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Constructionism in Learning: Sustainable Life Cycle Engineering Project (CooL:SLiCE)

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CooL:SLiCE is a distributed cyberlearning environment that facilitates consideration of engineering design impacts on the natural environment across product life cycles. Wayne State University, Oregon State University, Penn State University, and Iowa State University are developing CooL:SLiCE to support a constructionist line of inquiry within engineering design practice by providing learners with technologies and other learning resources for experimentation and collaboration. CooL:SLiCE is intended to enable students to attain a deeper conceptual understanding of sustainable lifecycle product design.

A vision for interactive cyberlearning platforms has been established, however, there are important and philosophical directions and challenges for sustainable engineering education, which have been discussed in the pedagogical and instructional methodologies literature (Crofton 1995; Desha & Hargroves 2010; Amadei 2014). Constructionist learning environments are thought to enable students opportunities to enact deeper understandings of the concepts (i.e., product design and environmental responsibility) than in instructionist-centric environments (Papert & Harel 1991; Kafai 2006). CooL:SLiCE provides a distributed constructionist cyberlearning platform designed by this multi-institutional research team to provide learning modules that allow investigations of the environmental impact of engineering designs.

The CooL:SLiCE platform learning modules include 1) the Online Computer Aided Design (CAD) and Product Design Visualization Modules, 2) the Manufacturing Analysis Module, and 3) the Sustainable Product Architecture and Supplier Selection Module (Figure 1). CooL:SLiCE learning modules are developed for design customization activities with drones and multi-copters and include drone design activities, handbooks and manuals, and tools for collaborative and individual reporting and assessment. Learners are also supplied with a library of 3D shapes, design data, and variant information (e.g., materials, dimensions, manufacturing processes, logistic costs, and potential suppliers) for drone design customization. The Product Visualization module facilitates the selection and display of various CAD (Computer Aided Design) models in the portal so learners can better visualize and communicate design alternatives. The Manufacturing Analysis module provides detailed information about the manufacturing and assembly processes used in production to facilitate cost, productivity, and environmental performance assessment during early product design. In the Sustainable Product Architecture and Supplier Selection (S-PASS) module**,** relationships between sustainable design requirements and their associated functions and architectural modules can be identified and evaluated against existing products. S-PASS assists determining whether the functions and requirements are satisfied in available product modules. Possible product architectures can be configured to create an initial product architecture set. Final

[1] DUE-1431481, DUE-1432774, and DUE-1431739

product architecture candidates and their suppliers are selected by evaluating the architecture's requirement satisfaction.

