Chapter 4

Design of Generalized E-Learning Model

4.1 e-learning standards

Since past few decades, it is widely adopted, open, and accredited that, standards are a fundamental requirement for revolutionary changes to “take off”. In the case of electricity, this was the standardization of voltage and plugs; for railroads, the standard gauge of the tracks; and for the Internet, the common standards of TCP/IP, HTTP, and HTML (of course, there are differences in browsers, but the main point still holds). In general, standards are prerequisites for the interoperability of systems from different vendors and therefore increase the flexibility and independence from customers to choose from a larger variety of products and services, but it also has advantages for the vendors as compared to customers. [59]

In specific interest for e-Learning the benefits are as follows.

Trainees may select from a larger collection of courses on different platforms because all standardized courses can run on all e-Learning systems which support those standards. If standards for learner profiles are fully defined and adopted trainees may also more easily move between institutions – anywhere in the world - with far greater ease than is currently possible, and comparatively lesser cost taking their academic record with them.

- For trainers and authors, e-Learning standards may make it easier to share course materials with colleagues, and to use materials produced by a much wider range of publishers without worrying about those materials being incompatible with their existing course management software making widespread use of learning materials.

- Institutions benefit from the increased interoperability of different systems and modules and can therefore build up a system which exactly matches their
needs and is made of modules from different software vendors and existing infrastructure.

- Publishers can reduce costs and time to market for their materials, because content does not need to be developed for multiple e-Learning platforms and learning management systems.

- Vendors of e-Learning systems will have more satisfied customers, due to the reasons mentioned above. Vendors supporting standards will therefore be preferred in comparison to vendors which only offer proprietary technology. However the clear downside of standards for vendors is that their clients can move on more easily to a competitor if they are not satisfied, which on the other hand is of course a clear advantage for customers.

e-Learning standardization efforts are made by a number of different consortiums of various types (research community, user and governmental organizations, or standards body) which concentrate on different aspects of e-Learning but which mostly work together in some direct or indirect way. The chapter will focus on what is going on in the field of e-Learning standards and who is trying to achieve what in cooperation with whom.

**AICC – Aviation Industry CBT Committee**

AICC is the oldest (since 1988) standardization consortium in the field of computer based training and e-Learning. It is an international association of technology-based training professionals and develops guidelines for the aviation industry in the development, delivery, and evaluation of CBT and related training technologies. As they had been the first dealing with standardizations they had a big impact on all industry sectors, not restricted to the aviation industry. Originally it had to deal with the requirements for operation systems, the standardization of hardware, icons and various document type formats like graphics, audio and video. “Web Based Computer-Managed-Instruction” which recommends guidelines that promote the interoperability of Web-based CMI systems. Interoperability means the ability of a given CMI system to manage CBT lessons from different origins. This includes the ability for a given CBT lesson to exchange data with different CMI systems in two ways (http and JavaScript -based), the ability to export and import AICC-compatible course structure files and the generation of
AICC-compatible lesson evaluation files. [26][61] Simply speaking this guideline recommends how to launch and track courses within an LMS.

**Dublin Core Metadata Initiative**

The Dublin Core Metadata Initiative (DCMI) is an organization dedicated to promoting the widespread adoption of interoperable metadata standards and developing specialized metadata vocabularies for describing resources that enable more intelligent information discovery systems. Its name comes from an initial workshop about metadata semantics in Dublin, Ohio 1995. More than 50 people discussed there how a core set of semantics for Web-based resources would be extremely useful for categorizing the Web for easier search and retrieval. [27][62-63]

The Dublin Core metadata standard is a simple yet effective element set for describing a wide range of networked resources. The Dublin Core standard comprises fifteen elements, which can be refined to add richness of description. The semantics of which have been established through consensus by an international, cross-disciplinary group of professionals from librarianship, computer science, text encoding, the museum community, and other related fields of scholarship. [64]

These are the fifteen elements:

1. **Title**: Typically, a Title will be a name by which the resource is formally known.
2. **Creator**: An entity primarily responsible for making the content of the resource. For example, authors in the case of written documents, artists, photographers, or illustrators in the case of visual resources.
3. **Subject and Keywords**: The topic of the content of the resource. Typically, a Subject will be expressed as keywords, key phrases or classification codes that describe a topic of the resource.
4. **Description**: An account of the content of the resource. Description may include but is not limited to: an abstract, table of contents, reference to a graphical representation of content or a free-text account of the content.
5. **Publisher**: An entity responsible for making the resource available
6. **Contributor**: An entity responsible for making contributions to the content of the resource.
7. **Date:** Typically, Date will be associated with the creation or availability of the resource. Recommended best practice for encoding the date value is defined in a profile of ISO 8601 and follows the YYYY-MM-DD format.

8. **Type:** The nature or genre of the content of the resource. Type includes terms describing general categories, functions, genres, or aggregation levels for content.

9. **Format:** Typically, Format may include the media-type or dimensions of the resource. Format may be used to determine the software, hardware or other equipment needed to display or operate the resource. Examples of dimensions include size and duration.

10. **Identifier:** An unambiguous reference to the resource within a given context. Recommended best practice is to identify the resource by means of a string or number conforming to a formal identification system. Examples of formal identification systems include the Uniform Resource Identifier (URI) (including the Uniform Resource Locator (URL)), the Digital Object Identifier (DOI) and the International Standard Book Number (ISBN).

11. **Source:** A reference to a resource from which the present resource is derived.

12. **Language:** A language of the intellectual content of the resource. Recommended best practice is to use RFC 3066.

13. **Relation:** A reference to a related resource.

14. **Coverage:** The extent or scope of the content of the resource. Coverage will typically include spatial location (a place name or geographic coordinates), temporal period (a period label, date, or date range) or jurisdiction (such as a named administrative entity).

15. **Rights:** Information about rights held in and over the resource. Typically, a Rights element will contain a rights management statement for the resource, or reference a service providing such information. Rights information often encompasses Intellectual Property Rights (IPR), Copyright, and various Property Rights.

**IEEE LTSC - Learning Technology Standards Committee**

The Learning Technology Standards Committee (LTSC) is chartered by the IEEE Computer Society Standards Activity Board to develop accredited technical standards,
recommended practices, and guides for learning technology. The LTSC coordinates formally and informally with other organizations that produce specifications and standards for similar purposes. [28][29] Over time up to 20 working groups have discussed different aspects of e-Learning. Currently five are still active:

- P1484.1 Architecture and Reference Model WG
- P1484.11 Computer Managed Instruction (CMI) WG
- P1484.12 Learning Objects Metadata (LOM) WG
- P1484.18 Platform and Media Profiles WG
- P1484.20 Competency Definitions WG

In addition to that there is also a study group about digital rights expression language.

The standards development is done via a combination of face-to-face meetings, teleconferences, and exchanges on discussion groups. Each of the working groups is headed by a WG chair and the whole committee is governed by the five Sponsor Executive Committee officers (chair, vice-chair, treasurer, secretary and information officer).

**Learning Objects Metadata (LOM)**

LOM is based on the work of ARIADNE, IMS and DCMI and defines a structure for interoperable descriptions of learning objects of different granularities. A learning object is defined as any entity -digital or non-digital- that may be used for learning, education or training. The LOM descriptions are grouped in general, life cycle, meta-metadata, educational, technical, educational, rights, relation, annotation, and classification categories. This standard does not define how a learning technology system represents or uses a metadata instance for a learning object; this is partly defined in IMS and ADL/SCORM. [30][60]

The purpose of this standard is to facilitate search, evaluation, acquisition, use, sharing and exchange of learning objects, for instance by learners or instructors or automated software processes such as course authoring and structuring tools.

