AC 2009-2107: INTROENGINEERING.ORG: A STRUCTURED WIKI COMMUNITY FOR INSTRUCTORS OF FIRST-YEAR ENGINEERING COURSES

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Abstract

Assembling content for a broad-based, first-year engineering course poses unique challenges. In order to be successful, first-year instructors must typically tailor material to accommodate the background and interests of their students, as well as to prepare students for the specific majors available in their institution. While a traditional textbook can provide both a framework and validated content for a first-year engineering course, it is also highly unlikely that any single, conventionally published book could fully meet the needs of instructors across a broad range of schools. To address this problem, this paper describes an open, online wiki-based community where instructors of first-year engineering courses can share materials. The system was developed through collaboration between a textbook author, a traditional publishing house, and a wiki specialist. The paper describes the organization and usage of the system, as well as addresses the publisher's perspective on this new technology in light of their changing business model.

Introduction

Fundamentally, a first-year engineering program must accomplish two things. First, it must attract students who may not be familiar with engineering to consider it as an academic and career path. Second, it must prepare students for success in the second year and beyond. Meeting these goals, however, raises some critical challenges. For example, the way that students and instructors use educational materials is changing rapidly, while at the same time, the path to success and the metrics for measuring that success are evolving. This means instructors are forced to reevaluate how they design and implement the first year course, which is no small task given the scattered resources currently available from which to draw.

While the Accreditation Board for Engineering and Technology (ABET) does specify standards for program outcomes, there is no standard "canon" of topics for an introductory engineering course—certainly not at the level of agreement as one might find in calculus, chemistry, or physics. This is especially true for introductory engineering courses that must address students destined for multiple specialties within engineering. Second, in order for an introductory engineering course to be stimulating to students, it must draw on real-world examples that are relevant to their daily lives. In addressing an ABET outcome such as, "an ability to design and conduct experiments, as well as to analyze and interpret data," students in the Los Angeles area may find examples from, say, design for earthquake mitigation to be more interesting, while students in southern Michigan may respond more strongly to examples from the auto industry. Thus, even if courses deployed across multiple campuses share common high level goals, it is desirable for instructors to customize materials to address local, community-based issues and needs. Further, the instructors themselves can better connect with their students if they have the opportunity to draw from examples relevant to the own experience.

Because of the need for local customization, instructors often have to develop considerable materials unique to their particular course, even if they use a supporting textbook. We have developed a comprehensive online community, IntroEngineering.org, for instructors of introductory engineering courses to share course materials. The site is implemented as a *structured wiki*, which gives users an unprecedented ability to search through existing resources or to contribute new resources, indexed according to a variety of criteria, including learning objectives, tags, and resource type. In this way, instructors can easily find resources that match the particular requirements of their course, as well as make it easy to contribute materials that can be readily located by other instructors. Instructional resources include homework problems and solutions, lecture slides, videos, project descriptions, and discussion and help topics. The site has been initially seeded with materials to accompany a commercially-published textbook[1], but both the publisher and the author have agreed to make the site available to any confirmed instructor of an introductory engineering course, independent of whether or not they adopt the textbook for use at their school.

The remainder of this paper is organized as follows. First, we give a brief introduction to the underlying wiki technology. We then describe the IntroEngineering.org wiki itself, in terms of its structure and the features that it provides users. Next, we give the publisher's perspective and their motivations for building an open online community. Finally, we conclude with open questions and some possible future directions.

Wiki Technology

Over the past few years, the term "wiki" has gone from being known only by a small community of programmers to being widely known by the general public, largely as a result of the phenomenal success of Wikipedia, which bills itself as "the free encyclopedia that anyone can edit." While Wikipedia has provided a compelling example of the power of harnessing mass collaboration, it is not entirely representative of the wikis in general. For this reason, we should clarify for the purposes of this paper exactly what we mean by this term, as well as a related sub-class of wiki software known as "structured wikis".

In simplest terms, a wiki is a type of server software that allows users to freely create and edit Web pages using any Web browser. The word wiki comes from the Hawaiian word for "quick" and is commonly used to refer both to this class of server software as well as websites that run such software. While Wikipedia is the largest single wiki site, the majority of wikis are created to support small, specialized communities-of-interest or work-teams and many, if not most, are not publicly viewable at all. The majority of wikis are to found on private intranets since wikis have become very popular for internal communication and collaboration in large corporations, government agencies, and in academia. There are also many types of wiki software designed for different purposes. While there are other kinds of server software that allow users to add or edit content (notably "content management systems" or CMS's), wikis are distinct for emphasizing a more flexible approach to collaboration.

The completely "structureless" approach of early wikis became seen by some as limiting their potential and this led to a new generation of wiki software that has become known as "structured wikis." These packages combine the flexible, free-form editing of the first generation of wikis—

which is often referred to as the "whiteboard" feature—with the ability to define formal database structures. The database features enabled designers to create more powerful and user-friendly searches and workflows, leading users through a series of action steps. This combination of the flexibility of wikis with the power of formal databases has greatly extended the potential of wikis as general-purpose knowledge-management platforms. Whereas the first generation of wikis enabled users to collaborate in creation of *content*, the second generation of structured wikis has enabled users to collaborate in creation of powerful *knowledge applications*.

The IntroEngineering.org wiki has been implemented on the TWiki[2] structured wiki platform, used for intranet applications by organizations including the University of Minnesota,Yahoo!, SAP, Motorola, and Disney. (It is currently being migrated to the Foswiki[3] fork of the TWiki project). A particularly powerful feature of TWiki and Foswiki is its ability to manage read and write access to the site as a whole, to *webs* within the site, or to individual pages by assigning users to *groups* with specified permissions.

