2015 Technology Fee Full Proposal

Title: Materials Selection Software to Support Education and Innovation

Proposer: Michele V. Manuel, Associate Professor, Department of Materials Science and Engineering, 152 Rhines Hall, email: mmanuel@mse.ufl.edu, ph: 352.846.3780, fax: 352.392.7219

Sponsoring Organization: College of Engineering

Purpose and Specific Objectives: A critical aspect of design is the process of materials selection. In most disciplines, materials are generally selected using data from handbooks, standards, and other published literature (which are considered outdated) in a non-analytical and often non-systematic fashion. Typical analysis tools used in materials selection heavily relies on estimation leading to over-designed systems. Furthermore, improper materials selection can lead to catastrophic failure and other devastating consequences.

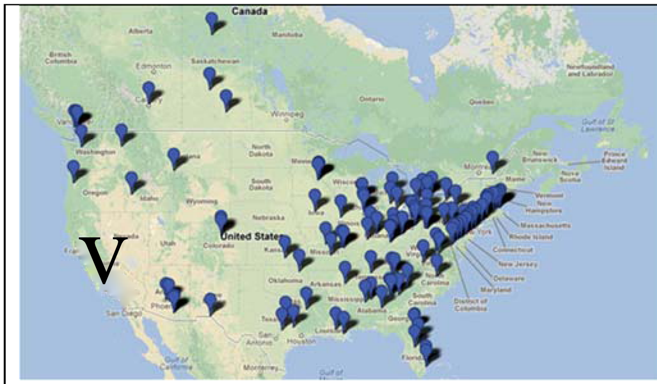

Figure 1. Graphical map of CES software users in North America.

A commercial educational tool called the Cambridge Engineering Selector (CES) has been developed to address this issue. The software provides a user-friendly environment making the process of selecting materials more efficient and accurate. Over 250 universities and colleges use the CES program as a teaching resource to support education in engineering, science, processing and design. The map in Figure 1 illustrates the vast nature of CES licenses distributed across the nation.

Table 1. Snapshot of universities who use CES software in the U.S. (out of over 250 universities in North America and over 1,000 universities world-wide).		
Arizona State University	Massachusetts Institute of Technology	University of California, Berkeley
Boise State University	Michigan State University	University of California, Los Angeles
California Polytechnic State University, San Luis Obispo	Northwestern University	University of California, Irvine
Case Western Reserve University	Pennsylvania State University	University of California, San Diego
Carnegie Mellon University	Purdue University	University of Illinois at Urbana Champaign
Colorado School of Mines	Rochester Institute of Technology	University of Maryland at College Park
Cornell University	Rutgers University	University of Michigan
Drexel University	Stanford University	Virginia Polytechnic Institute and State University
Georgia Institute of Technology	Texas A&M University	Worcester Polytechnic Institute
Harvard School of Design	The Johns Hopkins University	
Iowa State University	The Ohio State University	
James Madison University	The University of Alabama	
	The University of Texas, Austin	
Snapshot of universities who use CES software in the state of FLORIDA		
Embry-Riddle Aeronautical University, University of North Florida, University of Central Florida		

Impact/Benefit: This software enables you to 1) quickly find materials data, 2) understand the full benefits, constraints, and risks associated with various material options, 3) use the material data to easily communicate results to a wide audience. As a result students will be able to make and communicate decisions about materials selection based on high quality and fidelity data that is referenced and used as an industry standards. This avoids scenarios where students use "Google" or "Wikipedia" to find data about material properties, which may not be reliable.

Additionally, data in the software is renewed annually, thus providing the most up-to-date, latest findings on material properties.

Examples - Overview:

When the software is first opened, you arrive at a comprehensive list of materials (over 3,000), as shown in Figure 2 (Left). Clicking on a particular material will bring up an exhaustive list of information (as shown in Figure 2 - Right):