**LOM defines nine categories which group different data elements.**

The General category groups the general information that describes the learning object as a whole, such as identifier, title, language, description, keyword, coverage, structure (underlying organizational structure of the learning object, e.g. atomic, linear or
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hierarchical) and aggregation level (level of granularity – from raw media up to a set of courses)

1. The Lifecycle category groups the features related to the history and current state of this learning object and those who have affected this learning object during its evolution. Elements are version, status, and contributors of state of object

2. The Meta-Metadata category groups information about the metadata instance itself (rather than the learning object that the metadata instance describes). E.g. a unique identifier for this record, the contributors of the metadata, the metadata schema (e.g. LOMv1.0) and language

3. The Technical category groups the technical requirements and technical characteristics of the learning object. Elements are format (e.g. mime type), size, location (e.g. URL or URI), technical requirements, installation remarks, other platform requirements and duration.

4. The Educational category groups the key educational and pedagogic characteristics of the learning object. Included are interactivity type (active learning, like an exercise or a simulation vs. expositive=passive learning, like reading), learning resource type (e.g. exercise, simulation, questionnaire, diagram, figure, graph, index, narrative text, …), interactivity level (very low – very high), semantic density (degree of conciseness), intended end user role (teacher, author, learner, manager), context (school, higher education, training), typical age range, typical learning time, description and language.

5. The Rights category groups the intellectual property rights and conditions of use for the learning object. It consists of a cost field (yes/no), copyright (yes/no), and a description.

6. The Relation category groups features that define the relationship between the learning object and other related learning objects such as kind (nature of relationship, e.g. is/has part of, is/has version of, is/has format of, is referenced by, is based on, is basis for, requires, is required by), resource (target learning object resource) and description.

7. The Annotation category provides comments on the educational use of the learning object and provides information on when and by whom the comments were
created. It contains an entity (people, organisation who created the annotation), date and description.

8. The Classification category describes this learning object in relation to a particular classification system. Elements are the purpose (e.g. skill level, competency, security level, educational level, discipline, idea, prerequisite, educational objective, accessibility and restrictions), a taxonomic path in a specific classification system, a description and keywords.

Note: All LOM categories can be directly mapped to Dublin Core Metadata Initiative elements with the help of a mapping table.

**Computer Managed Instruction (CMI)**

This working group mainly covers the same aspects as AICC already addressed with the content to LMS communication interface specified in AGR010/CMI001-appendix A, but tries to further elaborate and correct it to better conform to and work with other existing (e.g. ISO) standards. In its most reason version it only focuses on the JavaScript API based communication process and has omitted the http-based communication, like ADL/SCORM also did.

Originally this working group also intended to specify a standard for course structuring and sequencing and relating student performance to objectives. This was later on omitted or moved to other working groups.

Currently the standard consists of two active Project Authorization Requests:

- **1484.11.1 Data Model for Content to Learning Management System Communication**, which describes the data model independent of its communication technology
- **1484.11.2 ECMAScript API for Content to Runtime Services Communication**, which describes a JavaScript based application programming interfaces between an LMS runtime environment and the content objects. In the meantime this standard is not only based on AICC, but also on ADL/SCORM and works in close cooperation with these two consortia to make it a certified standard (AICC and ADL/SCORM are not formal organization bodies).

This standard specifies a high level architecture for information technology-supported learning, education, and training systems that describes the high-level system design and the components of these systems. It aims to

- provide a framework for understanding existing and future systems,
- promote interoperability and portability by identifying abstract, high level system interfaces,
- incorporate a technical horizon (applicability) of at least 5-10 years while remaining adaptable to new technologies and learning technology systems.

The architectural framework developed in this standard does not address the specific details of implementation technologies necessary to create the system components, or the management systems necessary to manage a learning technology system, i.e., the standard will facilitate the development of configuration guidelines for general learning technology systems.

The standardization document distinguishes five refinement layers of architecture but only layer 3 is normative in this standard, the other four are just for information and completeness.

The LTSA abstraction-implementation layers. Only layer 3 (system components) is normative in this Standard and may be used to analyze interoperability requirements among major subsystems in learning technology systems.

The five layers of the system help to separate the “big picture” from the “details” and help to understand or analyze the system step by step. Each of the layers can be investigated independently because they do not influence each other. These layers are called:

1. Learner and Environment Interactions: Concerns the learner's acquisition, transfer, exchange, formulation, discovery, etc. of knowledge and/or information through interaction with the environment from an information technology perspective and is not a description of some sort of learning theory. It just expresses that the learner has new or different knowledge after some kind of learning experience.
2. Learner-Related Design Features: Concerns the effect learners have on the design of learning technology systems and are affected by the needs of learners and, in particular, the nature of human (in contrast to machine) learning.

3. System Components (normative): Describes the component-based architecture, as identified in human-centred and pervasive features. The LTSA identifies

- four processes: learner entity, evaluation, coach, and delivery process;
- two stores: learner records and learning resources;
- and thirteen information flows among these components: behavioural observations, assessment information, learner information (three times), query, catalogue info, locator (twice), learning content, multimedia, interaction context, and learning preferences.

The overall operation has the following form:

- the learning styles, strategies, methods, etc., are negotiated among the learner and other stakeholders and are communicated as learning preferences;
- the learner is observed and evaluated in the context of multimedia interactions;
- the evaluation produces assessments and/or learner information;
- the learner information is stored in the learner history database;
- the coach reviews the learner’s assessment and learner information, such as preferences, past performance history, and, possibly, future learning objectives;
- the coach searches the learning resources, via query and catalogue info, for appropriate learning content;
- the coach extracts the locators from the available catalogue info and passes the locators to the delivery process, e.g., a lesson plan; and
- the delivery process extracts the learning content from the learning resources, based on locators, and transforms the learning content to an interactive multimedia presentation to the learner.

Implementation Perspectives and Priorities: Describes learning technology systems from a wide variety of perspectives by reference to subsets of the system components layer. Different use case models for e-Learning systems are analyzed and their inter-process and communication models are sketched.
Operational Components and Interoperability — codings, APIs, protocols:
Describes the generic "plug-n-play" (interoperable) components and interfaces of an information technology-based learning technology architecture, as identified in the stakeholder perspectives. The specification of actual coding, API, protocols, etc., standards is outside the scope of LTSA.

Kompetency Definitions
This standard specifies the mandatory and optional data elements that should be included in a competency definition as used in e-Learning systems, competence and skill gap analysis, learner and other competency profiles to allow the creation, exchange and reuse of competency definition records. This group works closely with the Learning Objects Metadata group because metadata which describes learning content can contain one or more references to competency definition records that describe the learning objective for the content. The proposed base document for a draft standard suggests ten data elements in a competency definition, unfortunately this standard has not progressed very far but this topic has also been discussed within “IMS Reusable Definition of Kompetency or Educational Objective - Information Model”

IMS (Instructional Management Systems) Global Learning Consortium Inc.
IMS is developing and promoting open specifications for facilitating e-Learning activities such as locating, using and sequencing educational content enveloped and extended in an overall concept called learner design, tracking and reporting learner progress and performance, exchanging student records between different systems and making e-Learning accessible by people with disabilities.

