# Collaborative Authoring for On-Line Construction Curricula

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## ABSTRACT

This work is part of a regional initiative to build training and employment services into a career pathways system for the green building industry sector, with a particular focus on construction and retrofitting towards more energy-efficient buildings, and installation of alternative energy systems. It addressed the challenges of collecting and disseminating relevant information for innovative technologies and sustainability in a format that supports systems integration. The research team developed a collaborative content authoring and dissemination portal as part of an U.S. Department of Labor Energy Training Partnership grant with participation from Virginia Tech, regional community colleges, certification training institutions, and other industry stakeholders. The paper discusses the process of collaborative content collection and authorship, the potential of open-source software for content management, the development and implementation of envisioned concepts into a single online portal, and the feedback processes through multiple channels from various program participants. While comparing the resulting software implementation with the initial project goals, this paper provides recommendations on how to sustain an online project and the currentness of its content. Further work will examine the adaptability of the educational collaboration portal to address specific pedagogical formats, language barriers, and interoperability with recognized software formats.

## BACKGROUND

With the flatter world economy and global environmental issues, the construction industry is experiencing rapid change on three major fronts: innovative technologies, sustainability, and integrated building systems. Once driven by highly localized material supply and design strategies, construction is now rapidly transformed by the globalization of innovative products, standards, and technologies, which are actively disseminated by an increasingly international ownership of construction companies (Lee et al. 2011). At the same time, the built environment is faced with a higher level of expectations to address the industry's share of global energy challenges and consumer demand for comfort, indoor air quality, and energy management. As a result, the field of building design, construction, and operation has

become increasingly complex (Crabtree et al. 2004). Keeping up with these changes is difficult for the industry, and even more challenging for the now suddenly required green workforce and their relevant training and education needs.

Some of the challenges of information dissemination are due to the compartmentalization of trades and their construction professionals within the education system, which is divided along the same lines as evident in the industry. Construction management, as taught in colleges and universities, has been successful at facilitating the attainment of specialized skills and concepts (Hauck and Jackson 2005), but faces challenges to integrate evolving new technologies and knowledge into curricula, both on a macro and micro level.

The often practiced segmented topic-based approach (specifically at the community college level) does not easily support the teaching of the building as a system nor the broad integration of sustainability, which has been identified as one of the needed areas of training for students entering the workforce (Lee et al. 2011; Murray and Cotgrave 2007). The foundation in theory and relative isolation of the student environment lacks the necessary manufacturing interface for keeping pace with technology, such as renewable energy systems. Using input from 50 industry stakeholders, a study identified the lack of practical and conceptual engineering technology skills among building operators as one of the single most important barriers to improving the quality and performance of buildings (Crabtree et al. 2004).

Technology training, such as courses for renewable energy installation taught through community college curricula, faces the challenge of trying to expand the trade-specific focus on job-related training with the broader perspective of whole building systems, green technology, and world-wide environmental issues. This can become a liability in the workplace where technicians are now assuming functions previously performed by scientists and engineers, thanks to flexible information technologies (Carnevale 1991). The necessary transformation of technician education is widely recognized throughout the industrialized world, as are the challenges posed by the need to raise the status of technicians overall and to attract more capable students into technician-level fields (Mahoney and Barnett 1998).

Some innovations may experience industry adoption well ahead of full acknowledgement in traditional academic curricula. The stakeholder groups who are primarily responsible for either veto or endorsement of innovative products, processes and systems are the independent building contractors and tradesmen (McCoy et al. 2010). While the educational application of technology may lag behind industry innovations, education should nonetheless provide an underlying grounding in sustainable issues as a means of assessing emerging and innovative technologies.

