

Creating Sharable Learning Activities Examples from a Manufacturing Engineering Curriculum

Donald R. Falkenburg,
Wayne State University

Allie Knowlton,
Wayne State University

Mary Jo Cartwright,
CNC Connection Corp.

Abstract

Many engineering faculty have been involved in projects to improve teaching and learning using web-based resources. Information-based learning materials have proven to be adaptable and dynamic; they have enhanced the educational process. As the number of people involved in the development of IT-based educational materials expands, the engineering education landscape has become dotted with *islands of innovation*—isolated areas where IT-based materials are available. However, these materials are not available to a large number of users, thereby reducing opportunities for synergy, discourse, and exchange. The NSF-funded Greenfield Coalition has developed a technology strategy to facilitate an ability to re-purpose web-based learning activities for a new context, enabling reuse and exchange. This paper describes Greenfield's approach to share learning activities, and describes a suite of material that is available from the Coalition website.

A Unique Educational Environment

The Greenfield Coalition [1] is a coalition of five universities, three university affiliates¹, six manufacturing companies², the Society of Manufacturing Engineers, and Focus:HOPE. Focus:HOPE supports an amazing web of programs to underpin its educational objectives. Founded in 1968 after the urban riots in Detroit, it *pledges intelligent and practical action to overcome racism, poverty and injustice*—to make a difference within the city and its suburbs. Focus:HOPE began by feeding the undernourished needy (women with children and then adding senior citizens), but quickly added programs to enable inner city youth to acquire knowledge to seize opportunities for highly skilled and well paying jobs. Today, an individual may begin the journey by enrolling in *First Step* or *FastTrack*. These four and seven week programs use computer-based learning to build fundamental skills in mathematics and English. When the student graduates from *FastTrack*, they have skills certified at the ninth and tenth grade level in reading and math. This provides the appropriate prerequisite skills for entering the *Machinist Training Institute (MTI)*. MTI is a thirty-one week program in which students earn certification in the operation of material processing equipment (machining), metrology, computer-aided design, computer numerical control, and the associated math, computer, and communication skills. Alternatively, students may also choose to pursue a career pathway through Focus:HOPE's *Information Technologies Center*.

Greenfield presents an opportunity for graduates of MTI to cap their practical experience with further studies toward advanced university degrees. Those students who qualify, enter a 24 week pre-engineering program after completing MTI's basic machining program. After a series of diagnostic tests and interviews they become *Candidates* in the Center for Advanced

¹ Coalition Members: Lawrence Technological University, Lehigh University, Michigan State University, University of Detroit Mercy, Wayne State University; Affiliate Partners: Ohio State University, University of Michigan, Walsh College.

² Cincinnati Machine, DaimlerChrysler, Detroit Diesel, Electronic Data Systems, Ford Motor Company, and General Motors Corporation.

Technologies (CAT)—Focus:HOPE’s manufacturing facility. The Center for Advanced Technologies is a not-for-profit entity which is a first tier supplier of manufactured components and systems to Ford, General Motors, DaimlerChrysler, Detroit Diesel, and the U.S. Department of Defense. The Candidates are employed by Focus:HOPE and work in a broad range of manufacturing, production, and support activities. While this employment provides financial support, more importantly it becomes a real-world laboratory to support their learning.

Focus: HOPE Mission Statement

Recognizing the dignity and beauty of every person, we pledge intelligent and practical action to overcome racism, poverty and injustice. And to build a metropolitan community where all people may live in freedom, harmony, trust and affection. Black and white, yellow, brown and red, from Detroit and its suburbs of every economic status, national origin and religious Persuasion. We join in this covenant. (Adopted March 8, 1968)

Greenfield’s Instructional Design Strategy

The design strategy of the Greenfield Coalition is predicated on the set of beliefs about teaching and learning. In order to implement these beliefs, Greenfield has adopted a blended learning approach [2], where classroom exercises, manufacturing shop floor work experiences and technology merge to form a collaborative, reality-based learning environment.

Greenfield Beliefs

- Learning is a shared responsibility between learner and teacher.
- Faculty play a key role guiding students in the learning process.
- Learning is made real if it is integrated with real-world experience.
- Learners must prepare to engage in classroom experiences.
- Learning is a social process, which requires interaction with mentors and peers.
- By actively participating in their learning, students achieve deeper understanding and enhanced skills.
- Technology is not a silver bullet, which by itself promotes learning, but if used effectively, it can provide new capabilities to support learning.