IMS has two key goals:
• Defining the technical standards for interoperability of applications and services in distributed learning.
• Supporting the incorporation of IMS specifications into products and services worldwide. IMS promotes widespread adoption of specifications that will allow distributed learning environments and content from multiple authors to work together.
Currently the following specifications are either in draft or already in final state:
Guidelines for Developing Accessible Learning Applications

This is rather a set of guidelines than a specification on its own. It will analyze existing solutions and standards and will provide a framework which includes recommendations on how to use existing approaches and suggestions on how to extend them to target the distributed learning community and specifically address the challenges that exist in online education. Extension will also flow into other IMS specifications, such as Learning Design or Content Packaging, to increase their focus on accessibility.

The guidelines address several types of disabilities affecting vision, hearing, physical capacity, and cognitive skills because each disability presents unique challenges to computer users.

Content Packaging Specification

The IMS Content Packaging Specification provides the definition for describing and packaging learning materials, such as an individual course or a collection of courses, into interoperable, distributable packages while ensuring interoperability between content creation tools, learning management systems, and run time environments (which are usually part of an LMS).[67-69]

The IMS content packaging is the first specification describing the IMS content framework which also comprises a data model and a run time environment but has not been defined yet.

The top-level manifest is a mandatory XML element describing the package itself and consists of a metadata, organizations and resources section. The metadata XML element describes the metadata of a manifest as a whole, organizations describe zero, one or more organizations of content within a manifest and finally the resource elements contain internal (physical files) or external (outside, e.g. URL) references to all actual resources and media elements which are required, including metadata describing the resources.

- However the manifest file will not only be used by content packaging but can be seen as a general container for e-Learning data, such as learner profiles, learning object metadata and metadata for question & test interoperability.
**Enterprise Specification**

The main goal of this specification is to support interoperability between Learning Management Systems (LMS) and the following classes of Enterprise Systems:

- Human Resource Systems track skills and competencies;
- Student and Training Administration Systems e.g. support the functions of course catalogue management, class scheduling, academic program registration, class enrolment, attendance tracking, grade book functions, grading, course administration, course enrolment and completion functions etc.;
- Library Management Systems track library patrons, manage collections of physical and electronic learning objects, and manage and track access to these materials.

More specifically the Enterprise specification mainly defines how to maintain and interchange user and group profiles and group memberships which are also the three main element types an enterprise data object can consist of, apart from its own description and comments.

**Learner Information Packaging (LIP) Specification**

As the name already indicates this specification defines how learner information can be packaged for interoperability between different systems. To increase flexibility all elements within LIP are optional, but may also be extended by two facilities: It is possible to extend the elements within any of the segments of the specification. The second mechanism sits outside the segments to allow unrelated information to be added to the package.

The original specification includes eleven groups of XML elements:

- Identification: The basic information that helps to identify an individual
- Goal: the learner’s personal goals and aspirations
- QCL: This is the area for qualifications, certifications and licenses.
- Accessibility: this includes learner preferences, language information, disability/accessibility information and technical/physical preferences.
- Activity: This area contains the education/training work and service of the learner.
- Competency: This area provides elements for capturing skills the learner has acquired.
• Interest: This segment contains information on hobbies and other recreational activities.
• Transcript: This is a placeholder for emerging standards from other organizations.
• Affiliation: This includes descriptions of the organizations associated with the learner.
• Security Key: Here learner information such as passwords or security keys are packaged.
• Relationship: This area is used to store the description of the relationships of data contained in the other segments.

Multiple LIPs can be also aggregated within an IMS content packaging file.

**Learning Design Specification**

The Learning Design specification is intended to act as an integration of a number of other existing IMS specs: IMS content packaging, IMS Metadata/LOM, IMS Question and Test Interoperability (QTI) and IMS Simple Sequencing, IMS Reusable Competency Definition, IMS Learner Information Package and IMS Enterprise specification and hereby provides a generic and flexible language to support the use of a wide range of pedagogies in online learning. [66-67]

The language was originally developed at the Open University of the Netherlands (OUNL) and accepted as a draft specification within IMS. To support sophisticated collaboration, personalization and adaptability, whilst not making the spec too complicated to implement, IMS Learning Design is not defined in one single XML schema, but three progressive ones:

• Level A provides all the basic elements. It contains all the core vocabulary needed to support pedagogical diversity.
• Level B adds properties and conditions which will enable personalization and adaptability functions (sequencing and interactions) based on the learners profile.
• Level C provides a notification function for all of these elements to communicate outcomes of events in the learning activity.

The specification describes a model for learning design that contains three primary components:
1. A conceptual model that presents the vocabulary and functional relationships between the concepts and the relationship with IMS Content Packaging.

2. An information model that describes the IMS Learning Design elements for respectively the levels A, B and C.

3. A behavioural model which describes a set of runtime behaviours the delivery systems must implement.

The information model consists of the following elements:

- **Identifier**: A globally unique identifier
- **Title**: A mandatory text field describing the competency or learning objective
- **Description**: An optional human readable description of the competency
- **Definition**: An optional structured description, which provides a more complex definition of the competency. The definition contains the following sub-elements:
  - Model-source: referencing the source on which the definition is based
  - Statement: describing a single competency characteristic
- **Metadata**: An optional metadata record that further describes the competency.

**Simple Sequencing Information and Behavior Model**

This specification defines a method for consistently describing the branching or flow of learning activities through learning content depending on the learner’s interaction with the system. A course author can declare the relative order in which content objects shall appear and the conditions under which piece of content can be selected and will be delivered or skipped during presentation and navigation.

This specification is called simple because more advanced branching techniques like artificial intelligence-based or schedule-based sequencing, adaptive learning etc. are not included here, not because the model itself is simple. Simple sequencing recognizes only the role of the learner and is not dependant on other actors.

The specification is based on the same content organization and tree structure as the Content Packaging and can therefore be included in a manifest file.

Simple sequencing relies on the concept of learning activities. A learning activity may be loosely described as an instructional event embedded in a content resource. A learning activity may use a learning resource or it may consist of several sub-activities. E.g. an
activity “take lesson” can be composed of three sub-activities “take pre-test”, “attend lecture” and “pass post-test”.

Learning activities have the following characteristics:

- Learning activities have a discrete start and end
- Learning activities have well-defined completion and mastery conditions
- Learning activities can consist of sub-activities, nested to any depth
- Learning activities occur in context of their parent activity, if one exists
- Learning activities may or may not have associated learning resources

The Simple Sequencing process uses information about the desired sequencing behaviour to control the sequencing, selection and delivery of activities to the learner. The intended sequence or learning experience for a learner is described by a specific set of data attributes called sequencing definitions and the underlying model is called sequencing definition model which consists of a number of controls, rules and conditions.

A number of additional models are defined within simple sequencing to describe the possible sequencing operations and their parameters and hereby ensure that content delivery systems are able to correctly interpret the sequence information.

The ADL (Advanced Distributed Learning) Initiative & SCORM (Sharable Content Object Reference Model)

The Advanced Distributed Learning initiative was established by the US Department of Defence (DoD) in 1997 to develop a DoD-wide strategy for using learning and information technologies to modernize education and training and to promote cooperation between government, industry and academia to develop e-learning standardization. In the meantime it is supported by a number of other US governmental institutions and a large numbers of universities and commercial companies.

The ADL vision is to: “Provide access to the highest quality education and training, tailored to individual needs, delivered cost-effectively, anywhere and anytime.” Its goal is to provide an open architecture specification for a robust and dynamic Digital Knowledge Environment (DKE) by addressing:

- Embedded Training
- Job Performance Support Systems
- Simulation
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- Multiplayer Online Gaming
- Intelligent Tutoring Systems
- Multi-language and Multi-cultural Capabilities
- Distributed Repositories and Digital Knowledge Libraries

Apart from the specifications ADL also currently provides three “Co-Labs” which serve as a public and private sector forum for cooperative research, development and assessment of new learning technology prototypes, guidelines and specifications. In addition to that so-called “Plugfest” events are organized by these Co-Labs approx. twice a year to bring together early adopters of their standard specifications to discuss and demo their implementations and by that get feedback about the practicality of the standards.

