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Teaching Architecture, Engineering and Construction Disciplines: Using Various Pedagogical Styles to Unify the Learning Process

Jill Nelson P.E., California Polytechnic State University

Jill Nelson is an Assistant Professor for the Architectural Engineering Department at California Polytechnic State University (Cal Poly), San Luis Obispo, CA. Professor Nelson came to Cal Poly with over 25 years of structural design and project management experience. She is a registered Professional Engineer and Structural Engineer in the states of California and Washington. Jill Nelson received a B.S. degree in Civil Engineering from the University of Nevada, Reno and a M.S. degree in Civil Engineering from the University of Washington.

John W. Lawson, Architectural Engineering, California Polytechnic State University, San Luis Obispo

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Using Various Pedagogical Styles to Unify the Learning Process

Abstract

The Architectural Engineering Department at the California Polytechnic State University, San Luis Obispo (Cal Poly) teaches introductory sophomore level statics and mechanics of materials courses to students in three departments in the College of Architecture and Environmental Design. These courses are unique in that students in the Architectural Engineering Department share coursework with students in the Architecture and Construction Management Departments. While learning and problem solving in these multidisciplinary courses have many advantages, they also offer many challenges. The learning preference of the students in these three distinctly different disciplines requires a fresh approach to the course structure. The courses were reimagined in 2005 to improve the learning and subsequent passing rates of Construction Management and Architecture students. Currently the structure of the courses utilizes a traditional lecture format coupled with hands-on activities. These lecture and activity components have been developed to embrace various learning preferences in conjunction with active learning.

This paper examines the learning preferences of current students spread across the three different disciplines and compares the preferences to the delivery methods used in the courses. Over a period of three years, surveys have been taken to determine the mix of learning style preferences within the courses. The surveys have shown that the majority of the students in each discipline have a preference for the same two learning styles preferences; Visual and Kinesthetic. Yet these two predominate preferences are a mismatch with traditional teaching styles. This paper compares the preferred learning styles of the three separate majors enrolled in these courses and investigates correlations with existing instruction delivery modes. Conclusions have been made and suggestions offered for other institutions to improve course delivery and through these avenues improve learning for all students.

Background

As dedicated educators, it is our inherent desire to facilitate student learning. The keyword here is *facilitate*, which implies that both the student and the teacher have a responsibility. The same is in any communicative activity where both the speaker and listener, or writer and reader, must share some common framework of intercourse. Communication is most successful when the method of delivery utilizes the same *language* preferred by both parties. Teaching is most successful when the same *method of delivery* is preferred by both the student and the teacher.

In the presentation of coursework content, the method of delivery is sometimes referred to as the teaching style, and this is most successful when it matches a students' preferred learning style. While this concept of style can apply across the broad spectrum of higher education coursework, engineering curricula is uniquely challenged with it technical complexity and sometimes abstract concepts. For example, teaching three-dimensional rigid body statics and mechanics using a lecture format and chalkboard is not only difficult for some students to mentally grasp, but it can be equally difficult for the instructor to simply draw the rigid body and corresponding x, y, and z axes on the two-dimensional board. Here, the method of delivery is a very important factor for successful student learning of this subject matter. Complicating this issue further, at the authors' institution both engineering majors and non-engineering majors share some of the same rigorous engineering coursework.

In the Cal Poly College of Architecture and Environmental Design, programs in Architecture (ARCH), Architectural Engineering (ARCE) and Construction Management (CM) are fairly integrated in the first two years of coursework. The Cal Poly ARCE major is an intensive structures-based engineering program designed to train future structural engineers. Uniquely, this rigorous engineering program is not found in the College of Engineering, but instead is located within the College of Architecture and Environmental Design providing excellent interdisciplinary experiences for students in ARCH, ARCE and CM.

This College's identity has long been founded on multidisciplinary student integration within certain classes. The integration of ARCH, ARCE and CM majors within first year and second year courses, as well as a capstone senior year course, mimics their professional life after they graduate. In the spirit of interdisciplinary education diversity, ARCH, CM, and ARCE students together are taught statics and strength of materials in the same class. Besides the typical challenge of conveying technical engineering topics, instructors are faced with a group of students with varying aptitudes for this material. This diversity within the classroom increases the importance of communication with each student.

