Evaluation of Instructional Module Development System

by

Vaishnavi Raj

A Thesis Presented in the Partial Fulfillment
of the Requirements for the Degree
Master of Science

Approved May 2018 by the
Graduate Supervisory Committee:

Srividya Bansal, Chair
Ajay Bansal
Alexandra Mehlhase

ARIZONA STATE UNIVERSITY

August 2018

ABSTRACT

Academia is not what it used to be. In today's fast-paced world, requirements are constantly changing, and adapting to these changes in an academic curriculum can be challenging. Given a specific aspect of a domain, there can be various levels of proficiency that can be achieved by the students. Considering the wide array of needs, diverse groups need customized course curriculum. The need for having an archetype to design a course focusing on the outcomes paved the way for Outcome-based Education (OBE). OBE focuses on the outcomes as opposed to the traditional way of following a process [23]. According to D. Clark, the major reason for the creation of Bloom's taxonomy was not only to stimulate and inspire a higher quality of thinking in academia – incorporating not just the basic fact-learning and application, but also to evaluate and analyze on the facts and its applications [7]. Instructional Module Development System (IMODS) is the culmination of both these models – Bloom's Taxonomy and OBE. It is an open-source web-based software that has been developed on the principles of OBE and Bloom's Taxonomy. It guides an instructor, step-by-step, through an outcomes-based process as they define the learning objectives, the content to be covered and develop an instruction and assessment plan. The tool also provides the user with a repository of techniques based on the choices made by them regarding the level of learning while defining the objectives. This helps in maintaining alignment among all the components of the course design. The tool also generates documentation to support the course design and provide feedback when the course is lacking in certain aspects.

It is not just enough to come up with a model that theoretically facilitates effective result-oriented course design. There should be facts, experiments and proof that any model succeeds in achieving what it aims to achieve. And thus, there are two research objectives of this thesis: (i) design a feature for course design feedback and evaluate its effectiveness; (ii) evaluate the usefulness of a tool like IMODS on various aspects – (a) the effectiveness of the tool in educating instructors on OBE; (b) the

effectiveness of the tool in providing appropriate and efficient pedagogy and assessment techniques; (c) the effectiveness of the tool in building the learning objectives; (d) effectiveness of the tool in document generation; (e) Usability of the tool; (f) the effectiveness of OBE on course design and expected student outcomes. The thesis presents a detailed algorithm for course design feedback, its pseudocode, a description and proof of the correctness of the feature, methods used for evaluation of the tool, experiments for evaluation and analysis of the obtained results.

DEDICATION

I would like to dedicate my thesis to my family. My parents, with their unwavering love and support have given me the strength and determination to persevere through the difficult stages in life, including the challenges faced throughout the duration of my Master's and my brother, whose faith in me has always pushed me to do better.

ACKNOWLEDGMENTS

I would like to take this opportunity to thank Dr. Srividya Bansal for her incredible guidance and support for my thesis and in the other aspects of my career. I would also like to thank Dr. Ajay Bansal and Dr. Alexandra Mehlhase for being on my committee.

TABLE OF CONTENTS

Page

CHAPTER Page

LIST OF TABLES

Table Page

LIST OF FIGURES

Figure Page

CHAPTER 1

INTRODUCTION

1.1 Motivation

STEM education is continuously evolving, but in today's world there is a rapid increase in the rate of this evolution. To go hand in hand with the changing trends, academia needs to change the traditional strategy of teaching and focus on a result-oriented approach, that is, an effective mechanism to design a course is required. According to Boice [8], 95% of the new instructors take three to five years to come up with an effective course plan. A very small percentage of 5 can do it in one to two years. Usually instructors go about teaching the same way that they were taught, which might prove to be ineffective. Thus, there was a need to come up with a structured methodology and a design model that would guide instructors through the process of developing a successful course design.

Various organizations such as NSF, ABET and NAS have focused on finding methods to support STEM education that go beyond the existing traditional methods. The reason, according to Fairweather [22], is that recent years have seen a decrease in the number of students opting to choose a major belonging to the STEM field, in the number of students graduating and the number of students enrolling in STEM courses in undergrad. This has various social and economic consequences. According to Seymour and Ferrare [24], major reason is the poor STEM teaching practices in colleges. To address all these issues NSF has funded many educational research projects. Many universities have also tried to put in efforts to improve teaching and learning [25].

One of the most widely used version of Outcome-based Education is by Spady. According to Spady [9], for the instructors to be able to successfully help the student

achieve their goal, the objectives of the course pertaining to the outcomes expected has to be very clear. The following are the major steps to set up an effective curriculum: (i) Defining a course objective and the Intended Learning Outcomes (ILO); (ii) Designing assessments such that proof can be shown that the student did indeed learn what was intended; (iii) Designing student-centered teaching and learning activities. One of the main reasons the use of OBE is rapidly increasing is because of its focus on the process of learning and the learning environment [9].

The principles of OBE have already inspired a few models for course design such as – Effective Course Model by Fedler and Brent [4] and Integrated Course Design by Fink [5]. Not only is it important to come up with a course design methodology, it is also essential that we be able to prove the efficiency of the proposed approach.

1.2 Research Statement

IMODS is one such model implemented with the intention of providing a significant awareness to Outcome Based Education, which focuses on outcomes rather than the process or input. One of the goals of IMODS is to familiarize instructors to OBE and impart some knowledge on it. Results are what matter in STEM education and the tool is designed to structure an instructor's thoughts while they are going through the process of designing the course. The following are the major goals of the thesis:

1. Design a feature for effective feedback to the instructor based on their given learning objectives and chosen assessment and pedagogical techniques. Evaluate this feature for its correctness by conducting experiments and measuring the accuracy of it.
2. Evaluate how effective the tool is in familiarizing and educating instructors on Outcome-based Education as well as various other aspects such as the learning

objective creation, usability and the repository of techniques available for instruction(pedagogy) and assessments.

CHAPTER 2

BACKGROUND

2.1 Bloom's Taxonomy

The focus of Outcome-Based Education (OBE) is on the product and not on the process. So, defining the goals and objectives clearly is very important as the complete course design is dependent on them. Knowledge of Bloom's Taxonomy helps instructors compartmentalize the various aspects of the course objectives and design each objective with specificity and precision. Learning is classified into three categories – cognitive (mental skills), affective (emotional growth) and psychomotor (physical skills) [3]. There are different levels of knowledge and excellence that can be obtained for each of the learning domains and thus we have six domain categories – remember, understand, apply, analyze, evaluate and create [10]. Along with having domain categories, Bloom's taxonomy also has a mechanism of labeling the actual content – factual, conceptual, procedural, metacognitive. Any content can encompass a learning domain category and any combination of the knowledge dimensions.

2.2 Outcome Based Education

Unlike the traditional methodologies adopted for teaching, new ways are being looked for due to rapid change in the field of technology and for the need of it being included in a course curriculum. The focus of this method, as the name suggests, is the outcomes [12]. The learning outcomes need to be well-defined and specific. In traditional systems, the focus is on the process and not on whether the students learn any of the material.

The focus of OBE though is on maximizing the student performance by carefully designing the outcomes to match the level of learning expected from the

students. The main advantages of this method are clarity (having clear, well-defined objectives), flexibility (ability to adopt methods of instruction based on the needs of the student), comparison (it can happen within the class to the level of institutions) and student involvement.

2.3 Related Work

2.3.1 Theoretical Models

Traditional teaching methods including the OBE are approaches where the outcome defines the process. Decisions on how the content is organized, the strategies and assessment procedures need to be made. Based on the above requirements, OBE solves many of them and has been chosen for a variety of reasons:

1. Provides a solution to both the students and educators, by giving them a better success rate in learning and a structured way for the educators to design the courses.
2. Easy method to learn frameworks and then design learning environments.
3. In STEM fields outcome-based learning has gained a lot of traction with Accreditation boards such as ABET [11].

Many models have been developed to demonstrate the application of OBE for the design of effective courses.

1. Effective Course Model by Felder and Brent: This model develops a framework for designing instructional development programs to equip engineering educators to adapt to the growing trends of the modern world [4]. It stresses on the fact that many existing programs vary significantly – geographically and academically. To make any course effective, it requires the application of certain criteria to the design and delivery of the program and the involvement of faculty in the design.
2. Integrated Course Design by Fink: This model, like the above operates on a backward-looking design process [5]. The results are first identified and upon them assessments have been provided to achieve those results. The integrated course

design operates by taking the situational factors and provide a backward design approach on a closed loop of three factors, i.e, Learning Goals, Teaching and learning Activities, Feedback and Assessment.

3. Understanding by Design Framework (UbD): It has a three-stage backward design process for planning the curriculum for the course [13]. A template and a set of design tools for the process. One of the major concepts in UbD framework is the alignment. All the stages must clearly align, to both standards and to one another. Stage 1 content and understanding should be assessed in stage 2 and taught in stage 3. Stage 1 tries to understand the priorities and have a structure on it. It considers the goals, examine established standards and review the curriculum expectations. Stage 2 identifies two types of assessment, performance tasks and other evidence. The performance tasks ask the student to apply their learning on to a new problem, on which their understanding ability and the ability to transfer their understanding is judged. Stage 3 teachers plan their lessons and learning activities based on three different types of goals identified in Stage 1.

4. Content Assessment Pedagogy Model: The framework presented is based on outcome-based course design [14]. One of the key features of the paper is the authors argue about aligning content assessment and delivery. A comparison of this model can be made to an engineering design approach. Also, stresses on the fact that teachers of the 21st century need to consider setting aside their roles as teachers and take an active role in designers of learning experiences.