The IntroEngineering.org Wiki

Because IntroEngineering.org has been implemented on a structured wiki platform, it gives users an unprecedented ability to search existing resources or to contribute new resources. In this section, we describe the different kinds of resources supported by the wiki, and illustrate how users access them during a session. Figure 1 illustrates the types of objects defined for the IntroEngineering.org wiki and the relationships between them. Central to the organization of both the textbook and the wiki is the concept of a *Learning Objective*. In the context of the *Book*, a learning objective is a specific competency that a student should demonstrate upon completion of a *Chapter*. For example, in Chapter 1 of the book, "Engineering and Society," one of the learning objectives is that students should be able "to articulate a view of our environment as containing both naturally occurring and human-made or artificial things and to discuss the role of engineers in developing and producing these artificial things to meet human needs and desires," while a learning objective for Chapter 5, "Data Analysis and Empirical Models," is that students should be able "to use basic mathematical and graphical techniques to determine how well experimental data fits a theory." Each instance of an educational resource posted on the wiki is linked to one or more learning objectives. Types of resources include threaded *Discussions*, *Lecture* slides and notes, homework *Problems* and *Solutions*, *Project* descriptions, and *MATLAB* computer models.

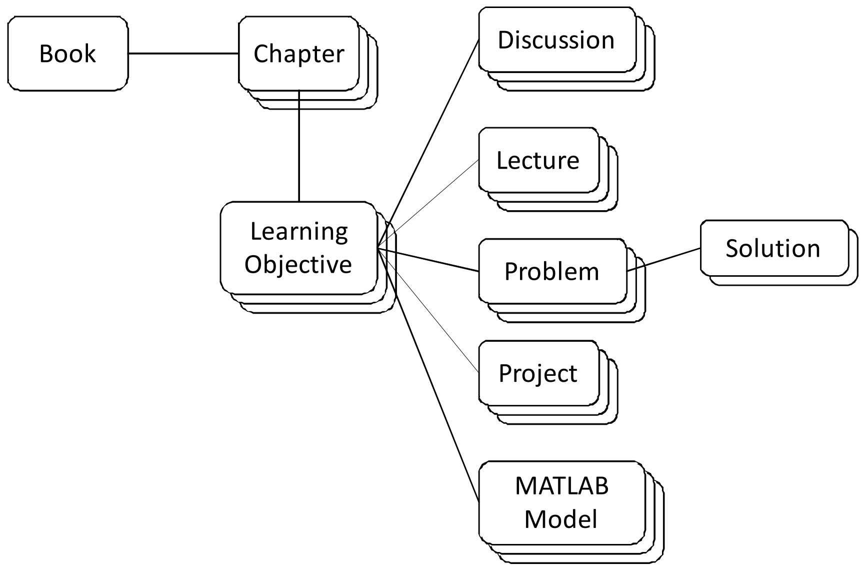


Figure 1: Objects and relationships in the IntroEngineering wiki

Given the organization of material as presented in Figure 1, instructors can search the wiki to find materials that support their desired learning objectives. Figure 2 illustrates the Instructor web homepage, which provides links to each of the main categories of resources. Access to this web is limited to instructors who have been validated by the site administrators.

Figure 3 illustrates the main *Learning Objectives* page, which retrieves and displays learning objectives in the system, searchable by chapter. Clicking on a learning objective, in turn, displays a page for searching for resources targeted towards that objective. Figure 4 shows the *Problem* resources associated with the *Learning Objective* “Engineering Disciplines” from Chapter 1.

Figure 5 illustrates a sample *Problem* page, which contains the problem itself, as well as all *Solutions* that have been submitted for that problem. In this example we see both a scanned, handwritten analytic solution, as well as a solution that uses MATLAB. In general, our wiki platform supports pages written either in a simple markup language or in HTML. Further, a WYSIWYG editor and translators from common formats, including Microsoft Office, simplify the process for users to contribute materials.