When designing a course, a team of subject matter experts from both academe and industry collaborate with an instructional designer, a programmer, and a media specialist in order to create instructionally-sound, technically-supported, engaging learning activities. The resulting material includes key manufacturing engineering concepts and directly applies these to real-world, on-the-job experiences. Often these materials include templates, tools and step-by-step instructions used by practicing engineers.

Using Gagne’s Nine External Events of Instruction as a guide [3], Greenfield is able to maximize the motivation for learning, add relevance to the content and foster an active learning atmosphere. Within our learning activities we present situations and pose questions to stimulate

thinking rather than engaging learners in fact memorization. Many of these situations and questions relate to real world problems that do not have a single answer. Learning activities encourage deeper thinking; they challenge typical solutions, and provide practice of skills necessary to the practice engineering. This is exemplified in *Greenfield Case Studies* where learners are challenged to determine the scope of the problem, how it can be solved, and what materials (textbook, Internet, instructor, knowledge and experience of peers) will be essential for completing the activity.

Greenfield Coalition courses and case studies are designed to allow students to apply new knowledge and skills, test theories, make unique connections to previous knowledge, and organize new concepts in a logical and relevant framework for themselves.

Learning Object Model

The Greenfield Learning Model (LOM) recognizes a hierarchy of objects. The curriculum object is the highest level in the model. Associated with the curriculum object are a set of high level objectives—the goals of our curriculum. Greenfield does not view the curriculum as simply a collection of courses. Rather, we organize the curriculum around a set of knowledge areas.

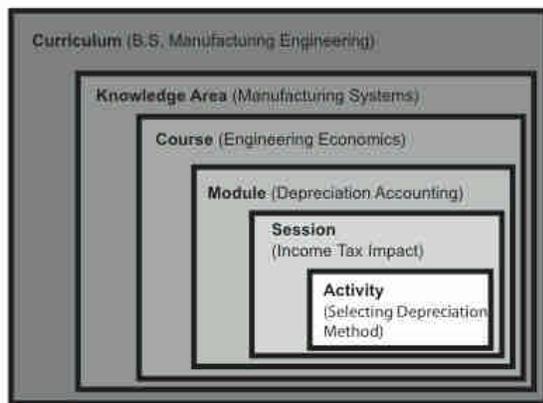


Figure 1: Greenfield Learning Object Model

Each of these knowledge areas has a set of objectives which support the curriculum goals. Mathematics, liberal studies, communications, engineering foundations, manufacturing processes and manufacturing systems are all examples of Greenfield knowledge areas. The KA's are collections of courses. The set of course objectives support the KA objectives. Greenfield organizes its courses into conceptual groupings called modules. In Figure 1, we show the module *Depreciation Accounting* embedded in the course *Engineering Economics*.

Greenfield uses the term *session* to be a subgroup of the Module. Hence, Our module on *Depreciation Accounting*, for example, contains

two sessions: *Depreciation Methodologies* and *Income Tax Impact*. Greenfield views the heart of learning not to be a topic, but to be a learning activity. A session typically begins with a group discussion to elicit prior knowledge about the material to be covered. The discussion continues focusing on prework including reading material and other exercises. Other activities may include individual or group work using e-learning resources. In this example, the session contains a learning activity presented in a web-based environment in which the learners work to discover the best depreciation methodology under a given set of conditions. Learning activities may also include presentations or reading. For Greenfield, learning is aligned with a set of activities not a lecture on a topic. A rich set of references targeting active learning is available on-line [4].

Implementation

Greenfield supports the delivery of its program with web-based learning resources, which are organized around the LOM described in the last section. Along with our software partner (CNC

Connection Corporation, Pinckney, MI) we have developed a web-enabled learning environment for authoring and sharing learning materials. Components of the learning system are stored as objects in a database. Using a web-based interface, this learning environment enables teams of faculty, instructional designers, graphics artists, application programmers, and industry partners to collaborate in the creation of course materials. The environment is data-driven, providing ease of design, implementation, and maintenance of learning objects. In this context, information sharing is embedded in learning activities constructed from components and assembled into sessions, modules, and courses.

This architecture separates content, display, and navigation. Rather than binding learning objects into courses, we provide dynamic linking to enter and exit objects. Thus, we can support the dynamic assembly of information by combining objects that reside on networks of multiple servers, supported by different databases and operating systems. Users can easily access individual activities, sets of activities that comprise a session, or all components which frame a module – a set of conceptually related material.

