Board 16: Work In Progress: New Pedagogical Strategies for Senior Design BME Projects Involving Industry Partners

Dr. KRYSTYNA GIELO-PERCZAK, University of Connecticut

Dr. Krystyna Gielo-Perczak is an Associate Professor in Residence in the Department of Biomedical Engineering at the University of Connecticut. Krystyna Gielo-Perczak obtained her combined B.S. and M.Sc. in Aeronautics and Mechanical Engineering and her Ph.D. in Biomechanics and Mechanical Engineering from the Technical University of Warsaw. After earning her Ph.D., she participated in the visiting researcher program of the University of Torino's Department of Mechanical Engineering. After that, she gained academic and teaching experience by serving as a faculty member at several universities around the world, including WPI, the University of Oregon, the University of Waterloo and the University of Toronto, Victoria University of Technology, and the Technical University of Warsaw. Just prior to joining the University of Connecticut, she worked as a scientist at the Liberty Mutual Research Institute for Safety and Health in Hopkinton for seven years. Her education interests center on multidisciplinary and systems engineering design approaches, and include modelling, data analysis and simulation software. Presently, at the University of Connecticut, she collaborates with industrial partners on several, multidisciplinary biomedical engineering senior design projects. Dr. Gielo-Perczak is best known for crossing the boundaries of traditional research by applying holistic and multidisciplinary approaches to improve the design of exoskeletons, robotics and medical devices.

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New BME Challenges Require Novel Pedagogical Strategies

The future of biomedical engineering (BME) depends on engineers' ability to contend with challenging biomedical problems and health care needs. The challenges ahead are more than any single branch of science can address. Therefore, a multidisciplinary and multifaceted teaching approach is needed to help prepare undergraduate students. This paper presents observations and insights from three design projects undertaken by seniors in UConn's Biomedical Engineering Department. Both standard and novel pedagogical strategies were applied. We examined how students applied emotion and intuition strategies to industrial design projects when skill-based design strategies proved inadequate. Initial observations suggest that the senior design project process, and the decision-making it involves, can benefit from both standard and novel pedagogical strategies.

Expanding Traditional Learning Frameworks

This project proposes a design strategy that supplements Rasmussen's cognitive engineering framework [1] with concepts related to dynamic human functioning, specifically, affordance, emotion, and intuition [2].

Since today's senior design projects require students to perform a variety of tasks (i.e. designing, testing and validating a prototype), a more expansive human-environment design strategy is needed to supplement Rasmussen's framework [3]. The expanded design strategy involves an ecological psychology approach proposed by Gibson that considers affordances and personal human attributes. Prior research indicates that affordances and personal human attributes, particularly emotion and intuition, are important in exercising control over the environment [3].

Application of Novel Pedagogical Strategies to Senior Design Projects Involving Industry Partners

Today's Senior BME design projects are more demanding than ever. Consequently,students may require both standard as well as novel pedagogical strategies to form their decision-making abilities. In addition to considering students' knowledge, this research examined how students applied emotion- and intuition-based strategies to address design problems of varying complexity.

The analysis focused on projects offered by three different industrial partners: Advanced Mechanical Technology, Inc. (AMTI), located in Watertown, MA; Hologic Inc., located in Danbury, CT; and Rowheels, located in Merritt Island, FL.

1. **AMTI** asked students to design a device and protocol to quantify the effect of errors that can occur when recording human balance.

   For the project, students applied a balance control measurement theory devised from their understanding of known mathematical relationships. They were thus able to apply existing theoretical balance control measurement concepts to the current design problem.

   Consequently, a skills-, rules-, and knowledge-based approach was sufficient for the project.

2. **Hologic Inc**. requested a non-invasive study to compare/investigate the physiological stress of mammography patients during compression with the SmartCurve™ breast stabilization system versus the standard of care (a flat paddle).

   The senior design students applied a strategy that incorporated skills-, rules-, knowledge-based skills and the concept of affordance. The affordance of the mammogram machine was created by adding a shoulder rehabilitation device which allowed for EMG muscle activity measurement.

   The concept of affordance had never been considered by biomedical engineering students in assessing the design requirements of a medical system. The students examined the multi-factorial complexity of the problem and, at the same time, they tried to learn techniques for detecting physiological stress. As a result of their interactions with the medical system environment, students were able to develop effective design solutions.

3. **Rowheels** requested a study to validate the effectiveness of a novel reverse propulsion wheelchair system that was designed to reduce wheelchair induced shoulder injuries. Rowheel's reverse propulsion system allows users to propel their wheelchairs forward by pulling backwards on the hand rims, in the same basic manner as a person would propel a rowboat.

   Students were asked to conduct a small-scale pilot study to compare muscle activation, acceleration, and mobility among users of conventional and reverse propulsion wheelchairs.

   Since no prior wheelchair assessments had been conducted, students needed to develop and validate a novel method for evaluating and measuring wheelchair effectiveness. They expanded the skills-, rules-, and knowledge-based design approach by incorporating novel concepts of affordance, emotion and intuition.

   The project required the involvement of actual wheelchair users who were emotionally engaged in the project and willing to fine tune their motor skills so as to detect wheelchair propulsion differences. It also required students' emotional engagement in their willingness to perceive, feel and describe the effects of the design change.

   Consequently, the study involved multiple trials, and numerous biomechanical measurements had to be approved by a university Institutional Review Board.

   The students' persistence, emotional involvement and intuition proved successful in that they were able to elucidate the relationship between the two different propulsion techniques and wrist health among manual wheelchair users.

Discussion and Future Work

Decision-making during the senior design project process may require both standard and more creative pedagogical strategies. The goal of this project was to characterize student decision-making processes that occur when skill-based design strategies and procedures prove inadequate.

In addition to considering students' knowledge, the project examined how students applied emotion and intuition strategies to deal with industrial design problems of varying complexity.

This project proposes an approach to the traditional design pedagogy that incorporates the ecological concept of affordances with the neural concepts of student emotion and intuition. This neuro-ecological approach extends the classical cognitive design engineering framework (skills-, rules- knowledge-based) and includes personal student attributes that are important in the work/design environment. The new framework is not a predictive model of student learning, rather, it describes the neuro-ecological learning processes of students and their design environment.

The novel pedagogy presented in this study aims to better meet the complex needs of today's students as they plan and implement their senior design projects. The pedagogy incorporates the novel concepts of affordance, emotion and intuition into traditional knowledge-, skills-, and rules-based teaching approaches to support student learning. Although focused on three diverse projects, the initial observations suggest that this extended pedagogy can be beneficial for a wide range of design projects.

Among the insights gained from the observations is the need to foster students' creativity by facilitating the concept of affordance in their senior projects. Affordance encourages, accelerates and directs a student's perception of specific design aspects. The importance of students' emotional engagement in the design process was also observed. By considering design challenges that directly impact students or members of their families, students became more engaged and invested in the design process and were therefore more creatively inspired in their solutions.

And finally, it was observed that student intuition could be incorporated into the senior project design process to improve design outcomes. It was found that in testing device prototypes, students were able to experience and thus "feel" the benefits of the proposed design. Designing a testing process by themselves made a significant impact on students' perception of the overall project and process.

These initial observations suggest this expanded pedagogy holds great promise for students and their industrial partners. Hopefully, this novel approach will be applied to future senior design projects so that more data can be collected to support our claims.

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Ethics Declarations

The wheelchair study was approved by the University of Connecticut Institutional Review Board (IRB# H019-014).

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