

Project Brief for Main Phase

Developing suitable pedagogical methods for various classes, intellectual calibres and research in e-learning

National Mission Project on Education through ICT Ministry of Human Resource Development Government of India

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Project Summary

Salient Information

PI, Pilot Phase PI, Main Phase Project Duration Project starting date Anchor Institution Anchor Institution Partner Institutions

Experts

Main Deliverables

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3 years

01-04-2013

Rs. 16 crores

IIT Kharagpur

27 (IITs, NITs, Universities and Engineering Institutions)

700+

- 1) Outcome based curriculum document for 80 B.Tech level 1 semester long courses partially developed during pilot phase.
- 2) Outcome based curriculum document for 120 additional 1 semester long B.Tech level courses started in the main phase.
- 3) 38 regional, national and international seminars, workshops and conferences for awareness and training in pedagogy and OBL
- 4) A sophisticated software tool to develop, monitor and manage OBL curriculum documents

Developing suitable pedagogical methods for various classes, intellectual calibres and research in e-learning

1. Project Outline

1.1 A collaborative project

This project is an experiment to systematically design and develop learner-centric curricula, suitable for outcome-based learning for 4 year degree programmes in six major engineering disciplines. This project is NOT, yet another attempt to develop content, although each curriculum document is expected to include around 80 pages of course notes and 120-125 self assessment problems and solutions. All development and review activities will be carried out collaboratively, using a specially designed web tool. A large number of motivated and experienced faculty members trained in pedagogy of teaching-learning, drawn from a diverse range of institutions across the nation are expected to participate in the development and the review process. The decision to involve such a wide section of faculty experts across India is deliberate, mainly to enhance acceptance and ownership.

1.2 Who are the beneficiaries?

Eventually, these or modified versions of these documents, are expected to be available in the departmental websites of all engineering degree awarding institutions. These documents are primarily meant for students, telling them (long before the commencement of academic sessions) what knowledge, skills and attitudes they should be able to demonstrate on completion of each course, where to find the necessary learning resources (in addition to approximately 80 pages of in-built course notes) and also providing them with opportunities for self assessment (around 120 - 125 practice problems / assignments with solutions). Used innovatively, these documents can promote self and group learning; can teach students how to work in small collaborative groups and how to learn on their own. All faculty members, in particular, those who may have to teach such a course for the first time, are likely to find these documents extremely useful. Since terminal objectives and learning resources will be carefully selected and explicitly stated, all stake holders - students, teachers, (paper setters and examiners in affiliated college systems) and potential employers are likely to benefit very significantly. Evaluation of student achievement can be made more valid and reliable as the benchmark of achievements is explicitly stated. Every institution who decides to implement this innovation is likely to find compliance with NBA requirements much easier.

1.3 What is the most significant deliverable?

By the end of the main phase of the project in March, 2016, a total of 200 curriculum documents of one semester long courses (equivalent to 40x1 hour classroom lessons) in CE, EE, ME, ECE, CSE and Chem. E disciplines, written in terms of Specific Instructional Objectives should be available as Open Educational Resource (OER) on the project website pedagogy.iitkgp.ernet.in. Anyone who wishes to use these may do so with full right to adopt / modify these courses to suit their own purpose. Provision to update these courses on a continuing basis, using a modified form of crowd sourcing method is under active consideration. These curriculum documents are not prescriptive in nature, nor do they represent the views of the institution/ department to which the development team belongs. These are examples created by expert faculty members drawn mostly from tier one institutions such as the IITs NITs, good universities and reputed institutions of national standing. They may, however be adopted/ adapted by those institutions who believe that their Mission, Vision and PEOs are close enough to the stated Mission, Vision and the PEOs. For potential users, the methodology is no less important than the final output as they may wish to modify an existing course to suit their Institution's Mission and Vision and the PEO of their own programme. They could act as guidelines for others who wish to develop their own curricula. The brief given to the curriculum development teams is to design and develop curricula, keeping academic requirements as the prime consideration, rather than be restricted by existing syllabus being followed in their own institutions.

There will be around 25 departmental core and selected elective (3rd to 8th semester level) courses in each of the 6 disciplines mentioned above. Around 25 additional (3rd to 8th semester level) courses from other disciplines (Architecture / Mining etc.), depending on the expression of interest by competent experts are also planned. In addition to the above 175 courses, around 20 to 25 common 1st to 3rd semester level courses (Physics, Chemistry, Maths, HSS, Management, Programming etc.) are also to be taken up.

