Integrating the Energy Efficiency and Assessment Components into Manufacturing

Dr. Ismail Fidan, Tennessee Technological University

Dr. Ismail Fidan is a faculty member at the College of Engineering of Tennessee Technological University. His research and teaching interests are in additive manufacturing, electronics manufacturing, distance learning, and STEM education. Dr. Fidan is a member and active participant of SME, ASME, IEEE, and ASEE. He is also the Associate Editor of IEEE Transactions on Components, Packaging, and Manufacturing Technology.

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Abstract

This paper reports the current developments and implementations on energy efficiency and assessment studies in an engineering technology program. The developments are basically in two categories: 1) Web-based teaching modules of Renewable Energy Education have been developed through a funded research project. Instructional Materials, Laboratory Practices and Assessment Exercises have been posted to iLearn (which a Desire2Learn system) and Canvas (which is an Instructure system). Developed materials have been tested by undergraduate engineering technology and graduate electrical engineering students. 2) Energy efficiency is an important component in manufacturing plants and there is an ongoing research on finding alternative ways to save energy in manufacturing processes and operations. Through a funded research project, a knowledge based catalog system has been developed. This catalog consists of the knowledge blocks collected from the Industrial Assessment Centers of the Department of Energy. The catalog has been tested with real industrial inputs and knowledge elements. This current paper will clarify the current progress in these projects.

Overview

Many higher education institution and system offer courses or programs in renewable energy [1]. However, there is a limited number of Web-based delivery tools and systems developed for renewable energy education [2]. Hassan [3] reported the formulation of a Bachelor of Science in Electrical Engineering curriculum with a concentration on alternative energy. Somerton and Bernard [4] discussed an alternative energy course at the Michigan State University which also introduced the related political, social, and economic issues. The course required students to complete a project on solar, wind, or fuel cell technology. Tamizhmani *et al.* [5] at Arizona State University offered an introductory course in fuel cell technology which incorporated a multi-disciplinary teaching approach. Shahidehpour and Li [6] proposed setting up a world-class smart grid education and workforce training center at the Illinois Institute of Technology to offer a university-level degree and certificate program in smart grid technology. Reed and Stanchina [7] presented course models for a post baccalaureate certificate in the clean energy - smart grid area. Rouch and Stienecker [8] conducted a Delphi study that suggested the course components that universities should consider in alternative energy. Belu [9] reported a number of Renewable Energy Virtual Platform/e-Learning System best practices developed and implemented for the engineering technology students at Drexel University.

The Energy Department's Industrial Assessment Centers (IAC) program is a workforce development initiative aimed to create the next generation energy engineers. IAC graduates possess a unique mixture of engineering and energy management expertise, combined with hands-on experience obtained by working directly with small-and medium size manufacturing facilities across the country. Each year, 250 to 450 engineering students within the IAC program

gain valuable knowledge evaluating the efficiency of key industrial operations, systems and processes. Since its inception, thousands of engineering students have participated in the IAC program, representing over 50 colleges and universities across the US. IAC/SME collaboration initiative is a new program started in 2013. TTU was one of the three pilot schools participating in this program. Student and faculty teams completed assessment visits related to both energy efficiency and productivity related improvement opportunities in 2013 [10].

The database resulting from assessments carried out by Universities for the Department of Energy's Industrial Assessment Center (IAC) program contain a list of recommendations involving enhancements in energy efficiency, waste minimization and manufacturing productivity. In order to organize the data in a useful way, a coding system called the Assessment Recommendation Code (ARC) has been developed to list each recommendation. The list is assembled and is maintained by the Center for Advanced Energy Systems (CAES) at Rutgers, the State University of New Jersey [11].

