June 20, 2022 Presentation

The Teacher's Guide to DESIGNING COURSES WITH ONLINE MODULES

INTRODUCTION

BACKGROUND

THE DESIGN PRINCIPLES

How this guide works

‘The teacher guide **seeks to provide support in designing online modules** for higher engineering education courses. This ‘teacher guide is a practical guide to illustrate how the ‘design principles’ are actually implemented. This guide provides the teachers with **examples and resources for each ‘design principles’.**

This ‘teacher guide’ **does not tell the teacher** to apply certain design steps, but **gives examples and shows how and why** a teacher might form different certain design decisions. The ‘teacher guide’ is not a final product, rather it is the first version of a collection of design practices for module design in higher engineering education.

If you **have experience** with designing modules for courses, you might want to work on the design principles together with the Teacher Guide on your own. You might want to skip some of the example articles provided in this Teacher Guide.

If you **don’t yet have experience** with designing modules for courses, it might be a better idea to: a) use the design principles and the Teacher Guide together with a teacher supporter and b) have a look at all the examples provided in this Teacher Guide.

Module category

How do you want to categorize your modules?

WHAT? The modules presented to the students can be grouped and sequenced differently. For example, it can be the case that the students are required to take all presented modules, and in a certain sequence. The examples below demonstrate on one hand a case where the modules are mandatory and sequenced and on the other a case where the students are not required to take all modules. In the second case, students take some of the modules voluntarily. The examples will help you make your choice on using modularization.

The '**WHAT**' part provides an overall introduction to what the 'teacher manual' presents for each 'design step'.

The 'WHO' is related to the authors of exemplary articles.

Links to the article if you want to read full-text.

Finally, 'SO WHAT' part presents the findings from the exemplary article in relation to modular course design.

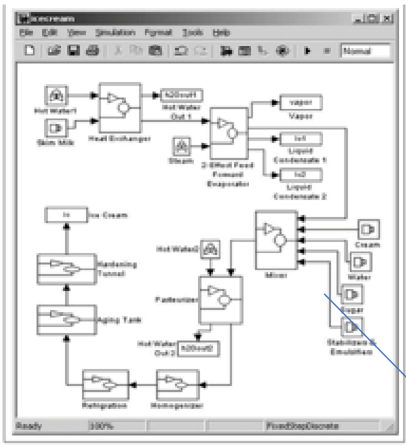
b. Modules covering part of the course LOs.

WHO? Diefes-Dux (2004).

HOW? Modules for a senior level design course; to address learning outcomes on use of a simulation tool to perform engineering design work. The tool was the Foods Operations Oriented Design System Block Library (FOODS-LIB); a multi-level steady-state food process design tool for food engineers, food scientists, and food ... DS-LIB is the MATLAB ... nd its SIMULINK dynamic system ... to facilitate learning to use ... g their knowledge to actual engineering design situations. The emphasis was on skills learned by the students while completing the learning modules and on the transfer of knowledge to their design work. To facilitate student learning of FOODSLIB, seven online learning modules were developed. Module 1 starts with an explanation of the GUI and data entry. Module 2 instructs students on how to build and execute a food process design using the library, Module 3 teaches students how to carry out an economic analysis on a process. Module 4 explains the use of SIMULINK and information flow in a process design as students construct the GUI for a unit operation not included in the library. This module introduces the first of two critical constructs for effective use of SIMULINK and therefore FOODS-LIB. availability of instructor and teaching assistant help for using modules.

Explanations related to 'HOW' include examples for how the design step is implemented in the exemplary article.

SO WHAT? Teacher assessment of student products as a result of using the modules coupled with student evaluations showed students' need for more ongoing support as they began using the modules in their design work. Students had the following recommendations to improve usage of the modules: (1) use FOODS-LIB in more courses, (2) devote a lab session every week to the use of FOODS-LIB or offer a 2–3 week course on FOODSLIB, (3) provide more explanation on FOODS-LIB and coding (4) make solution keys available, and (5) increase the



Screenshots from relevant parts of course modules.

Points to consider

Before moving onto the ‘design principles’, some additional information to consider:

- Number of students
- Grade level/age of students
- Availability of tutors
- Workload of teacher

1. Course content.

Which of your course LOs / topics do you want to cover with modules?

WHAT? Modules can be designed in several ways. For example, it might help you to design the practical (or hands-on) parts of your course, but you can also organize all course content into modules. Depending on the learning outcomes or the topics of your course you want the modules to address, different aspects have to be considered. The examples below illustrate on the one hand what is meant by designing modules for all course content or parts of it, and on the other hand what the implications might be. This will help you make a choice for this first 'design principle'.