The software system permits the creation of objects and the layering of these objects within the hierarchy. In the figure below we show the course design interface. We have used the intuitive windows object paradigm to represent learning objects. In this figure we show a partial picture of our course Metal Forming Technologies I. Child objects of the course include *FormingTechHome* (the home page for the course), *course description* and *course objectives*. The first module in the course is *Introduction to Metal Forming*. Among the child objects of this module are *objectives*, (a statement of) *purpose*, and a set of sessions which include: *Introduction to Metal Forming*, *Products Manufactured from Sheet Metal & Bar Stock*, *Classification of Metal Forming Processes*, and *Variables of the Metal Forming System*. New objects are created and named by the designer.

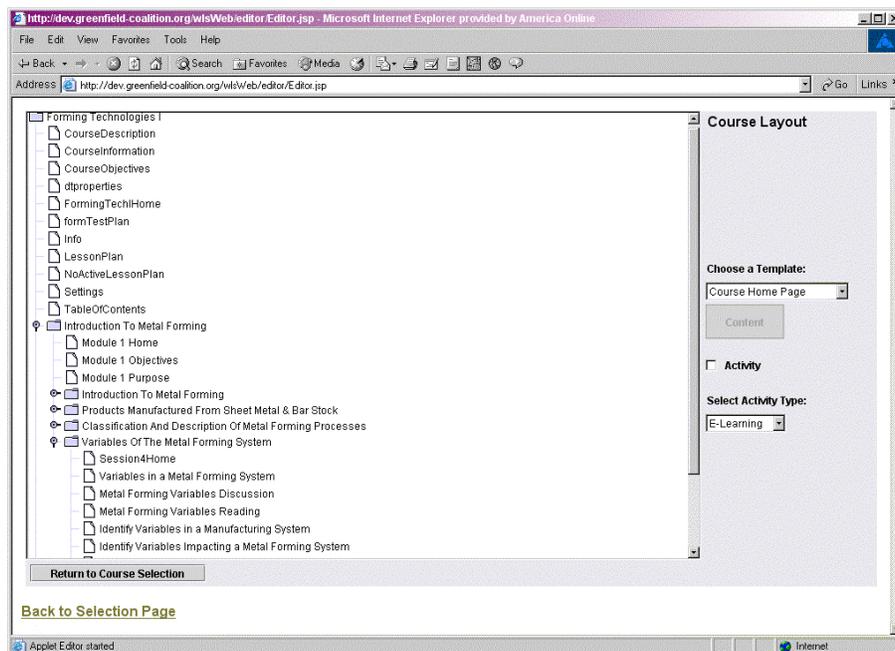


Figure 2: Object Structure of Greenfield Course

Content is stored in a database and displayed in templates. An example is shown in the next figure. Here we show a template for a course home. This is where content is added to the home page object. The graphical user interface permits the designer to define content. Although this data will be stored in a database, the authoring system does all of the work to define the structures in which the data will be stored as well as the mapping between the database and the targets in the template. The interface is quite intuitive and can be used by instructional designers and faculty. In addition to viewing the object in this template format, a window can be opened to display the web page that the learner will eventually see. In the Page Layout environment, the user can assign existing content to a page template by a simple drag-and-drop procedure. The user selects the content object (i.e., animation, graphic, text, interactive) from the content window and drags it to the desired location in the page template. At any time, the course content can be placed in a new page by selecting a new page template and assigning the content to the new format. Also, the user can use the same page format (template) and change the existing content. This enables the ultimate flexibility in the design of course content and presentation.

