

Inquiry-based Learning for First-Year Engineering Students

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Joining the Penn State engineering faculty five years ago, my professional interests as an instructor of engineering are developing and refining methods of engineering instruction that will allow students to gain confidence and to increase their own success. Previous experiences in the metals and piping industry as a principal engineer have allowed me to promote necessary skills which need to be developed in the classroom so that the students have success upon graduation.

Great Ideas for Teachers and Students:
Inquiry-Based Learning for First-Year Engineering Students
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Inquiry-based learning (IBL) is both a teaching and learning strategy employed universally in K-12 education. Teachers use this technique to increase motivation and engagement of students for content that students must learn. Engineering instructors are challenged in determining whether their students can understand, apply and extrapolate the content presented in the classroom. Traditional summative assessments do not always indicate the level of student engagement necessary for success. The level of engagement required for an engineering student in one course can depend on the background knowledge gained in prior courses. Not only do the students need to recall previous concepts but must be able to scaffold these in application for new material. The use of IBL in a first-year engineering course can provide motivation and engagement for the student that can be capitalized on in further years of study; by taking an interest in the content, the student outcomes are increased. Inquiry-Based Learning (IBL) is an effective approach for promoting active learning. When inquiry-based learning is incorporated into instruction, teachers provide guiding questions for students to actively explore the required knowledge in order to solve the problems.[1]

Instructors skilled in questioning can increase the level of student engagement during lectures which results in improved outcomes. This technique has limits in that the instructor controls student learning by asking the relevant questions, including those that tap into students' prior knowledge. IBL calls for the students to formulate the questions surrounding a topic which leads to increased interest and motivation.

Utilizing inquiry-based learning in an engineering classroom, especially introductory courses, can be challenging for the instructor. These inexperienced students simply do not know what to ask. This practice will establish a framework for the instructor that when utilized will allow students to develop and generate answers to questions, thus leading to student learning. Two different approaches will be discussed in this paper both to which yield favorable results and are appropriate for a first-year engineering course.

Instructors in first-year engineering courses can take advantage of the various discipline-specific engineering societies that offer free and low-cost memberships to students. Instructors can also access the available resources that the society's website may contain whether they have a membership or not. This technique's platform is based on the American Society of Mechanical Engineers monthly magazine, daily brief and other news-worthy features published either in print or electronically. Students can choose from several feature articles allowing the students to study a topic that peaks their interest. For example, in the April, 2019 edition of the Mechanical Engineering Magazine, a story featuring Purdue University engineering students who recently required the assistance of crutches decided to redesign the crutch so that a user's hands are free. Students can utilize IBL in the investigation of the design, asking questions about the mechanical engineering aspect of the new design and how CAD and human body ergonomic simulation was applied in order to ensure the validity of the design. Information from feature articles can provide solutions to highly complex problems or everyday problems that may affect the students themselves. Students can inquire as to how the requirements, constraints, risks and assumptions were derived by the designing engineer.

Significant organizations in major industries have websites that can provide a powerful resource and learning tool. Students can be assigned an industry's or organization's website and be instructed to investigate the information and inquire as to the organization's role within the industry. For example, a company such as Siemens has realized enormous success by providing solutions to almost every major industry. The organization can market solutions to problems that many companies have difficulty formalizing. Siemens uses an inquiry-based learning system where questioning often leads to the organization recognizing the problem that a company might have, and that Siemens can solve. Students can use the vast website to hone in on a specific industry and review the case studies that are posted. Students can often detect the inquiry-based questioning that was utilized in the formulation of the problem and how the Siemens engineers solved the issue. For example, large industrial cranes are used in the movement of cargo. Anytime cables and pulleys are employed in movement, the load sways. This sway not only presents a safety hazard but an efficiency problem as time is needed for the load to settle. Students can learn how Siemens came up with a solution to reduce and eliminate sway. An extensive list of evaluated websites representing industry-specific organizations, support services and professional societies is provided to the students. Instructors develop inquiry-based assignments while navigating websites. Websites that represent potential employers for engineering students provide insight into an early career engineer's role within the company. A first-hand description of a problem that cross-functional teams including engineers demonstrates to a student how these large-scale problems are broken down and eventually solved. Students can tour through posted specifications and information to understand the resources utilized in the solution. An instructor may want to assign a white paper posted on the site and ask the students how the findings in the paper apply to a real-world application. The professional learning community blogging on the site allow students to learn how engineers teach and learn from each other, a skill they may want to grow even as students. Students will ultimately learn some of the concepts and terminology associated with industries such as marine, mechanical, industrial, power generation and electronics possibly aiding and validating a decision to pursue a specific discipline.

Reference:

[1] W. Ji-Wei, J. C. R. Tseng and G. Hwang, "Development of an Inquiry-Based Learning Support System Based on an Intelligent Knowledge Exploration Approach," *Journal of Educational Technology & Society*, vol. 18, (3), pp. 282, 2015.