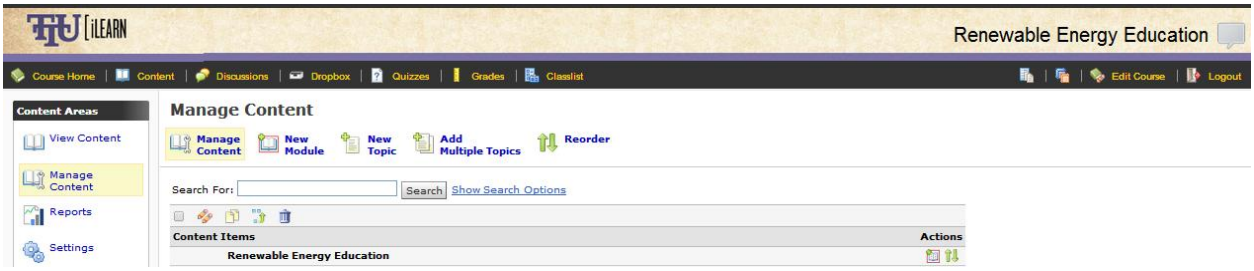
Most recommendations can be collected into new groups that focus either on the same system or on the same general strategy for enhancement. Attempts were made to develop a coding scheme which would be consistent along either one of these lines, but neither approach proved satisfactory. The resulting organization of recommendations has been done in an "expert system" fashion. Therefore, the code has been assembled to best collect recommendations which would be considered together by an experienced professional. For example, recommendations for energy savings for air compressors (a system) are grouped. In a similar fashion, recommendations for waste heat recovery (a strategy) are collected together.

Desire2Learn Renewable Energy System

Desire2Learn Incorporated (also known as Desire2Learn or abbreviated as D2L) is a provider of enterprise eLearning solutions and develops online Learning Management Systems used at more than 650 institutions in 20 different countries around the world. The company was founded in 1999 by president and CEO John Baker. The company is headquartered in Kitchener, Ontario, Canada, and has staff in the US, Canada, the UK, Brazil, and Australia.

Desire2Learn has a 98% client retention rate. Deloitte Technology's Fast 50 program has considered that Desire2Learn is among the fastest growing technology companies in Canada and is one of the Top 50 Small to Medium Size Employers for two consecutive years, 2011 and 2012. Desire2Learn was named the 2012 Business of the Year at the Greater Kitchener-Waterloo Chamber of Commerce Business Excellence Awards [12].

In Summer 2013, a Desire2Learn based renewable energy system has been developed at Tennessee Tech University. This development can be accessed through ilearn.tntech.edu course management system. This development contains a high number of learning modules, test banks and laboratory practices. Solution manual for the course instructors are also provided. Each course module has at least five laboratory exercises. These exercises are prepared for both students and teachers. The following figure is a sample snapshot of the lecture and laboratory components.



Unit 1: Renewable Energy Education

- Introduction to Renewable Energy Technologies
- Solar Energy
- Geothermal Energy
- Wind Energy
- Fuel Cell
- Biomass
- Future Directions

Unit 2: Q&As

- Solar Energy Questions
- Solar Energy Answers
- Renewable Energy Questions
- Renewable Energy Answers
- Geothermal Energy Questions
- Geothermal Energy Answers
- Wind Power Questions
- Wind Power Answers
- Fuel Cell Questions
- Fuel Cell Answers
- Biomass Questions
- Biomass Answers

Canvas Renewable Energy System

Instructure was founded in 2008 by two Brigham Young University graduate students with initial funding from Mozy founder Josh Coates (currently the CEO) and Epic Ventures.

In December 2010, the Utah Education Network (UEN), which represents a number of Utah colleges and universities, announced that Instructure would be replacing Blackboard as their preferred Learning Management System. By January 2013, Instructure's Learning Management System was in use by more than 300 colleges, universities and K-12 districts, and the company's customer base had increased to more than 425 halfway through 2013.