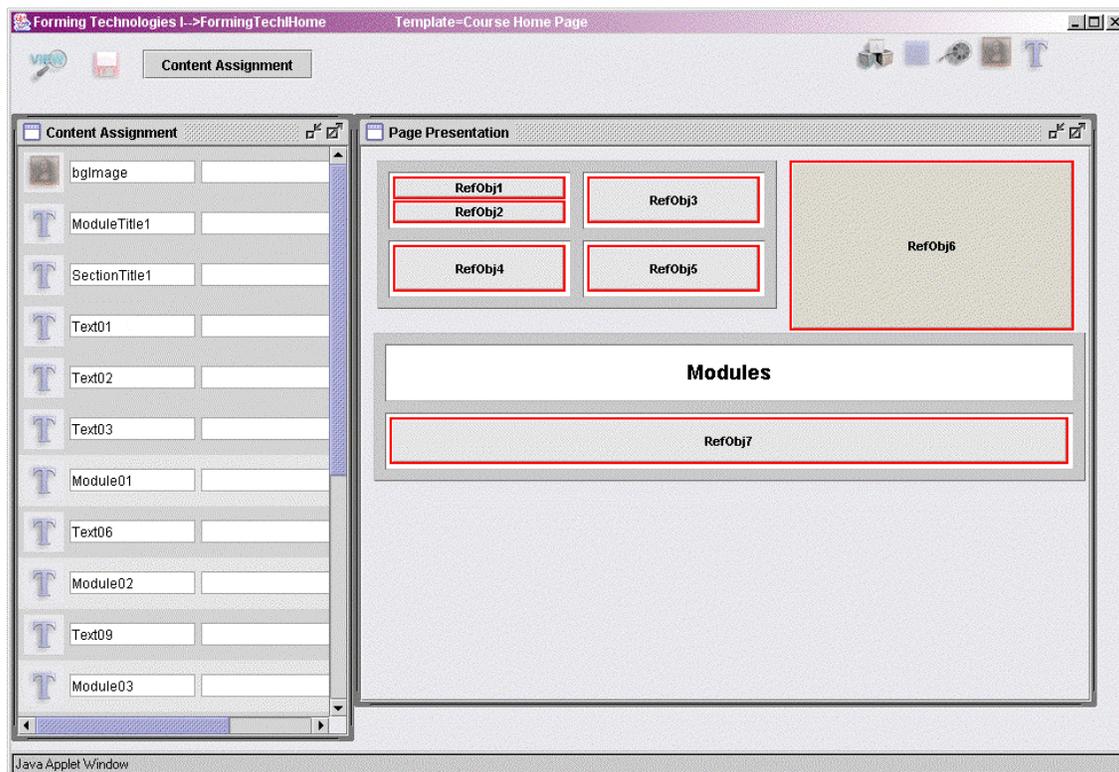


Figure 3: Content Mapping Template

There is a second level of programming that requires more detailed skill that can be used to define new templates.

The authoring system also has tools to construct Metadata to support an e-learning environment. Metadata has been defined as data about data. In fact, it is simply information about any object. In the context of learning systems, it is information about learning objects and their components and is maintained to help search for and manage those objects. The Greenfield Coalition is implementing a structure for metadata based on the IMS Learning Resource Meta-Data Information Model Version 1.2.1 [5]. In Figure 4 we illustrate some of the screens available to enter Metadata. The first of these describes general information (language, keywords and content description) while the second illustrates technical specifications required to access the material (browser versions, installation remarks, etc.).

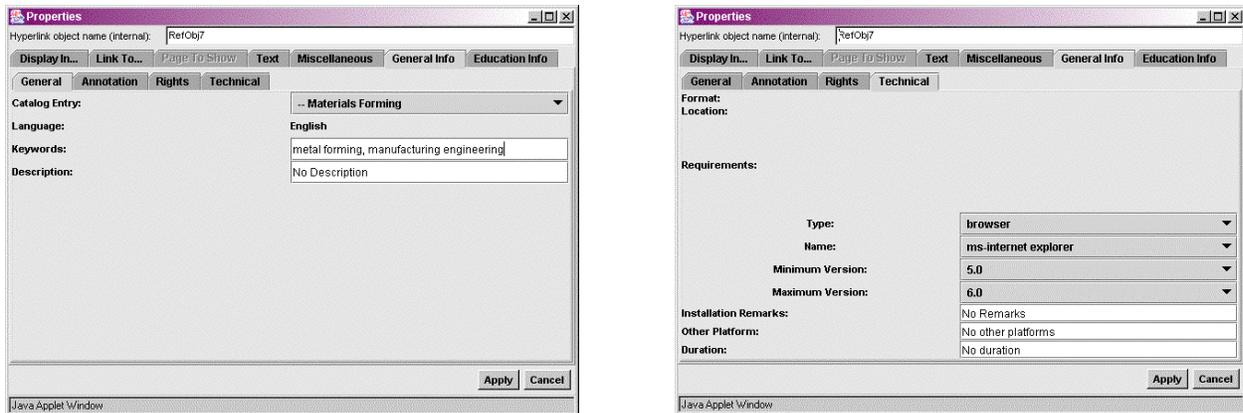


Figure 4: Metadata—General Information and Technical Information

Greenfield Courses

Under funding from the National Science Foundation, Greenfield has developed a series of courses to support a curriculum in manufacturing engineering. Current on-line courses include:

[Engineering Economics I](#) This course focuses on the relationship between present worth, future worth and equivalent annuity in order to gain a broader understanding of the time value of money and economic equivalence. Students gain familiarity with various methodologies for comparing project alternatives and allocation of capital resources among worthwhile projects.