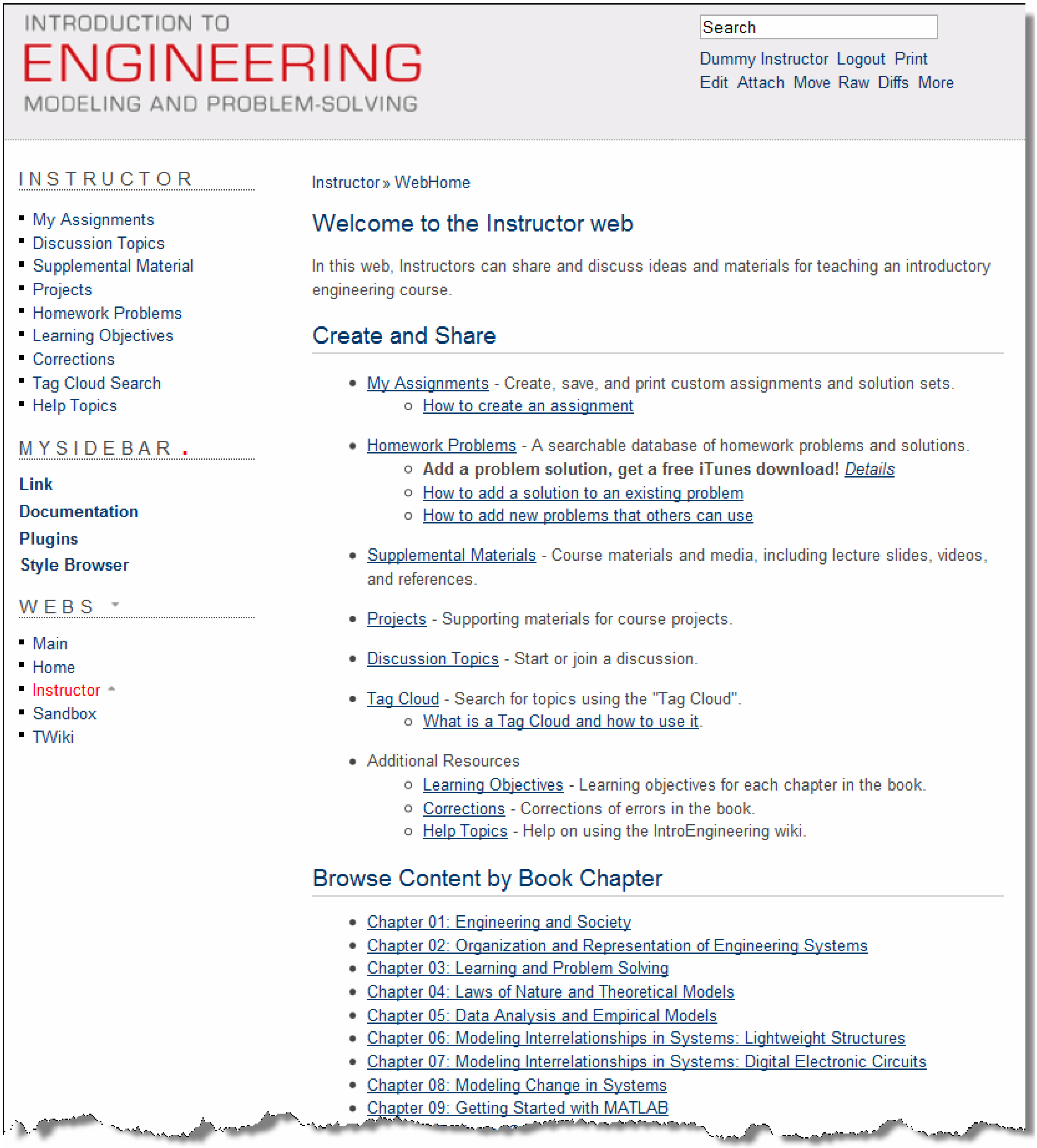
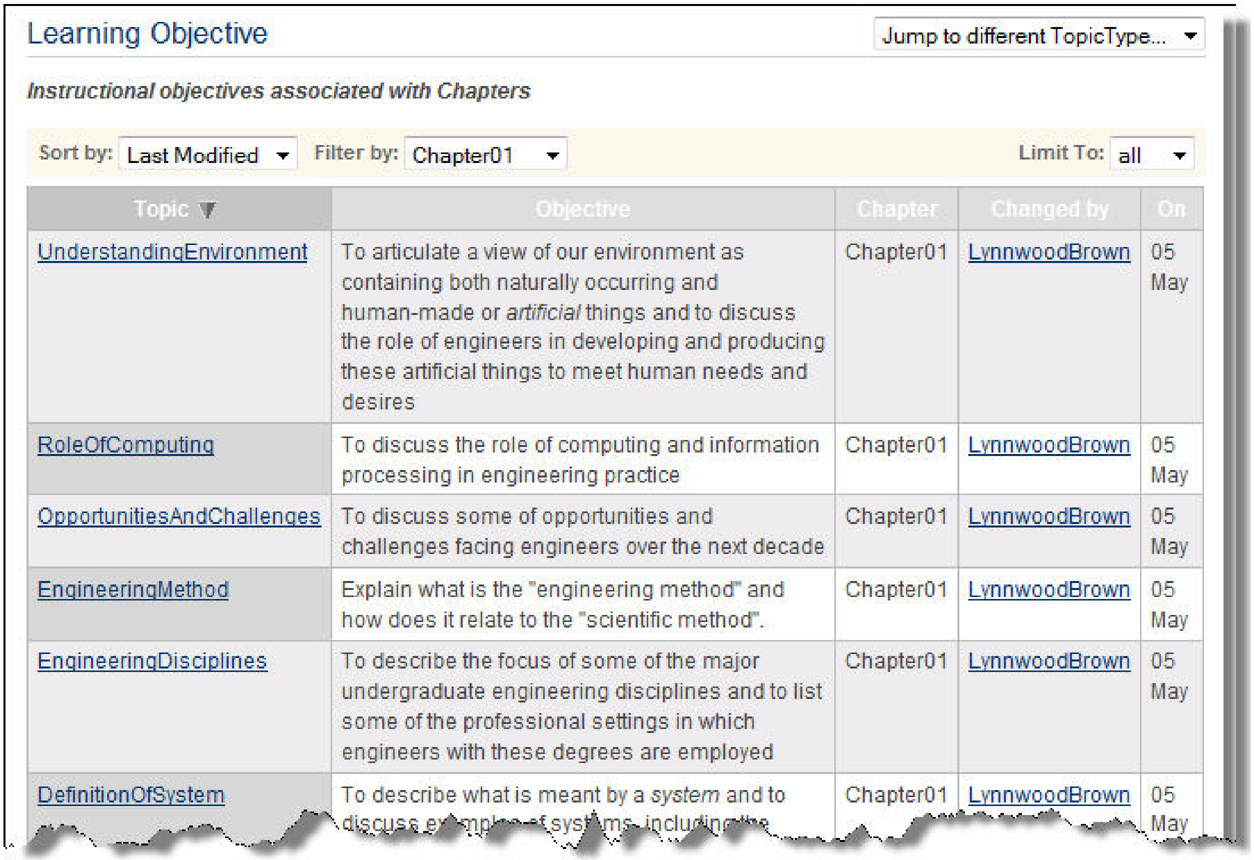


Figure 2: Instructor web homepage.