## MOTIVATION

Keeping pace with the many changes in innovative building technologies, sustainability, and systems integration is not only a challenge by the traditional structuring of education, but is increasingly a matter of sourcing current and relevant knowledge content. While traditional sources of information, such as textbooks, can effectively support the teaching of core skills, this form of information delivery is not intended to replace a dynamic interface for current information. Currently, educators seek out this information independently on the World Wide Web, which can be very

time consuming and/or result in partial information. Additionally, all collected information must then be converted to a lesson plan format. This research explores the possibility of an open accessible web portal, which could leverage the time and resources spent by educators and industry alike in contributing to a central database driven knowledgebase of learning content for specific topics.

## OBJECTIVES

The overall goal of this project, which was part of a U.S. Department of Labor funded grant, was to coordinate and streamline existing training and employment services for a more cohesive regional career pathway system for an energy efficiency focused construction workforce in general, and alternative energy system installers in particular. Grant participants included three regional community colleges that offer applicable construction career certifications and distinct areas of 'green jobs' specialization, a university institution, a non-profit training and certification provider, and regional workforce boards.

Although the existing curricula within the various community colleges addressed many necessary occupational skills, they lacked a broader perspective approach to allow for a coherent "pathway" system for the targeted building energy efficiency occupations. Relative to this need, the specific objectives of this portion of the research was to develop the supporting information and provide it through a portal for collaborative creation and sharing of learning content.

The objectives of this research were threefold:

1) To identify a software platform for a Learning Content Management System (LCMS) that would meet the following criteria: a) shared as open source code (i.e. no imminent and/or continuous license fees, while having full access to source code for future development and modifications); b) allows for communication channels such as collaborative authoring, peer review, community wide discussions, and individual user feedback; c) offers categorization of content for different knowledge levels; d) includes modularization and assemble methods of content for re-usability in individual courses; e) available on a global level to academia, industry, and the general public.

2) To implement the chosen software into a portal, and adapt the site for the specific application of collaborative authoring and modular course assembly.

3) To validate the implementation of this portal for the target participants to organize information in manner that is scalable, reduces redundancy, and can easily be combined into curricula.

## RESEARCH

### Instructional Design Process Model

The concept of on-line learning and the subsequent development of content portals is part of a larger field of instructional design, which is the converging state of the art of pedagogical opportunities in information technology and the shift of focus in education from instructors to learners. Specifically Content Management Systems (CMS), a software technology developed to address the need to jointly create and access large amounts of content among a group of participants, has been adopted by training or educational stakeholders early on. Some of the more popular examples of

CMS solutions are Drupal, WordPress, and Joomla. When used in an educational context a CMS is suited to support content-centric learning strategies and organizing content in a manner which is scalable for multiple purposes. It can be used as a standalone application in form of a generic, often searchable content repository. In contrast, a Learning Management System (LMS) is a learner-centric software solution suited for organizing online course and content delivery, virtual classrooms, and many other student focused applications. Some of the most common applications in this group include the open source solutions Moodle and Sakai, or Blackboard as a propriety solution. When combined and integrated into one software system, this hybrid Learning and Content Management System (LCMS) bridges the gap between learning content management and e-learning delivery methods (Ellis 2001). Rather than developing entire courses and adapting them to multiple audiences, An LCMS can provide authors, instructors, and even external experts an environment to develop and re-use learning content and thus reduce duplication of efforts. In such a system single educational components or modules can be modified and re-packaged for different audiences while maintaining various versions and tracking their history.

The learning and content management systems market is in a phase of early maturity in the US. In 2009, it was estimated that approximately 40% of U.S. training organizations utilize an LMS (Bersin, Howard, O'Leonard, & Mallon, 2009). The market is different in the UK, where there was a government commitment to make learning platforms ubiquitous in schools by 2008 (BESA, 2007).