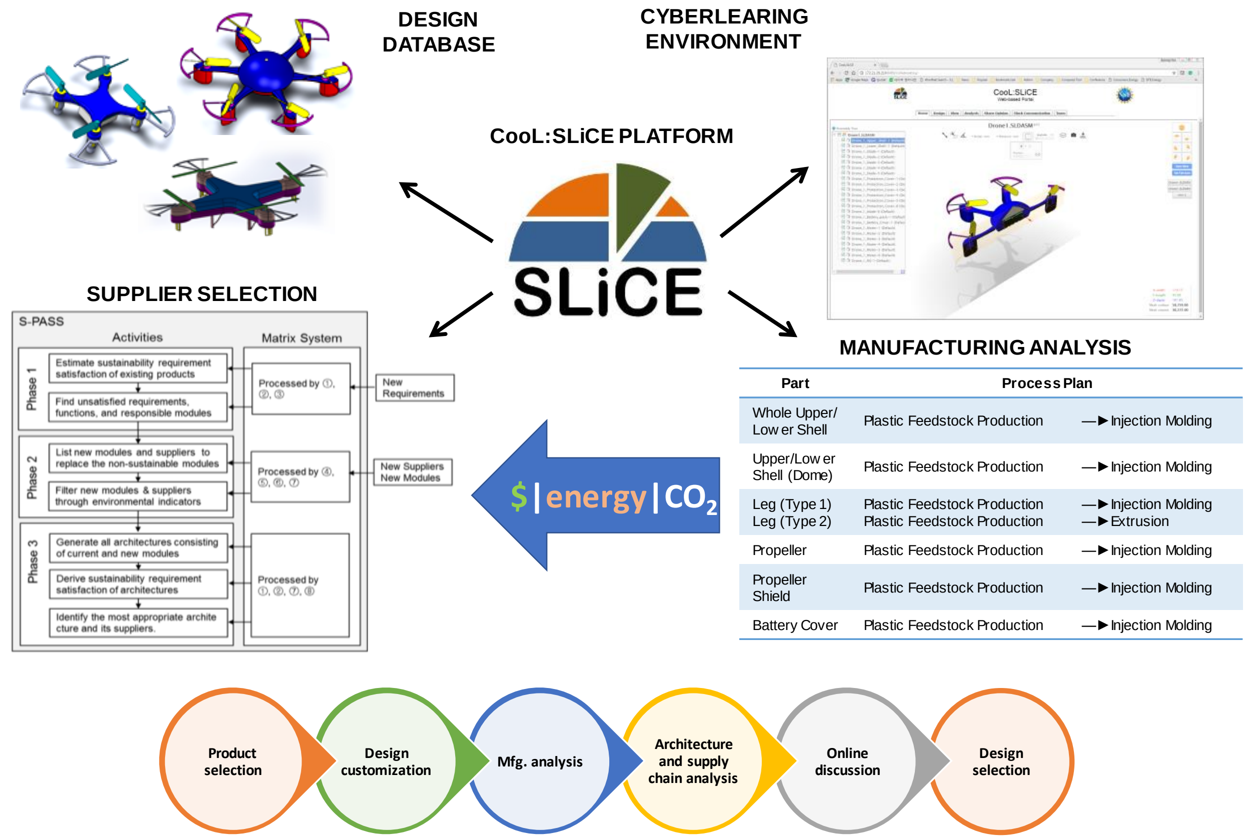

Figure 1. CooL:SLiCE Portal and Process

This 3-year project is now in its third year and project outcomes are in the process of being finalized. In the first year, a preliminary study of the learning context and students (n=117) at each university was made to inform the evaluation of the now developed CooL:SLiCE platform. This year, CooL:SLiCE was piloted by an intercollegiate team of graduate students who collaboratively designed sustainable drone customizations in the CooL:SLiCE distributed learning environment. Currently, CooL:SLiCE is being used by a collaboration of undergraduate engineering students at three different universities in their senior capstone projects. Additionally, CooL:SLiCE is currently incorporated into the sustainability modules of three engineering courses (i.e., Integrated Product Development, Computer Aided Design and Manufacturing, and Sustainable Manufacturing) offered at the three universities from which we expect to collect over 125 student assessments of CooL:SLiCE for analyses. Additionally, this research will provide behavioral findings by investigating how learners with different levels of autonomy engage in cyberlearning environments.

In one of the engineering courses (Integrated Product Development) that introduced CooL:SLiCE, semester-long group projects were assigned that expected students to develop competitive and innovative drone design concepts using the product development methods learned in the course. Most student teams opted to use resources provided by the CooL:SLiCE portal. An example of a student team's use of CooL:SLiCE resources for a sustainable drone design project is shown in Figure 2. The student team's vision for next generation drone technology is to assist manual agriculture with more precision while avoiding harmful environmental impacts. The team created three design alternatives that support laborious farming activities with manually operated drones and attachments. The sustainability performance of their drone design and attachment alternatives were evaluated by using assessments provided by CooL:SLiCE. The team's analysis compared aspects of the Octacopter with the Fixed Wing Drone configuration to see which would have the smallest carbon footprint (CF). The analysis allowed the team to observe that the Fixed Wing Drone would have significantly smaller CF.

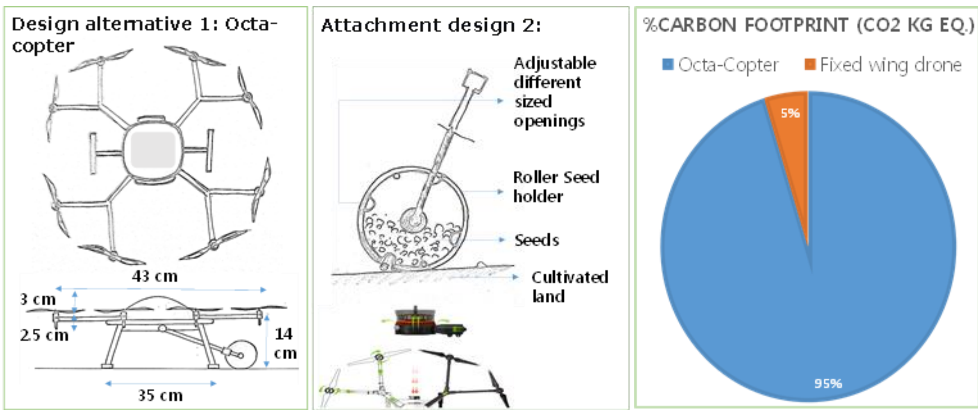

Figure 2. Example of Student Team's Sustainable Drone Design using the CooL:SLiCE Portal

CooL:SLiCE responds to the need for sustainability education to increase awareness of product design and environmental sustainability. Its capabilities for personalized design activities advance student multi-stage problem solving skills through its integrated learning environment that supports realistic, engaging examples. Students also develop enhanced teamwork skills while working on team design projects. Learning is promoted through a hands-on format and visualization capabilities that increases understanding and interest in product design and associated sustainability consequences.

Sustainability research is known to attract students from underrepresented groups to STEM disciplines and to broaden participation in next generation engineering research and education. This work helps to develop a new way for academic institutions to integrate sustainability into their curricula at a modest cost, which remains a challenge, and simultaneously prepares a workforce to meets industry needs for sustainable product development. The team continues to collect data to study the impacts of the CooL:SLiCE in the various class environments.

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