1.4 What will be the curriculum document will contain?

[Note: All terminologies are explained in section 2.5, pages 8-9]

- The actual/ assumed Mission and the Vision statement of the concerned institute.
- Programme Educational Objectives (PEO) of the concerned department.
- List of courses needed to meet PEO giving brief (2-3 lines) justification.

• Curriculum of each course divided into appropriate number of modules (typically 6-8) and each module divided into appropriate number of units (typically 5-7), totaling 40 units (equivalent to 40 hrs of classroom instruction), showing:

Overview and Objectives

Course Overview: 1/2 to 3/4 page length

Course Objectives: 5 to 6 groups of important objectives (1/2 page in length)

Module Overview: 1/4 to 1/2 page

Module Objectives: typically 5-7 depending on the number of units in a module. Unit Objectives: typically 1-3, depending on the level of the objectives. The higher the level (analysis/ synthesis/ evaluation), the less is the number of objectives.

Problems / Assignments matched with objectives along with full solutions

- 4-6 non trivial (MCQ, T/F types to be avoided) and original (ensuring no copyright violation) course level problems / assignments with full/all solutions mainly for self assessment purpose. Every problem/ assignment is expected to be clearly matched with instructional objectives of that course. Course level problems should require the achievement of all or most objectives of the complete course.
- 2 3 non trivial (MCQ, T/F types to be avoided) and original module level problems/ assignments per module, mainly for self assessment purpose, with full/all solutions, Every problem/ assignment is expected to be clearly matched with specific instructional objectives for every module (15 for 6 or 20 for 8 modules). Solution of module level problems should require the achievement of all or most of the objectives of the complete module.
- 2 3 non trivial (MCQ, T/F types to be avoided) and original unit level problems/ assignments per unit with full solutions, mainly for self assessment purpose. Every problem/ assignment is expected to be clearly matched with specific instructional objectives for every unit (total 100 for 40 units). Solution of unit level problems should require the achievement of all or most of the objectives of that particular unit.

Module Learning Strategy

For every module, a self study guide is to be prepared, outlining the important concepts, applications and inter-relationships. The curriculum development teams are expected to suggest details of page nos. / chapters of text books, most relevant journals, most relevant websites, simulation tools, virtual labs, NPTEL or other videos as applicable, to enable students to learn on their own, either individually or as members of small collaborative groups. The references are expected to be precise to reduce preparation time. Faculty team must keep in mind that majority of students can be expected to spend very limited time per hour of class room instruction. The text books and journals suggested are expected to be easily available and should be few in number.

Wherever possible, problem based learning, small group learning, collaborative learning, interdisciplinary projects; use of appropriate simulation/software tools may be suggested/ used/ encouraged with a view to addressing appropriate learning outcomes while mastering specified learning objectives in the domain area. The main aim of this is to encourage and guide the students to define their learning tasks in detail and gradually learn how to learn on their own or work in small groups. The learning objectives and the associated problems are meant to provide the focus for learning.

Unit Summary

There will be a short (around 2 pages) summary for every unit of each course (total 80 pages). Applications in real life / relevance to other units/ salient issues as applicable are expected to be included in the unit summary.

1.5 Curriculum Development Strategy

1.5.1 Development and Review Process

1.5.1.1 Compensation and Recognition

For the new courses to be taken up in the main phase, a token honorarium of Rs. 5.0 lakhs is admissible to each faculty team, subject to the condition that the maximum financial compensation is limited to 3 month's salary for every individual involved in the project. Honorarium will be paid only on satisfactory completion of the work, after all review comments have been acted upon. The right to declare a course unsatisfactory

will be the joint prerogative of the reviewers, the institute coordinator and the PI of the project, with clear understanding this prerogative should be used very sparingly. The share of honorarium for each member will be based on their declared contributions.

For the new courses to be taken up in the main phase, normally, only one reviewer will be appointed for technical review. A token honorarium of Rs. thirty thousand only is admissible. Honorarium will be paid only on satisfactory completion of the work.

Attempts will be made to fully recognize all significant contributions through print and electronic media. The project proposes to give wide publicity to the contributions of all concerned.

1.5.1.2 Course Budget

Estimated maximum cost / full new course Rs. (Lakhs)

Maximum honoraria to faculty team =	5.00
Honoraria to Technical Reviewer =	0.30
Technical/Secretarial Assistance =	0.60
Contingencies/ Consumables =	0.20
Maximum Co-ordinator's honoraria =	0.25
TA/DA =	0.35
HW/SW =	0.30
	7.00

Note: Excepting the honoraria component, institute coordinators may reallocate funds under all other heads as required.