Learning Objective

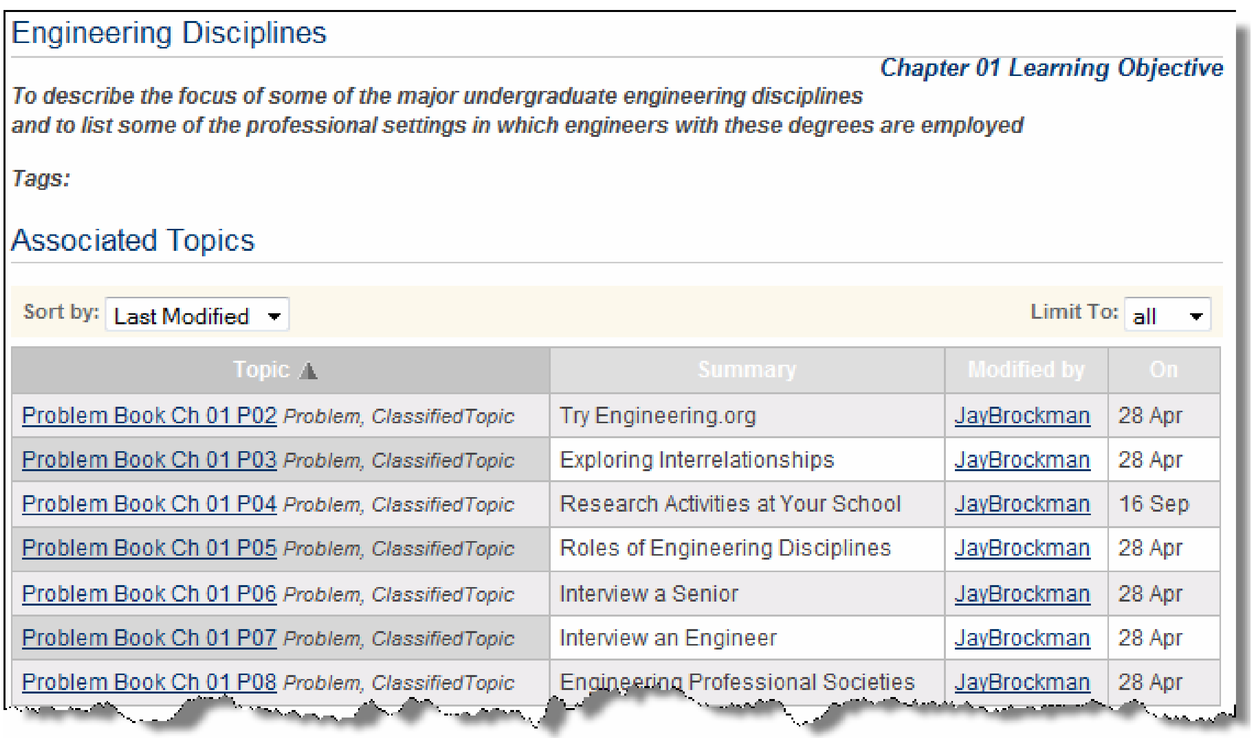
Jump to different TopicType...

Instructional objectives associated with Chapters

Sort by: Last Modified   Filter by: Chapter01   Limit To: all

Topic	Objective	Chapter	Changed by	On
UnderstandingEnvironment	To articulate a view of our environment as containing both naturally occurring and human-made or *artificial* things and to discuss the role of engineers in developing and producing these artificial things to meet human needs and desires	Chapter01	LynnwoodBrown	05 May
RoleOfComputing	To discuss the role of computing and information processing in engineering practice	Chapter01	LynnwoodBrown	05 May
OpportunitiesAndChallenges	To discuss some of opportunities and challenges facing engineers over the next decade	Chapter01	LynnwoodBrown	05 May
EngineeringMethod	Explain what is the "engineering method" and how does it relate to the "scientific method".	Chapter01	LynnwoodBrown	05 May
EngineeringDisciplines	To describe the focus of some of the major undergraduate engineering disciplines and to list some of the professional settings in which engineers with these degrees are employed	Chapter01	LynnwoodBrown	05 May
DefinitionOfSystem	To describe what is meant by a *system* and to discuss examples of systems, including the	Chapter01	LynnwoodBrown	05 May

Figure 3: Learning objectives page.



Engineering Disciplines

Chapter 01 Learning Objective

To describe the focus of some of the major undergraduate engineering disciplines and to list some of the professional settings in which engineers with these degrees are employed