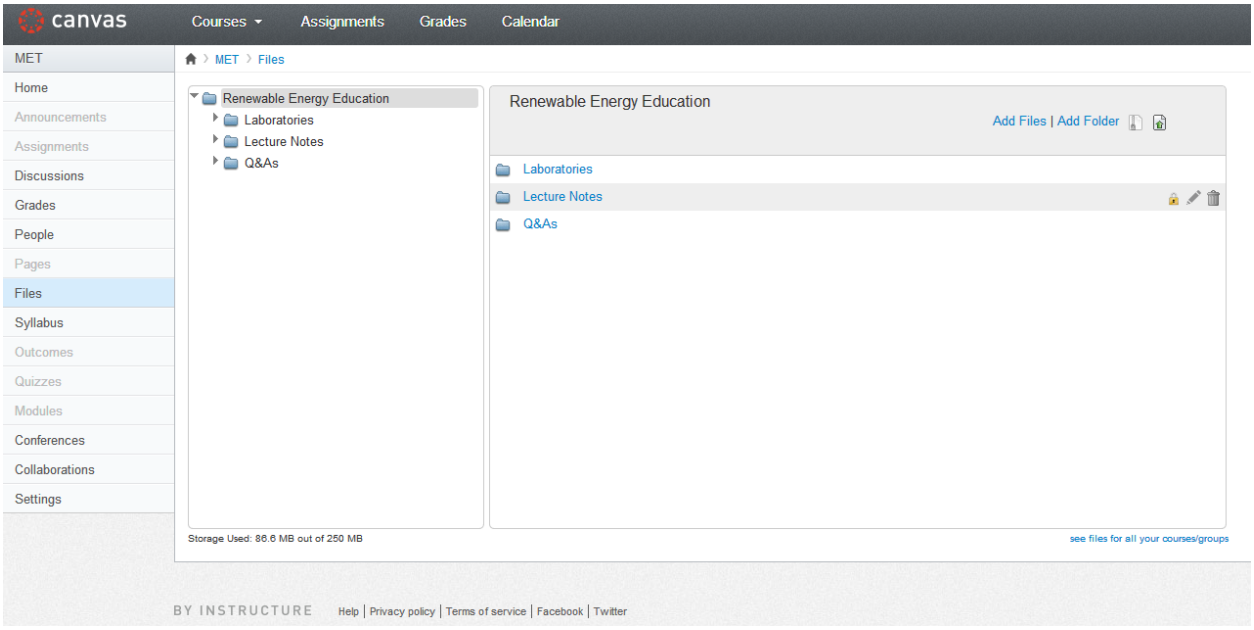
In February 2011, Instructure announced that they were making their flagship product, Canvas, freely available under an AGPL license as open source software. Instructure's announcement received coverage in the press. In February 2012, the company launched Canvas K-12.

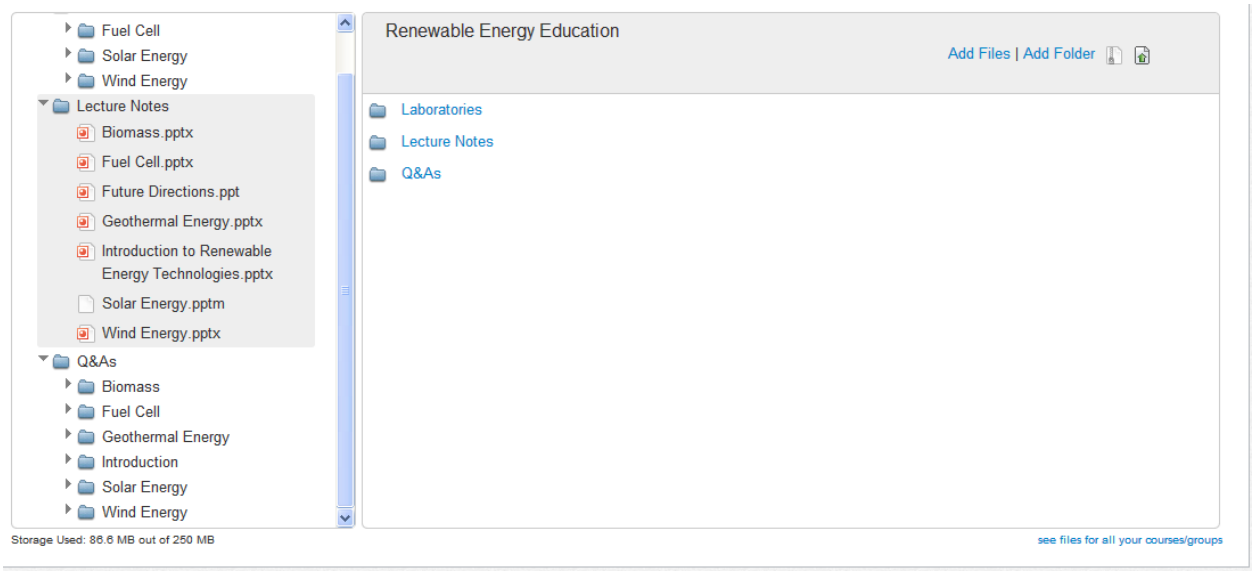
Instructure Inc. was created in order to support the continued development of a new learning management system originally named Instructure. Once incorporated, the founders changed the name of the software to Canvas. The Utah-based company tested the developed system at several