One common thing that has been observed through all the models mentioned above is the alignment between various components of a course, which will then provide relevant information for strategies. Another objective of the Content Assessment Pedagogy Model is to provide a model for aligning course content with assessment and delivery that practitioners can use to inform the design or re-design engineering courses.

2.3.2. Software Tools

Three major software applications are discussed below.

1. Electronic Performance Support System (EPSS): A system or a category of systems that helps users in improving performance is called an EPSS [15]. It is an electronic environment that helps users do their job with minimal help and support by others. Thus, it provides a complete range of information, data, tools and guidance to enable users to do their job on their own. Using this kind of system reduces training costs and helps save the time of the experts who would previously have to train and help the employees with their tasks. It is also helpful in scenarios where employees would be required to have a certain base knowledge about their job before they start working on it, by providing them with the relevant information. As one of the features of IMODS is guiding the user through a complex process in a systematic and organized manner, an EPSS is pretty much like IMODS.

2. Learning Management System (LMS): Some systems act as online instructors, and sometimes even replace classroom teachers. An LMS is such a system. According to [21], LMS is used for administration, documentation and progress reporting of the student. These systems can be used to provide subject matter and notes to the student, answer queries the student might have about a topic, and even conduct and grade online assessments. In contrast, IMODS is used to facilitate the instructor in course planning according to the instructors' learning objectives, instead of the tool's.

3. Knowledge Management System (KMS): A KMS is a system that helps knowledge sharing among people. It helps to organize knowledge by sharing experiences of the user, and by recording past successes and failures. Along with recording all the information, it can also be used for knowledge sharing. Information stored onto this system can be shared amongst people so that everyone with access to this system can make use of the information previously recorded. Thus, a KMS enables

organizational learning. Examples of KMS are Blackboard [16] and Moodle [17]. IMODS is quite different from KMS in that it focuses on institutional educational learning, and not organizational. However, a way both systems are similar is that both make use of ontologies.

2.4 Instructional Module Development System (IMODS)

2.4.1 Theoretical Framework

There are a few tools that have already been developed for course design that are based on OBE. All of them have considered the main components of the course design to be learning objectives, content, assessments and pedagogy [7]. Not only should these elements be included while designing a course, it is also important to maintain a level of alignment between all the components. Keeping the existing useful elements from the other models, IMODS has added various other elements that make it different. It deeps dive in the first step – defining the learning objectives.

Learning objectives are obviously one of the most important parts of designing a result-oriented course. And thus, Performance, Content, Criteria, Condition (PC^3) model was designed. It takes into consideration, the performance (expected from the course), content (things to be learnt), criteria (level of success to be achieved) and condition. Interactions of these elements are used to integrate the other components – Content, Pedagogy and Assessment. Performance and criteria are used for defining Assessment, content and performance are used to define Pedagogy and Content is defined based on content and condition components. The inclusion of additional components and the focus on the alignment among all aspects of course design makes IMODS highly effective.

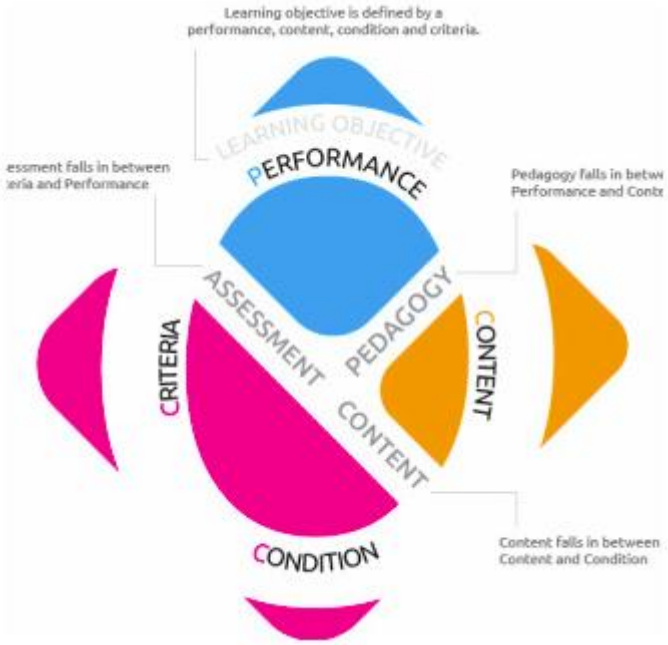

Figure 1: PC³ Model

2.4.2 Flow of IMODS Application

IMODS is a web application that assists instructors in designing curriculum based on OBE. For users not familiar with OBE, the application acts as a tutorial. As OBE is result-oriented, IMODS first prompts the user to have a set of well-defined learning objectives (based on learning domains and domain categories from Bloom's taxonomy). After learning objectives are defined based on a unique technique (PC³ model), assessment and pedagogy techniques need to be chosen. There is already a vast database of techniques for assessments and pedagogy that are suitable for a large portion of STEM-related courses. Each learning objective is tied to one or more assessment and pedagogy techniques. A user can also create new techniques that uniquely satisfies the user's need. This can be saved in the database for future use as well.

IMODS also provides the feature of scheduling on a calendar, all the activities can be organized and maintained. It generates a document of syllabus, course information and the assessment and pedagogical techniques used. The tool also provides control to the instructors over sharing of any course related information with the students. In the end, IMODS intends to have given the user a little more insight into OBE and how it can be used and be influential in getting results in a class.

2.4.3 Implementation of IMODS

The tool is meant to have a step-by-step process as mentioned in section 2.4.1. It is an open source web application. The system architecture is the Model-View-Controller (MVC) model. Several technologies were considered, and the best suited technologies were chosen for implementation [20]. The framework for MVC was chosen to be Grails (Groovy on Rails). PostgreSQL was the chosen NoSQL database, along with Jenkins for continuous integration and Git for version control.

The whole system adheres to the PC3 model, making sure that alignment is maintained between all the components – objectives, assessment and pedagogy.

2.4.4. Evaluation Instruments

New instruments need to be designed for evaluating the tool. Several different criteria need to be taken into consideration. The following factors have been considered with respect to the criteria for evaluation:

1. The usability of the tool [28].
2. The tool should be effective in achieving its main objective – guide the instructor step-by-step to design a course [29].

3. The tool should generate effective documentation [1].
4. The tool should educate the instructor on OBE [1].

In order to find instruments that can help in doing the above, I read several research papers and books on not only education techniques and its research but also web tools. For the tool's usability, I have used the questionnaire-based evaluation [26]. A usability questionnaire contains statements regarding the tool's intuitiveness and usage and asks the participant to rate their experience on a Likert scale.

The tool also generates syllabus document. This needs to be evaluated as well. So, I collected the syllabi documents of the courses designed using the tool - before and after. A comparison between these documents gave a clear picture of the things lacking in the old document and the faults in the auto-generated document as well.

Based on [22], the idea of using pre- and post- tests for evaluating the instructor's knowledge of OBE is chosen. This method basically consists of two sets (pre and post) of tests – with the same question set in both. The pre-test is administered before the use of the tool and the post-test will be taken by the participants after they have used the tool.

Apart from the above-mentioned techniques, the method of interviewing [27] has also been chosen as a way to get more insight into the instructor's experience using the tool and what they felt to be good and lacking. According to Alshenqeeti [27], interviews are a way of getting the data that cannot be uncovered with techniques like questionnaires and observations.

Thus, the final set of techniques chosen are – questionnaires, interviews and pre- and post-tests.

CHAPTER 3

APPROACH AND IMPLEMENTATION FOR COURSE DESIGN FEEDBACK

While the tool is intended to be intuitive, it is also necessary to provide the user with feedback required so that they can design the course as best as possible. So, along with the progress bar which indicates the level of their progress on the course, a feedback feature has been implemented. If the progress bar just indicates the level of progress and gives no indication of how exactly to achieve a hundred percent complete course structure, it is not very helpful. And so, in order to guide the instructors designing the course on where exactly their course might be lacking, a feedback feature is implemented.

3.1 Approach

The major components to have a complete course design are:

i. Course Overview
ii. Instructor Information
iii. Learning Objectives
iv. Content
v. Assessment Techniques
vi. Pedagogy Techniques

Counts are considered to determine the lacking components in the course. The criteria for each is as follows:

i. Course Overview – The required fields should be filled.
ii. Instructor Information – At least one instructor needs to be added.
iii. Learning Objectives – At least three learning objectives have to be defined.
iv. Content – Six content topics should be defined.

v. Assessment Techniques – At least one technique has to be selected for each learning objective.

vi. Pedagogy Techniques – At least one technique has to be selected for each learning objective.

The previous algorithm for progress calculation took into consideration the count of assessment and pedagogy techniques over the whole course. I have changed it such that, now each objective must have one assessment and one pedagogy technique.

3. 2 Implementation

The application has been designed in such a way that it requires the basic information of the course to be filled before moving forward in the process. It means that basically the Course Overview information is required (Course Title, Course Number, Start Date, End Date, Start time, End time and Subject Area). This takes care of the first requirement. Once the user fills out this information, the Instructor field, along with the Learning Objective tab, Content tab, Assessment Tab and Pedagogy Tab are displayed to the user.