**Table 1 Instructional Design Process Model adapted from Gagne and Ishii (Gagné 2005; Ishii and Tamaki 2009)**

| TQM Circle | ADDIE Model | Operations and methods | |
|---|---|---|---|
| Plan | Analyis | Needs Analysis | |
| | | Job Analysis | |
| | | Student Analysis | |
| | Design | Structuring | Determination of learning contents |
| | | Sequencing | Knowledge, skills, values |
| | | Programming | Determination of learning methods |
| | | | Consideration of student characteristics |
| | | | Determination of provision methods |
| Do | Development | Portal Setup | Installation and configuration |
| | | Additional Modules | Coding of additional software features |
| | Implementation | Tutoring | Beta-testing, user workshops |
| | | Mentoring | Training workshops - Train the Trainer |
| Check/ act | Evaluation | Evaluation subject | Usability - author and instructor persp. |
| | | | Content requirements - industry persp. |
| | | Evaluation Method | Formative evaluations |
| | | | Comprehensive evaluations |

The research method for selecting the optimized LCMS is organized according to an instructional design process model, which is based on the Total Quality Management (TQM) circle and adapted for the design process to follow the steps of analysis, design, development, implementation and evaluation (ADDIE) as shown in Table 1.

**Phase 1 – LCMS Selection**

*Analysis: Selection Criteria*

LMS and LCMS selection is very much dependent of the context of the implementation. In one study of LMS use in the U.S. Corporate Training Market (Bersin et al. 2009), some of the key sources of dissatisfaction were related to "out of the box" functionality, ease of customization, as well as inflexible data models and architectures. Responding to these gaps is one of the greatest drivers for the open source community, and draws on the strengths of collaborative innovation, lower cost, and community support. However, open source also bares some risks. For example, extensive use of (commercial) third party extensions may raise cost and create structural dependencies. And while there may not be licensing costs for core elements, all software needs support and maintenance and periodic updates from a knowledgeable IT team.

In a white paper prepared by a U.K. learning company (Aberdour 2007), a large number of learning content management systems were reviewed and pared down to 13 open source products, based on selected criteria, which included open source licensing, active development community, stable version releases, English language, SCORM compliance, published details about previous adopters, stable organizational support, and third party reviews. This short list of 13 was then analyzed by market sector. In the educational sector, the analyzed top contenders were ATutor, Ilias, Moodle, and Sakai. However, as this study was based on other selection criteria, the research team at Virginia Tech conducted a separate analysis based on identified needs for the specific application within this project.

The key components an LCMS should offer to be suitable for the analyzed project application are collaborative authoring options, data categorization and access management, a delivery interface, and administration tools. The authoring options should preferably provide templates and offer import and export filters to convert existing content. The data repository should allow for storing meta-data to tag and categorize individual learning objects. The delivery interface would ideally serve various publication options for sharing content, ranging from online delivery in SCORM format, to printed handbooks or individual handouts and worksheets for in class sessions. Any publications should be able to be modified to reflect a certain look or feel, such as organizational branding. Integrated collaboration tools, such as topic associated e-mail list or discussion groups are further components that are critical for collaborative authoring and reviewing.

The research team analyzed more than 200 LMS/CMS/LMCS systems regarding their capabilities and applicability towards the given needs. Due to limited financial resources the evaluation was further restricted to open source solutions that could be installed without licensing cost. The short list of 6 systems, Chamilo, Docebo, Dokeos, eFront, ILIAS, and Moodle were installed and configured on a

development server and evaluated on criteria compiled from LMS reviews as well as directly tested against the above defined, need-based criteria (Table 2).

The final selection fell on ILIAS, which required the least amount of additional programming and reconfiguration. It is the only platform that uniquely allows for collaborative authoring in a wiki-like approach, while providing the ability for modularization, lesson planning, and course assembly.