- modules address selected course content

WHO? Diefes-Dux (2004).

A senior level design course.

HOW? Modules to **address learning outcomes on use of a simulation tool.** The tool was the Foods Operations Oriented Design System Block Library (FOODS-LIB) a computer simulation tool to perform engineering design work. The platform for FOODS-LIB is the MATLAB computational software package and its SIMULINK dynamic system simulation toolbox. Modules aimed to facilitate learning to use features of the tool and transferring their knowledge to actual engineering design situations. The emphasis was on skills learned by the students while completing the learning modules and on the transfer of knowledge to their design work. To facilitate student learning of FOODSLIB, seven online learning modules were developed. Module 1 starts with an explanation of the GUI and data entry. Module 2 instructs students on how to build and execute a food process design using the library.

SO WHAT? Teacher assessment of student products as a result of using the modules coupled with student **evaluations showed students' need for more ongoing support** as they began using the modules in their design work. **Students had the following recommendations** to improve the modules: (1) use FOODS-LIB in more courses, (2) devote a lab session every week to the use of FOODS-LIB or offer a 2–3 week course on FOODSLIB, (3) provide more explanation on FOODS-LIB and coding (4) make solution keys available, and (5) increase the availability of instructor and teaching assistant.

- modules address all course content

WHO? Baughman (2019).

A project-based sophomore engineering design course

HOW? Modules were designed through collaboration between the Mechanical Engineering Department and a Center for Excellence in Teaching and Learning. The weekly 50-min lectures were eliminated with **nine interactive, online modules designed for different learning outcomes.** Assessments were created to expose students to new content prior to face-to-face lab sessions. Modules included course content videos and text materials; nongraded, content-related interactive activities; and videos, each a maximum of 15 min in length. Students worked through the learning modules at their own pace and completed a graded assessment (quiz) prior to the face-to-face sessions. All online materials located on the course management system were accessible 24 hr a day, 7 days a week.

SO WHAT? The primary pedagogical implication of this research points to the **affordance of using modules in providing sufficient time for student members to become cohesive teams**. As part of the student experience, engineering educators are encouraged to allow time for team formation and development in addition to content learning.

Course learning outcomes

1. Demonstrate effective team work skills.
2. Create technical reports using appropriate structure, grammar and tone.
3. Identify the ways in which social, economic, and environmental issues (the three legs of the sustainability table) impact or are impacted by the activities of the designer.

An exemplary course

Research Methods in Education

LO1. Explain the six basic concepts of education research	**Module**-Introduction to education research-I **Module**-Introduction to education research-II
LO2. Demonstrate an understanding of the scientific research process	**Module**-The scientific method
LO3. Describe and critique qualitative and quantitative research paradigms	**Module**-Qualitative and quantitative research **Module**-Contemporary approaches in qualitative research **Module**-Contemporary approaches in quantitative research
LO4. Analyze the fundamental characteristics of main research designs	**Module**-Main research designs in education **Module**-Causal-comparative research **Module**-Experimental research
LO5. Design a research proposal that can facilitate development of educational theory and practice	**Module**-Practicing education research

