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Analysis of Course Content Development using Pedagogic Framework – A Case Study

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Abstract
The article delineates a scaffold for analyzing the outcome based course objectives and ascertain the variance among unit, module and course level objectives with reference to the Bloom's taxonomy using pedagogic framework. It also investigates the correlation across the objectives at the course, module and unit levels. The key emphasis of the study is to develop a methodology to help the developer write objectives in an appropriate manner in engineering education system.

Keywords
Content Development, pedagogic framework, Bloom's Taxonomy

1. Introduction
Graduates of the 21st century should have the ability to arrive at informed judgments – that is, to effectively define problems, gather and evaluate information related to those problems and develop solutions. The graduate engineers need to have proven abilities not only in remembering and understanding the essential knowledge and applying various concepts, principles and theories learnt in the university, but also in analyzing complex engineering problems, synthesizing appropriate solutions, evaluating various alternative approaches and processes. This is the crux of the *Washington Accord* [1], which has also been accepted by the *National Board of Accreditation* (NBA) in India [2].

So far education in India has been largely teacher-centric. Teachers decide what to teach and how to teach; a syllabus is often no more than a list of topics, allowing different interpretation by different students and teachers. Students rarely have any idea about what is expected of them, until the course is over, and more often than not until they see the final examination paper. Most courses are taught to familiarize students with these topics rather than offering specific learning objectives that they would have to attain.

The emphasis is often on the ability to recall information, explain and at best apply some of the concepts learnt in class. Development of analysis, synthesis and evaluation skills rarely get the priority that they deserve. Encouraging active learning, teaching self-learning skills, effective communication skills, working in interdisciplinary groups are not practiced as a matter of policy. With the increase in popularity of web-based course delivery techniques in tertiary education, many university educators and curriculum designers are revisiting various course components. Learning activities, course outcomes, evaluation tools, communication techniques and assessment tasks are all under the pedagogical microscope. The *Washington Accord*, signed in 1989, was effectively the first major attempt to establish a benchmark for not only the level and content of the domain knowledge in a programme but also soft skills essential to learning development.

2. Background of study
The more conventional definitions depict pedagogy as either the science/theory or art/practice of teaching that makes a difference in the intellectual and social development of students. Today it means creating an educational process that will need to knowledge transfer to a new learner. It refers to how teachers influence the *learning* process. It comes from the idea that the whole point of teaching should be centered on what kind of learning takes place, i.e. the lessons should be learner-centered and not teacher-centered. More specifically, new research is defining pedagogy as "a highly

complex blend of theoretical understanding and practical skill" [3]. Sonwalkar (2013) observes that the term does not refer to presentation of content with evaluation and few information bits; it is the process of presenting content in the context of learning strategies that connect with a cognitive process. It now generally refers to creation of effective lesson plan for classroom instruction and online education [4].

The project Developing suitable pedagogical methods for various classes, intellectual calibers and research in e-learning, approved by the MHRD, Govt. of India under the NMEICT scheme and coordinated by IIT Kharagpur, is an experiment to systematically design and develop learner-centric curricula, suitable for outcome-based learning, for four-year degree programmes in major engineering disciplines with the help of a large number of motivated, trained and experienced faculty members drawn from a diverse range of institutions across the nation.

Outcome based learning is a student-centered strategy that keeps student learning at the centre of the teaching and learning process. The purpose is to assist students in attaining learning outcomes that would enable them to be competent professionals, engaged intellectuals and active and caring citizens. The cognitive domain involves knowledge and the development of intellectual skills [5]. This includes the recall or recognition of specific facts, procedural patterns, and concepts that serve in the development of intellectual abilities and skills. There are six major categories of cognitive processes, starting from the simplest to the most complex: *knowledge, comprehension, application, analysis, synthesis* and *evaluation*.

In this study, we focus on the software framework SHIKSHAN under the pedagogy project, where a pedagogical framework was developed for design the outcome based curriculum. It was originally developed by the Centre for Educational Technology (CET), IIT Kharagpur to implement under this multi-institution project. SHIKSHAN incorporates considerable guidance on the concepts of outcome-based learning and principles of pedagogy.

