My personal teaching philosophy

Psychology

My teaching philosophy focuses on the approach of “ learning by doing” combined with the application of technology in instructional practices and an integrated research and teaching program to provide students with the best possible educational experiences.

First, I believe that engineering students learn most when they have opportunities to participate in practical projects similar to those undertaken by professionals in the same fields. I have witnessed and experienced the effectiveness of the “ learning by doing” approach since I was a boy, when I often helped my father in his auto repair shop. My father not only taught me and many other trainees technical concepts and hands-on skills, he was also an extremely good teacher from whom I inherited my love of passing on knowledge to others. Later, I learned that this approach is adopted not only by my father but also by many technical schools and universities. Therefore, I strive to involve students in extensive lab work and projects to support the development of their theoretical knowledge.

Second, I view teaching as a process of engaging students in direct experiences connected to real-world applications of the concepts and problems discussed on the course. As students are more likely to be interested in a task that they find personally relevant or valuable, I try to design activities that are related, wherever possible, to students’ lives or current events. For instance, I have found students are more interested in a lecture if they are given a real-world problem, especially a recent example from their neighborhood. For example, during a lecture to introduce the concept of the curvilinear motion of a rigid body, I noticed that students became more focused when I gave them an example from a local newspaper reporting a car accident on a freeway onramp a week before. The satellite image of that onramp and characteristics of the car reported in that news article were sufficient inputs for a very real problem such as the radius of curvilinear motion, the car’s weight and height, and the friction coefficient. The students were excited because not only did they find the solution to this real problem as an amateur investigator but also they could apply this finding in their daily lives.

Third, I support the use of technology to enhance the learning experiences of students and make the best use of contact time in the classroom. For example, I use a combination of technology such as PowerPoint slides, mobile apps, online resources, learning management systems (such as Canvas, Blackboard, and D2L), and iClickers to facilitate the transmission of information and promote learning engagement. Since conceptual understanding and procedural skills play important roles in many engineering courses, I adopt teaching strategies that help students understand theoretical concepts better and improve their problem-solving skills. For example, research findings show that people learn better from practice when worked examples are presented before to-be-solved problems. Therefore, instead of letting students solve a series of problems by themselves, I walk them though a couple of worked examples step- by- step with clear solutions to reduce the extraneous cognitive load placed on them.

Fourth, my teaching extends well beyond the classroom and I try to help students as quickly and as conveniently as possible. Specifically, I adopt an open-door policy that allows students to reach me in my office at anytime. If I cannot help them on the campus, they can email or call me with any question regarding their learning experiences, assignments, or lectures. I also recognize that students enter college with different backgrounds and experiences, prior knowledge, skills, and motivations to learn. I thus strive to learn about each student individually and help them gain the skills and enthusiasm for their courses in order to improve their chances of success.

Finally, I support the integration of teaching with research. While the relationship between research and teaching rests upon institutional research policies and departmental arrangements, I believe that in order to be a good university teacher one must be an active researcher. I view research as knowledge generation and teaching as knowledge transmission, and believe that both these areas complement each other. For example, based on a deep understanding of the subjects I am teaching, I investigated the role of spatial abilities in learning engineering mechanics course. I found that spatial abilities affect the ways students solve three-dimensional mechanics problems and can explain why students tend to develop misconceptions about inclined plane problems. I suggested that engineering mechanics instructors should encourage their students to sketch diagrams from their viewpoints to optimize spatial information retrieval from the objects instead of passively adopting the diagrams offered in the problems.

My teaching interest focuses on two general areas: engineering mechanics and engineering management. Examples of courses in the first area include statics, dynamics, strength of materials, engineering design, and computer-aided design. Courses in the second area include engineering economics, manufacturing, and engineering statistics.

Research Statement

Current research

I currently have two lines of research. First, my research activities for the past three years have focused on the use of computer visual aids to improve students' conceptual understanding and procedural skills, the two most important types of knowledge in many engineering courses. Specifically, my research is part of a larger National Science Foundation (NSF)-funded project to study the effectiveness of computer simulation and animation (CSA) in teaching Engineering Dynamics courses. This research project is also my Ph. D. dissertation.

My second research project studies how tangible 3D objects combined with interactive virtual models improve the spatial abilities of K-12 and pre-engineering students. Spatial ability, along with mathematical and verbal skills, is one of the three primary cognitive abilities that people use to acquire new knowledge. Although spatial ability plays a critical role in science, technology, engineering, and mathematics (STEM) education, the teaching and learning of spatial reasoning have been neglected in the current educational system. Elaborations on these two research lines follow.

