Instructional Module Development (IMOD) System: A User Study on Curriculum Design Process

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Abstract— **A team of researchers are engaged in a User-Centered Design (UCD) approach to develop the Instructional Module Development System (IMOD), i.e., a software program that facilitates course design. This paper describes the results of the focus groups, and surveys facilitated to elicit feedback from potential users on the features and usability of the IMOD system.**

Keywords—instruction design; outcome-based education; semantic web-based application; user-centered design

I. INTRODUCTION

Outcome-based Education (OBE) is a result-oriented approach where the product defines the process. The learning outcomes guide what is taught and assessed [1], [2]. This approach contrasts the preceding "input-based" model that places emphasis on what is included in the curriculum as opposed to the result of instruction. OBE gained great traction at the K-12 level and was adopted by a number of school districts and state systems (including Kentucky, Michigan, Minnesota, Missouri, Pennsylvania and Washington). The model provides a win-for-all solution; not only has it lead to student success, shown through higher achievement test scores, and improved attendance and motivation [3]; but it provides educators with an empirically driven structure for tracking impact, and identifying problems. There is a growing demand and interest in faculty professional development in areas such as 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. A team of researchers at Arizona State University are engaged in the development of an Instructional Module Development (IMOD) System to further support these ventures and broaden the impact and reach of professional development in the scholarship of teaching and learning, particularly to STEM faculty. While there are a number of options available to faculty for receiving instructional development training (i.e., training focused on improving teaching and learning), most share similar format, features, and shortcomings. For example: workshops, courses and seminar series, the most common program structures, are often offered at a cost to the institution, department or individual attendee; delivered face-to-face at specified times; and accessible to a restricted number of persons. Even when interest is high, these factors can become obstacles to participation [4]. The IMOD system will facilitate self-paced instructional development training while the user creates his/her course design with the added benefits of being free to all who are interested, accessible almost anywhere through a web browser, and at any time that is convenient.

II. BACKGROUND

A. IMOD System

The IMOD system, currently under development, will be an open-source web-based course design software that:

(i) 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)

(ii) 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

(iii) Generates documentation of a course designs. In the same manner that an architect's blue-print 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

(iv) 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

(v) 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.

The IMOD system will be developed using a user-centered design (UCD), as opposed to technology focused, methodology [5]. This approach is well suited for the project given the high cognitive nature of outcome-based course design tasks, and the high levels of interactions required between the user and the system to not only facilitate the development of course designs,

but to help users build an enduring foundation of knowledge, skills and habits of mind about curriculum development.

B. User-Centered Design

UCD is an emerging design method that focuses on both operational and technical requirements by observing and understanding user needs and wants, as well as by prototyping and testing software throughout all phases of software lifecycle. It enables the capturing and resolution of any mismatches between users and software early on. The main objective of UCD is to allow for a closer match between users and the software, leading to a more intuitive interaction. As a design process, it also has the objective of reaching that goal in the most resource-efficient way, in terms of time and cost through careful planning and execution [6].

The UCD process can be divided into five main phases: Plan, User Research, Design, Develop, and Measure.

Plan:

In this phase, we carefully study and analyze the domain, the intended application concept, the stakeholders and their needs, the budget and time available, and the approach, tools, and deliverables to best serve the project needs. Initial budget needs and distribution, as well as high-level tasks and effort distribution are identified. A customized UCD process is planned, including the selection of specific tools and techniques, and the determination of deliverables and their templates. Each successive phase will have a minor planning part as well.

User Research:

User research has 3 parts. A) We expand on the part of the plan regarding user research. We determine how to approach the users, the number and locations of users, how to find and recruit a representative sample, how much it will cost, what questions to ask, and what data to collect. B) We execute the user research as planned, and collect the necessary data. C) Synthesis comes immediately after user research activities or- often enough- in parallel for greater effectiveness. The main objective of synthesis is to enhance our understanding of the real domain forces and user needs, and to present them in a format that is easy to communicate between team members. During synthesis sessions, we go through collected data and make the best sense of it. This is a critical phase and a challenging one as we cross from a subjective, seemingly unrelated, or even contradicting users' and stakeholders' data into concrete, concise sets of objective data that will eventually lead to a meaningful design.