Since the user does not get access to all the tabs in the first step, it doesn't make sense to give them feedback about those tabs. So, the first message says, "Please fill the Course Overview section to see the minimum requirements for completing the course design." Then, once the first section is filled, information regarding the next steps is given. The algorithm is shown in the tables below, for each component of the course design.

```
int minLo = 3;
int minContent = 6;
int minInstr = 1;
String initial =  'Please fill the course overview to see the minimum requirements to complete the course design.';
```

```
String instStatus = 'Add instructor Information </br>';
String loStatus = ‘At least three learning objectives need to be defined - ';
String contentSstatus = ‘ At least six content topics need to be defined - ;’
String asstStatus = ‘At least one assessment technique needed for each objective. </br>’
String pedStatus = ‘At least one pedagogy technique needed for each objective. </br>’
info = ‘IMOD Info’;
if (ImodID == “new”):
   info += initial;
else if (CourseOverviewCompleted):
   if !(InstructorInfoCompleted):
      info += intStatus;
```

Table 1: Defining constants and Course Overview Feedback.

```
int LoCount = 0;
LoCount = currentImod.learningObjectives.length;
if (LoCount <= minLo):
   info += loStatus + LoCount +‘ defined. </br>';
```

Table 2: Learning Objectives Feedback

```
int ContentCount = 0;
ContentCount = currentImod.contents.length;
if (ContentCount < minContent):
      info += contentStatus + ContentCount + ‘ defined. </br>’;
```

Table 3: Content Feedback

```
int AsstTechCount = 0;
AsstTechCount = currentImod.learningObjectives.Asst.count;
if ( AsstTechCount <= loCount):
   info += asstStatus;
   asstPercent = 100 – (loCount - AsstTechCount)/ loCount * 100;
else:
```

```
asstPercent = 100;
```

Table 4: Assessment Feedback

```
int PedTechCount = 0;
PedTechCount = currentImod.learningObjectives.Ped.count;
if ( PedTechCount <= loCount ):
   info += pedStatus;
  pedPercent = 100 – (loCount - PedTechCount)/ loCount * 100;
else:
  pedPercent = 100;
```

Table 5: Pedagogy Feedback

The screenshots below show the step by step process with all the feedback provided at each stage.

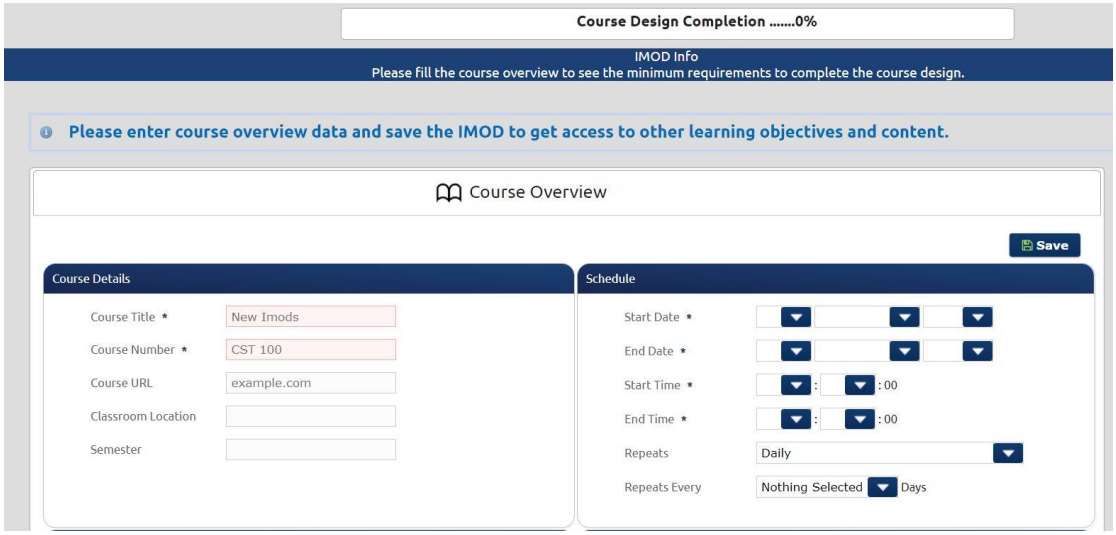

Figure 2: New IMOD - Initial Screen

Figure 3: New IMOD - Course Design Status

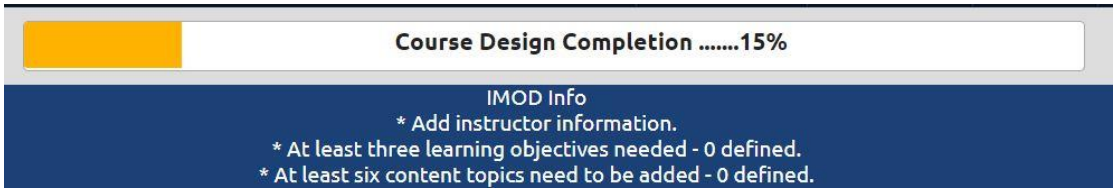

Figure 4: Course Overview Filled

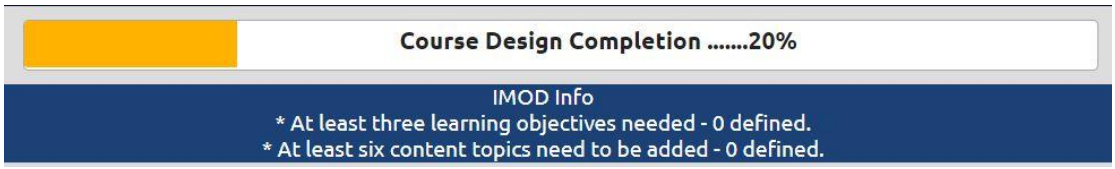

Figure 5: Instructor Information Added

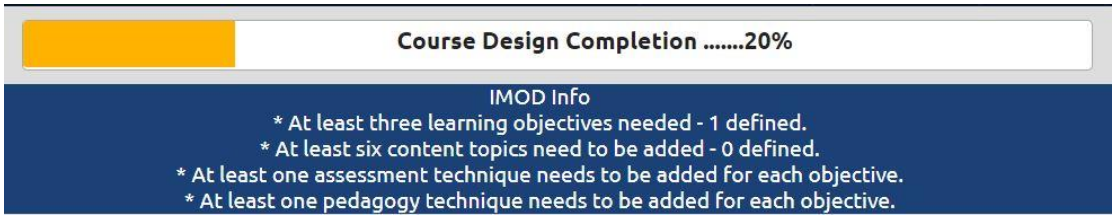

Figure 6: One Learning Objective defined

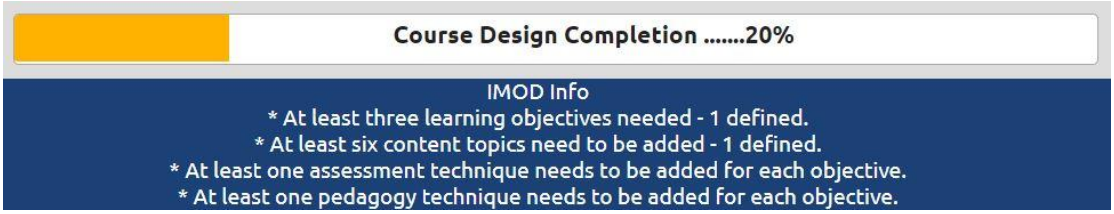

Figure 7: One content topic added

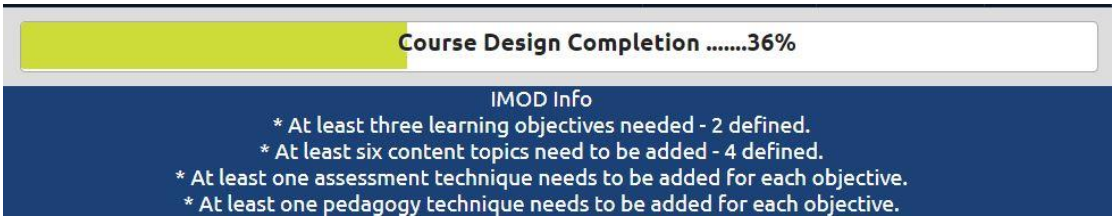

Figure 8: Two Learning Objectives and 4 content topics defined

Figure 9: Three Learning Objectives added

Figure 10: Six content topics added

Figure 11: Assessment technique added for one objective

Figure 12: Pedagogy technique added for one objective

Figure 13: Assessment techniques added for all objectives

Figure 14: Pedagogy techniques added for all objectives - design complete

3.3 Evaluation

The evaluation of this feature is presented in Chapter 5. The methodology adopted is explained here. All the major components required for the course design are taken into consideration. Each of those represent one column in the table. Each row is a new IMODS. A combination of various components is used to build each of these IMODS. The expected feedback result based on the conditions mentioned in the previous section and the actual feedback result obtained are compared. If both the expected outcome and the actual outcome match, then the condition for that part of the system is considered to be correct.

Ten sample IMODS have been created for testing purpose. The table and results are presented in Chapter 5.

CHAPTER 4

EXPERIMENTAL STUDY FOR EVALUATION OF IMODS

In this section, the research questions will be further broken down into sub-questions, the set up for the study will be explained in detail, the approaches to answer these questions will be described and the results will be discussed.

To evaluate the tool's performance, various aspects of it that needed to be tested had to be listed out. The following are the sub-parts in measuring the tool's effectiveness in achieving its purpose.

1) How effective is the tool in imparting knowledge on OBE?

2) How effective is the tool in providing a wide selection of appropriate pedagogy and assessment techniques?

3) How effective in the tool in the construction of learning objectives?

4) How effective is the tool with regards to the course documentation it generates?

5) How effective is OBE in course design and achieving student outcomes?

6) Is the tool user-friendly?

In the following sections, I will discuss further details about each of the above questions. But before that, another important aspect to discuss would be the approaches for the evaluation.