The primary purpose of the first research project was to determine if students studying rigid body dynamics (RBD) with traditional instructions and interactive CSA modules have higher learning gains than students studying RBD with traditional instructions only. In the first phase of the project, I used Flash Professional CS 5. 5 and ActionScript 3. 0 to develop 10 interactive CSA modules that cover typical concepts and problem-solving skills in RBD. In the second phase, I used the CSA modules as an intervention in a quasi-experiment to assess the effects of the modules on students' learning gains in terms of conceptual understanding and procedural skills.

The project used both quantitative and qualitative methods to collect and analyze data from two cohorts of 142 undergraduate engineering students. While the assessment of students' learning gains relied heavily on pretest and posttest quantitative data, other particular aspects of study such as a student's attitude towards and experiences with CSA modules were best captured by qualitative data. The data analysis of this project is ongoing. From this research, I have a co-authored paper in the proceedings of the American Association in Engineering Education Conference & Exhibition 2013 and two co-authored journal papers under review.

The second research line involves the design, development, and assessment of new teaching tools to help students improve their spatial visualization abilities in general and mental rotation ability in particular. In this project, I developed a set of 12 physical 3D models (or tangible models, TMs) and their corresponding computer graphics (or virtual models, VMs) in various geometric shapes similar to those in the Purdue Spatial Visualization Test. The TMs and their VMs work together in a real-time interactive manner with the help of sensor boards embedded inside the former. The sensor board works like any 6 DOF motion tracking system in a Virtual Reality system. It contains an attitude heading reference system (AHRS) that tracks and sends its real-time 3D orientation on three axes to a computer.

By manipulating the TMs and observing the corresponding VMs on a computer screen in real time, students will see the same objects that undergo rotations in space from infinite viewing angles, thus resolving visual ambiguities. I have also applied multimodal and multimedia learning theories to explain the combined use of TMs and VMs in spatial ability training. It is possible that the haptic channel provides learners with additional spatial information from these objects through their senses of touch, which therefore decreases the cognitive load on the visual-spatial sketchpad in a learner's working memory. I am planning to assess these spatial teaching tools in two 8th grade geometry classes (a control class and a treatment class) this semester at a local middle school.

Funding and potential funding sources

The second project is an extension of my student project for which I received a grant of $1, 000 from the Office of Research and Graduate Studies at Utah State University (USU) in 2013. In addition, the project received a Research Catalyst grant of $20, 000 from USU in 2014. The purpose of Research Catalyst funding is to help applicants develop new initiatives with pilot projects that will lead to new externally funded grants (the NSF in this case). While this project is still running, my proposals for external funding grants are being drafted with three targeted NSF programs that the project may perfectly fit: a) Discovery Research K-12 (DRK-12, NSF 13-601), b) Research on Education and Learning (REAL, NSF 13-604), and 3) Education and Human Resources Core Research (ECR, NSF 13-555). The assessment results of this project will help me obtain concrete evidence to convince the reviewers and program directors of the NSF programs of its intellectual merits and potential broader impacts.

Future Research

My future research goals focus on two general research areas:

The use of computer visual aids (such as simulation, animation, augmented reality, and virtual reality) in engineering education and industry workforce training:

I plan to use virtual reality to simulate workplace environments such as assembly workstations, oil and gas operations, and mining in realistic interactive virtual 3D environments to provide learners with experiences about machinery operation or safety hazards in real-world situations. I would like to embed critical thinking and problem-solving strategies into this virtual learning environment so that learners have the ability to troubleshoot and apply their knowledge to real-world environments. By exposing learners to critical tasks or virtual risks prior to real scenarios, industries can reduce overall training costs, reduce injuries, and improve employee productivity.

Spatial ability and visual thinking:

I would like to develop spatial visualization applications for mobile phones and use them as standalone spatial ability training tools or infuse them into engineering and science courses that require students to have strong spatial reasoning in order to learn, such as computer graphics, engineering design, organic chemistry, and so on. Like the AHRS sensor board and motion tracking system, there are many sensors inside a mobile phone including gyroscopes, accelerometers, and magnetometers. These spatial visualization applications will extract data from such sensors and synchronize the phone's orientation and motion with the learning object on a computer screen. I expect the applications to improve students' spatial abilities and understanding of spatially dependent engineering concepts.