Design:

Design activities focus on crossing the gap from user needs and requirements (problem domain) into solution domain, where we work on early application structure, wireframes, and storyboarding, as well as multiple levels of prototyping. At this stage, it is imperative for the development team to keep close collaboration with the users to ensure cohesion. This will ensure that developers design an application that the user really wants, not an application that *they think* they want. It is often

preferable to divide this phase into high-level design as well as detailed design sub-phases to provide a better handle on complexity, and to allow for on-the-spot improvement at higher level, without being overwhelmed by unnecessary details too early.

Develop:

With UCD approach, development starts much earlier than actual coding of the software application. As soon as the user needs and application conceptualization artifacts are clear enough, we start by developing multiple stages of prototyping:

1) Early paper mockups
2) Interactive electronic prototypes mockup; a low-cost throwaway version to test the interaction and navigation of the application.
3) Incremental prototype using the actual application framework and incrementally building the source code of the actual software.

Informed use of the most suitable prototype techniques, and related tools ensure fast and effective transition from vague requirements and needs into clear problem conceptualization and then into working software.

Measure:

Measuring software gives accurate and timely feedback and the needed modifications and corrections. UCD relies heavily on measuring the software from the early phases of high-level design, and repeating it on a parallel track henceforth. This is often done in terms of successive usability tests to ensure accurate and progressive feedback and guidance. We perform early usability tests using paper prototypes, and latter use high-level prototyping tools. This approach provides valuable feedback and inexpensive opportunity to clarify and modify the design as needed. We pay special attention to do just the needed amount of usability testing to avoid common cost overrun.

III. RESEARCH OBJECTIVES

While one of the key deliverables of the IMOD project is the software tool, the primary focus of this project is to advance the development of faculty expertise in course design for undergraduate STEM education. To this end, the project addresses the following two research goals:

(i) Identify areas of improvements in user interactions with existing course design tools.

(ii) Obtain consensus opinion on a representation of the required knowledge (learning taxonomies, help data and pedagogical and assessment strategies) for designing a course or learning environment.

IV. IMPLEMENTING THE USER RESEARCH PHASE

The IMOD project is at the end of the first year of the three-year development period. Thus far, the research team has focused on the user research phase of the UCD process. In this respect, 4 focus groups sessions were conducted with prospective users of the IMOD system to gather insights on how faculty approach the task of designing a course.

A. Recruitment of Participants

The research team comprises faculty from an engineering and computing systems department that offers both face-to-face and online programs. Participants for the focus group were recruited from faculty within the department and from the team of instructional designers that support the implementation of online courses. A recruitment email was sent out to the identified population describing the objectives of the study, and expectations for participation in the focus group sessions. Interested participants were then directed to an online form where they were able to identify their availability from the list of possible session options. Once a critical mass was attained for any given session i.e., at least 4 persons, the focus group was scheduled and a follow-up email was sent to the participants with instructions for completing pre-session background info and curriculum design tools surveys; and choosing food preferences, since lunch was provided as an incentive/compensation for participation.

B. Data Collection

Prior to the start of the focus group session, all participants received a consent form. Data (i.e., information from the pre-session surveys and contributions made during the session) was only used from participants who gave signed consent. To kick-off the start of the session, which lasted 90 minutes; the moderator (i.e., a member of the research group) provided a brief overview of the study and discussed the goals of the focus group. Participants were then presented with the scenario shown in Figure 1, and asked to respond.

Figure 1: Scenario presented at Focus Group Session

As participants provided responses, the moderator summarized the contributions aloud. This summary was then verbally confirmed by the participants and in turn, captured by the moderator, using key words, on a large flip chart, in one of three bins, labelled: Input, Processing and Output. Each session was audio recorded; however, most of the data that was processed from the focus groups came directly from the notes captured by the moderator on the large flip charts.