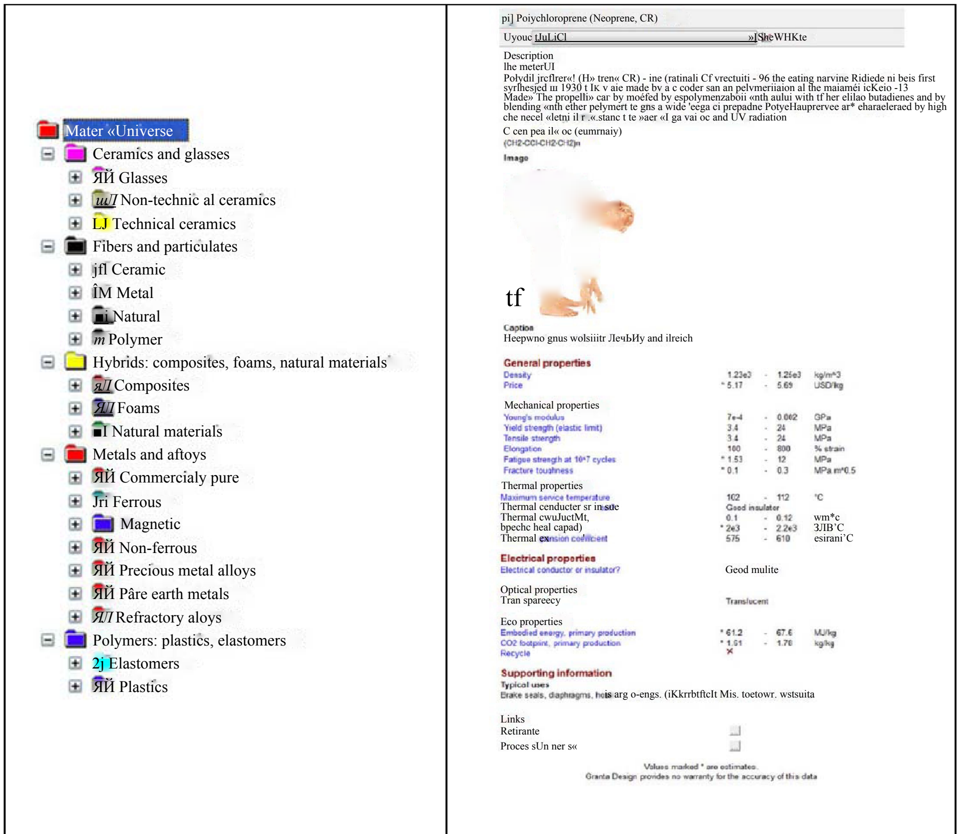

Figure 2. Left) How materials are classified in the software. Right) Materials description provided by the software for Neoprene (technical name: polychloroprene).

- General Properties: this includes the general designations or trademark names, composition, density and current price. Additional chemical information such as atomic number, atomic weight, date of discovery, crystal structure, and location on the periodic table are available.
- Thermal Properties: melting points, glass transition temperature (the temperature when polymers go soft), thermal conductivity, etc.
- Mechanical Properties: modulus (i.e. stiffness) in compression, shear, flexure, bulk and Young's. Strength's including yield and tensile.
- Electrical and Optical Properties: resistivity, dielectric constant, transparency, refractive index, etc.
- Durability: resistance to water, chemicals (acids and bases), sunlight, fluids, etc.
- Geo-Economic Data: annual world production, abundance on earth, ore grades
- Eco-Properties: carbon footprint, how much energy it takes to produce the material (this is separated by the energy or cost of the raw material itself, manufacturing, recycling, and transportation.

Figure 3 (left) illustrates how materials can be differentiated by their class and readily identifiable for their properties. In this example metals, polymers, ceramics and composites/hybrids are contrasted by their toughness. On the right side of Figure 3 (right), various types of carbon steels (AISI designations are shown which indicate the metal's chemistry) are shown illustrating the effect of chemistry, i.e. carbon content, on the strength and ductility of low, medium, and high carbon steels. This example shows how the software can be used to illustrate fundamental principals of chemistry and material physics.

As sustainability is an ever-growing concern, the impact of materials on the environment is gaining increased focus. Figure 4 (left) demonstrates how the eco-version enables direct comparison of a polymer and glass water bottles in their use of energy at different stages of their lifecycle, staring from raw material to disposal. This enables further classroom or research discussions on how different products impact the environment during the entire life cycle and