4.1 Instruments for evaluation

A specific set of methods needed to be defined for evaluation. I have employed the following techniques for conducting my study.

1) Pre/Post Tests

2) Interviews

3) Document Comparison and Analysis

4) Usability Survey

5) User Testing

6) Webinars

4.1.1 Pre/Post Tests

The pre-test and post-test, both have the same set of questions. This questionnaire consists of question on OBE and Bloom's taxonomy in general. The participants are supposed to take the pre-test before they start using the tool and the post-test after they have finished course design. There needs to be a significant amount of time between both the tests as recall has to be avoided as best as possible. These tests are useful in determining if there has been any increase in the knowledge of the participants with respect to outcome-based education. The questions were objective questions as follows:

a. What are the three domains of learning as specified by Bloom's Taxonomy?
b. What are the different learning categories under the Cognitive Domain?
c. Which domain involves the recall or recognition of specific facts, procedural patterns, and concepts that serve in the development of intellectual abilities and skills?
d. Which domain includes the manner in which we deal with things emotionally, such as feelings, values, appreciation, enthusiasms, motivations, and attitudes?
e. Which domain includes physical movement, coordination, and use of the motor-skill areas?
f. What are the four types of knowledge that learners acquire?
g. List the two different kinds of Assessments.

h. Outcome-based education is a theory that is _____
    - Process-based
    - Product-based
i. Which of the following is NOT an outcome?
    - Solve dynamic programming problems
    - Design a neural network algorithm
    - Attend four workshops
    - None of the above
j. Which of the following is related to Outcome-based Education (OBE)?
    - Exit outcomes are a critical factor
    - Input based education
    - Result oriented thinking
    - Emphasis is on the educational process

4.1.2 Interviews

One on one interview is an excellent method for getting a detailed account of their thoughts and opinions. The focus of the interviews was to get as much information regarding the process of course design as a whole, the problems they faced while developing the course, their perspective of the tool's role in education, their opinion on all aspects of the process – with special focus on learning objectives and the selection of techniques for assessments and pedagogy. Also, information regarding participant's teaching experience was also collected. The general question list was as follows with further probing as needed:

a. What was the course that was designed? Is it new or a redesign?
b. Was the tool helpful in the course design process? How?

c. What are some of the strengths and weaknesses of the tool?
d. Can you elaborate on your understanding of OBE?
e. What is your understanding of the knowledge dimensions of the topics?
f. Do you think the choice of assessment/pedagogy techniques presented for your course are appropriate?
g. Did the Learning Objective feature force you to think about the level of learning for students? Elaborate.
h. Can you provide a reflection on how the course designed would help in achieving expected student outcomes?
i. Was it useful to have the Learning Objective feature connected to Bloom's Taxonomy?
j. Did you find this backward/reverse approach of designing a course was effective?
k. What do you think of the provided support and help documentation?
l. How many years of teaching experience do you have?
m. How many courses have you taught? How many of those did you build from scratch?
n. What is the average class size in the courses you have taught?
o. Additional feedback?

The questions k-o are focused on getting the background information of the instructor's experience.

4.1.3 Document comparison/ analysis

The syllabus is one of the important documents in course design. It contains all the required information that students need regarding the subject – including the

expected outcomes, the topics to be covered, the rules etc. This document is what gives the student a firsthand idea as to what the course entails. And thus it is very important for the document to be clear, concise and consistent. And this is what I aim to compare – how helpful the tool is in covering all three aspects and also reducing the instructor's effort in writing the document from scratch.

4.1.4 Usability Test

For a software tool, no matter how amazing it is, to be truly successful, it has to be user-friendly. This questionnaire contains questions that asks the participant, several questions on the usability of the tool. Having played a role in either coming up with the idea for the tool or brainstorming or even implementing certain features for the tool, our perspective tends to be biased. And thus, even if we assume the tool is user-friendly, it is important to get the user's perspective on the matter. The questions are designed so that they can rate the tool on a Likert scale – Strongly agree, agree, neutral, disagree, strongly disagree. The questions in the survey are as follows:

a. The organization of information on the screen for IMODS was clear.
b. The IMODS application gave error messages that told me how to fix problems.
c. The titles for assessment and pedagogy techniques were self-descriptive.
d. The description of the assessment and pedagogy techniques was clear.
e. The documentation produced (assessment plan and instruction plan) for assessments and pedagogy is satisfactory.
f. The selection available for the assessment and pedagogy techniques is satisfactory.

g. It is easy to define custom assessment and pedagogy techniques.
h. The application doesn't need a supporting document to use.
i. The application was easy to navigate.
j. The font size and style are easy to read.
k. The application is intuitive and easy to use.
l. The application looks aesthetically nice.
m. The overall satisfaction with the application is high.
n. I would recommend this application to my colleagues.

4.1.5 User Testing

Given a set of instructions for a software tool, it should be easy to follow. The user interface has to be intuitive enough for a naive user to navigate using the instruction set. In order to evaluate the tool on this front, a user testing was done with a class of students. Never having had any teaching or course design experience, they simply had to follow the given instruction to create a complete course design. Around an hour of time was given and in the end the students gave a Usability survey with the same questions mentioned in the previous section.

4.1.6 Webinars

The final methodology adopted for data collection was webinars. A series of webinars were conducted for professors participating from India. There were around 20 participants who joined the webinar. The plan was to have two sessions each of an hour. The first session focused on introducing the tool, its background, help material for the tool and providing the participants with the link to the tool. The participants were expected to give the pre-test, go through the tool and design a course in a week's time. The second session was conducted exactly after a week and was meant as more

of a discussion – a way for them to share their experience with the tool and follow up with any questions they might have. At the end of the second session, the post-test and the usability questionnaires were shared.

4.2 Effectiveness of the tool in educating the instructors on OBE

One of the major goals the tool tries to achieve is to promote knowledge of OBE among instructors. Outcome based education is a methodology in which the product defines the process. The goals that need to be achieved are defined first and then the process to reach those goals is mapped out. IMODS is based on the principles of Outcome based education. It is proven to have a higher student success rate and is growing in popularity.

Study indicates that newly appointed instructors take about five years to perfect the process of effective course design through trial and error [8]. The students are most affected during this time. Coming up with an efficient way to help the instructors have a lower margin for error is of utmost importance. And thus, educating the instructors on OBE is one of the goals of the IMODS tool.

The pre/post-tests, as well as interviews are used to measure this particular aspect.

4.3 Evaluation of the repository of techniques

It is important to employ appropriate assessment and pedagogical techniques that align with the level of learning that is expected out of a target audience. Let's say for example that a student cannot be expected to create or evaluate a course-specific subject when the level of learning expected is that one simply needs to understand that particular topic.

Using the learning domains, domain category and knowledge dimensions, it is important to check if the techniques offered by the tools really do match up with the level of expertise chosen by the instructor [19]. Thus, it is important to evaluate the selection of techniques presented to the user.

The usability questionnaire contains questions regarding the repository of techniques. Interviews have also been used as a mechanism to get the opinion of the participants regarding the techniques.

4.4 Effectiveness of the tool in building learning objectives

The tool uses the principles of Bloom's taxonomy for the construction of the learning objectives. In order to understand this part, I will just summarize how exactly the learning objective gets constructed.

The first step is to choose the learning domain – Cognitive, Affective or Psychomotor. Based on the selection of the learning domain, the user will be presented will a dropdown box, using which a selection for the domain category has to be made. If, say, the learning domain is cognitive, the domain categories presented will be Remember, Understand, Apply, Analyze, Evaluate and Create. This is basically equivalent to choosing the level of learning to be expected. Further details and terminology regarding the level can be chosen using action word category and action word selection [18].