**Table 2 Comparison of Selected Learning Management Software Systems**

| Required Criteria | Docebo | Dokeos | Chamilo | eFront | ILIAS | Moodle |
|---|---|---|---|---|---|---|
| Open Source | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Server Based | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Zero Cost | ✓ | FEE | ✓ | FEE | ✓ | ✓ |
| SCORM Compliant | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Authoring | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Collaborative Editing | admin interface | ✓ | dokeos based | from parent | ✓ | |
| Commenting | NO | ✓ | | NO | ✓ | NO |
| *Edit History, Versioning* | NO | NO | | NO | ✓ | |
| Competency profiling | | NO | | … | ✓ | ? |
| Export Content | info only | NO | | | | |
| PDF | NO | NO | ✓ | ✓ | ✓ | NO |
| Powerpoint | NO | NO | ✓ | ? | NO | NO |
| Online | NO | NO | | | ✓ | |
| SCORM | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| *Preferred Criteria* | | | | | | |
| *Delivery Platform* | | | | | | |
| *Lesson Planning* | Tree | Learning Path | Learning Path | Modules | ✓ | NO |
| *Activity Sequencing* | ✓ | ✓ | *Agenda?* | | ✓ | ✓ |
| *Wiki Options* | ✓ | ✓ | per course | add-on | ✓ | Erfurt wiki |
| *Student admin system* | | Reservations | Personal | | low | low |
| *Learner feedback* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| *Self-enrollment* | ✓ | ✓ | | ✓ | ✓ | ✓ |
| *Batch registration* | limited | ✓ | | ✓ | ✓ | ✓ |
| Assets | | | | | | |
| Tracking Functionality | ✓ | | ✓ | ✓ | ✓ | ✓ |
| Assessment Engine | | ✓ | | | ✓ | ✓ |
| Social Media Tools | videoconf. | ? | fb, twitter | ✓ | ✓ | ✓ |
| Mobile Enabled | | videoconf. | twitter | | ✓ | |
| Collaboration tools | ✓ | ✓ | ✓ | in groups | ✓ | in groups |
| Integrated web services | ✓ | ? | ✓ | | ✓ | |

*Design: Structuring, Sequencing, and Programming*

The target participants are the instructors at the three regional community colleges who will draw material for their curricula. Input of information will ideally come from all participating faculty, though initially provided by university researchers. Future input into the portal will also be available through industry participants, which is a critical element in addressing gaps between industry innovations and academic curricula. A separate research portion of the grant identified and organized existing coursework of the participating building

construction and energy related programs within the community colleges into three tiers. These tiers represent a pathway system for a student progressing from the basic levels of certification through an associate degree.

Keeping in mind the objective of this portal to serve several authors, it was important to establish an overall framework for the portals, determining a hierarchy of the information and a standardized length of learning module. Learning modules are reusable, media-independent chunks of information organized by a meta-data classification system. They are the working core of this portal concept. Each Learning Module should consist of approximately 10–15 pages, and is listed under a specific parent topic. Within each Topic, there are introductory modules as well as follow-up modules, which can be integrated in subsequent, higher level courses. The researchers have identified and co-authored a sample program of 14 modules, which could be utilized to compile the Tier 1 *Sustainability Fundamentals* course, while the nature of the modules still allows for customization and individual selection and sequencing by instructors for other courses.

## Phase 2 – LCMS Portal Development and Implementation

*Development: Portal Setup and Additional Coding*

A standard ILIAS installation package was deployed to a development apache webserver operated by the researchers. The out-of-the-box installation can be deployed within a few hours for a web programmer, who has experience with server side database and script installation common to many online application systems. The initial configuration process (excluding any adoptions that require programming) will require some more time and learning, since the system allows for a multitude of specifications as well as structuring of rights and access rules to a variety of different objects. The installed system was configured to meet the specific needs of the application as defined by the project objectives. ILIAS includes a repository tree that can be configured to allow a variety of objects under each parent node. The core of the repository hierarchy was established as a root node that only includes a basic set of categories for broader classification of content (compare different shelves or aisles in a library). Categories can then host new subcategories (compare to subject area labels on shelves) or already topics (compare to books), which are the main containers for educational content. The core educational objects under each topic are learning modules, where collaborative authoring will take place. Other educational components that have been configured to be listed within a topic include web-links, media casts, exercises, and tests. ILIAS offers many more objects, but for the clarity of the application, the access to those has been hidden and blocked.