3. Objective

The objective is to compare the instructional objectives in terms of match/mismatch among unit, module and course level objectives with reference to Bloom's taxonomy in the course *Energy Technology* [6] under National Mission Project on Education through ICT: Developing suitable pedagogical methods for various classes intellectual calibers and research in e-learning by MHRD which is anchored by IIT Kharagpur.

4. Curriculum design procedure (according to the Pedagogy project)

In a curriculum document, a course should be written in terms of *specific instructional objectives* using appropriate *action verbs*, which are demonstrable and clearly measurable rather than as a list of topics. The instructors, the examiners, the students, the employers, the departments and the parents - unambiguously understand what the students should be able to do on successful completion of the course. Since the objectives are clearly defined, instructors can plan teaching in a focused way. Even if some students miss a lesson or for whatever reason, do not understand the instructor properly, they can try to learn on their own in a more focused way. Since only *action verbs* are used and they are measurable, assessment of student achievement is more objective and less erroneous. The course, module and unit level objectives were developed according to the Bloom's Taxonomy using appropriate *action verbs*. Ideally, there should be a perfect match among course, module and unit objectives. The objectives data was collected from the course *Energy Technology*.

Learning objective or the course outcome is a statement of what students would be able to do when they have completed instruction and they are the skills and attitudes that the students should be able to demonstrate in their chosen area of specialization as defined by the faculty members designing the course. These are not statements of the instructor's teaching / action plan. A learning objective has three major components: i) The performance component - describes what the student will be able to do; ii) The condition component - describes the conditions under which the student will perform the task; iii) The criterion component - criteria for evaluating the student performance.

Course level learning objectives/outcomes are written mostly as broad *General Objectives* and less as *Specific Instructional Objectives*. Course outcome are more commonly written as higher level ability, such as the ability to *analyze, synthesize, evaluate*, rather than lower level ability such as *recall, explain*, etc. which are more commonly used. Module level learning outcome are more specific and often should contain more *action verbs* to define the learning objectives. These objectives need to be, not only consistent with the course level learning objectives, but should actually be logically elaborated versions of the course objectives. A unit is a quantum of learning, equivalent to about 1-hour of class room lecture. These are to be written as *Specific Instructional Objectives* following well established learning taxonomies, such as that of Bloom's Taxonomy, using appropriate action verbs for appropriate domains and levels of learning. Typically, a course is expected to have no more than 5-8 groups of objectives, 5-10 modules, and typically a total of 40 units spread over the modules. A typical module may have 5-8 objectives and a unit may have 2-3 objectives.

The developed course structure will be available to all the learners for all the time. The learner now can figure out what they have to do at the end of the course, module and each unit along with the require learning resources. Now the learner has that facility that he can achieve the goal by self-learning or interact with the guide through discussion within their peer group. Eventually, the framework encourages the self-learning, group learning. This kind of teaching learning process changes the role of the teacher. Now the role of the teacher is to be a guide and mentor to the learner.

5. Case Study

The course content is to be developed keeping in mind the aforementioned procedure where student is at the center of learning. It is completely a self-learning course for the student and the course content is designed in such a fashion that it will provide the student with domain specific knowledge by understanding the concepts, apply them to the given situation or a problem statement; analyze it, synthesis it and finally evaluate the required parameters. This may help the learner to apply the same in the practical applications too. Though this course is listed under chemical engineering, but it is designed in such a way that student from any engineering, up to second year level will be able to do this course.

5.1 Development of the course

The development of the course is started with the course description giving the information about all the topics covered in the course. In order to attain a certain level of competency in the student, the objectives were set at the course level indicating their cognitive level. These were set by keeping in mind that once the student completes the course as per instructions given, he/she should have achieved a certain level of knowledge, competency and expertise. Based on the course description, the entire course was divided into nine modules. Since this course was open to multiple engineering disciplines, the first module covers the basic fundamentals required for the course, while the remaining modules were selected such that they cover various energy technologies. At the onset of each module, an overview is provided, followed by the objectives of the module. The objectives, set at each module level, depict the capability the student will achieve once completed. The individual objective level is set selecting a suitable *action verb*, which will set the level of skill set achieved by the student on module completion.