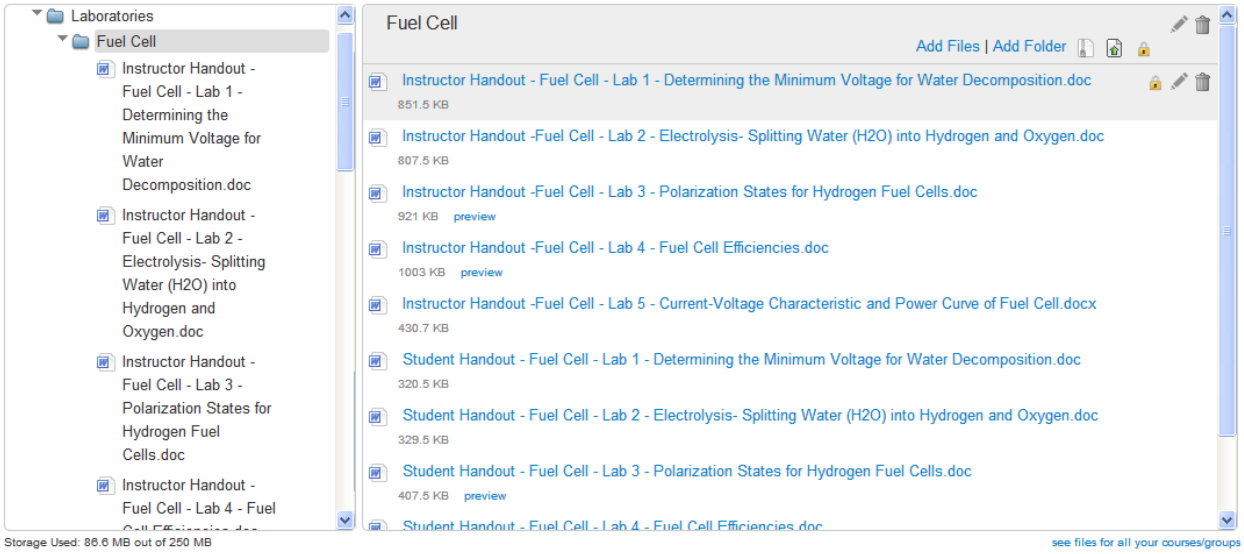
local schools including Utah State University and Brigham Young University before officially launching Canvas.

In November 2012, Instructure entered the massive open online course (MOOC) market by launching Canvas Network. Instructure's approach to MOOC has been to facilitate experimentation with pedagogy and new ways to use multimedia environments to change cognition and enhance the learning process [13].

In Summer 2013, a Canvas based renewable energy system has been developed at Tennessee Tech University. This development can be accessed through canvas.instructure.com/login system. This development contains the same Desire2Learn learning modules, test banks and laboratory practices. Solution manual for the course instructors are also provided. Each course module has at least five laboratory exercises. These exercises are prepared for both students and teachers. The following figure is a sample snapshot of the Canvas lecture and laboratory components.