[Engineering Economics II](#) This course covers depreciation accounting (including tax implications), investment decisions under uncertainty, and a case study in which students conduct an economic analysis of the balancing operation at the Focus: HOPE (FH) Center for Advanced Technologies (CAT), a tier one supplier to the automotive industry.

[Forming Technologies I](#) This introductory course on metal forming aims to teach the main concepts on equipment necessary, tooling, and lubrication for sheet and bulk metal forming processes. Four case studies accompany these course materials.

[Forming Technologies II](#) This secondary course in metal forming aims to teach advanced concepts of metal forming, including design and analysis of both sheet and bulk forming processes. Further, friction, lubrication and heat transfer are explored in this course.

Integrated Product Realization This course teaches students to use a systematic product development process to analyze, design, and develop real world products from concept to production launch. A case study in which students apply the process to a product produced at the FH CAT is the capstone for this course.

Manufacturing Case Studies These cases introduce learners to real situations faced by a tier-one supplier to the automotive industry. They support courses in Manufacturing Processes, Engineering Economics, and Tool and Fixture Design but can also be used for independent study outside of a course framework. The cases address both superficial as well as dimensional machining irregularities.

Manufacturing Organization & Its Environment This course provides an overview of the organizational context in which an engineer works. Application of engineering and manufacturing technologies is emphasized. Particular attention is given to how technologies affect organization design as well as the work requirements and activities of the people who work there.

Manufacturing Systems I Concentrating on the primary principles of manufacturing systems, this course covers how people function with procedures, data communication and network designs. It also addresses administrative principles, advanced analysis tools, and new operational models. These concepts and tools are integrated to enable students to employ the procedures in real world situations.

We are scheduled to release the following new courses over the next year:

Assembly Processes I This course provides students with theory and tools necessary to apply design for assembly methods. Fundamental concepts such as design for assembly, error proofing, and assessment of tasks for assembly operations are covered. (Estimated to be available by 02/28/03)

Electroscience This course combines the discussion of physics and electric circuits. It covers the concepts of AC and DC circuits and analysis techniques, including magnetic forces and fields, inductance, capacitance, superposition and power transfer. Transient circuits and sinusoidal steady state analysis are also examined. (Estimated to be available by 04/30/03)

Entrepreneurship This course covers the knowledge set and skills for learners to become effective entrepreneurs. Furthermore, principles of creativity, innovation and personal leadership styles will be applied. Issues of business planning, resource identification and organization building will be addressed. (Estimated to be available by 04/30/03)

Facilities Design This course provides an introduction to plant location theory and analysis of models of facilities design, determining plant size and time phasing. Design of manufacturing, warehouse and material handling facilities will also be discussed. (Estimated to be available by 08/31/03)

Instrumentation and Sensors This course explains various types of sensor modes and industry standard control loops. Simple control circuits with standard symbols will be utilized to illustrate the basic principles of industrial control circuits. (Estimated to be available by 09/30/03)

Joining This course examines joining processes, their physics, engineering and economics in the overall training of a manufacturing engineer. Various joining procedures and appropriate applications for their use will be covered. (Estimated to be available by 09/30/03)

Kinematics of Mechanisms and Machines This course will prepare students to choose and design the proper mechanism for a large number of machine design applications. Relative motions in the different mechanisms will be discussed. Further, this course will include an introduction to static and dynamic forces that exist in mechanical systems. (Estimated to be available by 09/30/03)

Machining Processes I This introductory course deals with basic machining operations including turning, milling, drilling, and broaching. Students design the best process or sequence of processes for producing a part as well as select the most appropriate methods for determining machining conditions. (Estimated to be available by 01/31/03)

Machining Processes II This secondary course in machining focuses on the analysis of machining processes. Also in this course, students learn about machining with abrasive wheels, with single-point tools and on CNC machining centers. (Estimated to be available by 01/31/03)