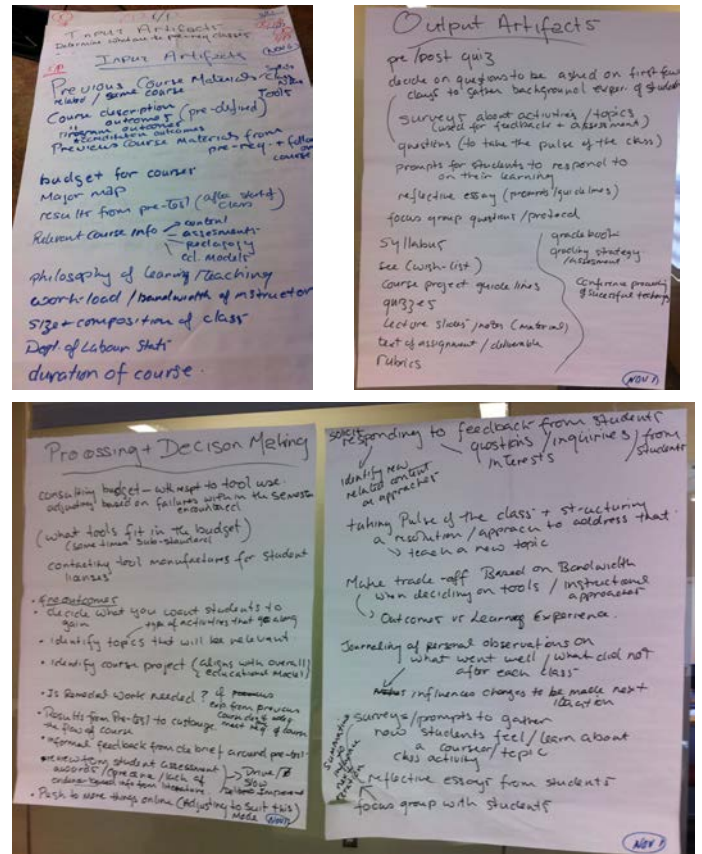Figure 2 shows an example of the notes recorded on a flip chart in the Input, Processing and Output bins.

Figure 2: Notes from Focus Group Captured on a Flip-Chart

C. Focus Group Participants

A total of 19 participants contributed to the focus groups. Tables 1 and 2 provide a breakdown of their background.

Table 1: Participant Background

	Tenured /Tenure Track	Clinical	Lecturer	Instructional Designer
Male	8	0	4	3
Female	0	1	0	3

Table 2: Participant Professional Experience

	Mean	# of Responses	Standard Deviation	Range
Number of undergraduate courses designed	4.4	19	3.2	2-15
Number of undergraduate courses taught	2.8	19	1.6	0-6
Years of Teaching Experience	15.7	19	12.4	0-36
Years of Industry Experience	5.9	17	7.5	0-30
Year of Research Experience	10.6	12	9.9	0-35

D. Analysis of Curriculum Design Tool Survey

Table 3 shows the list of the 10 most identified tools in the Curriculum Design Tool survey.

Table 3: Curriculum Design Tools

Tools	% of Participants
Blackboard	89%
Word	78%
PowerPoint	67%
Excel	56%
Whiteboard	44%
Email	33%
Webpages (with content related to course or other related education topics	33%
Learning Studio	22%
CATME	22%
Camtasia	22%

The Curriculum Design Tools survey data was analyzed and the following deficiencies in user interactions with the current course design tools were identified.
- Learning Management Systems do not optimize learning experience
- Tools provide too many features that are hard to use
- Clunky/poor interfaces and navigation is not intuitive
- Many tools are missing ease of use.
- Visualization improvements can be made
- Documentation and help tutorials that support use of a tool would be useful
- Poor support for different kind of platforms and devices
- Bugs and glitches in software
- Do not provide collaborative editing capabilities
- Concerns about data security and privacy

- Tools are expensive
- Time consuming to locate useful features and information
- Long and steep learning curve with some tools

E. Analysis and Synthesis of Focus Group Data

Consolidation Time Urgency

We put the goal to consolidate each session immediately after it was done, or within the following few days to overcome common consolidation challenges:

1) **The Formalization Barrier**:
As we capture the information during the focus group session, the moderator is typically flooded with a wealth of information. The challenge is identified at 3 levels:

   a. **The multitude of input**, where multiple participants tend to talk together

   b. **Relevance**, where the moderator needs to understand and filter the input on a real time basis, focusing on what is deemed relevant

   c. **Simultaneity**, where the moderator needs to write down a summary of the captured idea

While the moderator had only brief moments of formalizing the captured ideas in words and writing them on a sheet of paper, the sessions were generally manageable, where most participants held back their talking when the moderator started writing. In ideal situations, the participants also helped the moderator in formalizing the captured ideas into concrete and correct terms that accurately capture their thoughts and explanations. This greatly added to the quality of the information captured. However, the challenge was to really formalize the wealth of ideas in few accurate key words that are compact but descriptive enough to overcome the other barrier of recall.