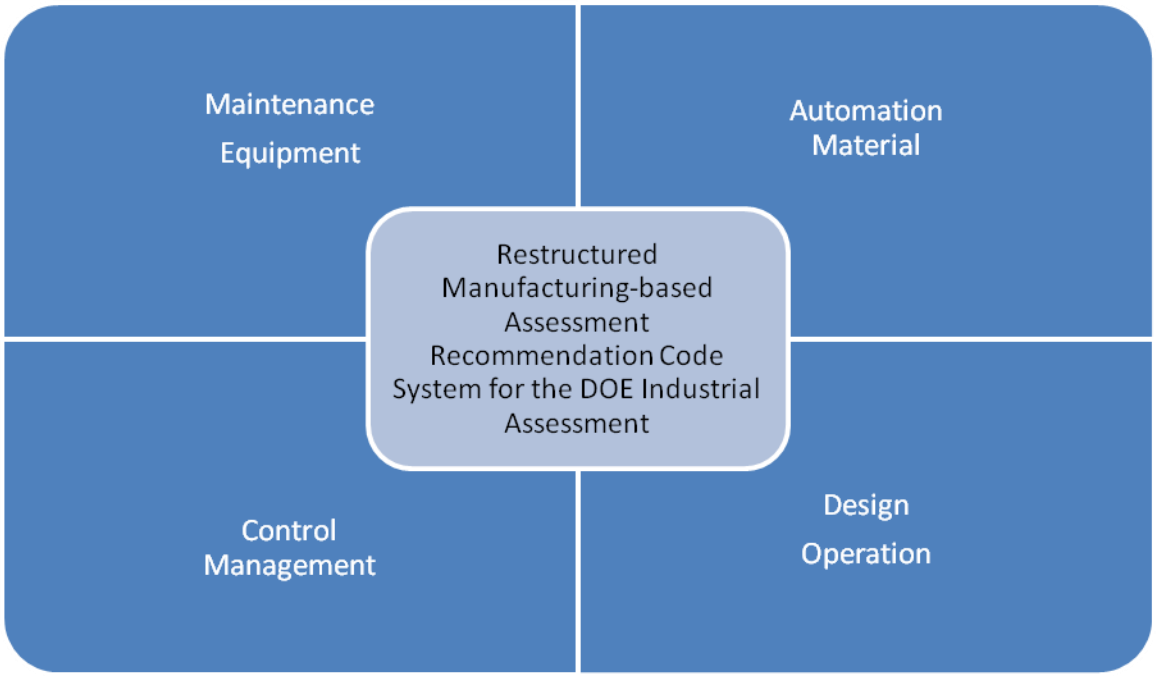






Manufacturing Knowledge Base Catalog for the Energy Assessment

In Summer 2013, A newly restructured catalog has been developed by the TTU students and faculty. In this new development, a number of the manufacturing related codes and numbers have been re-categorized into new knowledge blocks. The following figure represents the restructured knowledge elements.



Many manufacturing related codes and numbers have been re-categorized under this new system. The following is a sample showing the ones related to 'control'.

2.7131 ADD AREA LIGHTING SWITCHES
2.7132 INSTALL TIMERS ON LIGHT SWITCHES IN LITTLE USED AREAS
2.7133 USE SEPARATE SWITCHES ON PERIMETER LIGHTING WHICH MAY BE TURNED OFF WHEN NATURAL LIGHT IS AVAILABLE
2.7134 USE PHOTOCELL CONTROLS
2.7135 INSTALL OCCUPANCY SENSORS
2.7261 INSTALL TIMERS AND/OR THERMOSTATS
2.7262 SEPARATE CONTROLS OF AIR HANDLERS FROM AC/ HEATING SYSTEMS
2.7263 LOWER COMPRESSOR PRESSURE THROUGH A/C SYSTEM MODIFICATION
2.7264 INTERLOCK HEATING AND AIR CONDITIONING SYSTEMS TO PREVENT SIMULTANEOUS OPERATION
2.7446 UTILIZE SENSORS CONTROLLING ROOF AND WALL OPENINGS
4.6410 ELIMINATE SHUTDOWNS OF CONTROLS DUE TO OVERHEATING
4.6420 INSTALL SENSORS TO DETECT AND AVOID JAMS

Beta Testing

Newly-developed three systems have been tested by the engineering technology students and used in the industrial energy assessment visits in 2013. However, they were not fully implemented in any engineering technology course yet. The feedbacks received from the undergraduate and graduate students and industrial representatives are given below:

Desire2Learn System:

- The system is very well developed. PowerPoints are great.
- Laboratory exercises are great help for students and instructors.
- The best part of the work is solution manuals for all.

- Good support to renewable energy education

Canvas System:

- Excellent, pioneering work in a MOOC system.
- Better than Desire2Learn since you can freely access.
- No need to carry any hard copy course material anymore. All sources are soft copy for us!
- Want to see more sources.

Manufacturing Knowledge Base:

- Itemized codes are easy-to find.
- I am not searching anymore. Everything is easily in front of you.
- This is a comfort.
- Want to see all these in an online accessible system.

Conclusions

In Summer 2013, three new energy related tools have been developed. They are Desire2Learn Renewable Energy System, Canvas Renewable Energy System, and Manufacturing Knowledge Base Catalog for the Energy Assessment. They were beta-tested in Fall 2013 and positive feedbacks have been received from the students, instructors and industrial practitioners. More elements will be added in Spring 2014. Future plans of the three projects are to implement in more educational and industrial settings.

Acknowledgements

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