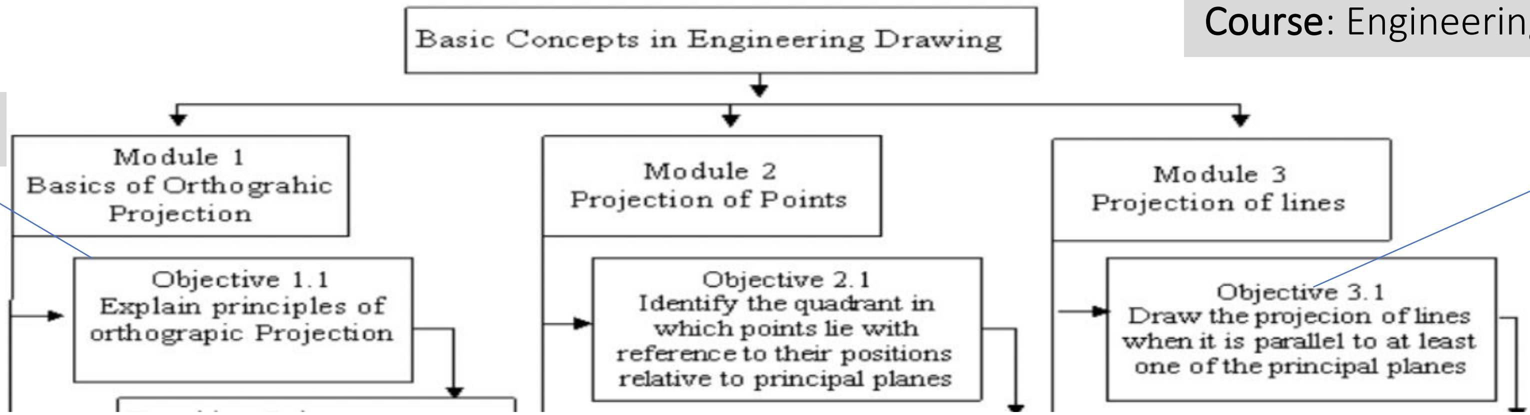
Exemplary course LOs

Course: Engineering Design

Module	Item	Learning Objectives of Modules
1	1	Understand the three GUI levels.
	2	Identify the three types of GUI blocks used by FOODS-LIB.
	3	Understand the types of information that the GUI requires the user to input.
2	4	Construct a food process design using existing FOODS-LIB blocks.
	5	Execute a steady-state simulation of a food process design constructed using FOODS-LIB.
4	6	Understand the use of the SIMULINK constructs in FOODS-LIB.
	7	Understand information flow in FOODS-LIB.
	8	Understand the u-array concept in FOODS-LIB.
	9	Construct a new FOODS-LIB block.

Course: Engineering Drawing

Content LO



A practical LO

- Content LOs.

Course: Engineering Cultures

WHO? Downey (2006)

HOW? Each module concentrated on engineering in a different nation e.g., U.K., Germany, Japan, Soviet Union/Russia, and the U.S. Each module addresses the same four questions in providing information for the students: (a) How did the nation state evolve?, (b) How have engineers emerged in this country? (c) What is a typical career trajectory for an engineer? (d) What are key emerging trends for engineers and engineering? Readings for each module include a combination of academic and popular publications woven together with content gathered and organized through extensive original research.

SO WHAT? Pursuing these questions trains students to anticipate and be able to understand differing patterns of social position and status among engineers in different countries. By understanding such differences, students learn to ask intelligent questions about co-workers and make reasonable predictions about their career goals and desire. These modules may also be useful as refresher courses for former students.

- Practical LOs.

Course: Biomedical engineering

WHO? Clyne. (2016).

HOW? The course gained a problem-based learning format with the designed modules. The 10-week course had 4 modules, each motivated by a real-world problem which demonstrated how a mechanical engineering principle could be applied to biological systems. In the biomanufacturing module, students created a bioreactor to tissue engineer a lung with a focus on recreating the mechanical environment. In the bio-microfluidics module, students developed a low-cost device to detect or monitor HIV/AIDS. And in the bioinspired robotics module, students designed and modeled a prosthetic limb for running and jumping.

SO WHAT? Trying the modules in two different institutions, findings indicate the benefits of using the problem-based modules in biomechanics courses. Students were willing to commit the time and effort to learn as long as the instructor was an active and helpful guide.

2. Module category
How do you want to categorize your modules?

WHAT? The modules presented to the students can be grouped and sequenced differently. For example, it can be the case that the students are required to take all presented modules, and in a certain sequence. The examples below demonstrate on one hand a case where the modules are mandatory and sequenced and on the other a case where the students are not required to take all modules. In the second case, students take some of the modules voluntarily. The examples will help you make your choice on using modularization.

- mandatory modules

WHO? Chatterjee (2010).

Course: Partial Discharge Phenomena

HOW? Students took the **mandatory modules in the same order.** A design experience is added to each module, depending on its level. A lower level module starts with a structured design project; the students gradually move toward a guided design project at a higher-level module. In the stage that comprises Module-III and Module -IV, the teacher no longer provides guidance in the form of step-by-step procedures. The design projects were implemented in this course as laboratory exercises as well as assignments.

The class lectures were divided into several sections, divided between Modules I-IV. Each module consisted of class lectures based on theoretical concepts and the corresponding laboratory experiments and assignments. The hourly load of each of the sections is dependent on the subject taught and the coverage given.

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SO WHAT? At the end of the course, students were asked to participate in a comprehensive discussion on contemporary engineering issues involving partial discharges in power equipment.