Manufacturing Processes I This course introduces a number of processes used to manufacture products. It integrates an understanding of process technology, materials selection, and design intent. (Estimated to be available by 08/31/03)

Manufacturing Systems II Beyond the core principles of manufacturing systems, this course concentrates on the implementation of advanced theories and use of authentic tools. Learners design manufacturing systems, solve production problems through the application of advanced analysis tools, and analyze the impact of new operational models on system management. (Estimated to be available by 02/28/03)

Measurement Fundamentals This course will discuss the need for standards, the distinction between accuracy, resolution and repeatability. Certain types of temperature, fluid flow and strain measuring instruments will be covered. (Estimated to be available by 09/30/03)

Operations Management This course primarily focuses on the production and operations management function involving the planning, coordination, and execution of all activities directly related to producing goods or providing services. The course consists of the design of production/service system, production planning and control, as well as managing supply chains. (Estimated to be available by 02/28/03)

Psychology/Sociology This course seeks to provide an integrated framework for the understanding of the scientific approach to fundamental questions about ourselves, what makes us tick, why we think, feel, react and behave in certain ways. Additionally, this course hopes to demonstrate how this knowledge can enhance individual and team effectiveness in manufacturing engineering education. (Estimated to be available by 09/30/03)

Statistics and Probability Case Studies In these case studies, students analyze real manufacturing data and make engineering decisions in order to gain a richer understanding of statistical processes. Among the topics covered in the cases are statistical randomness, random variables, reliability, probability and regression analysis. (Available now; Revised edition by 02/28/03)

Thermoscience Instrumentation Grinder These experiments support courses in which the concepts of thermodynamics, fluid mechanics, heat transfer, and thermal aspects are taught. They can also be used for independent study outside of a course framework. (Available 11/30/02)

Tool Design and Construction I This course addresses tooling in terms of enabling manufacturing processes that meet required production rates, quality standards, cost requirements, and safety standards. Jigs and fixtures, cutting tools and tool holders, and special machine tools are discussed.

Tool Design and Construction II This course addresses a systematic process of tool selection and design for both cutting tools and die design. Intermediate concepts and principles of selecting and designing cutting tools for manufacturing and the process of designing and understanding dies are introduced.

Accessing Greenfield Learning Objects

Because Greenfield had developed its learning materials in an object framework, we can share these objects at several levels. If you access a Greenfield course, you will be able to navigate to all levels in that course. You will have access to all course modules, sessions and activities. The following screen shot is from a learning activity embedded in the Greenfield Course *Forming Technologies I*. The navigation bar at the top has the general structure of Course>>Module>>Session. If the learner has completed this activity, this navigation bar permits return to the *Session*, *Module*, or *Course* level.