On the surface, one may initially assume that students of architecture, engineering, and construction share diverse outlooks on the world; however, in fact one could argue that the opposite is true. These students have all been attracted to their field of study from their desire to manipulate the visual and physical form. What has attracted them to their field of study unfortunately challenges them to thrive in traditional modes of instruction where information is offered in a static auditory and written form. Traditional instruction methods are less about visual and physical engagement and more about lecturing, reading, writing, and arithmetic. While non-engineering majors may thrive in this traditional lecture format for nontechnical subjects such as history or english, ARCH and CM students tend to struggle more in their engineering coursework when this instruction format is used.

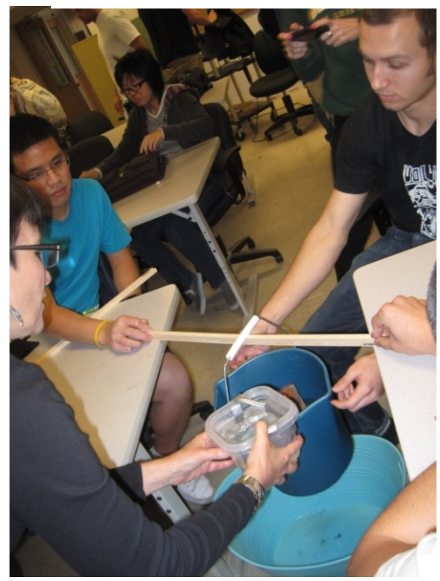
At Cal Poly the same requirement for engineering rigor in the introductory classes is placed on the ARCH and CM students as well as the ARCE students. Despite each having completed the necessary prerequisites of college level calculus and physics, in 2004 the college and department was concerned about the low passing rates of the ARCH and CM students. (Dong 2006).[1]

In some institutions this problem is minimized because architectural and construction management programs isolate their students into structures courses that are separate from engineering majors. While it is true that this more traditional approach allows ARCH and CM students to experience higher passing rates, it is often at the expense of material rigor and an integrated interdisciplinary experience.

Another approach to improving student success could be with a more selective admissions process. In the late 1970s the Cal Poly College of Architecture and Environmental design experimented with a supplemental admissions exam that among other things tested applicants for their ability to construct three-dimensional spatial relationships in their mind from a two-dimensional presentation sequence. More specifically, this test involved sequences of illustrative paper folding followed by a punched hole, and the applicant was required to determine the resulting hole pattern on the unfolded sheet of paper.

While this supplemental admissions process' goal was to result in an admitted class of students who had many of the tools to be successful in the architecture program, one could argue that this process was simply filtering out students who had different strengths in creativity or perception. It is generally recognized that a diverse student body enhances the education process with each individual having something different to contribute. This admissions experiment was short-lived and terminated due to funding constraints (Zweifel 2012)[2].

Figure 1 ARCE Activity



With the strong belief that ARCE, ARCH and CM students should remain together in the basic statics and strength of materials classes, ARCE 211 and ARCE 212, the ARCE Department embarked on a bold effort to raise passing rates of non-engineering majors without compromising the course content. In 2005 the department completely reconfigured the courses covering statics and strength of materials, ARCE 211 and ARCE 212 (Dong 2006)[1]. One of the major course revisions was to change the method of content delivery from (3) one-hour lectures per week to (2) one-hour lectures with an added two-hour hands-on activity. A significant objective of the change was to provide a method of delivery that responded to the Kinesthetic learning style to illuminate and reinforce the technical lecture content. This instruction format is in place today and is shown in Figure 1.

Leaving their consulting practices and entering university education on a tenure-track, both authors in 2009 taught ARCE 211 for the first time. At the start of that first academic quarter the authors were struck by how many students were initially having difficulty in understanding and applying basic engineering concepts despite having the calculus and physics prerequisites. After discussing these observations with other faculty, it became apparent that the challenge was likely the method of delivery and student learning preference instead of the material content.

At the completion of their first term teaching ARCE 211, the authors recognized the opportunities this class format has to engage the students with different modes of instruction and to incorporate active learning strategies. With the combination of disciplines in one class, the authors hypothesized that different delivery methods or a combination may be appropriate for ARCH, ARCE and CM majors collectively or separately.

