reflective (A/R) domain score of 8 or higher; least active (*i.e.*, strongest reflective) preference: ILS A/R domain score of 4 or less; or moderate active preference: all other A/R scores). Fourth, data were grouped by preference for sensory learning (strongest sensory preference: ILS Sensor/Intuitor (S/I) domain score of 8 or higher; least sensory (*i.e.*, strongest intuitive) preference: ILS S/I domain score of 5 or less; or moderate sensory preference: all other S/I scores). The specific numerical cutoff scores cited here were chosen to ensure that at least five students would be in any given analysis group.

Results and Discussion

Twenty-five students in each SLO group attended four or more SLO sessions. Demographic characteristics of these students are given in Table 1. Table 1 demonstrates that the groups were well-matched in demographic characteristics, so – although factors external to a study such as this study (*e.g.,* student grade point average, *etc.*) can never be perfectly controlled – external effects should be well-blended between these two groups and would not be expected to severely influence the study results.

Table 1. Demographics of SLO groups. Groups also contained well-matched numbers of students in terms of the various ES201 course instructors.

	Kinesthetic-Active	Classroom-Active		Kinesthetic-Active	Classroom-Active
Number of Students	25	25	Percent Female	40%	44%
Grade Point Average: *Mean*	2.93	3.05	Primary Majors: *Biomedical Engineering*	6	8
Median	3.09	3.03	*Computer Engineering*	2	2
Maximum	4.00	3.98	*Electrical Engineering*	6	3
Minimum	2.08	2.09	*Engineering Physics*	1	1
			Mechanical Engineering	10	11

Neither SLO group consistently outperformed the other group on the assessments, and assessment scores were generally similar across both sections. Assessments that were administered before and after SLO sessions showed improved post-session scores, indicating that students in both types of SLOs learned from the sessions. The SLO sessions were structured in slightly different styles of current best practices [10,11] , so it is encouraging that students learned from both types of sessions. Although overall assessment scores were similar across the SLO groups, we could identify specific assessment items on which students in one SLO group outperformed students in the other group. These items were consistent with the nature and activities within the specific SLO sessions. For example, one assessment item asked students to draw a free-body diagram of a box as it tipped off another box. This box tipping situation was similar to a hands-on activity conducted in the kinesthetic-active SLO group, but less similar to the box tipping example completed in the classroom-active SLO. Students in the kinesthetic-active SLO group significantly ($p < 0.04$, Mann-Whitney test) outperformed students in the classroom-active SLO group on this assessment item.

Not knowing which learning style instrument or domain would be the best for classifying a student's preferences, we analyzed the SLO assessment data three times in three different ways: grouping students in terms of strength of preference for active learning (using the ILS instrument), in terms of strength of preference for sensory learning (using the ILS instrument), and in terms of strength of preference for kinesthetic learning (using the VARK instrument).

We expected that students with active learning preferences (*i.e.,* who prefer to learn by doing anything other than just sitting and listening to a lecture) would be well-served by the instructional approaches of both SLO groups. Indeed, students rated with the strongest preference for active learning outperformed students with moderate and least preferences for active learning on four of six assessments in the kinesthetic-active SLO group; in the classroom-active SLO group, the strongest active and moderately active learners outperformed the least active learners on four of six assessments.

We expected that sensory learners (who tend to focus on and recall information gained from their physical senses) might perform best in the kinesthetic-active section, and that the least sensory learners (*i.e.,* the most intuitive learners, who tend to focus on and recall ideas and theories) might perform best in the classroom-active section. This hypothesis was supported by results from both SLO groups: in the kinesthetic-active SLO, students rated with the strongest and moderate preferences for sensory learning outperformed students with the least preferences for sensory learning on five of six assessments; in the classroom-active SLO, the moderate and least sensory learners outperformed strong sensory learners in all six assessments. Ratings of strength of preference for sensory learning were not correlated with overall grade point average, gender, ES201 course instructor, or primary academic major (maximum Spearman's rho correlation: 0.196, between gender (female) and stronger preference for sensory learning).