In order to achieve the desired learning outcome, a learning strategy is provided in every module corresponding to the topics, the units, covered and the references thereof. The unit wise references provided are as follows:

- A topic from a textbook with the details of the textbook up to a level of chapter number and page numbers.
- Any website of a similar course from institutes of repute along with the link.
- In some cases, for better understanding and with an aim to provide in-depth knowledge on the topic, references of some relevant journal papers are also given.
- To provide state-of-the-art knowledge, some reports of internationally renowned bodies, and laboratories are also cited.

Every module has a number of units, ranging from three to eight, depending on the portion required to be covered for learning of the complete module. At unit level also, individual unit summary is provided. Also the objectives were set at unit level so that overall unit objectives satisfy the module level objectives. In order to test the proficiency gained at the unit level, two to four test items are given. Students can attempt these tests and upload the answers and then crosscheck the answers with solution set provided. The student can get access to solution set once he/she uploads the answer/solution. The test items are designed as per the cognitive level set for a particular objective of the unit. On similar lines, the test items were given at module level, to test the capability level a student may achieve as per the objectives set. These test items are with a higher difficulty level compared to the unit level test items. Finally, the test items are provided at the course level to test the competency of the student at the course level. These test items require higher level of skill set as compared to the module level test items and also comply with the cognitive level set in objectives of the course. In this fashion, step by step competency of the student is built up, with increase in degree of difficulty from unit level to module level and finally to course level.

5.2 Analysis of the course

The instructional objectives defined at the course, the module and the unit level are analyzed from a pedagogical point of view on the basis of the taxonomy ranks, i.e. knowledge, comprehension, application, analysis, synthesis and evaluation. The various *action verbs* are used to analyze the objectives. The detailed analysis is presented below.

The analyses were carried out employing *Shikshan* - a software tool (2016). Figure 1 illustrates a screenshot of the software interface the user experiences while using the web-based pedagogy framework. Figs. 2-4 depicts the cognitive level analysis of the instructional objectives written in course, module and unit level respectively. The horizontal axis denotes the level of cognitive learning and the vertical axis denotes the number of objectives.

