# *Instructional Module Development (IMOD™) System: Building Faculty Expertise in Outcome-based Course design*

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***Abstract*— A well-designed and constructed course plan or curriculum is an integral part of the foundation of effective STEM instruction. This paper presents a framework for outcome-based course design process and its translation into a semantic web-based tool; i.e., the IMOD™ system. This system guides STEM educators through the complex task of curriculum design, ensures tight alignment between various components of a course (i.e., learning objectives, content, assessments, and pedagogy), and provides relevant information about research-based pedagogical and assessment strategies. The theoretical framework is presented, along with descriptions and screenshots of the implementation of key features.**

**Keywords—course design, instructional module, learning objectives, outcome-based education, semantic web application.**

## I. Introduction

At many colleges and universities, engagement in scholarly teaching is becoming a minimum expectation of faculty who are held accountable for the quality of the learning experienced by students enrolled in their course(s). These expectations are even greater for Science, Technology, Engineering, and Mathematics (STEM) faculty given the national demands for a well-trained STEM workforce [1]. Since education training is not typically included in the plan of study of most STEM programs, faculty who graduate with STEM degrees gain their teaching expertise post-appointment and "on-the-job". In the absence of formal training, most faculty can take as much as five years to truly become proficient teachers, and during that period, it is the students who are most affected [2].

There is a growing demand and interest in faculty professional development in areas such as outcome-based education (OBE), curriculum design, and pedagogical and assessment strategies. In response to this demand, a number of universities have established teaching and learning centers to provide institution-wide, and sometimes program specific support. This paper describes the development of the Instructional Module Development (IMOD) System, which further supports these ventures and broadens the impact and reach of professional development in the scholarship of teaching and learning, particularly to STEM faculty. The IMOD system is an open-source web-based course design software that:

- Guides individual or collaborating users, step-by-step, through an outcome-based education process as they define learning objectives, select content to be covered, develop an instruction and assessment plan, and define the learning environment and context for their course(s)
- Contains a repository of current best pedagogical and assessment practices, and based on selections the user makes when defining the learning objectives of the course, the system will present options for assessment and instruction that align with the type/level of student learning desired
- Generates documentation of course designs. In the same manner that an architect's blueprint articulates the plans for a structure, the IMOD course design documentation will present an unequivocal statement as to what to expect when the course is delivered
- Provides just-in-time help to the user. The system will provide explanations to the user on how to perform course design tasks efficiently and accurately. When the user explores a given functionality, related explanations will be made available
- Provides feedback to the user on the fidelity of the course design. This will be assessed in terms of the cohesiveness of the alignment of the course design components (i.e., content, assessment, and pedagogy) around the defined course objectives.

## II. Theoretical Framework

Many of the leaders in faculty development programs have identified facilitation by experts as a key ingredient in increasing the effectiveness of instructional development programs [3]. For the IMOD system, which will provide professional development with the use of an online tool, expert facilitation is embedded within its design, through the application of a framework that is informed by research in the area of instructional development for STEM disciplines. This framework translates the scholarship into a software platform that supports the development of a rich, meaningful knowledge structure that can be queried to: (1) identify omissions in a course design; (2) identify inconsistencies in the relationships between the elements of the course being designed; (3) identify relevant strategies for instruction and/or assessments; (4) provide just-in-time guidance to the user on the design process. The structure of the framework and its implementation in the IMOD™ system are discussed in the subsequent sections.

### *A. Previous Models of Outcome-Based Course Design*

Outcome-based education (OBE) is an approach where the product defines the process, i.e., the outcomes that specify what students should be able to demonstrate upon leaving the system are defined first, and drive decisions about the content and how it is organized, the educational strategies, the teaching methods, the assessment procedures and the educational environment [4]–[6]. This is a contrast to the preceding “input-based” model that placed emphasis on the means as opposed to the end of instruction. OBE was used as the principal guide for the development of the IMOD framework. It was chosen for the following reasons: 1) Win-for-all solution – OBE is shown to improve student success, provides a structure to educators for designing instruction, and facilitates reporting to external stakeholders in an accountability education climate; 2) It supports the How People Learn framework for designing learning environments [7]; 3) Growing adoption of outcome-based program accreditation – Accreditation boards such as ABET, have moved to an outcome focused model (what students learned) to assess the quality of programs in Applied Science, Computing, Engineering, and Engineering Technology; 4) Alignment with other models that are meant to increase innovation in STEM education – OBE dictates the end and not the means thereby allowing innovation in instruction. It also provides an empirical structure to track impact and identify shortcomings.