1.6 Development Team Composition, Responsibilities and EOI

A maximum of three and a minimum of two competent faculty members / experts drawn from the partner institutions and who have taught a given course for at least 3 years (preferably much longer) in the immediate past, are eligible to be members of the development team. They are required to fill up the Expression of Interest (EOI) Form available in the website: pedagogy.iitkgp.ernet.in and submit it online. The list of courses already under development and available in the website may be consulted and only new courses in the areas discussed earlier may be proposed. The deatails (including short course description) of all freshly proposed EOIs will also be visible in the website as and when they are submitted. To avoid duplication of efforts, this new list should also be consulted before submitting the EOI. In exceptional cases the same course may be alloted to two different teams.

All members of the development team need not be from the same institution. One member must assume the role of the Principal Developer by mutual agreement. Only the Principal Developer will be assigned a Login and a Password for all activities related to the course development by the team. Other members, who are co-developers, are expected to use the same login and password to ensure that the Principal Developer is always kept in the loop. In case, any of the co-developers leave before completing their work, the Principal Developer is required to find a suitable replacement to get the work completed in time. In case the Principal Developer leaves midway, the institution level coordinator, in consultation with the team is required to find a suitable replacement. The quality and timely completion of a course will be primarily the responsibilty of the Principal Developer. All development team members are required to submit a signed declaration (Form available online) stating that their work does not violate any copyright and they agree to allow their work to be treated as an Open Educational Resource (OER). On completion of the course, team members are expected to submit (Form available online) a mutually agreed statement about the percentage contribution of individual members in the completed work.

1.7 Supports to Development Team

Budget support has been provided for technical/secretarial assistance, contingencies/ consumables, TA/DA, HW/SW on per course basis. Different courses may need different amount of support under different heads. The Institute coordinators have the authority to reallocate funds as required. Faculty teams may need to seek assistance from students / research scholars and sometimes even junior colleagues to research literature, check websites, draw diagrams, type mathematical expressions, create/ solve/ verify problems/assignments. The token budget provided may be used to meet these expenses.

1.8 Reviewer's Responsibilities and Review Process

Every course will need to be peer reviewed to ensure quality, completeness and accuracy. Reviewers are also expected to point out if there has been any copyright violation, if the objectives are appropriate, if the problems/ assignments are non-trivial and original and they match with the objectives which they are supposed to test. Detailed guidelines for the reviewers will be available on the

<u>website</u>. Development team members are expected to suggest a panel of 3 of the best experts in the given area who may be approached to act as the technical reviewer.

The format is shown in the EOI form. Every course will also be reviewed by a team of pedagogic reviewers and a specially developed software suggesting improvements.

While the technical review will begin only after the development work is completed and the development team indicates readiness for review, the pedagogic reviewers may provide continuous feedback, if considered necessary.

1.9 Coordinator's Responsibility

- a) Help identify courses / development team members / reviewers
- b) Appoint reviewers in consultation with the PI
- c) Keep track of progress and take corrective action as and when necessary
- d) Help in conducting workshops/ seminars/ conferences
- e) Check reviewer comments and cross check course team response
- f) Keep track of all expenses and operate budget in consultation with the PI
- g) Any other work for smooth functioning of project

2. Project Rationale:

2.1 Some assumptions

- Knowledge in every field will continue to grow at an ever increasing rate.
- ICT tools will continue to make access to high quality learning resources easier with every passing day.
- Even a four year period is too short a time to learn / teach everything, forcing all professionals to learn many new knowledge and skills throughout their lives and mostly on their own.
- 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.
- They should have the ability to function in a global community through the possession of a range of attitudes and dispositions including flexibility and adaptability, ease with diversity, motivation and persistence, ethical and civil behavior, creativity and resourcefulness.
- All graduates should have a guaranteed level of competence in a given field.

• All graduates should have a demonstrated ability to deploy all of the previous characteristics to address specific problems in complex, real-world settings, in which the development of workable solutions is required.

2.2 Pedagogic implications of the above assumptions

- The curriculum and the pedagogic design must be so integrated as to ensure that students are carefully guided "how to learn" on their own
- It is important to plan teaching-learning activities in such a way that all students learn how to make effective use of ICT tools in searching, indexing, storing and retrieving information quickly.
- Our curriculum should be so designed and the pedagogic strategies so aligned as to ensure that along with the minimum set of competencies in their chosen specialization, graduates also acquire these generic skills and attitudes as an integral part of their programme of study.
- It is necessary to state explicitly these generic skills in the curriculum as essential <u>learning outcomes</u> that need to be demonstrated by all students to be eligible for the award of a degree.