Fig. 1 Pedagogy framework software user interface

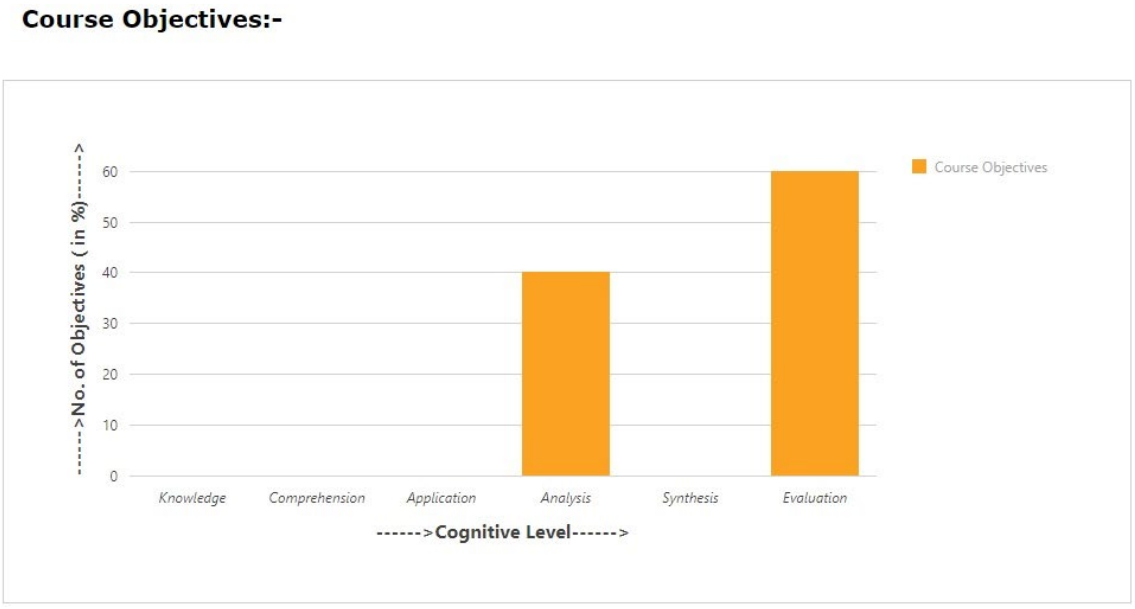

Fig. 2 Course objectives analysis

Module Objectives:-

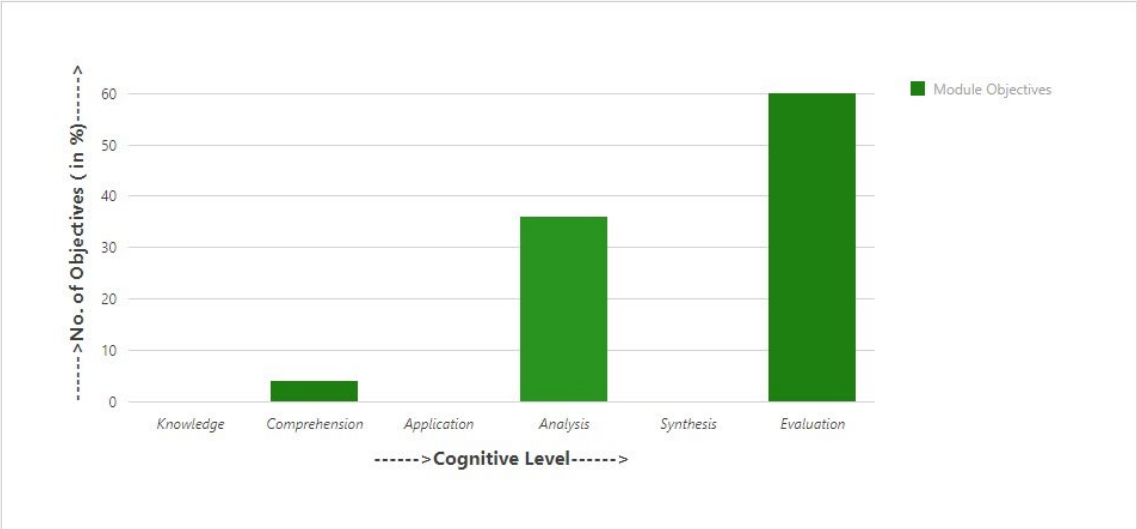

Fig. 3 Module objectives analysis

The histograms exhibit that the instructional objectives mainly focus on higher order cognitive level of learning. The *course level objectives* (Fig. 2) start from analysis level and focus on evaluation level to a greater extent. The *module level objectives* (Fig. 3) comprise a small fraction of units on comprehension along with substantial presence of units reflecting analysis and evaluation levels of learning, while the *unit level objectives* (Fig. 4) cater to all levels of cognitive learning to various extents. Ideally objectives at course, module and unit level should have the same level distribution; however, as one moves down from course level to unit level, the level of cognitive learning goes on spreading where the learner needs some knowledge, comprehension and synthesis too. It can be observed from these histograms that the claim in course objective is well supported by module and unit objectives. On the other hand, the course encourages the development of higher cognitive level skill set leading to an inference that it is a fairly well structured and designed course which exhibits strong compliance with the *Washington Accord*.