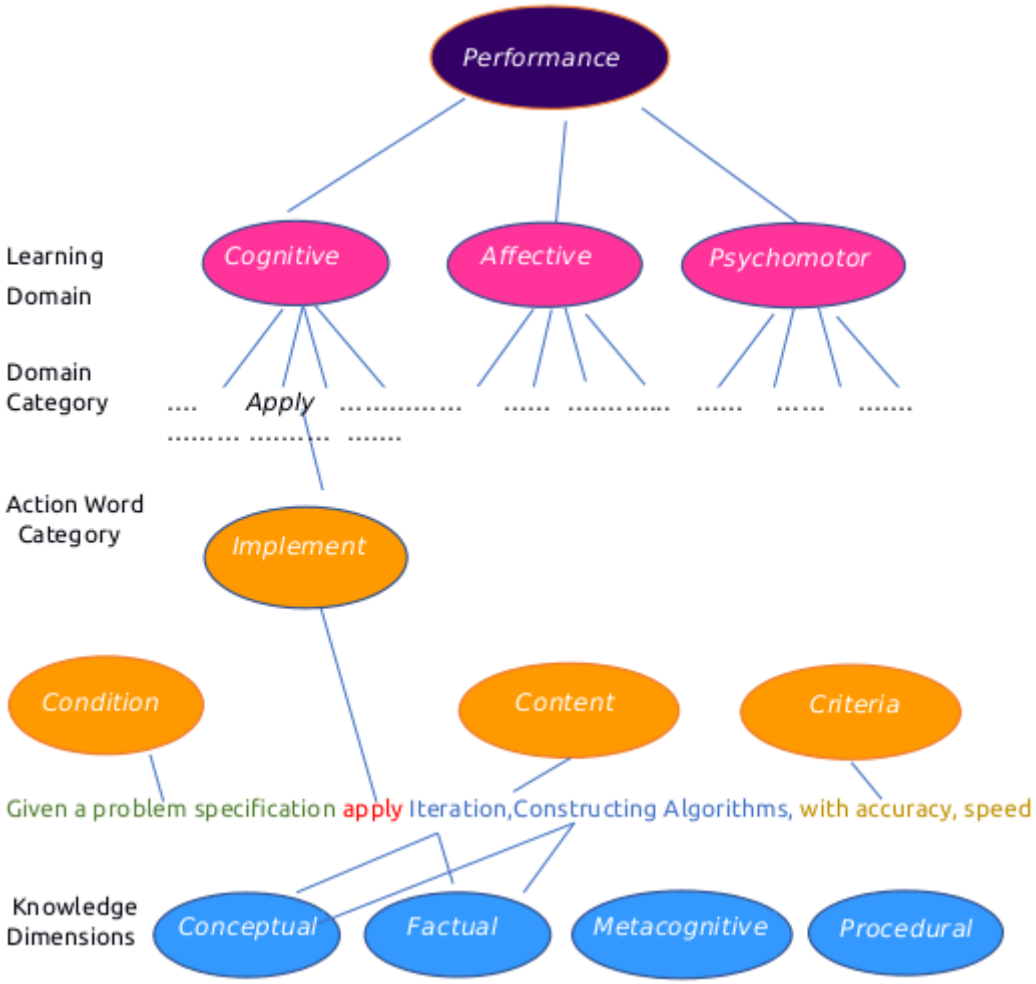

Figure 15: Learning Objective Construction

In the next step, content with respect to the learning objective is created and/or chosen. Each content topic is associated with a knowledge dimension – conceptual, factual, procedural or metacognitive. Then, the criteria, which can be defined as the level of competence, has to be decided followed by the conditions under which the criteria should be met. This basically constructs the rough outline for the learning objective. The whole process is outlined in figure 15.

The user of given the option of making changes and refining the resultant learning objective. This part of study is aimed at figuring out how good the tool generated learning objective is, without the use of this option of customizing the

learning objective, as simply writing the whole learning objective, defeats the purpose of the tool.

Interviews are the main source for this information to be collected.

4.5 Evaluation of documents generated by the tool

After all the steps of course design are completed, a complete syllabus is generated by the tool based on the various selections made by the user. This document is ready for direct distribution among the students. An option of hiding certain aspects of the syllabus is provided if the instructors wishes to do so.

Evaluating the auto-generated documents is yet another way of establishing that the tools is useful and reduces extra effort from the instructor's point of view.

Interviews are used to evaluate this aspect along with actual comparison of documents obtained for syllabus using the tool and the existing syllabus.

4.6 Effectiveness of OBE course design and achieving student outcomes

One way of measuring this particular aspect would be to analyze two consecutive offerings of the same course – the first being designed traditionally, without the tool and the next using the tool and comparing the student feedback for the course as well the achieved student results. But in an ideal scenario it would also require the same set of students, along with the same level of knowledge while entering the class. This is, however, not possible. So instead, a discussion with the participants on their thoughts about the student performance based on their experience is used for evaluating this particular aspect.

Interview is the method used for collecting data about perceived student performance and the influence on OBE on it.

4.7 Evaluation of the tool's usability

Usability is one of the core qualities that is expected from a software. Along with being functionally effective, the tools also need to be easy to use as otherwise, not many will be inclined to use a tool that requires more effort in just navigating through it. Not only should it be aesthetically pleasing, it should also be intuitive. The user shouldn't have to read through a ton of documentation to understand its working. Thus, usability was chosen as one of the aspects to evaluate the tool on.

4.8 Study set up

The study has been conducted with diverse groups of participants using a different process for each group.

1) Students – The tool was given to a class of students with a set of very specific instructions and a sample syllabus. The goal of this was for the students to be able to follow simple instructions and be able to design a course that was 100% complete.

2) Instructors – A group of six instructors were recruited. The first step for this group was to give a pre-test prior to any exposure to the tool. The pre-test consists of a set of questions focusing on Outcome-based education. After the completion of this step, the participants are given ample amount of time to explore the tool, go through the documentation, help videos and seek any further help required from the research team in order to build either a previously taught course or a brand new one. An interview is conducted after the successful completion of course design, with a focus on gathering information on their experience, their prior

expectations, acquired knowledge about OBE, their perceptions on expected student outcomes, any challenges faced during the process and feedback for further improving the tool. Then, a post-test was conducted followed by a usability survey.

CHAPTER 5

ANALYSIS AND RESULTS

5.1 Evaluation of feedback feature

The feedback feature was designed using the conditions described in Chapter 3. But the UI of the feature was not intuitive. There was a horizontal blue bar that said “IMOD Info.” The user has to hover on this text for a gray colored bar to appear along with the required information for course design completion. During the interviews, it came to my attention though that half of the participants did not even notice that feature because of its lack of obviousness to its existence. After the feedback received, I have removed the hover feature, which turned out to be a major design flaw and made the feature more obvious and central.

The headers for table 6 are too big and thus I have assigned the following codes for better visibility:

1. IMOD ID – ID
2. Course Overview – CO
3. Instructor Information – II
4. Learning Objectives – LO
5. Assessments – A
6. Pedagogy – P
7. Expected Feedback – No code
8. Actual Feedback - AF

ID	CO	II	LO	C	A	P	Expected Feedback	AF
1	×	×	×	×	×	×	Please fill the course overview to see the minimum requirements to complete the course design	✓
2	✓	×	×	×	×	×	Add instructor information. At least three learning objectives needed – 0	✓

							defined. At least six content topics need to be added – 0 defined.	
3	✓	✓	×	×	×	×	At least three learning objectives needed – 0 defined. At least six content topics need to be added – 0 defined.	✓
4	✓	✓	✓	×	×	×	At least three learning objectives needed – 1 defined. At least six content topics need to be added – 0 defined. At least one assessment technique needs to be added for each objective. At least one pedagogy technique needs to be added for each objective.	✓
5	✓	✓	✓	✓	×	×	At least three learning objectives needed – 1 defined. At least six content topics need to be added – 1 defined. At least one assessment technique needs to be added for each objective. At least one pedagogy technique needs to be added for each objective.	✓
6	✓	✓	✓	✓	×	×	At least three learning objectives needed – 2 defined. At least six content topics need to be added – 4 defined. At least one assessment technique needs to be added for each objective. At least one pedagogy technique needs to be added for each objective.	✓
7	✓	✓	✓	✓	×	×	At least six content topics need to be added – 4 defined. At least one assessment technique needs to be added for each objective. At least one pedagogy technique needs to be added for each objective.	✓
8	✓	✓	✓	✓	×	×	At least one assessment technique needs to be added for each objective. At least one pedagogy technique needs to be added for each objective.	✓
9	✓	✓	✓	✓	✓	×	At least one pedagogy technique needs to be added for each objective.	✓
10	✓	✓	✓	✓	✓	✓	You have met the minimum requirements of an IMOD.	✓

Table 6: Feedback Feature Evaluation Table

The expected results and the actual results match in all ten cases. The feedback feature works as expected which proves its correctness. One thing that was observed was that, for a learning objective to count, just adding the action word was

sufficient – which means that once the action word is added, the system does not take into consideration whether the condition, content and criteria part of the learning objectives were added or not. For this issue to be fixed, there should be sort of mechanism to take into consideration the components of the learning objectives as well.

5.2 Interview Results

In this section, I present a consolidated view of the results obtained from the interviews using the question mentioned in section 4.1.2.

a. Was the tool helpful in the course design process?

Participant	Yes	No
1	✓	×
2	✓	×
3	✓	×
4	✓	×
5	✓	×
6	✓	×

Table 7: Tool Helpfulness Table

All the participants agreed that the tool was helpful in the course design process.

b. Did the tool familiarize you to OBE?

Participant	Yes	No	Already knows
1	✓	×	×
2	✓	×	×
3	✓	×	×
4	✓	×	×
5	✓	×	✓
6	×	×	✓

Table 8: Familiarization to OBE Table

Most of the participants did not have any prior knowledge on the concept of OBE, but the tool was successful in familiarizing/increasing their knowledge on OBE. Check mark in both the "Yes" column and the "Already knows" means that the participant knew a little bit about OBE and tool increased their knowledge as well.

c. Do you think the choice of assessment/pedagogy techniques presented for your course are appropriate?

Participant	Yes	No	Sparked new ideas
1	✓	×	✓
2	✓	×	✓
3	✓	×	✓
4	✓	×	×
5	×	✓	✓
6	×	✓	×

Table 9: Repository of Techniques Table

Almost all the participants wanted a generic assessment technique – Assignment. Thus, 33% of the participants were not satisfied with the choice of techniques presented to them. One major flaw turned out to be that the repository did not contain any techniques for the CREATE level domain category.

d. Do you think the course designed using the tool would help in achieving expected student outcomes?

Participant	Yes	No	Maybe	Cannot make an educated guess
1	×	×	✓	×
2	×	×	×	✓
3	✓	×	×	×
4	✓	×	×	×
5	✓	×	×	×

6	×	✓	×	×

Table 10: Student Outcomes Table

To answer this question, the experiment was supposed to have an extra step. The course was supposed to be used in session to record student performance. But due to the time constraint it was not possible. So, I asked the participants to provide an educated guess on the matter considering all the facts. Only 50% of the participants believed that a focused course design would indeed have an impact on the student performance and outcomes.

e. Was it useful to have the Learning Objective feature connected to Bloom's Taxonomy (BT)?

Participant	Yes	No	No idea about BT
1	×	×	✓
2	×	×	✓
3	✓	×	×
4	×	×	✓
5	✓	×	✓
6	✓	×	×

Table 11: Learning Objectives/Bloom's Taxonomy Table

f. Did you find this backward/reverse approach of designing a course was effective?