A well designed curriculum must specify:

- Clearly stated domain related learning objectives (Specific Instructional Objectives), corresponding assessment tools and the evaluation methods for all the courses in a particular specialization.
- Teaching-learning methodologies to be adopted to ensure that all graduates are able to demonstrate the possession of the stated learning outcomes (generic skills and attitudes)

2.3 Evidences from pedagogic research

- There are significant differences amongst various classes of learners in terms of learning styles, learning needs, intellectual abilities, preparation, motivation and similar factors known to affect learning.
- Except in special cases where the class size is very small, traditional teacher-centric approach is unable to take care of such individual differences amongst learners.
- Adoption of learner-centric approach, problem based learning and small group collaborative learning, particularly for the higher education is significantly more

- effective compared to the traditional *teacher-centric*, *expository* and *passive learning approach*.]
- Implementation of learner-centric approach, problem based learning and small group collaborative learning particularly for large classes is usually very effort intensive.
- Use of blended learning methods where instructor led teaching is combined with elearning tools can go a long way in adopting learner-centric approach, problem based learning and small group collaborative learning
- ICT tools have enormous potential in designing and delivering high quality education to a much larger student population.

2.4 Need to conform to Washington Accord

Educationists across the world generally agree that in addition to a set of **clearly specified domain knowledge** in their chosen field of study, graduate engineers who successfully complete a four year programme of study after 12 years of scool education, need to possess a **range of generic knowledge**, **skills and attitutudes** to succeed in their professional life in the 21st century world. These generic skills are referred to as **GRADUATE ATTRIBUTES** in the Washington Accord (WA). Boards of Accreditations of all WA signatory nations are required to ensure compliance with broadly similar attributes before recognising any programme of study in their own country. India is now a WA signatory nation and the National Bureau of Accreditation (NBA) of India has specified very similar attributes which need to be complied with by all degree awarding institutions. WA graduate attributes, which are more comprehensive, are reproduced below.

In this document we shall call these attributes as the generic **LEARNING OUTCOMES** of all UG level engineering degree programmes

Washington Accord Graduate Attributes (LEARNING OUTCOMES)

On completion of an accredited programme of study typified by four years or more of post-secondary education, a student should be able to:

1) Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the conceptualization of engineering models.

- Identify, formulate, research literature and solve complex engineering problems reaching substantiated conclusions using first principles of mathematics and engineering sciences.
- 3) Design solutions for **complex engineering problems** and designsystems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
- 4) Conduct investigations of **complex problems** including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions
- 5) Create, select and apply appropriate techniques, resources, and modern engineering tools, including prediction and modeling, to **complex engineering activities**, with an understanding of the limitations
- 6) Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- 7) Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.
- 8) Demonstrate understanding of the societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to engineering practice.
- 9) Understand and commit to professional ethics and responsibilities and norms of engineering practice.
- 10) Understand the impact of engineering solutions in a societal context and demonstrate knowledge of and need for sustainable development.
- 11) Demonstrate a knowledge and understanding of management and business practices, such as risk and change management, and understand their limitations.
- 12) Recognize the need for, and have the ability to engage in independent and life-long learning.

It is important to note that these knowledge, skills and attitudes are independent of the domain knowledge and are common to all disciplines.

Definitions of Complex Engineering Problems

Engineering problems which cannot be resolved without in-depth engineering knowledge and having some or all of the following characteristics:

- Involve wide-ranging or conflicting technical, engineering and other issues
- Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models
- Requires in-depth knowledge that allows a fundamentals-based first principles analytical approach
- nvolve infrequently encountered issues
- Are outside problems encompassed by standards and codes of practice for professional engineering
- Involve diverse groups of stakeholders with widely varying needs
- Have significant consequences in a range of contexts
- Are high level problems possibly including many component parts or sub-problems.

Definitions of Complex Engineering Activities

Complex EngineeringActivities means *activities* or projects that have some or all of the following characteristics:

- Involve the use of diverse resources (and for this purpose resources includes people, money, equipment, materials, information and technologies)
- Require resolution of significant problems arising from interactions between wideranging or conflicting technical, engineering or other issues,
- Involve creative use of knowledge of engineering principles in novel ways
- Have significant consequences in a range of contexts
- Can extend beyond previous experiences by applying principles-based approaches

2.5 Systematic Design of Curricula

Explanation of Terminologies

• Mission and Vision of an Institution

Every University/ Institution *is expected* to have explicit statements about their Mission and Vision. In reality, many do not declare these explicitly.

A major purpose of these statements is to clearly articulate the kind of job roles that their students are expected to be prepared for. The curriculum structures and the Programme Educational Objectives of all constituent departments need to be alligned to fulfill the Mission and Vision of the University / Institution.