ILIAS allows for a refined user role and rights management system. Specific user roles ranging from Author, Co-Author, Instructor, Staff, Industry, and Student users were created and assigned different rights on each level in the repository. Only staff administrators can change and maintain the categorization layout. Authors and co-authors come in at the topic level, where they join (subscribe to) a topic of their expertise or can start their own topic (or book) inviting other co-authors to join them.

The group module that comes with ILIAS has been modified and re-coded to facilitate a subscription model for collaborative authoring within topics. This subscription mechanism allows for tracking and communicating among co-authors

regarding the direction and organization of educational content within a topic. Authors can create their own, or edit and review learning modules of others, and share them directly with their peers. There is no mechanism built in to lock content when edited by any author or co-author. Though preventing concurrent editing, such a feature could in turn trigger issues with users leaving an open editing session (i.e. just closing the respective window instead of clicking "cancel" or "save", which typically unlocks the content again to be edited by others) and thus make content inaccessible for editing by any other user if not reset by an administrator. However, all changes to the document are continuously tracked. Through this version history, any changes can be reviewed by all authors, and rolled back to previous versions within the portal interface.

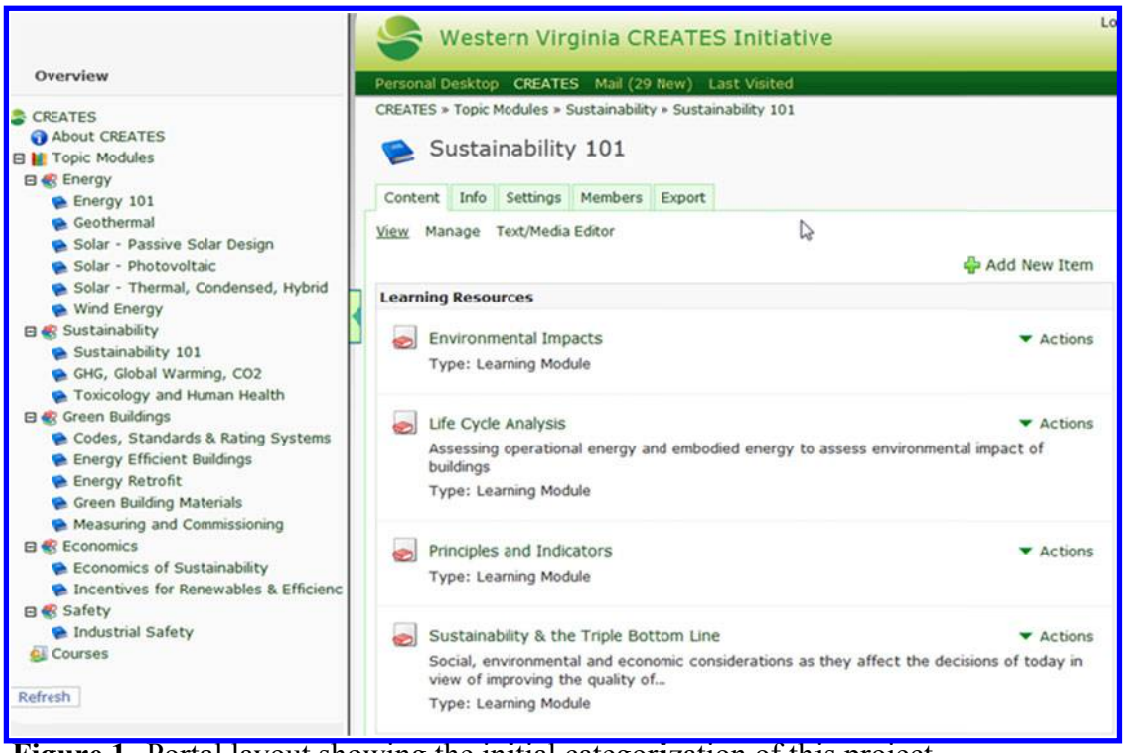


**Figure 1** Portal layout showing the initial categorization of this project

*Implementation: Beta Testing and Training*

The initial categories and subsequent topics for the portal were developed to align with the pathway system introduced in the programming section above, and provide the content for a fundamental course in sustainable energy systems. A core set of categories (Energy, Sustainability, Green Buidlings, Economics, and Safety) were created to host topics ranging from very generic content (e.g. Sustainability 101) to more specific topics such as Solar Photovoltaics or Wind Energy. Within each topic there are several individual learning modules (i.e. learning units). Combined across all topics and categories, these modules are the building blocks of e-learning content and allow for assembly of material for a specific course syllabus (**Error! Reference source not found.**).

While every effort has been made to cut down on complexity for the user experience, the need for individual user training became quickly apparent. Each

software system has its own peculiarities, ILIAS included. Unfamiliar user interfaces can quickly lead to user frustration and rejection of an otherwise highly effective system. Thus the project team co-authored tutorial modules to guide the different users in their specific roles and possibilities within the portal. Additional training workshops with participating faculty were required to break down technical and functional barriers related to the portal and its content.

**Phase 3 – LCMS Evaluation**

All topics were setup with a discussion forum to communicate topic needs, gaps, and future directions. The individual learning modules themselves provide mechanisms for (external) user comments visible to all participants as well as personal notes. Additionally, special style sheets were developed to include instructor notes directly within the page content, which are only visible to author or instructor roles. These paragraphs can facilitate discussion feedback, and ultimately guidance immediately next to relevant content. This project is in the early stages and is now being released to the peer reviewers and open for instructor and industry input.