Participant	Yes	No
1	✓	×
2	✓	×
3	✓	×
4	✓	×
5	✓	×
6	✓	×

Table 12: Effectiveness of Backward Approach Table

g. What do you think of the provided support and help documentation? Which of the help features did you/would you use?

Participant	Video	Information Tab	User Manual
1	✓	×	×
2	✓	×	×
3	✓	×	×
4	✓	×	✓
5	✓	×	×
6	✓	×	×

Table 13: Support Documentation Table

Based on the study and the participants' feedback, it was clear that they preferred the videos (a short 2 min video), rather than reading through textual information.

h. Were you able to design the Learning Objectives without using any of the help material?

Participant	Yes	No
1	✓	×
2	×	✓
3	×	✓
4	✓	×
5	✓	×
6	×	✓

Table 14: Ease of LO Construction Table

Learning objective is the central part of the IMODS system. So, it is important to have this feature be as intuitive as possible. Only 50% of the participants found the tool intuitive to use without any help. But everyone was able to use it once they watched the help video.

i. Were you satisfied by the documentation generated by the tool (syllabus document)?

Participant	Satisfied	Not satisfied	Satisfied but felt it was restricted	Consistent
1	×	×	✓	✓
2	✓	×	×	✓
3	✓	×	×	✓
4	✓	×	×	✓
5	✓	×	×	✓
6	×	×	✓	✓

Table 15: Documentation Table

One feedback common among all the participants was that the syllabus document generated helps in having consistency across all the courses and that was one of the best things about the tool-generated document. But 33% of the participants also felt that the document was restrictive and wanted a more flexible structure to it.

j. Did the LO feature force you to think about the level of learning?

Participant	Yes	No	Yes, but it was still overwhelming
1	×	×	✓
2	✓	×	×
3	✓	×	×
4	✓	×	×
5	✓	×	×
6	✓	×	×

Table 16: Domain Category Table

This is the one of the main goals of OBE. And all the participants agreed that the tool met its major goal by forcing them to think about their audience and the level of learning to be set for them.

k. Would you be inclined to write your own objectives using the edit feature of the learning objectives without using the actual building structure?

Participant	No	Yes
1	✓	×
2	✓	×
3	✓	×
4	✓	×
5	✓	×
6	×	✓

Table 17: Edit Feature Usage Table

Writing the learning objectives by using the edit functionality defeats the whole purpose of the tool. And one of the participants agreed that they would be inclined to using the edit function rather than using the structure of IMODS for constructing complete learning objectives when they already have pre-defined objectives. There should be some sort of a way to prevent the users from doing this.

m. How many courses have you taught? How many of those did you build from scratch? What is the average class size in the courses you have taught?

This question provides insight into the background of the participants. The results are tabulated in the table below.

Participant	Teaching Experience (in years)	Total Courses	New Courses/ Major Redesign	Average Class Size
1	8	9	4	70
2	2	6	0	40-50
3	4.5	4	3	60
4	1.5	1	0	70

5	7	73	73	30-40
6	1.5	5	1	150

Table 18: Participant Information Table

5.3 Webinar Results

The audience consisted of more than 25 participants for the first session. But only 10 participants completed the pre-test before the start of the second session a week later. Many of the participants were first-timers for the second session – which defeated its purpose. The second webinar had to be conducted the same way as the first because of the presence of new participants. There were a few participants who attended the previous session as well. All the questionnaires were handed out at the end of the session. One participant resubmitted the pre-test they had given the week before and the post-test. Just one response was collected for the post-test. The webinars didn't really turn out to be useful in terms of data collection tool evaluation or feedback.

5.4 Evaluation of the tool

For evaluating the Instructional Module Development System, various aspects have been considered and different criteria has been chosen to evaluate each of the aspects. The results for each of the aspects are discussed below.

5.4.1 Educating instructors on OBE

Each question was given a score of 10. For questions with multiple answers, the points were equally divided. For example, if the multiple answer question had two

correct options, each one carried a partial credit of 5 points each. The questions which all the participants got right in both the pre and post test were disregarded. There were three such questions, each of them testing the participant's ability to identify the learning domain given its description.

Participant	Pre-test score	Post-test score
1	47.5	69.17
2	47.5	72.5
3	50	98.33
4	75	75
5	69.17	75
6	70	85

Table 19: Scores for OBE Tests

A combination of pre and post-tests was used for this particular evaluation, in combination with in-person interviews. There were six participants in the study and their results (scores out 100) are shown in the table above. There is an overall gain of 24.38% in the knowledge of the instructors after using the tool.

The gain formula is as follows:

Gain = (Sum of Post – Sum of Pre)*100/Sum of Post

All the participants got 3/10 questions right in both the pre and the post tests. The questions c,d and e from section 4.1.1 – which are basically about recognizing the learning domain given its definition. So not taking into account those questions, the new scores are shown in the table below. Overall increase in knowledge based on this table is 39.2%.

Participant	Pre-test score	Post-test score
1	17.5	39.17
2	17.5	42.5

3	20	68.33
4	45	45
5	39.17	45
6	40	55

Table 20: Updated Scores of OBE Tests

5.4.2 Repository of Techniques

From the data collected from 54 participants this year, 72.3% agreed that the selection of techniques available for both pedagogy and assessment was satisfactory (figure 3) and 61.1% agreed that the titles used for the techniques are self-explanatory (figure 4). But only 57.4% of the total participants agreed the description of the techniques to be clear (figure 5).

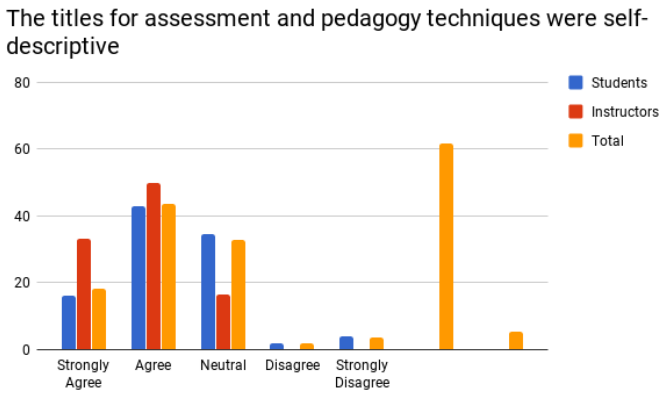

Figure 16: Bar Chart for descriptive power of Technique titles

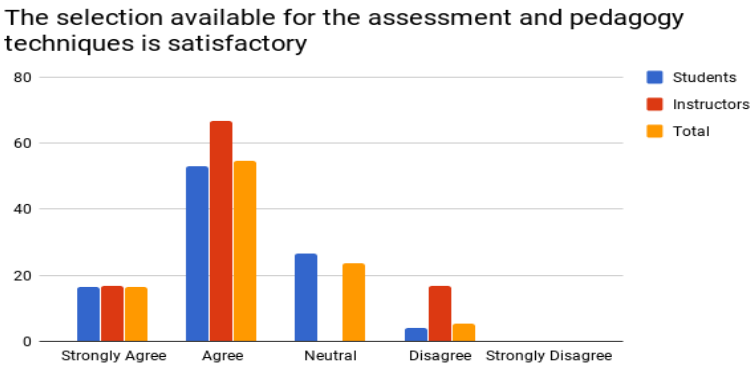

Figure 17: Bar Chart for Selection of Techniques

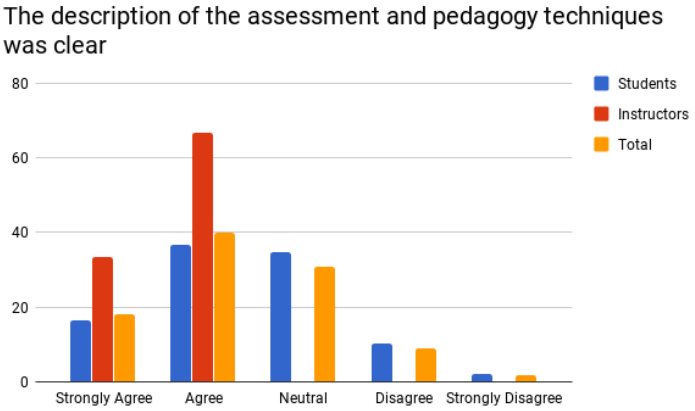

Figure 18: Bar Chart for description of techniques

5.4.3 Building Learning Objectives

Three different learning objectives are considered from the courses designed with and without the tool during the course of the study.

i. Sample Learning Objective 1

With IMODS:

(LO1) Given an algorithm, apply Analytical Analysis and Empirical Analysis.

- Assessments – Midterm Test

- Instructional Techniques – Lecture

Without IMODS:

(LO2) Students can analyze existing algorithms and use these techniques in designing algorithms.

ii. Sample Learning Objective 2

With IMODS:

(LO3) After completing the course, the student will be able to analyze Number Representation with 95% accuracy.

- Assessments – Assignment
- Instructional Techniques – Lecture

Without IMODS:

(LO4) Convert between common number systems (including: Binary, Decimal, and Hexadecimal), in support of program outcome Technical Competence.

iii. Sample Learning Objective 3

With IMODS:

(LO5) After completing the course, the student will be able to apply user interaction models and prototypes with accuracy.