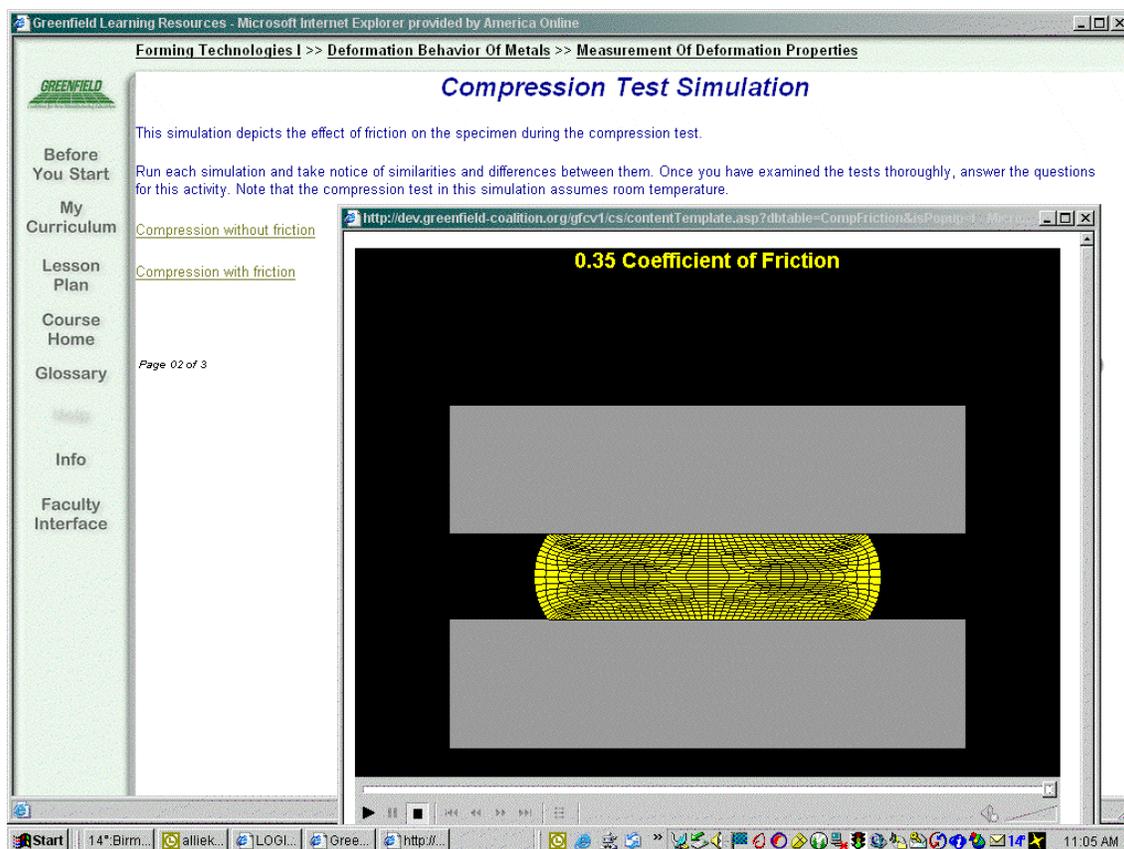


Figure 5: Learning Activity Forming Technologies I

Greenfield can share an entire course; it can also share single learning activities, groups of activities (session) or a thread of conceptually related material (module). Therefore, an individual who is interested in using a Greenfield activity need not have students navigate the course to find the activity. Rather, that activity can be accessed directly from the Greenfield server by pasting a reference to it on their own web page or within a learning management system (e.g. Blackboard) supporting their class delivery. If a Greenfield session is accessed, the

session object and its child objects (activities) are available. If an activity object is shared, navigation is permitted only within the resources embedded in that activity. If a single activity is accessed, only the content frame in Figure 5 will be displayed.

The Greenfield approach to learning objects separates content, display, and navigation. The binding of activities into sessions, sessions into modules, and modules into courses is dynamic. Each of the learning objects exists on the Greenfield server and can be multiply configured into any new configuration of learning objects. This provides great flexibility and supports reusability.

Details of accessing the Greenfield courses and learning objects can be found at our website:

<http://www.greenfield-coalition.org>

Acknowledgement

The Greenfield Coalition is partially supported by a Grant EEC-9630951 under the Engineering Education Coalitions Program at the National Science Foundation. Focus:HOPE, our industry and academic partners have contributed valuable resources to support the development of Greenfield.

References

- 1 Falkenburg, Donald R., "Engineering Education Coalitions: The Greenfield Retrospective," *Proceedings 2002 International Conference on Engineering Education, INEER* (Manchester, UK, August, 2002).
- 2 Troha, F. J. May 2002. "Bulletproof Instructional Design: A Model for Blended Learning." *USDLA Journal*. Vol. 16: No. 5. Available online: http://www.usdla.org/html/journal/MAY02_Issue/article03.html.
- 3 Gagne, R.M., *Principles of Instructional Design*, Holt, Rinehard and Winston, Inc., New York (1962).
- 4 Felder, R. Active and Cooperative Learning. Available online http://www2.ncsu.edu/unity/lockers/users/f/felder/public/Cooperative_Learning.html.
- 5 IMS Learning Resource Meta-data Specification, IMS Global Learning consortium, <http://www.imsglobal.org/metadata/index.cfm>

Biographical Information

DONALD R. FALKENBURG is Director of the Greenfield Coalition and Professor of Industrial and Manufacturing Engineering at Wayne State University, Detroit, Michigan. He received his Bachelor of Mechanical Engineering and Master of Science degrees from Clarkson University, Potsdam, New York and his Ph.D. from Case Western Reserve University. falken@focushope.edu

ALLIE KNOWLTON is Programming Manager at the Greenfield Coalition. She received her Bachelor of Computer Science and Master of Arts degrees from University of Detroit Mercy, Detroit. knowlta@focushope.edu

MARY JO CARTWRIGHT is a vice president at CNC Connection Corporation. She received her BSEE from the University of Michigan and her MBA from Eastern Michigan University. mjc@cnc-connect.com