*Usability: Peer Evaluation of Author and Instructor Perspective*

The collaborative authoring process has been so far evaluated by the immediate investigators and is now distributed to invited academic peers asking for contributions and review of the authoring process. The peer reviewers will test the communication features among authors, contribute their individual knowledge of the subject matter where applicable, and provide additional instructional information directly within the page content.

*Content: Industry Perspective on Learning Requirements*

The industry review process is currently under way and is facilitated by members of the projects advisory board and other invited regional industry partners. This review will primarily focus on content discussion. Industry users do not have edit rights for educational objects. Their role is to review content presentation and extent. Industry users can review and comment on individual learning module pages, identify deficits, or point out elements, where they would prefer more clarity. Furthermore they can participate in general topic discussions and thus create an information pull from academic institutions.

## CONCLUSIONS AND FUTURE WORK

The development of an academic portal is based on the premise that the many educators and industry participants would be well served by combining their resources. The research presented here identifies an appropriate software technology for the specific need of collaborative authoring and exchange of learning contents, configured this technology to facilitate role-based access and functionality, and has collected and provided the initial organization of the data. The organization of data and the central source can reduce the amount of redundancy. However, topics may still have several similar learning modules, each of which can be scaled to a particular level of academic achievement.

Further work will examine the adaptability of the portal to address specific pedagogical formats, language barriers, and interoperability with globally recognized software formats. A particular issue that has been identified by many participants is the need of simpler import mechanisms of existing documents, such as PowerPoint files or Adobe documents. A critical focus for these import filters is that they can convert content into the flexible wiki format, rather than just storing these files as static content, which would limit the system to a simple file repository.

Another focus that has not been resolved within this pilot project is the avoidance of redundancy of authoring content for different educational levels. In the current implementation single learning modules can be re-used and expanded for higher educational levels. However, changes to the base module will not propagate through modules. Ultimately it would be most effective if a future version would allow for referencing content elements of other modules. An alternative solution would be to provide a mark-up mechanism to tag certain page and content elements for different academic levels, which can then be filtered in different user views presented to the student.

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