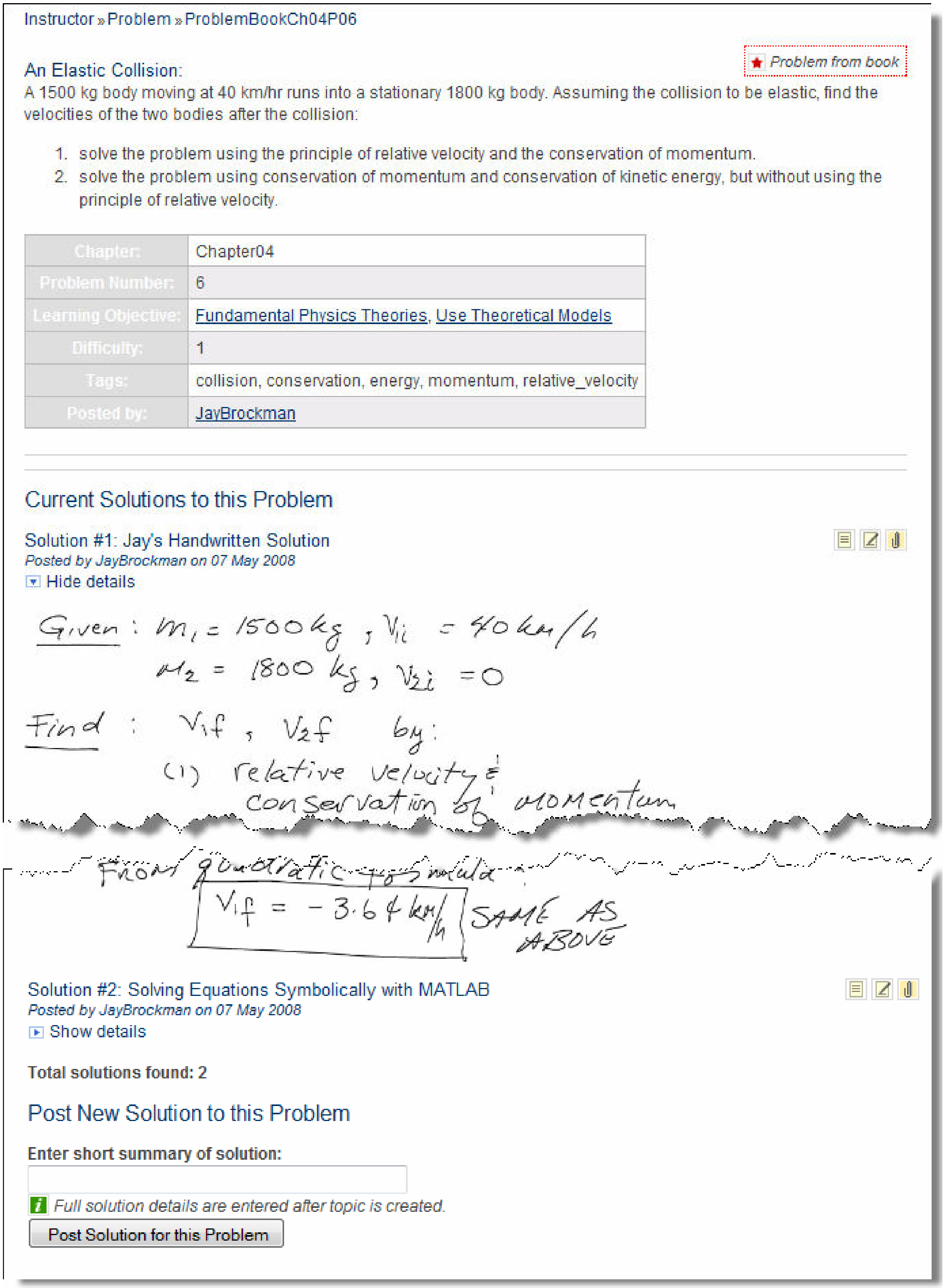
Tags:

Associated Topics

Sort by: Last Modified   Limit To: all

Topic	Summary	Modified by	On
Problem Book Ch 01 P02 *Problem, ClassifiedTopic*	Try Engineering.org	JayBrockman	28 Apr
Problem Book Ch 01 P03 *Problem, ClassifiedTopic*	Exploring Interrelationships	JayBrockman	28 Apr
Problem Book Ch 01 P04 *Problem, ClassifiedTopic*	Research Activities at Your School	JayBrockman	16 Sep
Problem Book Ch 01 P05 *Problem, ClassifiedTopic*	Roles of Engineering Disciplines	JayBrockman	28 Apr
Problem Book Ch 01 P06 *Problem, ClassifiedTopic*	Interview a Senior	JayBrockman	28 Apr
Problem Book Ch 01 P07 *Problem, ClassifiedTopic*	Interview an Engineer	JayBrockman	28 Apr
Problem Book Ch 01 P08 *Problem, ClassifiedTopic*	Engineering Professional Societies	JayBrockman	28 Apr

Figure 4: Problem resources associated with the Chapter 1 learning objective "Engineering Disciplines".



Instructor » Problem » ProblemBookCh04P06

Problem from book

An Elastic Collision:

A 1500 kg body moving at 40 km/hr runs into a stationary 1800 kg body. Assuming the collision to be elastic, find the velocities of the two bodies after the collision:

1. solve the problem using the principle of relative velocity and the conservation of momentum.
2. solve the problem using conservation of momentum and conservation of kinetic energy, but without using the principle of relative velocity.

Chapter:	Chapter04
Problem Number:	6
Learning Objective:	Fundamental Physics Theories, Use Theoretical Models
Difficulty:	1
Tags:	collision, conservation, energy, momentum, relative_velocity
Posted by:	JayBrockman

Current Solutions to this Problem

Solution #1: Jay's Handwritten Solution

Posted by JayBrockman on 07 May 2008

Hide details

Solution #2: Solving Equations Symbolically with MATLAB

Posted by JayBrockman on 07 May 2008

Show details

Total solutions found: 2

Post New Solution to this Problem

Enter short summary of solution:

Full solution details are entered after topic is created.

Post Solution for this Problem

Figure 5: Sample problem page, showing multiple solutions.

Unlike a static web page, where the author is responsible for creating and updating links as new pages are added to the system, the IntroEngineering wiki creates pages dynamically, with the underlying TWiki/Foswiki infrastructure retrieving references to pages that match the specified criteria. This is a critical feature of the IntroEngineering wiki: it means that contributors from a large community can freely add information that can easily be retrieved by others, without the need of a librarian to continually categorize and classify documents. In order to make a document retrievable in this manner, users must annotate their contributions with information about the document called *metadata*. To add metadata to a page, users click on a tab in the editor that brings up a form, shown in Figure 6. This lets the users link their new contribution to one or more *Chapters* and associated *Learning Objectives*, as well as to select *tags*. A tag is simple a piece of text that helps further identify a document, independent of the hierarchical classification system of *Chapters* and *Learning Objectives*. The IntroEngineering wiki uses a *tag cloud* as a means for displaying available tags to the user. A tag cloud is simply an alphabetical listing of tags, where the font size of an entry in the list reflects how often that tag is used, so that the most commonly used tags stand out. If a user wishes to apply a tag that is not already in the cloud, he or she may simply type it into the tags text box, and the tag will automatically be added to the cloud.