- Assessments – Assignments, Final, Semester project.
- Instructional Techniques – Critical Debate, thinking aloud pair problem solving

Without IMODS:

(LO6) After successfully completing SER315, the student will, construct user interaction models and prototype,

- in support of SER student outcome Technical Competence
- in support of SER student outcome Design

The above objectives are part of the results obtained from the study. Prior to the use of the tool, the learning objectives defined were either vague or specific to the

content topics. But there was no mention of the either instructional or assessment techniques that would be employed to achieve or measure the outcome. The process of defining the learning objectives using the tool basically forces the instructor to put some thought into the assessments and instruction of content to assure that the alignment between these components is maintained. The table below shows a clearer picture.

Learning Objectives	Performance	Content	Condition	Criteria	Alignment with Pedagogy and Assessment
LO1	✓	✓	✓	×	✓
LO2	✓	✓	×	×	×
LO3	✓	✓	✓	✓	✓
LO4	✓	✓	×	×	×
LO5	✓	✓	✓	✓	✓
LO6	✓	✓	✓	×	×

Table 21: Learning Objectives Evaluation Table

From the above table, it is clear that the alignment with assessment and instructional techniques was missing in all the objectives that were designed not using the IMODS. All the components of PC^{3}are included in the objectives built using IMODS.

5.4.4 Document Comparison

The syllabus generated by the tool follows a specific format. If the tool is employed at all levels, the consistency provided by these documents will be very high. Referring to a pre-requisite course while in the process of designing an advanced course becomes significantly more insightful, providing the instructor with the

general level of knowledge in the incoming class. This helps the instructor to set a basic level of inherent knowledge the class will possess which in turn helps in appropriately setting off the level of learning from the class. And that is what basically IMODS strives to achieve.

The syllabus generated by the tool also maintains the alignment in learning objectives, giving the student a clearer picture of the course and instructor expectations. Also, a nifty feature called the time ratio gives the students an idea of the amount of time they are expected to spend in class to out of class helping them understand the time commitment expected from the course and help them make better decisions.

5.4.5 Usability Testing

In the previous section, the questions for the Usability Survey have been listed. Students took this survey as a part of user testing, as well as the instructors who built their own courses using the tool.

Bar charts (shown in figure) has been used as a way to represent the results. The blue bars represent the students, the red bars represent the instructors and the yellow bars represent the total – combination of both. The horizontal axis shows the Likert scale – and the vertical axis shows the percentage of participants. Data collected over last few years was compared to look for improvement with incorporation of user feedback. Figures 19 show this progression.

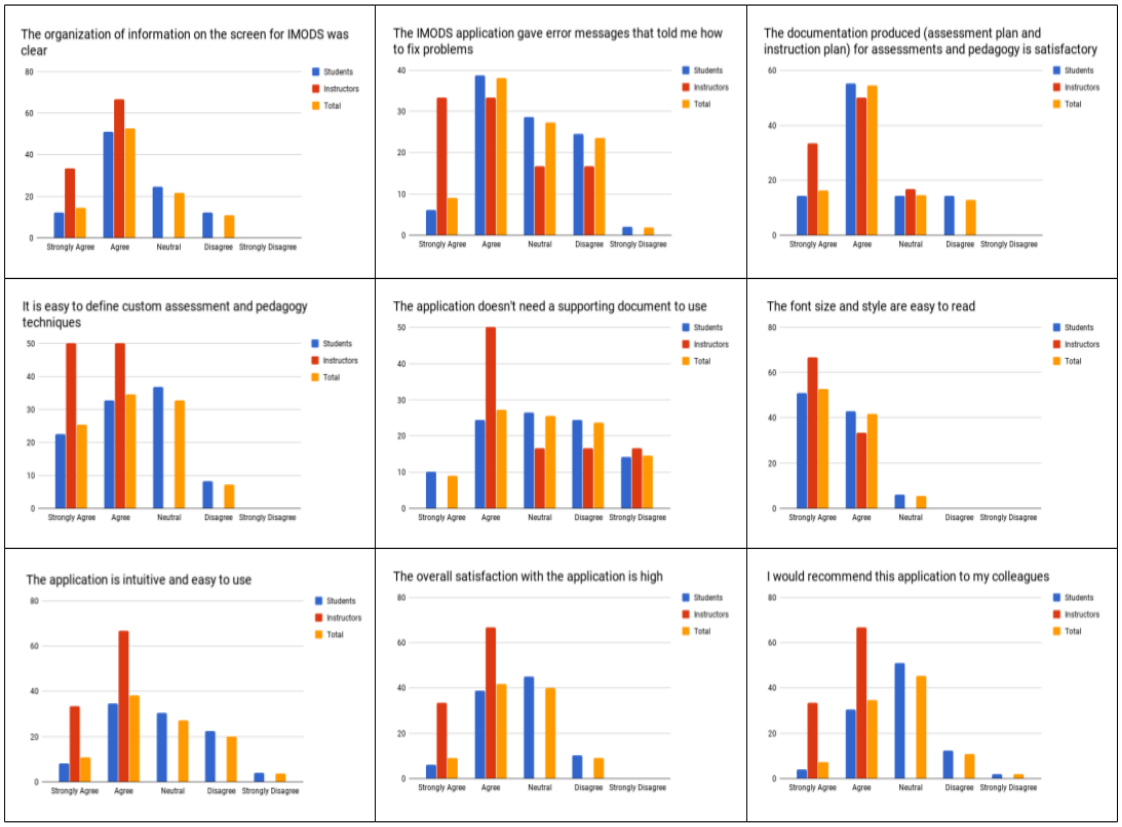

Figure 19: Usability Results

Radar charts are used to show the continuous feedback received throughout the years 2015-2018. For both the charts, the percentages are considered as they better represent the data rather than the count as the number of participants vary from year to year. The rate of disagreement over the years has decreased for almost all the questions on usability.

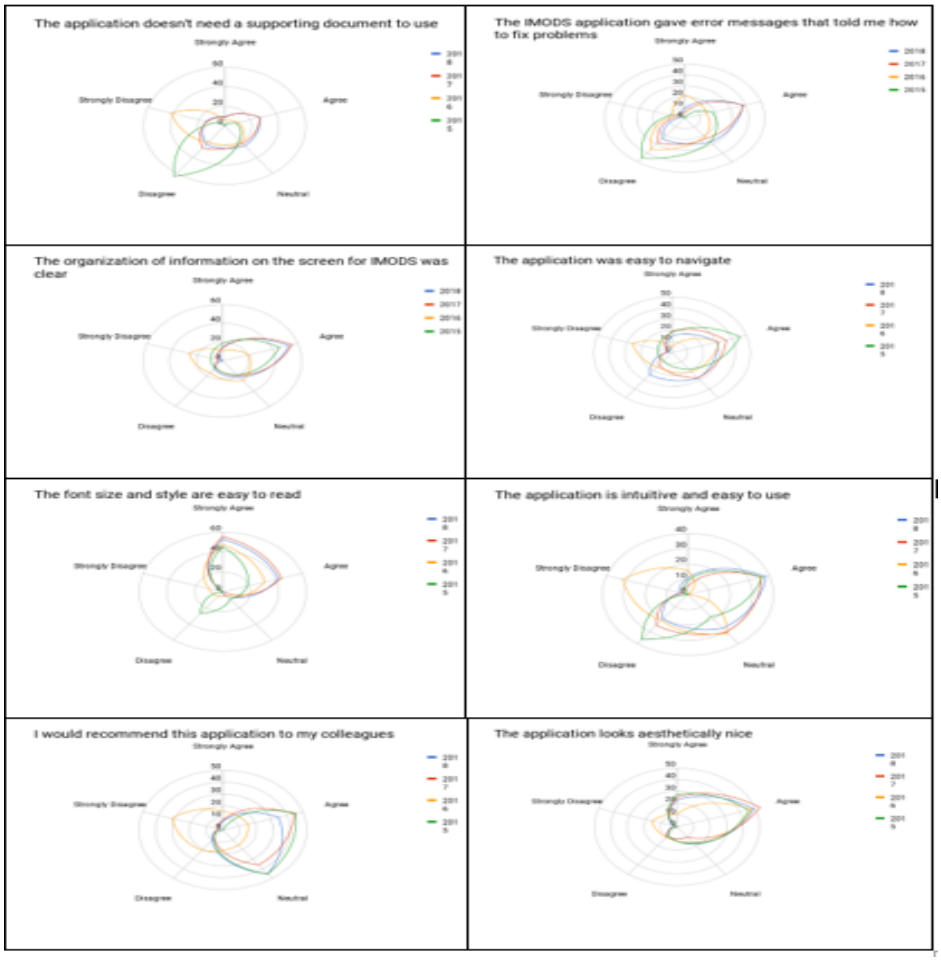

Figure 20: Radar Charts for Usability

CHAPTER 6

CONCLUSION AND FUTURE WORK

The results of the study demonstrate that for the most part, IMODS achieves the goals that it has aimed to since its inception and has improved over the years. The study also helped identify a list of improvements to the system that would go a long way in increasing its effectiveness. The evaluation has shed light on some of the issues that escaped the development team's notice.

6.1 Findings

The system offers a limited number of sections for the syllabus. The repository of assessment and pedagogy techniques needs to grow and a variety of techniques for various subject areas must be added. Making this software more flexible is one of the future goals for improvement. The study was conducted with a small group of participants and conducting this study with improved questionnaire with a larger group can have more promising results. One of the interview questions that helped in finding more about this was - "What are the strengths and weaknesses of the tool." The results are tabulated in the table below.

Strengths	• Forced to have a structure • Step-by-step process • Provides scaffolding for the best way to design a course. • Action words are helpful. • The tool keeps you honest; calls attention to stuff and makes you think about things deeply. • The criteria part is a nice thing to have. • Assessment and Pedagogy are nice to have listed out – makes you think about them. • References in the techniques are good.