Currently the standard specifications are summarized within the Sharable Content Object Reference Model, abbreviated as SCORM. SCORM defines a Web based learning “Content Aggregation Model” and “Run-Time Environment” for learning objects. Assets, which are raw media files such as text, images, sound, Web pages, assessment objects or other pieces of data that can be delivered to a Web client. An Asset can be described with Asset Metadata to allow for search and discovery within online repositories.

- Sharable Content Objects (SCOs) are a structured collection of assets with metadata applied and include a single launch-able resource that utilizes the SCORM Run-Time Environment to communicate with Learning Management Systems. SCOs are intended to be subjectively small units, such that potential reuse across multiple learning objectives is feasible.

- A Content Aggregation is a content structure which provides the mechanisms for defining the structure and sequence of learning resources that are presented to the user and mainly consist of a number of SCOs and Assets. The SCORM 1.3 draft specification also introduces a fourth level, called Sharable Content Assets (SCAs). SCAs are mainly the same as SCOs but do not contain an interface for communicating with the LMS.

SCORM 1.2 is mainly based on the following existing e-Learning standards with minor modifications:
• IEEE/LTSC CMI draft standard, which took over the JavaScript-API communication interface specification of AICC, for the SCO – LMS interaction process
• The IMS content packaging specification
• The IEEE/LTSC LOM specification in combination with the IMS metadata elements definition

The SCORM 1.3 draft specification also includes the support of the IMS Simple Sequencing concept with some minor changes.

4.2 Model of e-learning

Benjamin Bloom (1956), identified three domains of educational activities:

- **Cognitive**: mental skills (*Knowledge*)
- **Affective**: growth in feelings or emotional areas (*Attitude*)
- **Psychomotor**: manual or physical skills (*Skills*)

Bloom’s Cognitive Processes:-

• Remembering
• Understanding
• Applying
• Analyzing
• Evaluating
• Creating

**Remembering**

- Remembering involves retrieving relevant knowledge from long-term memory
- The relevant knowledge may be factual, conceptual, procedural, or some combination of these
- Remembering knowledge is essential for meaningful learning and problem solving as that knowledge is used in more complex tasks
- Sub-processes: Recognizing, recalling, listing, mentioning, stating, drawing, labeling, defining, naming, describing, proving a theorem etc

**Understanding**
We are said to understand when we are able to construct meaning from instructional messages.

Instructional messages can be verbal, pictorial/graphic or symbolic.

Instructional messages are received during lectures, demonstrations, field trips, performances, or simulations, in books or on computer monitors.

**Understanding: Subprocesses**

- Interpreting: translating, paraphrasing, representing and clarifying
- Exemplifying: Illustrating and instantiating
- Classifying: Categorizing and subsuming.
- Summarizing: Generalizing and abstracting
- Inferring: Find a pattern
- Comparing: Contrasting, matching, and mapping
- Explaining: Constructing a model

**Applying**

- Using procedures to perform exercises or solve problems
- Closely linked with procedural knowledge
  
  Sub-processes:
  
  - Executing and Implementing: determining, calculating, computing, estimating, solving, drawing, relating, modifying, etc.

**Analyzing**

- Involves breaking material into its constituent parts and determine how the parts are related to one another and to an overall structure
  
  Sub-processes:
  
  - Differentiate: Identifying (Adequacy, assumptions, attributes, biases, causes, central issues, completeness, concepts, consequences, contradictions, criteria, defects, distortions, effects, elements, errors, exceptions, fallacies, inconsistencies, inferences, limitations, main ideas, nature of evidence, organization, plausibility, problems, procedures, reasoning, relationships, relevance, stereotypes, trends, validity, variables) discriminating, selecting, distinguishing, and focusing
  
  - Organizing: Structuring, integrating, finding coherence, outlining, and parsing.
• Attributing: Deconstructing

**Evaluating**

• Making judgments based on criteria and standards
• Criteria used include quality, effectiveness, efficiency and consistency
• The standards may be either quantitative or qualitative

Sub-processes:

**Checking: Testing, detecting, monitoring, coordinating**

**Critiquing: Judging** (Accuracy, adequacy, appropriateness, clarity, cohesiveness, completeness, consistency, correctness, credibility, organization, reasonableness, reasoning, relationships, reliability, significance, standards, usefulness, validity, values, worth, criteria, standards, and procedures)

**Creating**

• Involves putting elements together to form a coherent or functional whole
• While it includes objectives that call for unique production, also refers to objectives calling for production that students can and will do

Sub-processes:

• Generating: Classification systems, concepts, models, explanations, generalizations, hypotheses, predictions, principles, problems, questions, stories, theories)
• Planning (designing)
• Producing

**What is Knowledge?**

• Knowledge is relationships, facts, assumptions, heuristics and models derived through the formal and informal analysis or interpretation of data.
• Knowledge is defined as remembering previously learned material. Knowledge represents the lowest and most basic level of learning.
• Knowledge is the internalization of information, data and experience
• Knowledge is the psychological result of perception of learning and reasoning

**Types of knowledge**

• Conceptual knowledge
• Conditional knowledge
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- Content knowledge
- Disciplinary knowledge
- Declarative knowledge
- Discourse knowledge
- Domain knowledge
- Episodic knowledge
- Explicit knowledge
- Factual knowledge
- Metacognitive knowledge
- Prior knowledge
- Procedural knowledge
- Semantic knowledge
- Situational knowledge
- Sociocultural knowledge
- Strategic knowledge
- Tacit knowledge

Proposed types of knowledge
1. Factual Knowledge: terms and facts (bits of information).
2. Conceptual Knowledge: general concepts, principles, models or theories.
3. Procedural Knowledge: “knowledge of how” to do something ranging from completing fairly routine exercises to solving novel problems.
4. Metacognitive Knowledge: knowledge about cognition

Factual knowledge
- basic elements students must know if they are to be acquainted with the discipline or solve any of the problems in it
- exists at a relatively low level of abstraction

Subtypes of Factual Knowledge
- Knowledge of terminology
- Knowledge of specific details (including descriptive and prescriptive data) and elements
Knowledge of terminology

- verbal and nonverbal labels and symbols (e.g., words, numerals, signs, pictures)

Examples

- Knowledge of the alphabet
- Knowledge of engineering or technical terms
- Knowledge of mathematical and graphic representations

Knowledge of specific details and elements

- knowledge of events, locations, people, dates, sources of information, and the like

Examples

- may include very precise and specific information, such as the exact date of an event or the exact magnitude of a phenomenon
- may also include approximate information, such as a time period in which an event occurred or the general order of magnitude of the phenomenon
- Knowledge of products, companies, and major stakeholders related to computing
- Knowledge of important events people in the evolution of computing
- Knowledge of important features of different types of computers
- Knowledge of currently used semiconductor devices and technologies used for fabricating them.
- Knowledge of performance characteristics of commercially available integrated circuits

Conceptual Knowledge

- A concept denotes all of the entities, phenomena, and/or relations in a given category or class by using definitions.
- Concepts are abstract in that they omit the differences of the things in their extension
- Classical concepts are universal in that they apply equally to every thing in their extension.
- Concepts are also the basic elements of propositions, much the same way a word is the basic semantic element of a sentence.