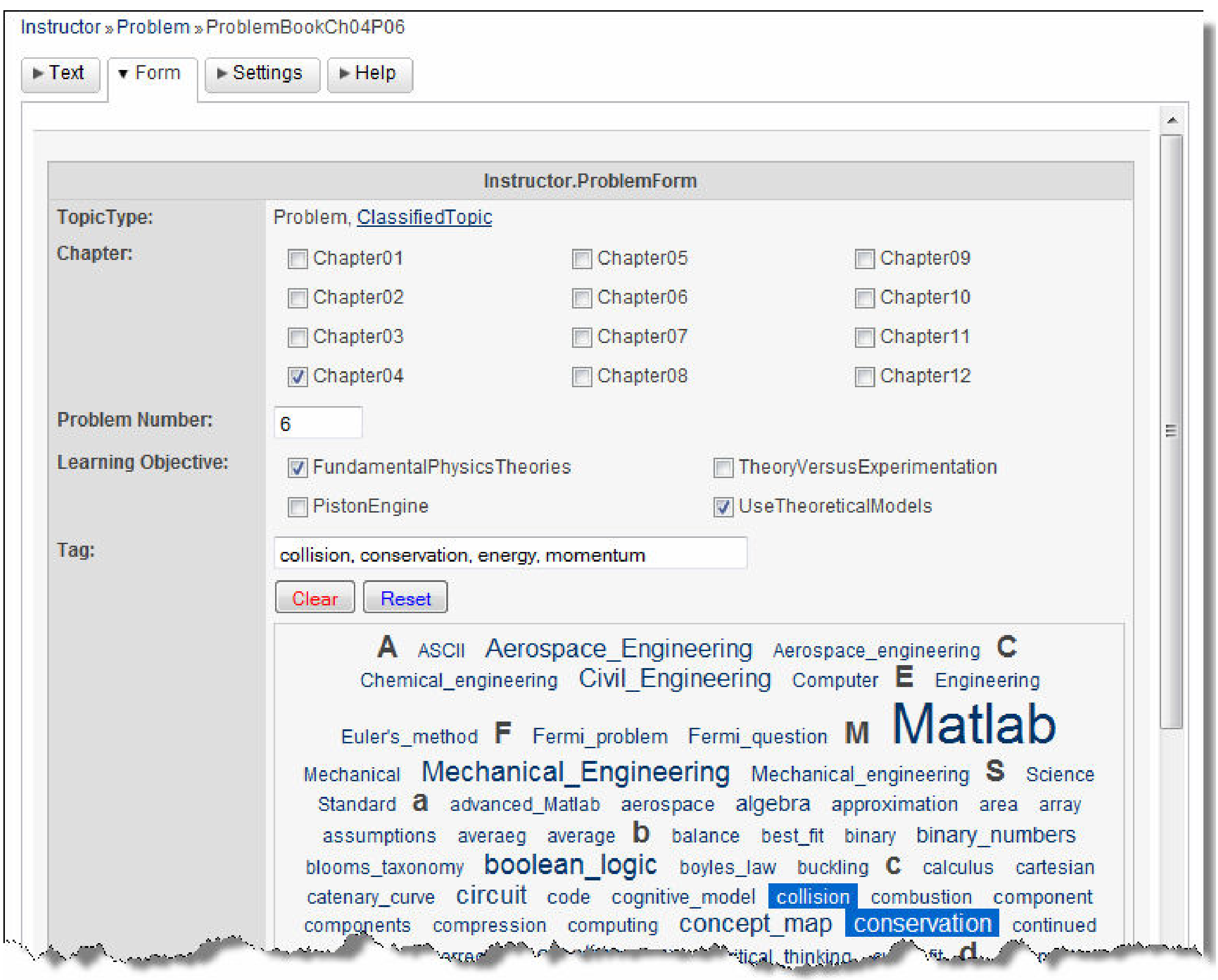


Figure 6: Form for assigning metadata to a resource.

One of the more powerful features of the IntroEngineering wiki is a facility for building homework assignments. Figure 7 shows a query form where the instructor searches for *Problems* applicable to “Chapter 4,” with the *Learning Objective* “Fundamental Physics Theories,” and the tags “energy” and “conservation.” Figure 8 shows problems located by the search, which may be added to an assignment and saved. Assignments are aggregated under a “My Assignments” page, and users may view assignments created by other users at other institutions.