2) **The Recall Barrier:**
The amount of information discussed in each focus group session of 90 minutes is relatively large. Several reductions help reduce it (irrelevant information, noise, unclear, or non-understandable information). However, a good deal of relevant and important information is discussed during each session. The reality is that the moderator has few moments to write some representative keywords on the flip chart sheet (the externalized part). The majority of information is held in the memory of the moderator and the reserach team (the internalized part). The retention part typically decays fast over the following few days. Research has shown an exponential decay rate of the amount of information held and recalled, following an exponential drop known as the power law of forgetting [7]. This can greatly reduce the quality of information in two different ways:

a. Key words that were captured on the flip chart could lose the associated meaning and details after few days since they were only cryptically recorded (externalized) on paper, but the related explanation (the internalized part of it) was held only in moderator's memory.

b. Relevant information that was important but was never captured on the flip chart due to the lack of time during the session could be forgotten if the moderator did not consolidate them in the next few days.

Reviewing and Overviewing

The primer tracks that were identified early on (Input, Processing, and Output bins) remained relevant throughout all the focus group sessions, so the research team used them as the three main tracks for the final consolidated artifacts. Namely, the consolidated data findings collected from all the sessions included three groups following the original primer tracks. The first consolidation session went through the data captured during the first focus group session (raw data), and after discussions among the three main investigators, a more concise, refined, and relevant set of data (processed data) was produced. For each successive focus group session, a consolidation session followed immediately afterwards to consolidate the new raw data into the existing processed data. In the end, we had one set of consolidated data for each of the three primer tracks that was the collective knowledge accumulated throughout the entire series of focus groups. Figure 3 shows the consolidated data from the Input bin. Figure 4 & Figure 5 show the consolidated data from Processing and Output bins respectively.
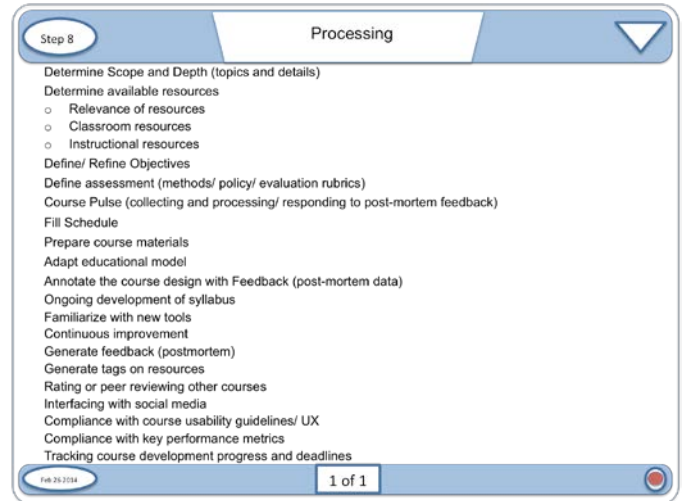

Figure 3: Consolidated Input data

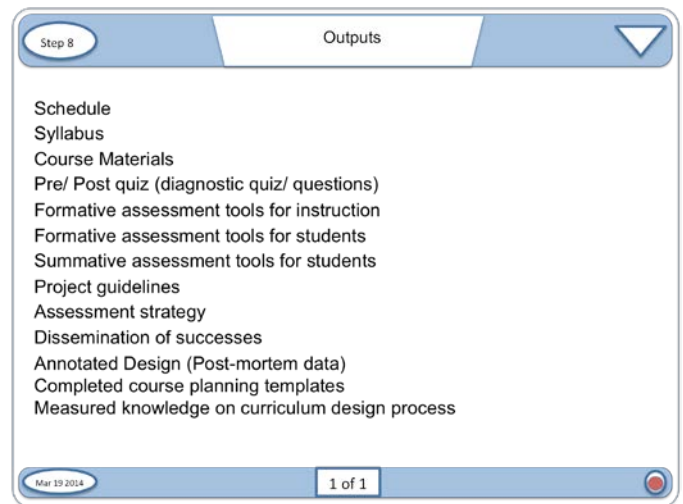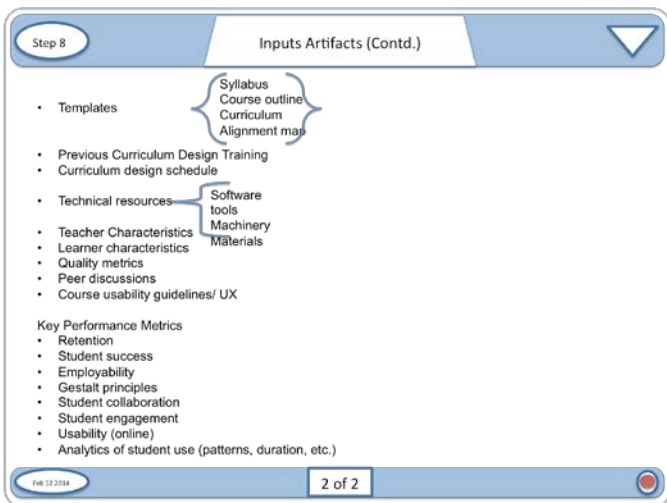**Figure 4: Consolidated Processing data**

Figure 5: Consolidated Output data

Resulting Artifacts

Additional artifacts were also identified to help support the project like an ontology, which defines the relevant terms of the domain and identifies their specific meaning as well as the potential relationships between them; and mental model, which is a tool to improve understanding of the user needs and activities.