Most tier one Institutions and Universities expect many of their alumni to take up teaching and research functions. Usually their mission also includes producing leaders and innovators. The products of these institutions are expected to be responsible for undertaking activities which cater to the long term needs of the country.

Some Institutions and Universities aim to produce human resources who are expected to be good design and development engineers/ technocrats and are capable of taking care of midterm (around 5-10 years ahead) requirements. There are still others, who aim to produce engineers to take up the responsibility of keeping the wheels of industry running on a day to day basis.

Programme Educational Objectives of Departments (PEO)

PEOs are statements that define the intentended common profile of the graduates of a particular programme of study in a department. Typical PEOs are similar to but not identical with the WA graduate attributes / requirements specified by the Accreditation Authority of the concerned country.

Most departments have distinct strengths and weaknesses and their own ideas about the kind of engineers they would like to produce. Some wish to produce engineers with one kind of specialization within a particular branch of engineering; others may prefer a different kind of specialization / emphasis.

Departments need to formulate and state Programme Educational Objectives explicitly and choose courses that will fulfill these PEOS. PEOs should be consistent with the Mission and Vision of the organization to which they belong.

Instructional / Learning Objectives (Please see Annexure 1 for details)

Learning Objectives are 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.

Learning Objectives are unambiguous statements <u>defining in clearly measurable</u> <u>terms what the student will be able to DO</u> on successful completion of the course / module / unit. These are <u>NOT</u> statements of the instructor's teaching / action plan.

2.6 Selecting Appropriate Instructional Objectives

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/solutions/ products and processes. While designing a course for an engineering degree programme, it is essential to select Instructional Objectives with major emphasis on the higher level cognitive skills like the ability to analyze synthesize and evaluate problems and solutions. If a course is designed where the instructional objectives mainly require a student to remember facts and figures, methodologies, conventions, trends, sequences etc and at best understand and apply some of the important concepts/ principles, then the course is more likely to be suited to a technician than an engineer.

Most engineering courses, particularly those taught in the 4th to 8th semesters should ideally attempt to develop higher order (level) cognitive skills (creation, evaluation, synthesis, analysis etc.) instead of concentrating only on the lower order skills such as the ability to recall, to understand and to apply. Even within a course it is expected that the emphasis would shift from lower to higher cognitive levels as the course progresses. If the majority of the courses in a programme of study are designed to develop mainly the lower order skills then such a programme is more suitable for award of a diploma than a degree.

Arbitrarily assuming that a typical 40 unit course has 100 unit objectives (average of 2-3 /unit) then to ensure mastery of a topic requiring a high level cognitive skill (say Synthesis), adequate number of lower level cognitive skills (knowledge/recall, comprehend/understand, application, analysis) need to be mastered in earlier units (or should be assumed to be prerequisite for that course). Unless prerequisites are adequately defined, a great many units need to be provided for mastering low level cognitive skills before higher level skills can be achieved. Thus the distribution of

learning objectives of most courses is expected to be larger at the lower level and gradually reducing in number for higher levels.

Overview and Course Level Learning Objectives

A Course Overview statement defines the scope of the course. It can be written as a list of topics or a short description of the nature of the course. It does not define any measurable performance outcome that the learner needs to demonstrate on completion of the course. Articulating Course Objectives becomes easier when Course Overview is written first. Course Objectives are more commonly written as higher level demonstratable abilties such as the ability to "analyze", "synthesize", "evaluate", rather than lower level abilities such as "recall", "explain" etc which are more commonly applicable to unit level objectives. 5 to 6 groups of comprehensively written important learning objectives (1/2 page in length) are usually quite adequate at course level.

An example of a very well written Course Objectives

Course name: Introduction to Algorithm Design

Course Objectives

Students pursuing this course should be able to

1. Knowledge: Given an English language problem description, define the problem precisely with Input / output requirements, examine its inherent complexity and develop a generic or setof initial solutions (which can be

explored for various design options) and justify their correctness.

2. **Analysis:** Given a problem definition, **explore** different alternative algorithmic solutions, compare them with respect to time and space complexity and choose the design schemes and/or design parameters and data structures appropriately to obtain the best possible choice(s) that can be converted to an executable program.

- Analysis: Given an algorithm description, analyze the time and space complexity of the algorithm in the worst case, average case and amortized scenario as needed in terms of asymptotic orders of complexity.
- 4. <u>Analysis:</u> Examine and prove whether a problem is of polynomial complexity, hard (NPComplete) or otherwise and develop optimal and approximation algorithms for them as applicable
- Synthesis: Design and analyze algorithms using the methods studied to solve problems in important applications including those related to sorting, searching, strings, graphs, matrices, data structuring and combinatorial optimization.