Subtypes of Conceptual knowledge
- knowledge of classifications and categories
- knowledge of principles and generalization
- knowledge of theories, models, and structures

Knowledge of classifications and categories

includes specific categories, classes, divisions, and arrangements that are used in different subject matters

more general and often more abstract than the knowledge of terminology and specific facts

Each subject matter has a set of categories that are used to discover new elements as well as to deal with them once they are discovered.

When one is concerned with realizing a logic expression the major categories include ‘binary variables’ ‘logic functions’, ‘truth-tables’, ‘hardware logic units’, ‘assertion levels’ etc.

Knowledge of classifications and categories: Examples
1. Knowledge of number systems
2. Knowledge of sequential systems
3. Knowledge of different IC packages
4. Knowledge different passive networks

Principles and Generalizations

are composed of classifications and categories.

These include abstractions that summarize observations of phenomena, and have greatest value in describing, predicting, explaining, or determining the most appropriate and relevant action or direction to be taken.

Principles and generalizations bring together large number of specific facts and events, describe the processes and interrelationships among these specific details

Knowledge of principles and generalizations: Examples
1. Knowledge of fundamental laws of physics
2. Knowledge of fundamental relationships in electrical networks
3. Knowledge of Boolean algebra
4. Knowledge of the principles that govern arithmetic operations

Knowledge of Theories, Models and Structures
include different paradigms, and epistemologies that disciplines have for structuring inquiry.

Students should come to know these different ways of conceptualizing and organizing subject matter and areas of research within the subject matter.

**Example**

1. The relevant operating characteristics of electrical and electronic devices are adequately described through currents and voltages as time functions at appropriately selected points or point pairs.
2. Knowledge of network theory
3. Knowledge of graph theory
4. Knowledge of field theory
5. Knowledge of control theory
6. Knowledge of behavioral, cognitive and social constructivist theories of learning

**Procedural knowledge**

- is the “knowledge of how” to do something
- it often takes the form of a series or sequence of steps to be followed.
- includes knowledge of skills, algorithms, techniques, and methods, collectively known as procedures
- also includes knowledge of the criteria used to determine when to use various procedures.
- is specific or germane to particular subject matters or academic disciplines

**Subtypes of procedural knowledge**

- Knowledge of subject specific skills and algorithms
- Knowledge of subject-specific techniques and methods
- Knowledge of criteria for determining when to use appropriate procedures

**Knowledge of subject specific skills and algorithms**

- can be expressed as a series or a sequence of steps
- end result is generally considered fixed

**Examples**

- Knowledge of algorithms used in mathematics exercises
- Knowledge of algorithms for minimizing logic expressions
- Knowledge of algorithms for processing analog and digital signals
• Knowledge of pattern-search algorithms in Artificial Intelligence

Knowledge of subject-specific techniques and methods
• knowledge that is largely the result of consensus, agreement, or disciplinary norms rather than knowledge that is more directly an outcome of observation, experimentation, or discovery.

Examples
• Knowledge of methods of management research
• Knowledge of system dynamics methods to model complex socio-technical systems
• Knowledge of feedback control methods to improve the performance of a dynamic system

Knowledge of criteria for determining when to use appropriate procedures
• involves knowing the ways they have been used in the past
• conditions under which a given procedure is to be applied.

Examples
• Knowledge of the criteria for determining which statistical procedure to use with the data collected in a particular experiment.
• Knowledge of the criteria for determining which transformation to be applied in a particular signal processing problem.

Meta cognitive knowledge
• is knowledge about cognition in general as well as awareness of and knowledge about one’s own cognition.

• Categories of Metacognitive knowledge
  o Strategic knowledge
  o Knowledge about cognitive tasks
  o Self-knowledge

Strategic knowledge
Knowledge of the general strategies for learning, thinking and problem solving.
• Rehearsal strategies: repeating words or terms to be recalled over and over to oneself
• Elaboration strategies: use of various mnemonics for memory tasks and techniques such as summarizing, paraphrasing, and selecting the main idea from texts. They foster
Design of Generalized E-Learning Model

deeper processing of the material to be learned and result in better comprehension and learning

*Organizational* strategies: various forms of outlining, drawing “cognitive maps”, mind mapping or concept mapping, and note taking; students transform the material from one form to another

- *strategies* that are useful in planning, monitoring, and regulating their cognition.
- strategies for problem solving and thinking
- strategies for deductive and inductive thinking
- various general heuristics students can use to solve problems, particularly ill-defined problems that have no definitive solution method

Examples of heuristics:

- means-ends analysis and
- working backward from the desired goal state

*Knowledge about cognitive tasks: contextual and conditional*

- knowledge about when and why of using the strategies appropriately
- the local situational and general, conventional, and cultural norms for using different strategies

Example

- the strategies used in a classroom learning situation may not be most appropriate ones to use in a work setting

*Self-knowledge*

- includes knowledge of one’s strength and weaknesses in relation to cognition and learning

*Motivation*

- Self efficacy beliefs
- Beliefs about goals or reasons students have for pursuing a specific task (e.g., learning vs. getting a good grade).
- Students’ perception of their personal interest (liking) for a task as well their judgments of how important and useful the task is to them
- accuracy of self-knowledge seems to be most crucial for learning.
The role of the teacher is to help students make accurate assessment of their self-knowledge and not attempt to inflate students’ academic self-esteem.

**Vincenti’s Categories of Engineering Knowledge**

1. **Fundamental Design Concepts**
   - Operational principles of the devices.
   - Operational principles for the components within a device.

2. **Criteria and Specifications**
   - It is necessary to translate the qualitative goals for the device into specific, quantitative goals.
   - Design criteria vary widely in perceptibility.
   - Assignment of the values or limits is usually particular to a design, and is best looked upon as part of the design process.

3. **Theoretical Tools:**
   - Mathematical tools
   - Physical principles
   - Theories based on scientific principles but motivated by and limited to a technologically important class of phenomena or even to a specific device
   - Assortment of theories involving some central and ad hoc assumptions about phenomena crucial to the problem that may be termed as phenomenological theories
   - Quantitative assumptions introduced for calculative expedience

4. **Quantitative Data:**
   - Descriptive (physical constants)
   - Prescriptive (how things should be) data

5. **Practical Constraints:**
   - An array of less sharply defined considerations derived from experience in practice, considerations that frequently do not lend themselves to theorizing, tabulation, or programming into a computer.

6. **Design Instrumentalities**
   - Procedural knowledge including the procedures, way of thinking, and judgmental skills by which it is done

**Additional categories**
Categories “Theoretical Tools” and “Quantitative Data” can be subsumed under “Conceptual Knowledge” and “Factual Knowledge”

Four categories of engineering knowledge “Design Principles”, Criteria and Specifications”, “Practical Constraints” and “Design Instrumentalities” need attention in preparing instructional objectives.

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**Figure 4.1: Types of Knowledge**

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**Figure 4.2: Most important relationship between Institutes & Industry**

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What is competency?

- an effective ability, including attributes, skills and knowledge, to successfully carry out some activity which is totally identified
- a set of skills, related knowledge and attributes that allow an individual to perform a task or an activity within a specific function or job
- is an integrated demonstration of a cluster of related knowledge, skills and attitudes that are observable and measurable, necessary to perform a job independently at a prescribed proficiency level (Earnest, 2001)

Role of competencies

- The placement is based on the competencies the students have
- An organization assigns tasks, and builds project teams on the basis of competency profiles of their employees.
- The training of employees is decided on the present competency profile of the individual.