In subsequent courses, the authors implemented a different approach on the first day of class by discussing learning style preferences with the students. The philosophy behind this discussion was to force the students to acknowledge their inherent learning preference and the resultant need to branch out and aggressively learn in different formats. In addition, the authors discussed with the students the purpose of various active learning strategies that might be employed during the course to engage Visual and Kinesthetic learners. Following the basic discussion, students took an on-line learning style preference survey assignment as shown in Figure 2 utilizing a VARK typology (Fleming 1995)[3]. Each student was asked to report on their learning preference and list a minimum of three techniques for higher retention of information based on their preference. Since that original assignment over 150 students have been surveyed across three major disciplines and the results tabulated. A review of the data shows some consistent trends and supports the current lecture/activity format as well as suggests opportunities for further improving the delivery of information.

Learning Styles Preferences

It is generally accepted that people learn in many different ways and that most students have a preferred style of learning. Teachers are most successful when information is exchanged in multiple styles to capture and engage all students in a course. As students progress and specialize in a specific expertise it is common to have the student learning preferences cluster around a norm, but at the lower levels of instruction it is not uncommon to have multiple learning preferences. Research (Tanner and Allen 2004)[4] has hypothesized that the high number of students leaving math and science is in part due to the information delivery methods that create roadblocks to understanding.

In the late 1970s there was a surge of interest in assessing learning preferences, and between then and now many researchers developed typologies that assess learning style preferences (Hawk and Shah 2007)[5]. One of the most common methodologies is VARK, discussed in the 1995 paper by Neil Fleming titled “I’m different not dumb; Modes of presentation (VARK) in the tertiary classroom.” Fleming is one of the developers of VARK. As stated by Fleming, VARK is not focused on labeling but is focused on selecting practical strategies that enhance learning. VARK stands for the four basic means of exchanging information; Visual learners (V) are student learners who like information conveyed by graphs and pictures. They are sensitive to spatial arrangements and work well with symbols. Auditory learners (A) are student learners who process the spoken word to learn. Read/Write (R) learners are students who prefer to access information through printed words. Kinesthetic learners (K) learn by all their senses; they want to touch and feel. They like multi-sensory experiences such as field trips and hands-on experiments. Some students will have a single dominant learning preference whereas other students may have multiple preferences. Students with multiple preferences are often more successful in an educational setting since they can more easily adapt to various teaching styles.

Much of higher education uses the auditory and read/write preferences as a predominate means of exchanging information. Students with strong visual and kinesthetic preferences must work at their learning since their preferences are not as commonly employed in the traditional classroom.

The Survey Process

VARK was chosen as the typology for surveying predominate modes of learning in ARCE 211 due to VARK’s focus on strategies for information delivery and its ease of application. Starting in 2010 students in ARCE 211 were asked to complete an online questionnaire that scored their preferences and offered suggestions for enhancing their learning based on those preferences. Figure 2 is a copy of the Learning Preference Assignment.

Figure 2 Learning Preference Assignment

Activity Assignment #1
LEARNING STYLES

Objective:
To determine your personal learning style(s) to help you get more out of this course and your other college coursework.

Background:
Every individual has a different learning style. Some students prefer to read the course material slowly instead of listening to a lecture. Some students can only understand lecture material when it is in their hands through a demonstration. Others need to be involved in a group discussion to understand the course material.

This course has been designed to involve as many different learning styles as practical. Some teaching will seem like it "speaks to you" while other teaching will be more difficult to appreciate. Keep an open mind throughout this course, while some learning will be more difficult than others.

Assignment:
Visit the following website and complete the online test:

http://www.metamath.com/multiple/multiple_choice_questions.html

Think about your specific learning style and fill in the following information:

Name ______________________________________
Major ____________

Enter your learning style scores and circle your predominate learning style:

Visual/Nonverbal __________
Visual/Verbal __________
Auditory __________
Kinesthetic __________

On the back of this paper, list 3 things you can do as a student to improve your learning in the course.

Between Fall 2010 and Winter 2012 seven classes have been surveyed for a total of 128 students. The breakdown between the disciplines is: 26 ARCE students, 64 ARCH students and 38 CM students. In summer 2012 the original survey was no longer accessible. In Fall 2012 an additional 46 students were surveyed in a similar VARK survey. The breakdown of disciplines for the 46 students is: 14 ARCE students, 21 ARCH students and 11 CM students. The result of the different surveys is reported separately.