Comments and suggestions:

 a) This is an excellent example of Course Level Objectives. All objectives require high level cognitive skills (application, analysis, synthesis/design, evaluation etc).

They are demanding and have the potential to bring out the best in students.

- b) The objectives selected, not only fulfill the demands of the specific course (domain knowledge), but also fulfill the first 5 Learning Outcomes mentioned under section 2.4: Outcome-based Learning (generic skills).
- c) All objectives have been written using appropriate action verbs which leave very little room for different interpretation by different people. The objectives specify what the students are able to do at the end of a course, rather than what the course is all about. Proof of their ability to perform these actions through appropriate tests may be taken as the evidence that they have achieved the objectives.
- d) The first 3 Instructional Objectives also include the *Condition Components* such as given an English language problem description; given an algorithm description; given a problem definition, using the methods studied Ideally all well written Instructional objectives should include condition components to

specify under what condition the learner should be able to do what is expected

of them, but many instructors miss this clause.

e) The third important component of a well written instructional objective is the

criteria of acceptable performance describing how well the learner must

perform to be considered acceptable.

f) These instructional objectives

are set at levels which are very appropriate for engineering degree

programme in CSE in a tier 1 institution

fulfill many learning outcomes

are expressed using correct action verbs, including condition components

and defining purpose (which can be explored for various design options;

as needed in terms of asymptotic orders of complexity; that can be

converted to an executable program) for additional clarity.

are sufficiently comprehensive to serve as Course Objectives.

An example of a badly written Course Objectives

Course: ABCDEF......

Course Objectives

2. The course will develop an awareness regarding yyyyyyyyyy

3. The course will provide an overview on various zzzzzzzzzzzzzzzzzzz.

4. The course will reveal different technologies to design aaaaaaaaaaaaaaaa

5. Will generate interest for doing higher studies/research in this field.

6. To promote efficient use of acfsvdbfhgy related to nhgbvfdcaser

7. How to aaaaaaaaaaa and to improve abcdabcdabcd.

Comments and suggestions:

- a) None of the above specifies what the learner will be able to DO (performance component) under what given situation (condition component) or what the criteria for acceptance are?
- b) None of the above remotely resembles Instructional Objectives and hence will render the rest of the work invalid. Without a clearly defined set of instructional objectives, it is impossible to write problems, assignments which test the achievement of those objectives.
- c) Very major rework is called for.

Module Level Learning Objectives

Each course is expected to be divided into a number of logically structured modules. Module level Learning Objectives are typically 5-7 in number, depending on the number of units in a module. They 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.

• Unit Level Learning Objectives

A unit is a quantum of learning, equivalent to one hour of class room lecture and a maximum of 1 hour of corresponding homework. These are to be written as Specific Instructional Objectives following well established Learning Taxonomies (such as that of Bloom's Taxonomy, explained later) using appropriate Action Verbs for appropriate Domains and Levels of learning. Typically a course is expected have at least 40 units (equivalent to 40 x 1 hour lectures and corresponding homework). Each Instructional Objective should be written separately (more than one should not be combined in one sentence) so that it is possible to test whether a student has achieved an objective independent of other instructional objectives.

2.7 The Challenge

2.7.1 Course Matrix

The challenge lies in devising teaching / learning strategies to ensure that the programme/course level **learning objectives** in the concerned engineering discipline and the **Learning Outcomes**, mentioned above **are learnt (taught) simultaneously**

It is important to understand that **Learning Objectives at all levels have close relationships with the Learning Outcomes as defined earlier.** Faculty members wishing to become members of course design and development teams need to realize that design of learning strategies which are likely to ensure achievement of the specified learning objectives and the specified learning outcomes at the **same time** is probably the most crucial and also the most difficult part of the proposed work.

It is possible to teach a course on communication to achieve Learning Outcome (6) of WA or other specially designed courses to teach one or the other of the outcomes. A better alternative is to devise learning strategies for each course in such a way as to ensure that on successful completion of each of these courses, the student learns not only the course specific learning objectives but also the generic Learning Outcomes to the extent possible.

An example of a well written, concise yet comprehensive set of Course Objectives of a course on Introduction to Algorithm Design, shown below in a Course Matrix format illustrates this concept. The course matrix tells us that if a particular course level instructional oblective (shown in the rows) is achieved fully (as evidenced by student achievement evaluation through well designed tests), then which of the Learning Outcomes (shown in the columns) are likely to be met (fully = 3; partially = 2; inadequately = 1). It also indicates which Learning Outcomes are unlikely to be met for this particular course.

