A Project-Based Case Study for Students Interested in Biomedical Engineering

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Abstract

With the development and evolution of functional devices from low-cost components, there is an opportunity to devise project-based learning experiences for students interested in biomedical engineering. When creating new learning experiences, it is important to ensure that the learning goals, activities, and assessments align. The goals-activities-products-assessments (GAPA) framework is one tool for achieving alignment in project-based learning. This work aims to demonstrate the utility of a project goals framework in defining student-centered learning goals for a new learning experience.

Keywords

project-based learning, project goals, biomedical engineering

Introduction

Project-based learning is a flexible teaching approach that encourages students to address the purpose of what they are trying to achieve with a project[1]. The literature strongly supports the value of project-based learning[1-5]. Imagining project goals and objectives helps clarify the purpose of the project-based experience, communicate intent to students, generate ideas that align with the project goals, and critically evaluate the success of the course project[1]. The goals-activities-products-assessments (GAPA) framework[1] is the approach we have chosen to use.

Approach

This work focuses on creating a semester project for a second-year engineering design course. The course challenges students to integrate human-centered design plus professional, ethical, and social responsibility into engineering design processes. Working collaboratively, students develop and construct a device, system, or process to meet the need or improve the quality of life of a client.

The project goals framework consists of ten aspects to consider when defining project goals. There is a low-to-high slider bar associated with each aspect, which allows instructors/designers to articulate the degree to which each aspect explicitly connects to the activities, products, and assessments for the project[1].

Discussion of Results

The co-authors completed the goals-ranking exercise independent of one another. The results are summarized in *Figure 1*. The green circles represent goal ratings from the course instructor and

Figure 1. The Project Goals Framework[1] displaying the co-authors' goals-ranking

the orange circles represent goal ratings from the collaborating undergraduate researcher. Note the close agreement in some goal areas, and disagreement in other areas.

The co-authors appear to have the shared vision that the project should encompass hands-on skills, design and creativity, real-world context, and intrinsic motivation at similar degrees of connection to the project activities, products, and assessments. More divergent views were revealed in the areas of content learning, critical thinking, disciplinary integration, communication skills, teaming/collaboration, and self-directed learning.

The co-authors then prioritized the project goals according to the well-known backwards design approach devised by Wiggins and McTighe[3]. Results are summarized in *Table 1*.

The co-authors had a shared vision for the importance of hands-on skills, design and creativity, real-world context, and intrinsic motivation; therefore, those were automatically characterized as "enduring understandings." Communication skills, teaming/collaboration, and self-directed learning were added on the basis of strong potential for direct integration into the project. More specifically, to address communication, we now aspire to include a "future work" component to have student teams articulate potential next steps in the life of the project to pass the project to the next class of students. We embraced teaming/collaboration as an opportunity to elevate disciplinary integration by having student teams to designate each member as a content expert on a topic directly related to the project. Last, we concluded that self-directed learning might manifest as student teams articulating their own goals for the project and documenting their progress toward achieving them.

Table 1. Project goals prioritized using the backwards design approach[6]

backwards design prioritization	**project goals**
enduring understandings *worthy of being an explicit project goal and expected to be retained in the long-term*	• Hands-on skills • Design and creativity • Real world context • Intrinsic motivation • Communication skills • Teaming, collaboration • Self-directed learning
important to know and do *worth knowing and doing to add value though not an essential project goal*	• Critical thinking • Disciplinary integration • Entrepreneurial mindset* • Ethical responsibility* • Environmental factors* • Economic factors*
worth being familiar with *advantageous though definitely not an essential project goal*	• Content learning

Critical thinking and disciplinary integration were placed in the "important to know and do" category because it was not something we wanted student teams to explicitly demonstrate, but that it would happen naturally as they worked collaboratively to synthesize all of the information about the project. The co-authors concluded that content learning described more traditional instructor-led activity aimed at teaching material. Such approaches seemed inconsistent with the higher-order cognitions inherent in problem-based learning; therefore, content learning was placed in the "worth being familiar with" category.

ABET Criterion 3 student learning outcomes emerged as strong candidates for potential customized goals[1]. We noted that some were already addressed through the Project Goals Framework (e.g., teamwork, communication, and complex problem solving). Entrepreneurial mindsets (e.g., curiosity, connections, and creating value), ethical responsibility, and consideration of economic and environmental factors were added to the "important to know and do" category, to add depth and value to the project.

In conclusion, the Project Goals Framework proved to be a powerful analytical tool for defining project goals in the development of a new project for a second-year engineering design course. We hope that others might be inspired to use it as part of the broader GAPA framework to align project goals, activities, products, and assessments in the creation of student-centered learning experiences.

References

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Sirena Hargrove-Leak is an Associate Professor of Engineering and Director of the Engineering B.S. Program at Elon University. The mission of the university and its commitment to undergraduate education have led her to explore the scholarship of teaching and learning in science, technology, engineering, and mathematics (STEM). More specifically, her current engineering education interests include entrepreneurial mindsets, user-centered design, project-based learning, and broadening participation in STEM. She also has interests in heterogeneous catalysis for fine chemical and pharmaceutical applications and membrane separations.