Survey Results

A scoring system was developed to compare the student results and to determine a predominate learning style for a specific discipline. Each student score was worth one point. That point was awarded to the student's learning preference highest score. In the case of a tie between two preferences a half point was awarded to the two tying preferences.

The data gathered from Winter 2010 to Winter 2012 is summarized in the figures below. Figure 3 shows the breakdown of student population as an overall percentage. Figure 4 illustrates the aggregate learning style preferences for the combined student body. Overall the total population has a strong preference for visual and kinesthetic learning.

Figure 3

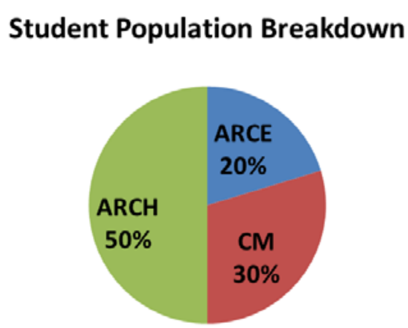
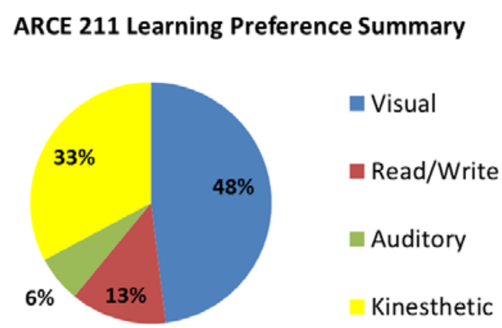
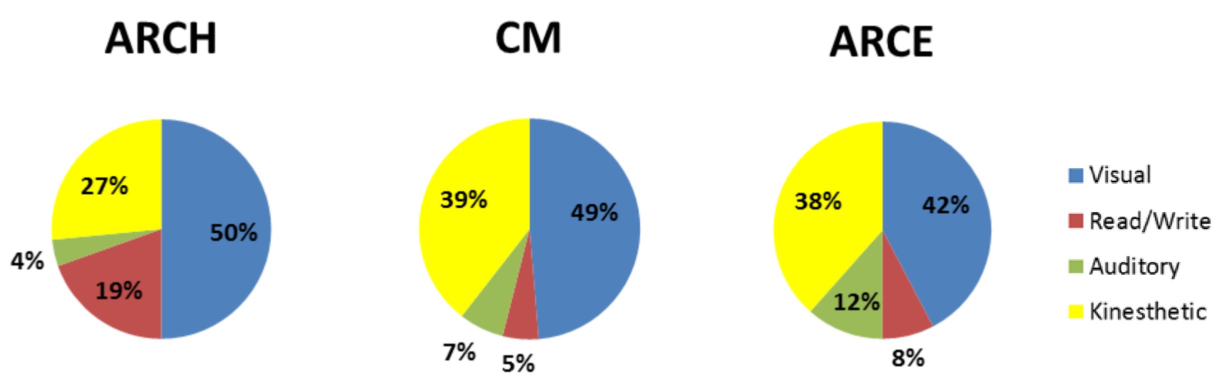


Figure 4



Looking at the specific disciplines separately shows some minor variance in learning preferences. Figure 5 illustrates the learning preferences by discipline.

Figure 5 Learning Preferences by Discipline



The same information is portrayed in tabular form in Table 1 on the following page

Table 1 Learning Preferences Survey Data
Winter 2010-Winter 2012

Major	Visual		Auditory		Read/Write		Kinesthetic		Total/major
	Points	%	Points	%	Points	%	Points	%	Number
ARCE	11	42.3	3	11.5	2	7.7%	10	38.5%	26
ARCH	32	50.0	2.5	3.9	12.5	19.5%	17	26.6%	64
CM	18.5	48.7	2.5	6.6	2	5.3%	15	39.5%	38
Total	61.5	48.0	8	6.3	16.5	12.9%	42	32.8%	128

Because the original survey was no longer available to the students, a new but similar survey was assigned in Fall of 2012. The results of the 46 students who participated in the Fall 2012 survey are shown in Table 2.