	COURSE OBJECTIVES	LEARNING OUTCOMES*											
		1	2	3	4	5	6	7	8	9	10	11	12
1.	Given an English language problem description, define the problem precisely with input/output requirements, examine its inherent complexity and develop a generic or set of initial solutions (which can be explored for various design options) and justify their correctness.		3	3	3	3	2	-	-	-	-	-	-
2.	Given an algorithm description, analyze the time and space complexity of the algorithm in the worst case, average case and amortized scenario as needed in terms of asymptotic orders of complexity.		3	3	3	3	2	-	-	-	-	-	-
3.	Given a problem definition, explore different alternative algorithmic solutions, compare them with	2	2	3	3	3	2	-	-	-	-	-	-

	respect to time and space complexity and choose the design schemes and/or design parameters and data structures appropriately to obtain the best possible choice(s) that can be converted to an executable program.												
4.	Design and analyze algorithms using the methods studied to solve problems in important applications including those related to sorting, searching, strings, graphs, matrices, data structuring and combinatorial optimization.	3	3	3	3	3	2	-	i	-	-	-	-
5.	Examine and prove whether a problem is of polynomial complexity, hard (NP Complete) or otherwise and develop optimal and approximation algorithms for them as applicable	2	2	2	3	3	2	-	•	-	-	-	-

The numbers 1, 2 or 3 entered for a particular objective (rows) and a particular Outcome (columns), indicate how well that objective will address the corresponding outcome. A - mark denotes that the grade (1/2/3) will depend on the teaching/ learning strategy followed by the instructor / learners. For example, if the strategy of collaborative group learning, self learning is used as a common practice then the grades would be high for those learning outcomes.

- 1= Objective addresses corresponding Learning Outcome marginally
- 2= Objective addresses corresponding Learning Outcome somewhat satisfactorily
- 3= Objective addresses corresponding Learning Outcome very satisfactorily

Learning Outcome Numbers 1 to 12

- 1. Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the conceptualization of engineering models.
- Identify, formulate, research literature and solve complex engineering problems
 reaching substantiated conclusions using first principles of mathematics and
 engineering sciences.
- 3. Design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
- Conduct investigations of complex engineering problems including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions
- 5. Create, select and apply appropriate techniques, resources, and modern engineering tools, including prediction and modeling, to complex engineering activities, with an understanding of the limitations

- Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- 7. Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.
- 8. Demonstrate understanding of the societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to engineering practice.
- 9. Understand and commit to professional ethics and responsibilities and norms of engineering practice.
- 10. Understand the impact of engineering solutions in a societal context and demonstrate knowledge of and need for sustainable development.
- 11. Demonstrate a knowledge and understanding of management and business practices, such as risk and change management, and understand their limitations.
- 12. Recognize the need for, and have the ability to engage in independent and life-long learning

2.7.2 Programme Matrix

The Programme Matrix shows which courses are likely to meet which learning outcomes to what extent. A Programme may be considered to have met all learning outcomes if every outcome appears to be met at level 3 by a significant number of courses. It also shows what improvements are needed in the course design.

	PROGRAMME MATRIX – AN EXAMPLE													
COURSE	LEARNING OUTCOMES*													
NOS.	1	2	3	4	5	6	7	8	9	10	11	12		
EE 100	3	3	3	3	3	2	1	-	-	-	-	-		
	3	3	3	3	3	-	2	1	2	1	1	1		
PH103	3	3	3	3	2	1	-	-	-	-	?	-		
	-	-	-	-	1	2	3	2	3	3	2	2		
MA 203	3	3	3	2	2	2	?	-	-	-	-	-		
	1	2	-	2	1	1	3	1	3	1	1	1		
	1	2	-	2	1	1	3	1	1	1	1	1		
EE409	3	3	3	3	3	1	?	-	-	-	-	2		
	1	2	1	3	1	3	3	1	2	1	1	1		
HS211	1	2	2	3	3	1	3	2	3	-	1	3		

1. Taxonomies of Learning.

Historical Background

A group of college and university professors led by Benjamin S. Bloom published a handbook in 1956 called "Taxonomy of Educational Objectives –The classification of Educational Goals". Bloom's Taxonomy is used extensively for planning of teaching / learning activities

Domains of Learning

According to Bloom's Taxonomy, all learning can broadly be classified into one of the following three domains:

- 1. COGNITIVE DOMAIN: Involves mainly Thinking
- 2. PSYCHOMOTOR DOMAIN: Involves mainly Action
- 3. AFFECTIVE DOMAIN: Involves Feelings / Attitudes

Each domain has 5 -6 levels that are hierarchical in terms of complexity

► COGNITIVE DOMAIN

Cognitive Domain is the domain most involved in higher learning. It has seven levels.