Types of competencies

- Managerial
- Generic
- Technical/Functional

Managerial competencies

- Strategic thinking and Scenario building
- Analysis
- Problem solving and Decision making
- Planning and Organizing
- Change management
- Managing small organizational groups
- Managing large organizational groups
- Team leadership
- Information management
- Innovation and Creation
- Mediation and Negotiation
• Mentoring and Coaching
• Facilitation and Group moderation
• Presentation and Public speaking
• Interviewing

Generic competencies
• Important non-technical abilities and skills for employment.
• Abilities and skills that would be transferable to new situations.

Include
• Social Development
• Personal Progression, Physical & Psychological Development
• Learning, Intellectual Development, Ethics and Aesthetics
• Career

Social Development
- Leadership: To direct a team to work towards a common goal and to motivate teammates.
- Teamwork: To cooperate effectively with teammates and to share team responsibilities.
- Interpersonal Effectiveness: To fit in with different social situations and to develop relationships with different people.
- Communication: To apply oral and writing skills to communicate effectively with others.

Personal Progression, Physical & Psychological Development
- The progress we make day by day
- the ability to use our body with increasing purpose, skills, body awareness and control
- the capability of managing our own emotions and communicating our emotions with others

Learning
The process of how we learn and process information
- Global Outlook: To communicate with people from other cultures and to appreciate the relationships between current international affairs.
Lifelong Learning: To have the motivation and abilities to master new knowledge and skills independently throughout one’s life.

Intellectual Development

Creative Thinking: To discover and apply new angles, ideas, and methods to understand and deal with routine matters. The ability to think critically and to understand complicated ideas.

Critical Thinking: To state strong reasons or evidence to support a given argument and to identify illogical reasoning.

Problem Solving: To identify a problem and to plan and carry out an approach to solve it.

Ethics

A set of values guiding us to choose what is right and to avoid what is wrong

Social and National Responsibility: To show concern over the rights and welfare of others and to care about one’s own country.

Aesthetics

It is associated with good taste and appreciation of beauty

Cultural Appreciation: To evaluate various artistic/cultural forms and to appreciate the cultural heritage of one’s own country.

Career

A sequence of work experiences, which you are committed to, throughout your life time

Entrepreneurship: To discover, create and catch new opportunities and to take considerable risk for new prospects.

Competency Levels

In an organization several levels can be associated with any competency.

Each level can be predefined to communicate expectations of the organization to the concerned.

Every course in an engineering program is expected to build a set of competencies in the students.

All engineering programs have some specializations.

Each area of specialization can be associated with a set of interrelated courses.
Databases: Level 1 Competencies

- Start and exit the program.
- Open or create a database: create/modify a database structure with fields of different type (i.e., text, numeric, date, etc.).
- Add, delete, and edit records.
- Sort/index a database on single and multiple keys in ascending or descending order.
- Display selected fields from a database.
- Display selected records based on single or multiple conditions and use logical operators such as AND, OR, NOT.
- Use simple functions to produce summary calculations (SUM, COUNT, etc.).
- Print selected fields and records

Databases: Level 2 Competencies

- Explains a single database management system (DBMS), its components and how they relate to each other.
- Demonstrates the ability to use a good knowledge of data manipulation language (DML) and data definition language (DDL).
- Codes/tests basic database access modules (e.g., stored procedures).
- Troubleshoots, at a basic level, to understand database problem and identify where to direct it (e.g., basic database accessibility).
- Recognizes the importance of database basic recovery and, with guidance, performs backup and recovery.
- Understands database release management, applications business rules, data integrity issues, database security implementation, workload manager and interaction with DBMS (e.g., CICS, NT).
- Performs data population, debugging and testing.
- Conducts basic impact analysis for database change management

Database Practice: Competencies

1. Retrieve data from Oracle database including selecting rows, limiting the selection, and single-row functions
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2. Display data from multiple tables, and using group functions, subqueries and runtime libraries.
3. Alter the tables and constraints, create sequences and views, and control user access.
4. Develop a PL/SQL block, interact with the Oracle database, control PL/SQL process flow, handle cursor, and handle errors.
5. Demonstrate an understanding of the architecture of Oracle, start and stop Oracle instance, and create an Oracle database.
6. Access and update data, and manage transaction concurrency, database structure and storage allocation.
7. Manage rollback segments, tables and indexes, clusters, and data integrity constraints.
8. Manage users, resource usage and database access and roles, and audit the database.
9. Explain backup and recovery motives, methods of recovery, and failure scenarios.
10. Use logical export and import to perform functions including migration of database objects between different Oracle databases and versions.
11. Manage database failure and recovery without archiving.

Perform incomplete and complete recovery operations with archiving that support 24 hour operations

Check List

1. Does each competency is in alignment with the instructional intent of the instructor?
2. Do the competencies represent higher orders of learning adequately?
3. Are the competencies attainable (do they take into account students’ background, prerequisite competences, facilities, time available and so on)?
4. Are the competencies in harmony with the stated program educational objectives?
5. Does the competency begin with an action verb (e.g., state, define, explain, calculate, determine, identify, select, plan, design etc.)?
6. Is each competency stated in terms of student performance (rather than teacher performance)?

7. Is each competency stated as a learning product (rather than in terms of the learning process)?

8. Is each competency stated in terms of students’ terminal performance (rather than the subject matter to be covered)?

9. Is each competency stated at the proper level of generality (i.e., is it clear, concise, and readily definable)?

10. Is each competency stated so that it is relatively independent (i.e., free from overlap with other objectives)?

Exercise

- Identify the competencies the students are expected to acquire at the end of the course and achieve the selected subset of program outcomes

**Concept Map (using C-Map Tool)**

As we discussed Categories of Knowledge are:-

- Factual knowledge
- Conceptual Knowledge
- Procedural Knowledge
- Meta-cognitive Knowledge

So a course can be organized as mixture of

1. Conceptual knowledge
2. Procedural knowledge
3. A combination of conceptual and procedural knowledge

C-map Tool

- Graphical tool for organizing and representing knowledge (http://cmap.ihmc.us/)
- It includes
- Concepts
- Relationships between concepts indicated by a connecting line linking two concepts
Linking phrases specifying the relationship between the two concepts
C-Map Tool is like UML Tool as we make diagrams in UML for software design, similarly we can use C-Map Tool for our course design.

**Organization of a Concept Map**

- Concepts are represented in a hierarchical fashion with the most inclusive, most general concepts at the top of the map and the more specific, less general concepts arranged hierarchically below.
- The hierarchical structure for a particular domain of knowledge also depends on the context in which that knowledge is being applied or considered.
- Construct concept maps with reference to some particular question we seek to answer, called as focus question.

**Concept Maps can be used for**

- To generate ideas (brainstorming)
- To design complex structures (long texts, hypermedia, large web sites)
- To communicate complex ideas
- To aid learning by explicitly integrating new and old knowledge
- To assess understanding or diagnose misunderstanding

**Propositions used in concept map**

- Is, are, has, have, in, of, for, with, from, into, whose, where, that are, may be, may, may lead to, between, as in, e.g.,.....(→), e.g. alters....., e.g. produces....., becomes, did, comes in, goes to, forms an, include (ed), are modified,
- Represent (s), show (s), consist (s) of, include (s), varies, begins with, necessary for, is comprised of, contains, uses, combines with, produces, to those, submitted by, suggests, located in, collaboration between, some have
- Absorbs, requires, develops, results in, results from, created by, used from, connected using, used to make things, to effect, are visited by,
- Constructed in, needed to be, help to answer, needed to answer, are (is) determined by, is lower (higher) in, is longer (shorter) in, is made of,
- Is destroyed by, is part of, specially (→)
System Software: Concept Map

Figure 4.3: Concept Map for Course_1
Object Oriented Programming: Concept Map

Figure 4.4: Concept Map for Course_2

Course contents
- Course contents are organized as Modules and Learning Units.
- Concept map can be structured to clearly identify the modules and learning units
- If the concept map becomes unwieldy to include all the learning units, break the concept map into multiple concept maps.
- Create the first level concept to include only the Modules and second level concept maps for all the Modules to identify all the learning units.