	• One of the participants said, “Alignment is what you are stuck with and what the tool holds you to.” This is one of the best part of the tool. • According to one of the interviewee, “Part of teaching is knowing what your students can and can’t do.” The tool forces the user to think about this.
Weaknesses	• Doesn’t explain the aspects of OBE and BT – problem for a new user. • Access to other tabs (Content, Assessment, Pedagogy) before finishing the current one (Learning Objectives) is confusing. • Sample IMOD is too simple. • The repository doesn’t have techniques for higher levels of domain categories.

Table 22: Strengths and Weaknesses of the tool

6.2 Future Work

6.2.1 Bugs and Action Items

During the usability testing, multiple bugs in the application were discovered. Each of them can be considered as an action item that needs to be fixed in the future. All the major bugs are tabulated in the tale below.

No.	Bugs
1	Server-side scripting happens for the Learning objectives
2	Grading Policy – Changed to competency based but doesn’t stick even though it shows competency-based in the syllabus.
3	Techniques – A few combinations did not have ideal matches. Selections did not stick. Page needed to be refreshed sometimes for the changes to stick. The slow performance of the progress bar makes it happen.
4	Topics appear in random order while creating learning objectives, although edit option is available, but it would be good if topics in learning objectives appear in the same order as they are listed in the content.
5	An undescriptive error occurred when attempting to add a new pedagogy

6	Login registration if incomplete doesn't display the proper error to use when trying to login before authentication.
7	End date can be exorbitant e.g. an 8 year class
8	Couldn't select more than one technique without refreshing the page.
9	Another issue was where when adding content, the generic response, even when selected, sometimes wouldn't be saved to the learning objective
10	When clicking save on a few pop up add topic boxes, it would let show a message saying that information might be lost. But on saving, there were multiple instances of the topic
11	Credit hours field allowed to enter text.
12	If you try to delete a sub-topic, it will delete the above topic not the one you tried to delete. for example, if you have topic 1 - sub topic 1 and try to delete sub topic 1, then topic 1 will be deleted and you will be left with sub topic 1
13	IMOD Info shouldn't be something that you hover over.

Table 23: Bugs found by Usability testing

6.2.2 Suggested improvements

During the evaluation process, feedback obtained from the participants – both student and instructor, provided insight into the features/items that need to be added to the tool. The table below shows the consolidated list.

No.	Items
1	Instructor – No role for lecturer
2	Techniques – A few combinations did not have ideal matches.
3	The tool could be a bit more step-by-step visually
4	The videos could give a little background (OBE and Bloom's Taxonomy) or links on the concept behind each feature.
5	Pre-requisites to be included in Syllabus
6	More flexible Course Overview section to provide a more complete syllabus
7	Graph representation for dependencies between objectives – display and feedback – This means that the learning objectives should be represented as a network and provide feedback. For eg., if a person is trying to incorporate an objective that needs prior knowledge that

	is connected to another objective, the system should warn the user that the other objectives is not yet completed.
8	The Progress Bar feature is very slow and sometimes leads to the users assuming application errors when they are not able to select techniques until the progress bar is completely loaded. Its performance needs to be improved a lot.
9	A feature to preload the basic information – like Course Overview, Instructor Information, Course policies etc., will remove redundancy from the course design process.

Table 24: Suggested Improvements

6.3 Personal Outcomes from the Thesis

In this thesis, I have worked on designing the feedback feature and evaluating the tool. I have always worked with software tools in development mode. During this thesis I got to learn more about the importance of the Software Engineering process. Development is not the only thing that's important, evaluation also plays a vital role. Evaluation of any software product is imperative if the tool intends to serve the user better in a world with rapid changes and where there are new technologies and offerings every day.

One major feedback received was on the UI of the tool. If this evaluation was not conducted, we would not have gotten the information that the application looks outdated and needs to be changed to adapt to the newer views of web pages.

I also got to learn more about the importance of designing an easy-to-use UI. The feedback feature I designed needed the user to hover on the text "IMOD Info" for them to get the feedback. It was way too easy to be missed by the user. Based on the feedback, I removed the hover feature which was completely unnecessary. Design flaws such as these are very easy to be overlooked by the developer and evaluation process, a part of the Software Engineering cycle, is helpful in fixing these flaws to have a better application.

REFERENCES

[1] O. Dalrymple, S. Bansal, K. Elamparithi, H. Gafoor, A. Lay, S. Shetty, "Instructional Module Development System: Building Faculty Expertise in Outcome-based Course Design," in *Proceedings of Frontiers in Education Conference (FIE),* Oklahoma City, USA, October 2013.

[2] R. Mager, "Preparing Instructional Objectives: A critical tool in the development of effective instruction. 3rd ed.," *The Center of Effective Performance, Inc,* 1997.

[3] D. Clark, "Bloom's Taxonomy of Learning Domains," 1999. [Online]. Available: http://www.nwlink.com/~donclark/hrd/bloom.html

[4] R. Fedler, R. Brent, M. Prince, "Engineering Instructional Development: Programs, Best Practices, and Recommendations," *Journal of Engineering Education,* vol.100, no. 1, pp 89-122, January 2011.

[5] L. Fink, "Creating significant learning experiences: An integrated approach to designing college courses," San Francisco: Jossey-Bass, 2003.

[6] S. Bansal, O. Dalrymple, V. Menon, K. Andhare, V. Moghe, "IMoD: Semantic Web-based Instructional Module System," in *Proceedings of the 2012 IASTED Software Engineering and Applications Conference (SEA),* Las Vegas, Nevada.

[7] S. Bansal, A. Bansal, O. Dalrymple, "Outcome-based Education Model for Computer Science Education," in *Proceedings of Second Intl. Conference of Transformations in Engineering Education,* Bengaluru, India, January 2015.

[8] R. Boice, "Advice for new faculty members," Allyn & Bacon, 2000.

[9] W. G. Spady, K. J. Marshall, "Beyond Traditional Outcome-Based Education," *Educational Leadership*, vol. 49, no. 2, pp. 67–72, 1991.

[10] L. W. Anderson, D. R. Krathwohl, "A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives (Complete ed.)," New York, 2001.

[11] R. M. Felder, R. Brent, "Designing and teaching courses to satisfy the ABET engineering criteria," in *Journal of Engineering Education*, 92(1), 7–25, 2003.

[12] G. C. Furman, "Outcome-Based Education and Accountability," *Education and Urban Society*, *26*(4), 417–437, 1994.

[13] G. P. Wiggins and J. McTighe, "Understanding by design. Assoc.," for *Supervision & Curriculum Development*, 2005.

[14] R. A. Streveler, K. A. Smith, M. Pilotte, "Aligning Course Content, Assessment, and Delivery: Creating a Context for Outcome-Based Education," in *Outcome-Based Education and Engineering Curriculum: Evaluation, Assessment and Accreditation*, Hershey, Pennsylvania: IGI Global, 2012.

[15] G. J. Gloria, "Electronic performance support systems," 1991.

[16] “Blackboard” [Online] : www.blackboard.com

[17] “Moodle” [Online] : www.moodle.org

[18] K. Andhare, O. Dalrymple, S. Bansal, “Learning Objectives Feature for the Instructional Module Development System,” in the *Proceedings of the ASEE PSW Section Conference Cal Poly* - San Luis Obispo, 2012.

[19] S. K. Bansal, O. Dalrymple. "Repository of Instructional and Assessment Techniques for OBE-based Instructional Module Development System," in *Journal of Engineering Education Transformations (JEET),* 29.3: pp. 93-100, 2016.

[20] S. K. Bansal, O. Dalrymple, A. Gaffar. “Design, Development and Implementation of Instructional Module Development System,” in *Proceedings of American Society for Engineering Education Conference(ASEE) - NSF Grantees session*, Seattle, USA, , June 2015.

[21] “Learning Management System” [Online] : www.epharmasolutions.com/our-solutions/learning-management-system

[22] J. Fairweather. “Linking Evidence and Promising Practices in Science Technology, Engineering and Mathematics (STEM) Undergraduate Education,” in *A Status Report for The National Academies National Research Council Board of Science Education.*

[23] M. H. Davis. “Outcome-based Education,” in *Journal of Veterinary Medical Education*, vol. 30, No. 3, 2015.

[24] E. Seymour, J. J. Ferrare, “Talking about leaving: Why undergraduates leave the sciences,” in *Gardner Institute Symposium on Student Retention*, Ashville, NC, USA, June 2015.

[25] A. E. Austin, M. McDaniels, “Preparing the Professoriate of the Future: Graduate Student Socilaization for Faculty Roles,” in *Higher Education: Handbook of Theory and Research* book series, vol. 21, Chapter 8.

[26] S. Roy, P. K. Patnaik, R. Mall, “A Quantitative approach to evaluate usability of academic websites based on human perception,” in *Egyptian Informatics Journal,* vol. 15, Issue 3, November 2014.

[27] H. Alshenqeeti, “Interviewing as a Data Collection Method: A Critical Review,” in *English Linguistic Research*, 3. 10.5430/elr.v3n1p39, 2014.

[28] P. J. Lynch, S. Horton, P. Morville, “Web Style Guide: Basic Design Principles or Creating Web Sites,” Yale University Press, ProQuest Ebook Central, 2009.

[29] S. Bansal, O. Dalrymple, “Instructional Module Development System (IMODS),” in *Proceedings of 21st ACM Annual Conference on Innovation and Technology in Computer Science Education (ITiCSE),* Peru, July 2016.