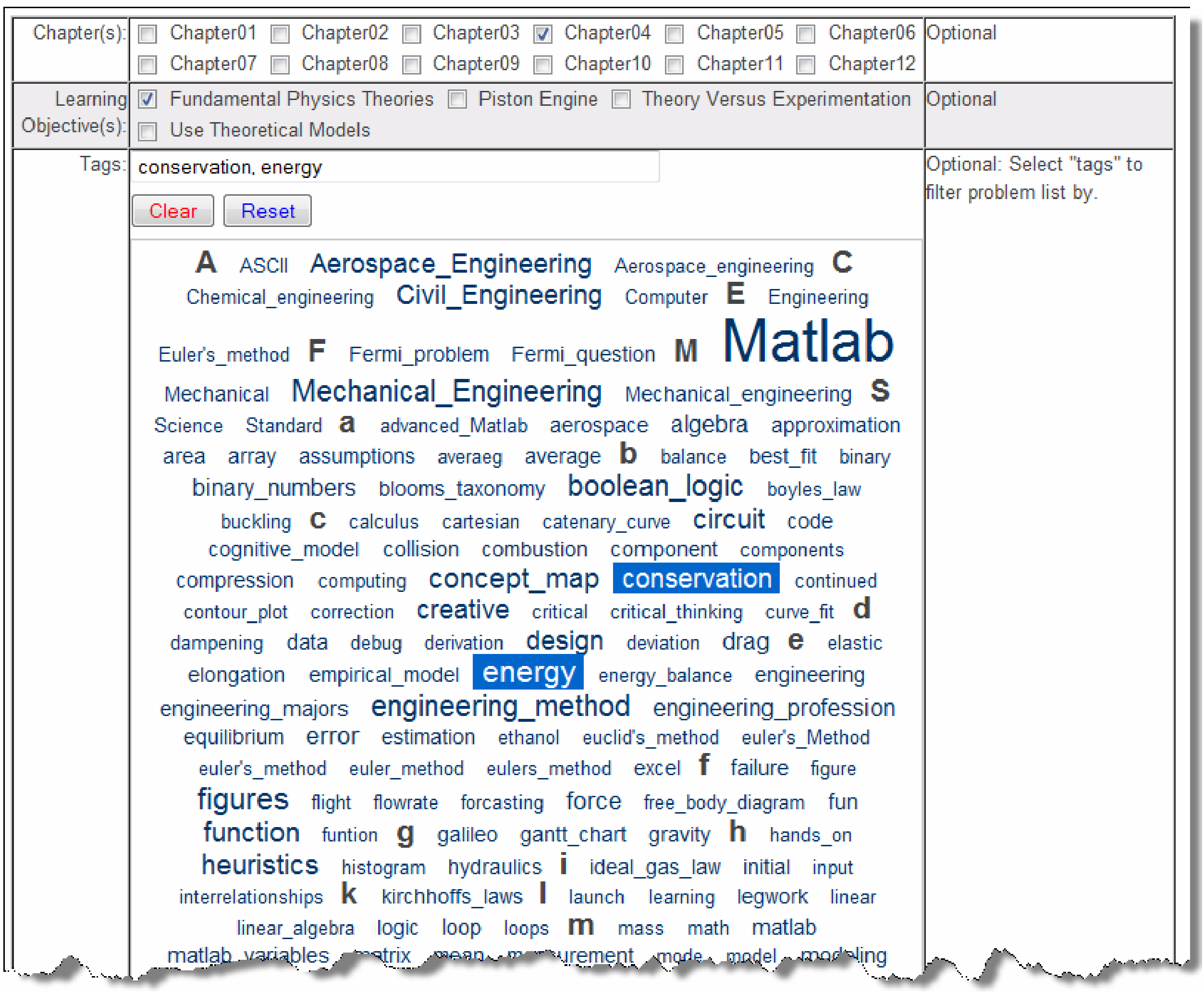


Figure 7: Assignment builder query form.