Table 2 Learning Preferences Survey Data
Fall 2012

Major	Visual		Auditory		Read/Write		Kinesthetic		Total/major
	Points	%	Points	%	Points	%	Points	%	Number
ARCE	1	7.1	2	14.3	3.5	25.0	7.5	53.6	14
ARCH	9.5	45.2	5	23.8	1	4.8	5.5	26.2	21
CM	3	27.3	3	27.3	2	18.2	3	27.3	11
Total	13.5	29.3	10	21.7	6.5	14.1	16	34.8	46

Comparison of two sets of survey results shows the two highest learning preferences for all participants remain as Visual and Kinesthetic. In all the surveys prior to Fall 2012 the most predominant learning preference was Visual followed by Kinesthetic; however, in the later survey there is a preference for Kinesthetic followed by Visual. Although many students may score as having either a Visual or Kinesthetic learning preference, a deeper review of the data indicates that many of the students can be considered with multiple preferences when the defined multiple preference range between the individual scores is widened from 1 to 2. Using this criterion for data collected from Winter 2010 to Winter 2012, 40.6% of all students would be defined as having multiple preferences that include both Kinesthetic and Visual. For data collected in Fall 2012 the percentage is 39.1%. For these purposes, multiple preferences is defined as students with any combination of learning preferences that includes Visual and Kinesthetic and the difference between any two of those preferences is not greater than two. A student is considered to have a single preference if the highest number of points varies from the second highest by more than 2. This sensitivity may explain the difference between the survey results. Other factors could be due to differences is the survey itself, the limited sample size or the start of a trend.

Evaluation of Existing Instruction Modes

The current ARCE 211 and ARCE 212 courses have strong components appealing to both the Visual learner and Kinesthetic learner. Successful visual approaches to the subject matter involve graphical solutions to force vector addition, stress-strain diagrams, axial force diagrams, as well as the progression of load, shear, moment, curvature, and deflection diagrams. Freebody diagrams showing all acting force vectors appeals to the Visual learner. These visual modes of instruction are commonplace in engineering education, not only because instructors find them useful to communicate, but also because many engineering students also prefer visual instruction modes. The survey results also reveal that many students of architecture and construction management share these same learning style preferences. More unique yet engaging visual instruction exercises can be utilized drawing upon humorous events or everyday life to keep students engaged (Conniff, D., Morris, M., & Klosky, J. 2004)[6].

As mentioned previously, the ARCE 211 and ARCE 212 courses were reconfigured to add a Kinesthetic mode of instruction during a weekly activity to increase passing rates of non-engineering students. As evidenced from the survey, the kinesthetic mode of instruction is equally beneficial to the engineering students, and is likely increasing student success among all disciplines. These kinesthetic activities are tailored to demonstrate major concepts with hands-on work. Typically in teams of two or three, students use cardboard, small wood dowels, string, and hot-melt glue to build three-dimensional working models. Students experience first-hand stability, degrees of freedom, centroid balance, suspended equilibrium, deflected shapes, material stresses and strains, truss stability and redundancy. A number of sources are available to introduce kinesthetic methods into the engineering classroom (Dong 2008)[7]. For advocates of inductive learning, these activities can occur immediately prior to the main lecture, or for deductive learning can occur afterwards to reinforce lecture content. As revealed in the student survey, significant portions of ARCH, CM and ARCE students prefer this instruction mode for their learning.

Conclusions and Recommendations

The vast majority of ARCH, CM and ARCE students surveyed show strong learning preferences in the visual and kinesthetic areas. Faculty often focus their teaching in their preferred learning style (Hawk and Shah 2007)[4]. In rigorous engineering courses there is a strong need for faculty to be aware of and accommodate where possible the students' preferred mode of instruction/learning. If faculty tailor their coursework to the students' preferences there is a strong likelihood that there will be an increase in students' success.

The reconfiguration of Cal Poly ARCE 211 and ARCE 212 in 2005 has proven to be successful across all three majors. Students are more engaged and the passing rates for students have increased. A major factor in this success is the activity feature with its strong kinesthetic focus tying lecture material into a tactile experience. Continued student surveying indicates that this feature aligns with a dominate preferred learning style.

Considering the course success, it is reasonable to suggest that the course configuration needs only minor tweaking to remain successful. However when one considers the future pedagogical trends forming today, there may be a need for significant rework to adjust to larger class sizes and online delivery methods. If significant rework takes place, the integration of visual and kinesthetic teaching approaches will need to be maintained to ensure the success of *all* students.

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