Unit Objectives:-

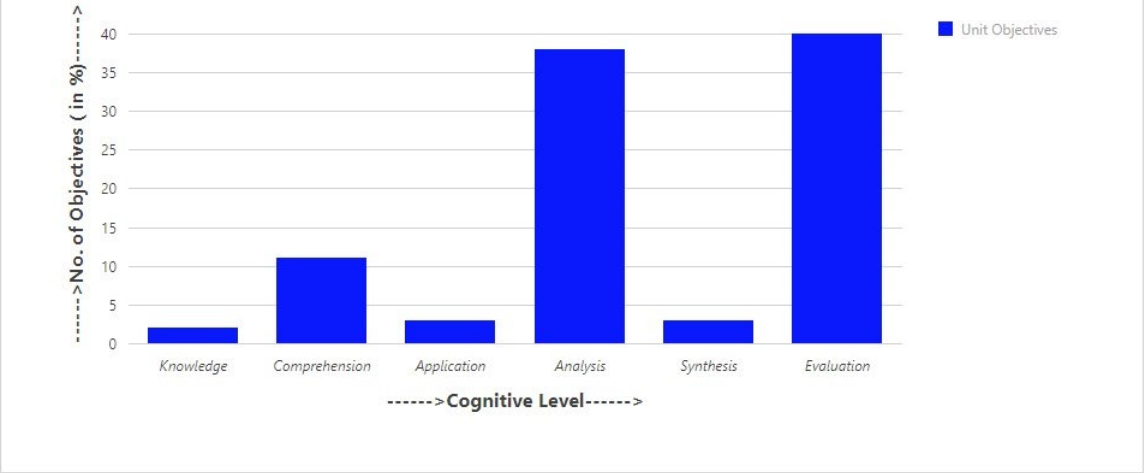

Fig. 4 Unit objectives analysis

6. Conclusion

As per the *Washington Accord*, the graduate engineers need to have competencies in terms of grasping the essential knowledge, conceptualizing it, and applying the concepts learnt in analyzing complex engineering problems to synthesizing appropriate solutions and evaluating various alternative approaches and processes. In order to achieve this objective, the engineering courses should be developed as per pedagogic framework, where the course is designed in modular fashion and which is further discretized in small units. The outcome based instructional objectives are set in terms of the pedagogic structure, at course, module and unit level with a strong correlation between these at all level.

In the present work, a course *Energy Technology* has been developed as per the pedagogic framework and has been tested using a *Shikshan* software tool. It has been observed that from a pedagogic perspective and cognitive level context, there is a near to perfect correlation between course, and module level. At the same time, there is a very good correlation between module and unit level as well.

The present and future educational needs command that courses for an engineering degree programme must encourage higher levels of cognitive learning. Thus it is essential to select instructional objectives with major emphasis on the higher level of cognitive skills such as the ability to analyze, synthesize and evaluate problems and present solutions. Higher cognitive levels were attained at the course and module level in this example course presented. However, at unit level, certain portion at lower cognitive level ushers deeper understanding of the course.

In the present era of information technology, the self and quick learning is the mantra. When ocean of information is available at the fingertip, such student centric course content developed using pedagogic framework under Washington accord gives opportunity to the learner to achieve one's objectives quickly without entering into conventional monotonous and time consuming traditional modes of learning.

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Biography

Manoj Kumar Soni is an Associate Professor in Mechanical Engineering department at BITS, Pilani. He has total teaching and research experience of 22+ yrs. Prior to joing BITS, he was a faculty at VNIT Nagpur. He has total 29 publications in high impact factor international journals and international conferences in his name. His coveted lecture on Spiritual thermodynamics is very well appreciated by the students, academicians and industries. He has delivered this lecture at University of South Florida, many Indian universities and industries.

Tamali Bhattacharyya completed her Masters in Economics (1989) from Calcutta University and PhD (2012) from the School of Education Technology, Jadavpur University on Impact of educational software on learning outcome in secondary school children. Currently she is engaged with the Teaching Learning Center, BITS Pilani as a consultant. She has been offering an online course on Outcome based pedagogic principles for effective teaching under SWAYAM/MOOC from IIT Kharagpur and has conducted several Faculty Development Programmes organized by

IIT Kharagpur over the last 5 years. In the recent past, she has been a Research Project Manager in several education technology based projects at IIT Kharagpur. During her free time, she runs an NGO "ASMA" in West Bengal which among other activities, runs a school employing technology for tribal under privileged children in a village near IIT Kharagpur campus.

Bani Bhattacharya is an Associate Professor in CET, IIT Kharagpur. Her broad areas of expertise are Education Technology, Instructional Design, Pedagogy, Technology Enhanced Education (TEL) and Distance Education. She is the project Principal Investigator of "Developing suitable pedagogical methods for various classes, intellectual calibers and research in e-learning" under MHRD. She is the Coordinator of "National Programme on Technology Enhanced Learning (NPTEL)" Programme – Govt. of India