Most difficult to master 7. Creation

6. Evaluation

5. Synthesis

4. Analysis

3. Application

2. Comprehension

Easiest to master

1. Knowledge / Recall

Bloom and his colleagues used the term "knowledge" not in the traditional way but to refer to those cognitive skills which only needed memorization. Brief explanation of each of these domains is given below.

Evaluation: The ability to make judgments about the value of ideas or materials

Synthesis: The ability to build a structure or pattern from diverse elements and/or put

parts together to form a whole, with emphasis on creating a new meaning or

structure.

Analysis: The ability to break down material into its component parts so that its

structure may be understood

Application: The ability to use a concept in a new situation.

Comprehension: The ability to grasp meaning of material.

Knowledge: The ability to recall information (Lowest Level)

Knowledge can be subdivided into many sub levels such as knowledge of:

terminologies,

specific facts,

conventions,

trends and sequences,

classifications and categories,

various criteria,

methodologies,

principles and generalizations,

theories and structures

It is essential to gain mastery of the **knowledge level** before one can grasp the meaning of any new learning situation / concept / theory / principle (**Comprehension**). It is clear that each level requires mastery of all the lower levels.

Action verbs for stating Behavioral Objectives in the Cognitive Domain

Knowledge: Remembering previously learnt material

Cite, label, name, reproduce, define, list, quote, pronounce, identify, match, recite, state

Comprehension: ability to grasp the meaning

Alter, discover, explain, rephrase, substitute, convert, give examples, summarize, give idea, restate translate, describe, illustrate, reword, interpret, paraphrase

Application: ability to use learned material in new and concrete situations

Apply, relate, classify, employ, predict, show, compute, prepare, solve and demonstrate

Analysis: ability to break down material into its component parts so that its organizational structure may be understood.

Ascertain, diagnose, distinguish, outline, analyze, divide, point out, associate, differentiate, examine, reduce, conclude, discriminate, find, separate, designate, dissect, infer, determine

Synthesis: ability to put parts together to form a new whole

Combine, devise, originate, compile, expand, plan, compose, extend, synthesize, conceive, generalize, revise, create, integrate, project, design, invent, rearrange, develop, modify

Evaluation: ability to judge the value of material for a given purpose

Appraise, conclude, critique, judge, assess, contrast, deduce, weigh, compare, criticize, evaluate.

This is an example, randomly selected from the list of courses under development to explain the importance of setting appropriate objectives and adopt appropriate teaching learning strategies.

▶ Psychomotor Domain

Psychomotor Domain includes physical movement, coordination, and use of the motor-skill areas. Requires practice, measured in terms of - speed, precision, distance, procedures, or techniques in execution

(Lowest) (Highest)

Imitation Manipulation Precision Articulation Naturalization

Imitation:

Observing and patterning behavior after someone else. Performance may be of low quality. May repeat an act that has been demonstrated or being able to perform certain actions by following instructions and practicing - until it becomes habitual. Learner still isn't "sure of him /herself.

Example: Creating work of art on one's own, after taking lessons, or reading about it.

Precision:

Refining, becoming more exact skill has been attained. Proficiency is indicated by a quick, smooth, accurate performance, requiring a minimum of energy. The overt response is complex and performed without hesitation. Few errors are apparent.

Example: Working and reworking something, so it will be "just right".

Articulation:

Coordinating a series of actions, achieving harmony and internal consistency, involving an even higher level of precision. The skills are so well developed that the individual can modify

movement patterns to fit special requirements or to meet a problem situation.

Example: Producing a video that involves music, drama, color, sound,

Naturalization:

Having high level performance- becomes natural, without needing to think much about it response is automatic. The individual begins to experiment, creating new motor acts or ways of manipulating materials out of understandings, abilities, and skills developed.

Example: Michael Jordan playing basketball

AFFECTIVE DOMAIN:

Levels in the Affective Domain:

(lowest) (highest)

Receiving Responding Valuing Organizing Characterizing

Receiving - is being aware of or sensitive to the existence of certain ideas, material, or phenomena and being willing to tolerate them

Responding - is committed in some small measure to the ideas, materials, or phenomena involved by actively responding to them.

Valuing - is willing to be perceived by others as valuing certain ideas, materials, or phenomenon

Organization - is to relate the value to those already held and bring it into a harmonious and internally consistent philosophy.

Characterization- by value or value set - is to act consistently in accordance with the values he or she has internalized.