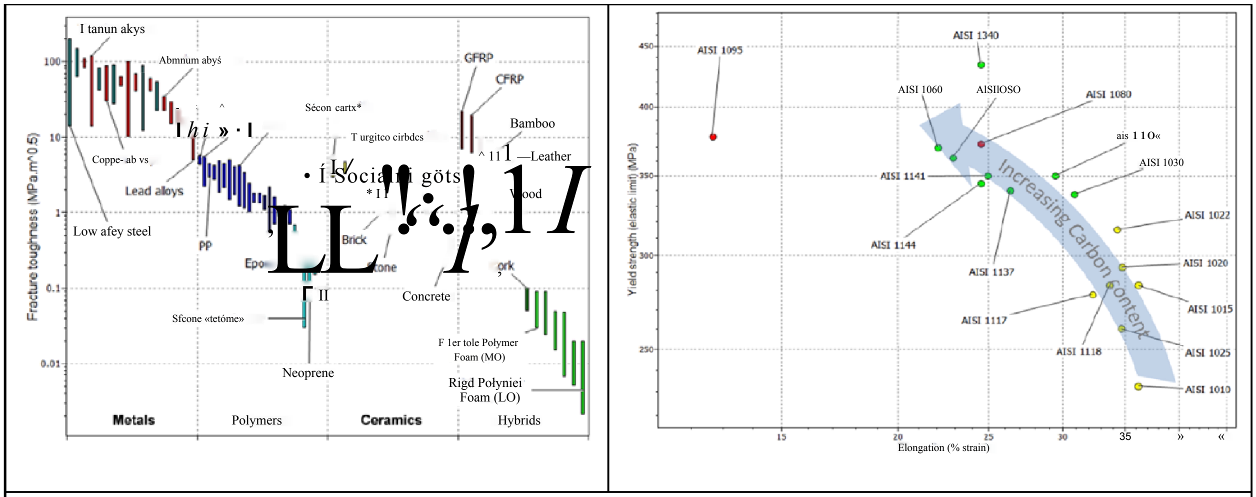

Figure 3. Left) Materials are shown by their class, illustrating how different material classes have various degrees of toughness. Right) The effect of carbon content on low, medium, and high carbon steel.

ways to decrease this impact. Figure 4 (right) shows the processing component of the software. Since determining which processing methods to use to manufacture a particular material or component

is important in the design process, details regarding various manufacturing process (including illustrations, cost estimates on production, tooling, labor, etc., as well as physical attributes (tolerance, surface roughness, resultant part geometry) are all embedded within this program. In this example, various processing methods are categorized by their general type (rapid prototyping, machining, casting, etc.) and batch size (i.e. the number of parts which the process then becomes economically viable).

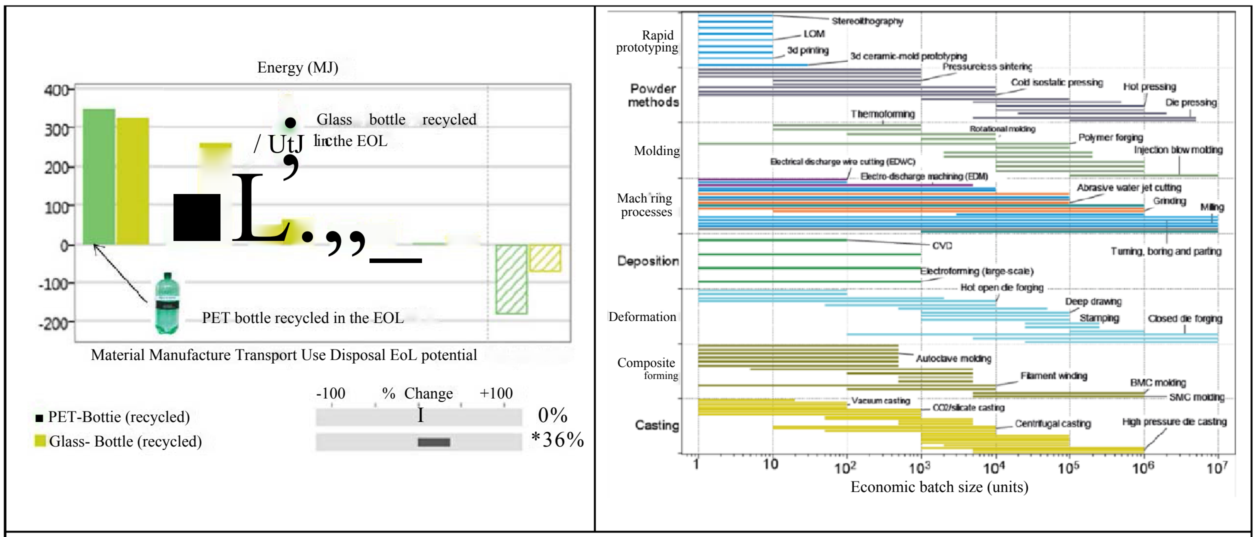

Figure 4. Left) A comparison between a plastic and glass beverage containers on the amount of energy consumed a various stages of their life cycle. It can be seen that although the polymer bottle takes more energy to produce the raw polymer, the glass bottle takes a significant more amount of energy to manufacture. Right)

Impact on Teaching Methods: This software has the flexibility to the used in a variety of teaching environments. Project -based learning is enabled as this software is ideal for student project or design teams who need access to comprehensive databases of information to materials-related problems. Problem-based learning can be used to provide deep understanding of the fundamental behavior and scientific principles behind the materials they are using. Also, since any student has access to the software, the onboard teaching modules enable self-teaching for those wanting exposure to the software or using the software for more advanced functions.