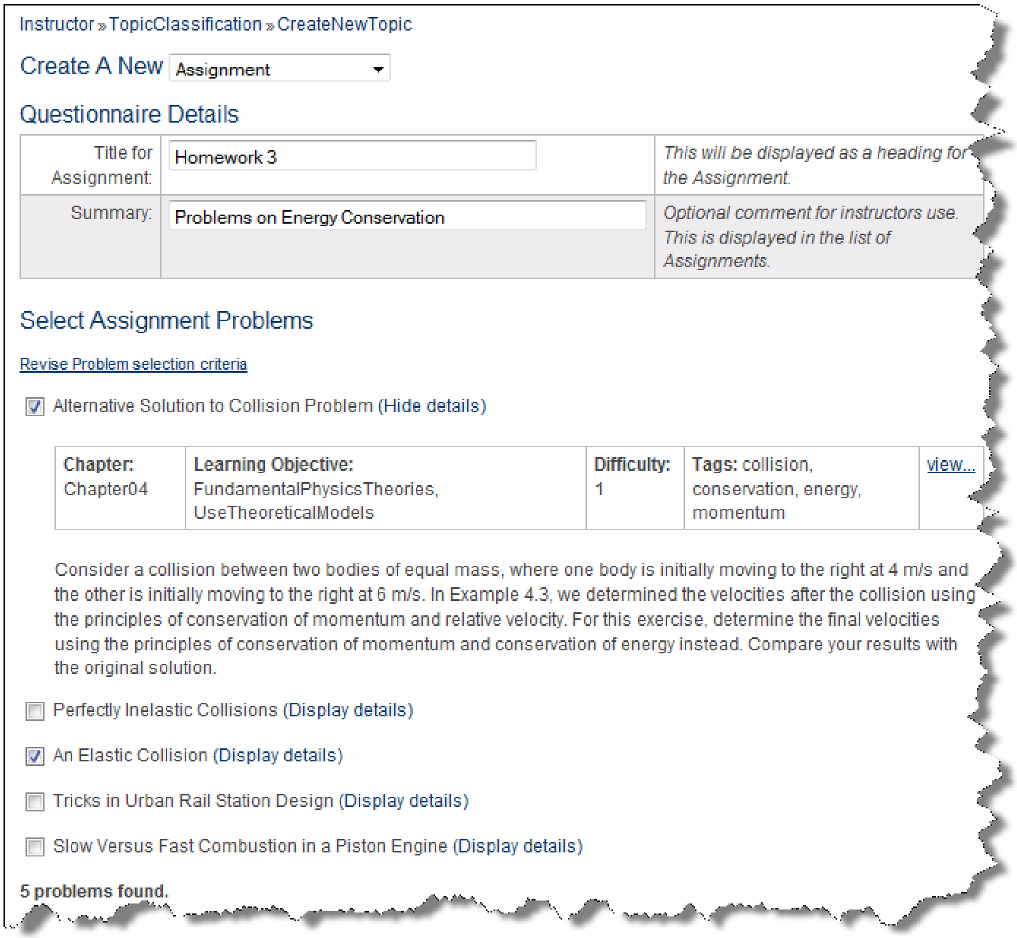


Figure 8: Results of a query from the assignment builder

The Publisher's Perspective

Traditional textbook-centric model

Publishers recognize that the way students and instructors use educational content is changing. The traditional model involves an instructor selecting the best textbook that he or she deems available for the course. Readings for the course and homework assignments are drawn from the textbook and learning objectives for the course are supported by the content found in the book. Also in this model, the publisher provides a package of instructor resources to assist with lecture preparation and homework grading. Students purchase the book at the beginning of the term and reference it throughout the quarter or semester. This has been the model for many years.

In recent years, publishers have begun offering instructors with options to customize a particular book or combine chapters of multiple books to create a resource that better matches their particular course. The ability to customize a required textbook is especially valuable for someone teaching an introduction to engineering course. As mentioned earlier, there is no standard canon for this course that defines how it is taught at various schools. Each course can include a broad array of topics, learning objectives and assessment models. Furthermore, the audience for this course can vary widely from undeclared majors, engineering majors and engineering majors in specific fields, such as mechanical engineering, electrical engineering, and so on.

Despite the added flexibility of a customizable book, the resource is still based on a traditional form of publishing. This model has many positives for instructors and students, but it also has many limiting factors as well. For example, the creation of these products is extremely time and cost intensive. A first edition textbook can take between 2-10 years to publish and reach a classroom. After this, the textbook may be updated with revisions every 2 to 5 years, depending on the market. Printing, shipping and warehousing costs are other factors that inhibit flexibility.

Why is the wiki format compelling to a traditional publisher?

Increasingly instructors are seeking a more flexible resource for their introduction to engineering courses, one that provides more value to their course than a traditional textbook and better prepares them to deliver a successful course. For example, the incorporation of hands-on projects is a key feature of many introductory engineering courses. These projects, however, are very difficult to develop, implement, and assess. Projects, and other types of interactive learning, don't necessarily lend themselves to traditional textbook presentations. Publishers can help facilitate the creation and development of projects and learning modules for courses.

The value of sharing locally developed course and curricular materials has been widely recognized, and there are today a number of important web-based initiatives designed to facilitate this. Engineering Pathway[4] provides links to thousands of educational resources for engineering and related fields for K-12 as well as higher education. Curriki[5] is an online community for share free and open source materials among K-12 educators. MERLOT provides access to a large collection of peer-reviewed online teaching and learning materials across a broad range of subjects for higher education[6]. Publishers excel at providing top quality, professionally vetted content to the market, and are expert aggregators. In a time where information access and creation is changing radically from traditional models, we embrace innovative platforms like the IntroEngineering.org structured wiki.

In addition to the changing needs of instructors, and perhaps driving some of those changes, are the new types of students taking engineering courses. Students have different expectations of educational content than they did 20 or even 5 years ago. Mastering learning objectives will always be a goal, but publishers recognize the need to provide different avenues for students to reach mastery, whether it's through the use of more multimedia resources, realistic examples, or new assessment techniques. Instructors share a desire to teach the course in the most effective way possible while addressing the new learning styles of students, which often means taking advantage of new technologies.

Collaboration has always been central to the creation of successful books. Authors collaborate with their colleagues in the manuscript creation stage. Editors collaborate with authors throughout the process, and the collaborative feedback received through various iterations of peer review shapes and defines the finished product. The wiki environment allows for more expansive collaboration. The collaborative process is more fluid and just-in-time, and thoughts don't end when a book comes off the press. In a wiki environment, connections can be more easily made to related content and resources to complement what might have once been the core book content.

From our perspective, a structured wiki could allow us to provide more access to our entire catalogue of content. This helps us fulfill one of the core promises that we make to our authors which is to enable them to impact and influence education in the biggest way possible. The business model is clearly different than the traditional textbook centric model and the precise articulation of sustainable business models for this new environment are the topics of much thought and debate at the leading educational publishers.

What's next?

We believe that IntroEngineering.org represents a compelling opportunity to experiment with new models of providing educational content to instructors and students. We foresee a time when the site becomes the gateway to the course for instructor preparation and student learning. It is also conceivable that the IntroEngineering.org model could be readily adapted to meet the needs of other courses and disciplines.

The opportunity to provide varied forms of content at different points during a course will help publishers bring more value to the educational experience. Distribution of our content through the wiki will help us track how our content is used and allow us to update and improve material as needed. This new model will also change how resources are acquired and reviewed. The traditional framework of book editions and chapters may go away, but a premium will still be placed on high quality, vetted content that best enables instructors to teach a successful course and students to master the topics.

Bibliography

1. Jay B. Brockman. *Introduction to Engineering: Modeling and Problem Solving*. John Wiley & Sons, Inc. 2009.
2. TWiki® - The Open Source Enterprise Wiki and Web 2.0 Application Platform. http://www.twiki.org
3. Foswiki - The Free and Open Source Enterprise Wiki. http://foswiki.org
4. Engineering Pathway. http://www.engineeringpathway.com
5. Curriki Project Home Page. http://www.curriki.org
6. MERLOT – Multimedia Online Resource for Learning and Online Teaching. http://www.merlot.org