A number of models have been developed to represent the application of OBE in the design of effective courses. Four key models widely discussed in the engineering education literature are: 1) the Effective Course Model by Felder & Brent [8]; 2) Integrated Course Design by Fink [9]; 3) Understanding by Design Model [10]; 4) Content Assessment Pedagogy Model by Streveler, Smith, & Pilotte [11]. All of these models either directly or indirectly identify four main elements that must be tightly aligned when defining a course design, i.e., course objectives, content, assessments, and pedagogy. Therefore, one of the main challenges in adhering to an outcome-based approach is maintaining the alignment between course elements. Inconsistencies in the interrelation of these elements can lead to the overall incoherence of the course.

One approach for achieving alignment among course elements is through a “backward-looking” design process where the desired results are identified first, and then assessments are designed to verify that these results have been achieved. The learning experiences and instruction are then formulated around the desired results and the assessments. The use of this approach forms the basis of the Understanding by Design model, and it is also applied by the other models. One of the key functions the IMOD system is expected to perform is the evaluation of the fidelity of the course design. To achieve this, the IMOD framework must include machine processable constructs that can be used to make inferences on the inconsistencies in the relationships between the elements of the course being designed. While the backward-looking process dictates an ideal sequencing of tasks, it is limited in its ability to support automated inferencing on course element coherence. The IMOD framework, therefore, expands on the current models with the inclusion of new constructs.

### *B. IMOD Framework*

The IMOD framework adheres strongly to the OBE approach and treats the course objective as the spine of the structure. New constructs (not included in the models previously discussed) are incorporated to add further definition to the objective. The work of Robert Mager [12] informs the IMOD definition of the objective. Mager identifies three defining characteristics of a learning objective: Performance – description of what the learner is expected to be able to do; Conditions – description of the conditions under which the performance is expected to occur; and the Criterion – a description of the level of competence that must be reached or surpassed. For use in the IMOD framework an additional characteristic was included, i.e., the Content to be learned – description of the factual, procedural, conceptual or meta-cognitive knowledge; skill; or behavior related to the discipline. The resulting IMOD definition of the objective is referred to as the $PC^3$ model.

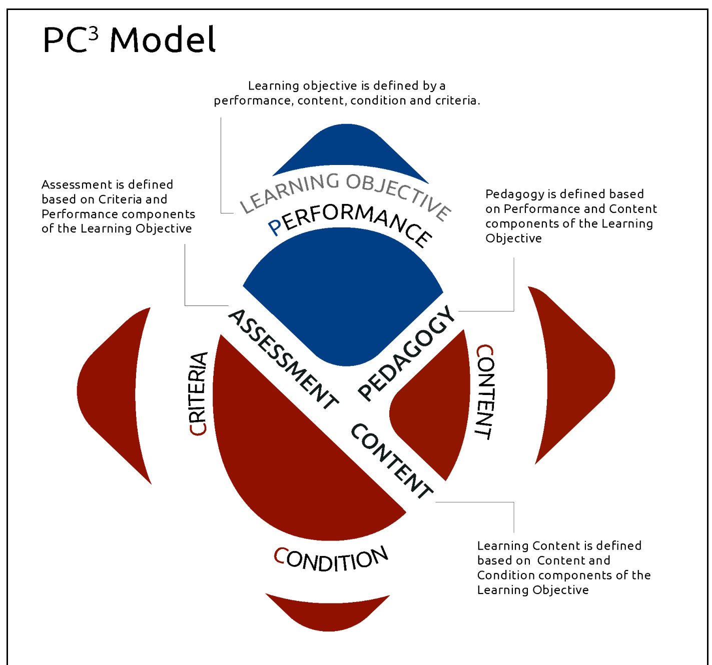


Figure 1: $PC^3$ Model

The other course design elements (i.e., Content, Pedagogy, and Assessment) are incorporated into the IMOD framework through interactions with two of the $PC^3$ characteristics. Course-Content is linked to the content and condition components of the objective. The condition component is often stated in terms of pre-cursor disciplinary knowledge, skills or behaviors. This information, together with the content defined in the objective, can be used to generate or validate the list of course topics. Course-Pedagogy is linked to the performance