1) Ontological Model

The IMOD software system will use Semantic Web technologies to provide intelligent interactions with the users, dictate a course design process in conformance with the underlying framework, check for omissions and inconsistencies in the design, provide feedback to the user on their course design, and recommend relevant assessment and pedagogical approaches along with help on how they are implemented. The

IMOD framework will be translated into a rich meaningful knowledge structure in the form of an ontology, i.e., an explicit and formal specification of a conceptualization [8]. During the course design elicitation process, logical inference algorithms will test the course design for consistency and adherence with the ontological model.

The results from the focus group helped identify important terminology that will server as ontological concepts and relationships between concepts. Figure 6 shows the hierarchy of concepts.
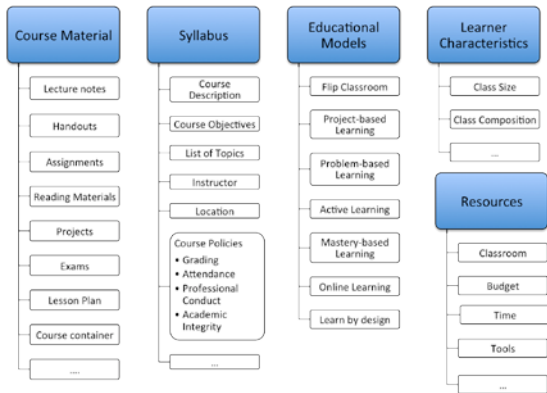

Figure 6: Ontological concepts and relationships

2) Mental Model:

We used mental modeling as a supplemental tool to improve our understanding of the user needs and activities. The process started with a high-level identification of the "User Mental Space", which is a graphical representation of the users' view of the application in terms of their motivation (why they need/want to use the tool for), Goals (What they need to achieve), tasks (Steps), and activities (detailed actions). After discussions, we look for patterns of repeated and common activities. We decided to limit the process of building a mental model to one session due to resource limitations, but we were able to get good results and build a representative model. We grouped them by building an affinity diagram of similar activities, and organized them sequentially into 9 towers as shown in Figure 7, upper half. The lower half included the detailed and relevant activities that would roughly correspond to application features and functions.

V. FUTURE WORK

Following the user research phase of the project, the next step will be the high-level design of the IMOD system. We plan to use 2 tools that will be most suitable for this phase of the project: Navigation Model and Prototyping. The navigation model will illustrate how all user interface screens should be connected. Ideally this should reflect the user's mental model to facilitate intuitive navigation between screens to accomplish the task of instructional design. We also plan to create a high-fidelity prototype that will provide details of all the key screens and a number of auxiliary screens with appropriate navigation between them. We will conduct usability testing of the prototype using user interviews and other usability testing methods.
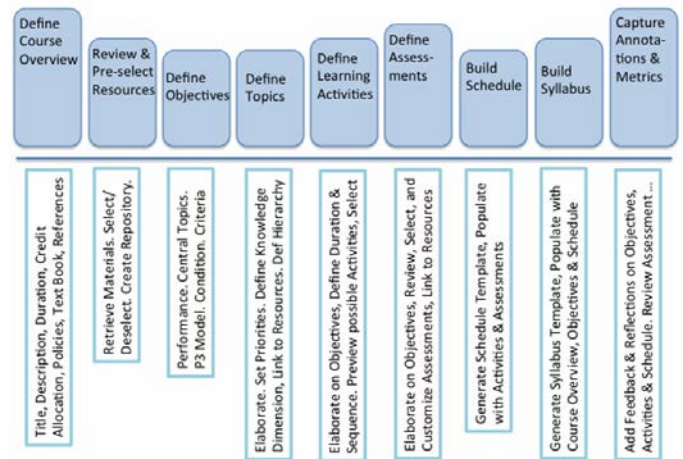

Figure 7: Mental Model

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