Exercise
- Identify the Conceptual Knowledge that need to be mastered to achieve the identified competencies of the course.
- Draw the concept map(s) for the course.
- Identify the course contents in terms of Modules and/or Learning Units.

Instructional methods are defined as “ways of helping someone to learn”
- A large number of instructional methods are used in practice
- Theoretical basis for many of the methods has been worked out
Examples
- Classroom lecture
- Apprenticeship
- Model building
- Learning centers
- Tutorial groups

Efficacy of an instructional method depends on the
- nature of the subject
- instructional setting
- experience of the instructor with the method

Instructional methods should be thoughtfully matched to the learning outcomes

**Classification of instructional methods**
- Teacher-centered approaches
- Learner-centered approaches

Teacher centered approaches
- Lecture
- Demonstration
- Lecture-discussion

**Lecture**
- Very effective if not over used
- If the presenter is knowledgeable, perceptive, engaging, and motivating, then lecture can stimulate reflection, challenge the imagination, and develop curiosity and a sense of inquiry
- Because lecture is teacher-centered and student activity can be mainly passive, the attention span of students may be limited.
- Many students, because of learning style preferences, may not readily assimilate lectured content
- Lectured content is often rapidly forgotten.
- Many instructors still believe that comprehension was entirely the students' responsibility.
As we become more knowledgeable about cognitive research, however, it is apparent that much of that burden is the responsibility of the instructor as well.

**Lecturing with concern for understanding**
1. Provide a preview of information prior to an explanation.
2. Organize information within a step-by-step lesson sequence.
3. Assess student learning when information is being given.
4. Signal transitions between information.
5. Use multiple examples to illustrate information points.
6. Stress important points during explanations.
7. Provide for brief pauses at appropriate times during the lecture
8. Eliminate additional unexplained content nonessential to current explanation.
9. Present less to be more effective.
10. Review information frequently.

**Demonstration**
- Demonstration involves the teacher showing students a process or procedure
- Involving students in demonstrations allow this method to be less passive.

**Lecture-discussion**
- Lecture-discussion is a combination of lecture and teacher questioning of students

**Active Learning**
- Focuses the responsibility of learning on learners
- Practice after initial learning is of vital importance in one's education/career, and is important for cognitive development,
- practice is required during learning
- Being active during learning, not merely behaviorally but cognitively, greatly improves learning.

**Active learning allows**

*Reflection & Observation*
- Enables participants to reflect on the experiences identified in the active learning phase.
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- Participants will think about these experiences, analyzing them in a critically reflective manner.
- Critical incident journaling facilitates this stage.

\textbf{Abstraction/Conceptualization}

- Theory is generated to conceptualize the named experiences.

\textbf{Practice and Application}

\textbf{Learner-centered Instruction Methods}

- Simulations
- Case studies
- Cooperative learning
- Group discussions
- Group assignments
- Bulletin Boards and FAQs
- Problem-based learning
- Co-operative Learning Group
- Journals and blogs

\textbf{Simulations}

- Put the student in a "real" situation without taking the risks.
- Students are able to experience consequences of their behavior and decisions
- Models, game formats, structured role plays, or an interactive computer or video program can be used
- During simulation activities, students become active participants in the learning process.

\textbf{Group assignments involve}

- asking and refining questions
- debating ideas
- making predictions
- designing plans and/or experiments
- collecting and analyzing data
- drawing conclusions
communicating their ideas and findings to others
- asking new questions
- creating artifacts

Benefits of group assignments
- Integrates curriculum areas, thematic instruction, and community issues.
- Encourages the development of habits of mind associated with lifelong learning, civic responsibility, and personal or career success.
- Overcomes the dichotomy between knowledge and thinking, helping students to both "know" and "do."
- Assesses performance on content and skills using criteria similar to those in the work world, thus encouraging accountability, goal setting, and improved performance.
- Engages and motivates bored or indifferent students.
- Supports students in learning and practicing skills in problem solving, communication, and self-management.
- Creates positive communication and collaborative relationships among diverse groups of students.
- Meets the needs of learners with varying skill levels and learning styles.

Group Assignments
- Case preparation
- Case discussion
- Solving an open ended problem
- Report
- Mini-project
- Conducting a survey
- Product design

Problem-based Learning (PBL)
- PBL is a student-centered instructional strategy in which students collaboratively solve problems and reflect on their experiences

Characteristics of PBL are
- Learning is driven by challenging, open-ended problems
Students work in small groups

Teachers take on the role as “facilitators” of learning

**History of PBL**

Howard Barrows introduced PBL in the medical school of McMaster University, Canada in 1980

In 1990s it was adopted by several schools in USA

It was adopted by several individual teachers in engineering programs

Republic Polytechnic in Singapore conduct all their programs based on PBL

**Principles underpinning PBL**

Students do not start on an empty slate. Prior knowledge, assumptions and experiences are critical in helping students find meaningful entry points into the problem

Learning happens in a social context, with meaning negotiated in a collaborative team setting

Strategies are consciously applied to deal with unfamiliar information, handling team dynamics and working out feasible and well-thought through solutions

Learning takes place through self directed discovery and questioning

The use of problems acts as a stimulus for learning

Critical reflection happens throughout the learning process

**Role of PBL teacher**

Decides what content knowledge, skills, and attitudes a problem should help students develop, but they are no longer the center of attentions as students learn

Guides students through the process of answering PBL question, but they provide no answers themselves.

Plays key role behind the scenes, designing the problem, subtly guiding students through it, and evaluating their performance

Students’ success at solving the problem without constant direction is an indication of teacher’s success at using PBL.

Teacher develops the problem and fits it into curriculum

Teacher guides students through the problem

Evaluates performance of students as they solve the problem
Exercise
- Determine an instructional strategy (collection of instructional methods) you wish to use for your course (Group level decision)

Assessment
- It is the process of documenting in measurable terms, knowledge, skills, attitudes and beliefs
- To many, "assessment" simply means the process by which we assign students grades

Assessment provides
- Refers to all the plans and materials an instructor uses to facilitate learning
- All communications with students (Course description, how it is conducted and assessed, schedules etc.)
- How classroom sessions are conducted
- Presentations in the classroom
- Plans for instructional activities (description, rubrics, processes, evaluation and feedback)

Quality of Learning
Improving the quality of learning in a course involves
- determining to what extent students have mastered course content at the end of the course
- determining to what extent students are mastering content throughout the course
- Assessment should help students "become more effective, self-assessing, self-directed learners"
- Assessment drives student learning
- Assessment tools tell students what we consider to be important
- Students will learn what we guide them to learn through our assessments
- Is the glue that links the components of a course - its content, instructional methods, and skills development

Traditional testing methods
- Are limited measures of student learning
- Are of limited value for guiding student learning
Design of Generalized E-Learning Model

- Are inconsistent with the increasing emphasis being placed on
  - the ability of students to think analytically
  - to understand and communicate at both detailed and "big picture" levels
  - to acquire life-long skills that permit continuous adaptation to workplaces that are in constant flux

Types of Assessment

- Formative and summative
- Objective and subjective
- Referencing
  - criterion-referenced
  - norm-referenced
  - ipsative
- Informal and formal
- Internal and external

Summative assessment

- It is also referred to as “assessment of learning”
- Measures learning outcomes and report those outcomes to students, parents, and administrators
- It generally occurs at the conclusion of a class, course, semester, or academic year
- It is typically used to assign students a course grade

Performance-based assessment

- It is similar to summative assessment
- Proficiency is demonstrated by providing an extended response to a well-defined task.
- The performance may result in a product, such as a painting, portfolio, paper, or exhibition, or it may consist of a performance, such as a speech, athletic skill, musical recital, or reading.