Since the course was an elective, it was obvious that the students were well motivated. Overall, students liked the course and felt it was helpful for their professional advancement. Two aspects to consider were that the students did not like the strong team work, and that the **students found the course load too demanding.**

Module 4: "Recording PD Data from Test Sample"
- Class lecture
- Laboratory experiment
- Module-end assignment
- Module-end presentation

- mandatory modules

WHO? [Martinez (2019)]

Course: CBL Course for Mechatronic Engineering

HOW? In the CBL course, each module corresponds to different design steps of the challenge work. One challenge was: **design a milk flow sensor in automated milking stations.** The content of the modules corresponded to the requirements of the challenges; competencies that are sought to be achieved were created. The **students received five modules along with the challenge modules**, e.g., a module focusing on analysis of client's needs.

SO WHAT? An example for the principles: (a) learning based on challenges; (b) flexibility in how, when and where you learn; (c) a memorable university experience; and (d) inspiring teachers was successfully presented.

A learning **module is a structure for the organization of conceptual and procedural contents with learning activities** grouped under a theme that identifies and integrates them.

Module	Stage	Stage name	Evaluation instrument
Methodologies for designing a mechatronic system General methodology of design of a mechatronic product. Analysis of the client's needs	1	Analysis of the client's needs	Report and its rubric
Approach and selection of solutions to a problem Interpretation of the client's needs. Technical specifications. Generation and selection of concepts. Selection matrix. Validation of the concept	2	Generation and selection of concepts	Report and its rubric
Architecture of a mechatronic system and its specifications System specifications. Modular architecture. Design methods at the system level: functional decomposition and morphological matrix	3	System level design	Report and its rubric

Three of the mandatory challenge modules

- There are voluntary modules

WHO? Syed (2019)

Course: A sophomore level mechanical engineering laboratory

HOW? Select VR-based materials were introduced to students via fourteen online course modules. Exercises have been added at the end of each module for participants to practice what they learn in the module before moving to the next section. In this manner, they receive immediate performance feedback and can choose to review the content again if necessary.

SO WHAT? **Students with better grades generally completed more modules** and showed a remarkably higher performance improvement. In other words, the increase in students with grade A is much higher than other grade categories. But once four of the modules were made mandatory there was a sharp increase in the average number of students who completed those modules in the lower grade groups. This shows **the inherent lack of drive of the lower percentile students to put in extra effort towards their courses without incentive.**

Supplemental e-learning modules

Module	Title
1	Popular Measuring Instruments
2	Industrial Instruments: Temperature & Pressure
3	Industrial Instruments: Force, Torque, & Flow
4	Electrical Measuring Instruments
5	Properties of Engineering Materials
6	Engineering Materials
7	Production Process
8	Machining Operations
9	Special Processing
10	Safety at Facilities
11	Environmental Control and Noise
12	Material Handling and Electrical Safety
13	Machinery, Hand Tool and Equipment Safety
14	Personal Protection and First Aid

- There are voluntary modules

WHO? Henson (2002)

Course: Senior level elective course in civil engineering

HOW? **Online laboratory modules have been developed to provide students with hands-on, albeit virtual, learning experiences.**

All modules are voluntary. Lectures were provided during classroom time. Modules are both theory based and teach practical applications. Modules include animations and interactive tasks for students. on-line surveys was placed at the end of each on-line module to solicit subjective feedback on the module.

The use of the modules was made strictly voluntary**, although students were encouraged to use them**. Motivation was created through synchronous student-student and student-instructor interaction in modules is promoted through the use of e-mail, the announcement sand news Web page, and through the bulletin board discussion list. Students are encouraged to post questions about class material on the bulletin board where other students, the instructor, graduate students and corporate sponsors can asynchronously respond.

SO WHAT? The use of **well-designed and pedagogically sound Internet**-based supplemental modules provide students with a better understanding of course material.

Topic	*Module(s)*	*Quiz*
Physical and Mechanical Properties of Wood	Moisture Content	Pre- and Post-Quizzes
Design Loads	Wind Loads	None
Structural Wood Products	Adjustment Factor Quiz Adjustment Factor Scenarios Duration of Load	Pre- and Post-Quizzes
Member Design: Beams Tension Members Compression Members Combined Loading Members	 None None None None	 Pre- and Post-Quizzes Pre- and Post-Quizzes
Connections	Connections Dowel Bearing Strength	Pre- and Post-Quizzes None
Assemblies	Shearwalls	Pre- and Post-Quizzes

The internet-based elective modules