Table 2. Mean Assessment Scores, by Degree of Preference for Sensory Learning. Note that the magnitudes of the scores across assessments are not meaningful; each assessment was scored in a different way. Gray cells highlight the highest score for each assessment in each SLO group.

	Assessment					
	1	2 (pre)	2 (post)	3 (pre)	3 (post)	4
Kinesthetic-Active SLO Group: *Strongest Sensory Learners* (*n* = 12)	2.58	4.17	4.08	3.50	4.08	0.17
Moderate Sensory Learners (*n* = 7)	3.00	3.57	3.57	3.29	3.86	0.71
Least Sensory Learners (*n* = 6)	2.50	3.00	3.33	3.33	4.17	0.17
Classroom-Active SLO Group: *Strongest Sensory Learners*(*n* = 11)	3.27	3.09	3.09	2.73	3.55	0.09
Moderate Sensory Learners (*n* = 6)	3.50	2.83	3.00	3.00	3.17	0.17
Least Sensory Learners (*n* = 8)	3.38	3.50	3.75	3.88	4.00	0.00

We also expected kinesthetic learners (who tend to learn best when they have a real-world experience; similar to sensor and possibly active learners) to perform best in the kinesthetic-active SLOs. Interestingly, in the kinesthetic-active SLO group, students rated as the *least* kinesthetic learners outperformed moderate and strong kinesthetic learners on four of six assessments. Similarly, in the classroom-active SLO, students rated as the *most* kinesthetic learners outperformed moderate and least kinesthetic learners on three of six assessments. Ratings of strength of preference for kinesthetic learning were not correlated with overall grade point average, gender, ES201 course instructor, or primary academic major (maximum Spearman's rho correlation: 0.257, between gender (female) and stronger preference for kinesthetic learning). These results contrast with the other analyses, and could be interpreted in multiple ways. For example, perhaps our study population did not contain a proportion of highly kinesthetic learners – our population of 'strongest kinesthetic learners' might in fact be considered only moderately kinesthetic on an absolute scale, and this might reduce or mask any potential benefit of hands-on learning. Perhaps the assessments of this study, which were geared toward testing ES201 course concepts and learning objectives, did not assess anything that would be strongly affected by kinesthetic, physically-active learning – perhaps the assessments were in some way better suited to detect learning differences that could be linked to active or sensory/intuitive learning preferences. Finally, the primary and original purpose of both the VARK and the ILS instruments is simply to help people create study strategies that are likely to be efficient and effective for their individual styles. This study did not examine the helpfulness of study strategies, but instead sought evidence of the helpfulness of teaching strategies – a logical and related, but secondary, application of these instruments. Further research will be needed to determine which of these interpretations is the most appropriate.

Conclusions

As with the majority of educational research projects, a number of caveats should be acknowledged. The population size of this study was small; only 50 students total, and some analysis groups contained only five or six students. This study involved only one offering of only one course. The SLO activities were created specifically for this study, and because the kinesthetic-active SLOs were a major departure from standard ES201 teaching practices (these SLOs will be described in detail elsewhere [9]), they may need refinement. The SLO assessments may additionally need refinement. In the next iteration of this study, we plan to share the assessments with all SLO instructors prior to the sessions, to minimize inadvertent biases associated with differing interpretations of questions and to maximize commonality of learning goals across the SLOs. Overall, however, in this study, students successfully learned engineering problem-solving skills from two different types of teaching environments – a classroom-active learning environment, and a hands-on active learning environment. Students classified as active learners by the ILS appeared to benefit from both environments. Although these results are preliminary, and further investigations are currently ongoing, matching student preference for sensory/intuitive learning with the teaching environment may have benefited student learning. This supports the general idea that using varied teaching styles/approaches within a given course may help students with a broad range of learning styles, rather than only a few students whose learning styles happen to match a single teaching style. Engaging multiple learning styles should allow each student to work in (and benefit from) their preferred learning style at least some of the time, while allowing them to practice learning in other styles some of the time. The result should be more well-rounded and better-educated students.

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