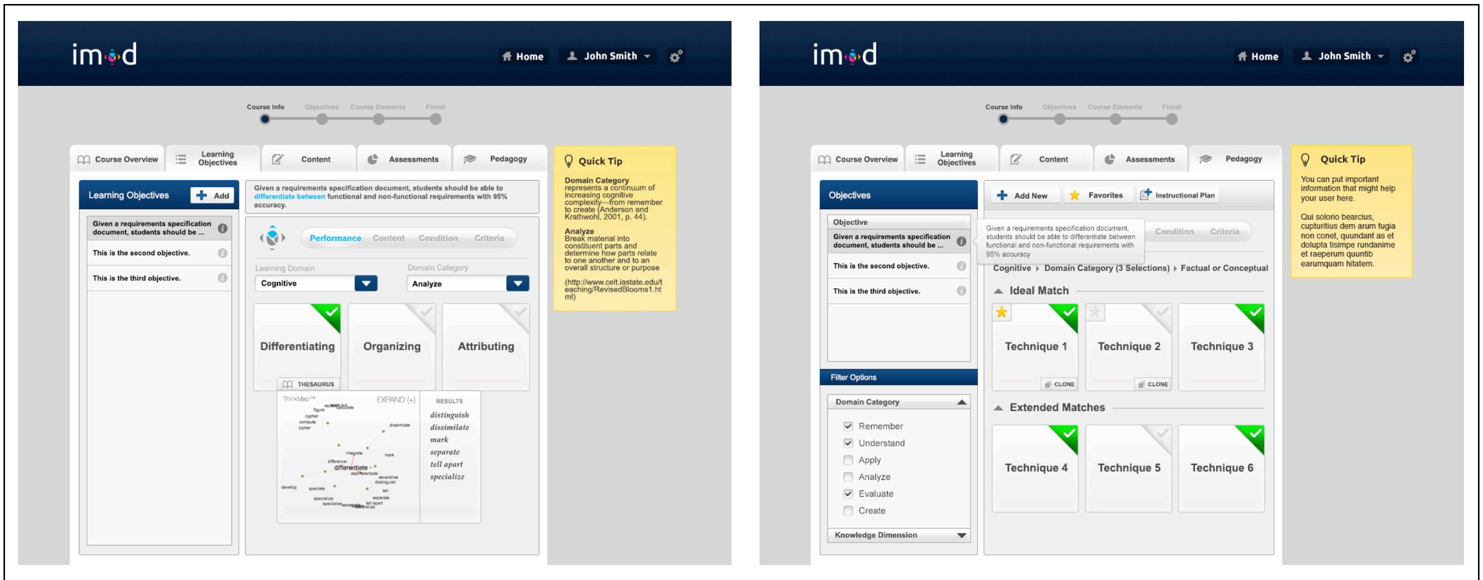


Figure 2: Screenshots of Learning Objective and Pedagogy tabs of the IMOD™ system

and content components of the objective. The types of instructional approaches or learning activities used in a course should correspond to the level of learning expected and the disciplinary knowledge, skills or behaviors to be learned. The content and performance can be used to validate pedagogical choices. Course-Assessment is linked to the performance and criteria components of the objective. This affiliation can be used to test the suitability of the assessment strategies since an effective assessment, at the very least, must be able to determine whether the learner's performance constitutes competency. Figure 1 shows a visual representation of the IMOD framework.

## III. IMPLEMENTATION OF IMOD™ SYSTEM

The implementation of the IMOD system shown in Figure 2, consists of five features described below. 1) *Course Overview* – a feature used to capture information on the learning environment (e.g., type of course, meeting days and times, instructor(s) information, course policies, etc.). 2) *Learning Objectives* – a feature used to guide the user through the creation of learning objective statements that conform to the PC$^3$ model. Revised Bloom's taxonomy of learning objectives [13] was also used in this feature to help the user describe performance characteristics. 3) *Content* – a feature used to capture information on the course topics. The content prioritizing model by Wiggins and McTighe [10] and the Knowledge Dimension from Anderson and Krathwohl version of Bloom's taxonomy [13] are also used in this feature. 4) *Assessment* - features used to suggest relevant assessment techniques based on the type of learning and evaluation criteria specified in the learning objectives. 5) *Pedagogy* - features used to suggest relevant instructional techniques based on the type of learning and knowledge specified in the learning objectives.

## IV. FUTURE WORK

The design of the IMOD system is still ongoing, and will be further described in future publications. Some of the implementation has already underway. Once the first version is completed, user testing will be conducted to test for effectiveness, efficiency and usability.

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