Figure 5. Schematic of all of the relevant disciplinary areas where the software will create meaningful impact.

Concurrent with the license is the access to the Granta Teaching Resource website which includes the following to enrich the traditional classroom environment:

- Over 80 PowerPoint lectures
- Over 30 exercise with solutions
- Expert advise and technical support
- Regular webinars
- Solutions manual for textbooks
- Interactive cases studies
- White papers and "teach yourself" booklets
- Video tutorials
- Numerous materials and process selection charts

Research Benefits/Impacts: As a repository of materials property information, faculty, post-docs, and students can utilize the data generated by the software in manuscripts, grant proposals, and extension activities. The data allows researchers to make informed decisions about selecting materials and use it as a comparative tool for benchmarking. Furthermore, the software can be used as a tool for integration into the "Data Management Plan" that is frequently being requested on grant proposals by many funding agencies. The software would serve as a repository where data is organized and collectively stored.

Number of People Benefiting: Primary target users are students and faculty in the Departments and Schools of Materials Science and Engineering, Mechanical Engineering, Biomedical Engineering, Civil Engineering, Environmental Engineering, Chemical Engineering, Industrial Engineering, Architecture, Building Construction, and Interior Design. This would potentially impact over 100 faculty and at least 1,000 students. A summary of all of the fields that could be potentially impacted by the implementation of this software on campus is provided in Figure 5.

Accessibility: Software will be available to students enrolled in specific courses on all academic technology computer labs and UFApps.

Meeting ADA requirements: The proposed software has been evaluated against Section 508 of the Rehabilitation Act and has been shown to meet the applicable provisions. The software supports standard Windows accessibility. Additional supporting information regarding compliance with ADA requirements can be provided upon request. To ensure course accessibility for all students with disabilities, the Center for Instructional Technology and Training (CITT) will be consulted throughout the installation and launch process.

Sustainability: The license term will be for 3 years. This is an annual license and thus the data will be updated once a year with the latest information. The 3-year term was chosen due to the appreciable discount that GRANTA offers for multi-year annual license purchases. PI Manuel will work with the Academic Technology staff and point-of-contact faculty in the Departments of Materials Science and Engineering, as well as Mechanical Engineering to launch the software program in the Fall of 2015. Every summer thereafter until 2018, PI Manuel will evaluate enrollment statistics. She will also expand the user space to the Departments of Biomedical, Civil, Environmental, Chemical, Industrial Engineering, as well as Architecture, Building Construction, and Interior Design. If demand is demonstrated over this 3-year period, the accumulated fee costs from 2015-2018 will be enough to renew the software for another 3-year term.

Timeline:

	Summer 2015	[illegible]	Summer 2016	[illegible]	Summer 2017	[illegible]	[illegible]
Work with AT to Install CES Software on Campus	■						
Begin 3 Year license (launch in Departments of Mechanical Engineering and Materials Science and Engineering)		■					
Evaluate Course Enrollment Statistics for the 2015-2016 Academic Year			■				
Evaluate Course Enrollment Statistics for the 2016-2017 Academic Year					■		
Evaluate Course Enrollment Statistics for Entire 3-year license period.							■
Renew the 3-year License Contract Supported by Course Fees From the Previous 3 Year Period							■

References:

• Ashby, M.F., Melia, H., Silva, A., Supporting and Complementing Undergraduate Materials Science Teaching: Callister-Based Courses and CES Edupack, GRANTA Teaching Resources, 2007.

• www.grantadesign.com

• Pfennig, A., Materials Science Comes to Life for Engineering Students," GRANTA Product Overview: CES Edupack Brochure.

Budget:

License Structure: Annual license based on estimated course enrollment. Software will be available to students enrolled in specific courses on all academic technology computer labs and UFApps. The technology fee will cover first three years of funding and future costs will be gauged based on usage.

Option 1 (term: 1 year which expires in 2016, type: annual license)

	Maximum Users	**Cost**	**Cost per Student**
Eco Edition	1000	$19,690	$19

Option 2 (term: 2 years which expires in 2017, type: annual license)

	Maximum Users	**Cost**	**Cost per Student**
Eco Edition	1000	$36,950	$18

This is a discounted rate (i.e. multi-year discount) for buying 2 years of the annual license. Regular price $48,400.

Option 3 (term: 3 years which expires in 2018, type: annual license)

	Maximum Users	**Cost**	**Cost per Student**
Eco Edition	1000	$47,900	$15

This is a discounted rate (i.e. multi-year discount) for buying 3 years of the annual license. Regular price $72,600.

This proposal seeks funding for a 3 year license.