Formative assessment

- It is also referred to as "educative assessment" or “assessment for learning”
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It is used to aid learning and is generally carried out throughout a course or project.

It is used by teachers to consider approaches to teaching and next steps for individual learners and the class, and would not necessarily be used for grading purposes.

It is defined as “all those activities undertaken by teachers and/or students, which provide information to be used as feedback to modify the teaching and learning activities in which they are engaged”

Assessment for learning: Key features

- High quality interactions based on thoughtful questions, careful listening and reflective responses;
- Involves students and instructors in deciding next steps in their learning and identifying who can help.
- Students and instructors are given timely feedback about the quality of their work and how to make it better.
- Sharing criteria: Students and instructors are clear about what is learned and what success would be like.

Formative assessment: Other forms

- Diagnostic assessment: measures a student's current knowledge and skills for the purpose of identifying a suitable program of learning.
- Self-assessment: a form of diagnostic assessment which involves students assessing themselves.
- Forward-looking assessment asks those being assessed to consider themselves in hypothetical future situations.

Objective and Subjective Assessment

- Objective assessment is a form of questioning which has a single correct answer.
- Objective question types include true/false answers, multiple choice, multiple-response and matching questions.
- Objective assessment is well suited to the increasingly popular computerized or online assessment format.
- Subjective assessment is a form of questioning which may have more than one correct answer (or more than one way of expressing the correct answer).
Subjective questions include extended-response questions, essays, hypothesizing, creating plans etc.

**Referencing**

Test results can be compared

- against an established criterion
- against the performance of other students
- against previous performance

**Criterion-referenced assessment**

- Candidates are measured against defined (and objective) criteria
- It is used to establish a person’s competence (whether s/he can do something)

Example: the driving test

**Norm-referenced assessment**

- Colloquially known as “grading on the curve”
- Norm-referenced measures are designed to compare students: disperse average student scores along a bell curve, with some students performing very well, most performing average, and a few performing poorly
- Examples: IQ, CET, GATE, CAT, SAT and GRE
- They permit a fixed proportion of students to pass
- Standards may vary from year to year, depending on the quality of the cohort

**Impassive assessment**

- It is self comparison
  - in the same domain over time
  - comparative to other domains

**Informal and Formal**

- Formal assessment implicates a written document, such as a test, quiz, or paper
- Formal assessment is given a numerical score or grade based on student performance,
- An informal assessment may include observation, inventories, checklists, rating scales, performance and portfolio assessments, participation, peer and self evaluation, and discussion.
- Informal assessment does not contribute to a student’s final grade
Internal and External

- Internal assessment is set and marked by the institution
- Students get the mark and feedback regarding the assessment
- External assessment is set by the governing body, and is marked by non-biased personnel.
- Students only receive a mark without feedback

Quality and Standards

High-quality assessments have a high level of

- reliability
- validity

Reliability

- Reliability relates to the consistency of an assessment
- A reliable assessment is one which consistently achieves the same results with the same (or similar) cohort of students.

Factors that affect reliability

- ambiguous questions
- too many options within a question paper
- vague marking instructions
- poorly trained markers

Reliability of an assessment

It is based on the following:

- Temporal stability: Performance on a test is comparable on two or more separate occasions.
- Form equivalence: Performance among examinees is equivalent on different forms of a test based on the same content.
- Internal consistency: Responses on a test are consistent across questions

Validity

- A valid assessment measures what it is intended to measure.
- It would not be valid to assess ability to design a circuit through asking the student to explain the theory of devices used in the circuit.
When you complain that some examinations do not properly assess the syllabus upon which the examination is based, you are questioning the validity of the examination.

**Gauging Validity**

Validity of an assessment is gauged through examination of evidence in:

- **Content** -- Does the content of the test measure stated objectives?
- **Criterion** -- Do scores correlate to an outside reference?
- **Construct** -- Does the assessment correspond to other significant variables

**Reliability and Validity**

A good assessment has both validity and reliability

In practice, an assessment is rarely totally valid or totally reliable

The more reliable is our estimate, the less certain we are that we are actually measuring that aspect of attainment

**Methods of Assessment**

- Written objective questions
- Written short-answer methods
- Written long-answer methods
- Discussion methods
- Artifact methods
- Performance methods
- Quasi Assessment methods

**Written objective questions**

Objective refers to the methods of marking questions

- Multiple choice questions
- True/False
- Matching
- Fill in the blank

**Short-answer Questions**

Can be used to test a wide range of learning

- Fill-in-the-blank
- Producing a list
- One-sentence answers
Completing a table
Completing a diagram
Several sentences/a series of steps/a series of calculations etc.
Essay outlines (logical order, key points made, counter arguments considered, and sensible, sustainable conclusions)

**Long-answer Methods**

- Plans
- Reports
- Essays
- Dissertations

They all require

- Having a sense of audience and purpose
- Choosing the arguments (and its boundaries) to be presented
- Ordering the argument
- Selecting the evidence
- Presenting an argument logically
- Avoiding problems such as unstated premises

**Discussion Methods**

- Conference
- Brainstorm
- Case discussion
- Topic discussion
- Buzz session
- Committee Problem solving
- Role playing

**Artifact Methods**

Learner creates an artifact

Examples of artifacts

- Type a letter
- Fabricate an item in the workshop
- Write a poem
Create a database
Change a wheel on car
Produce a product

The emphasis is on product and not on the process

Performance Methods
- Presentation
- Acting
- Dancing
- Singing
- Playing a musical instrument

Quasi Assessment Methods
- Projects and Placements
- Diaries, journals and logs
- Case studies
- Portfolios when used for assessment

Rubrics
Scoring instruments for performance assessments
- Check Lists
- Scoring guides

Rubrics (Holistic Rubrics and Analytic Rubrics)
Rubrics are scoring guides, consisting of specific pre-established performance criteria, used in evaluating student work on performance assessments.

A holistic rubric requires the teacher to score the overall process or product as a whole, without judging the component parts separately

An analytic rubric requires the teacher to score separate, individual parts of the product or performance first, then sums the individual scores to obtain a total score

Holistic rubrics
Holistic rubrics are utilized when errors in some part of the process can be tolerated provided the overall quality is high
Use of holistic rubrics is probably more appropriate when performance tasks require students to create some sort of response and where there is no definitive correct answer.

It involves assessment on a uni-dimensional level

Use of holistic rubrics can result in a somewhat quicker scoring process than use of analytic rubrics

Analytic rubrics

Analytic rubrics are usually preferred when a fairly focused type of response is required that is, for performance tasks in which there may be one or two acceptable responses and creativity is not an essential feature of the students' responses.

Analytic rubrics result initially in several scores, followed by a summed total score-their use represents assessment on a multidimensional level

Both their construction and use can be quite time-consuming.

Assessing several different skills or characteristics individually requires a teacher to examine the product several times.

Assessment Pattern

- Written Tests & Assignments
- Discussions
- Reports
- Projects & Presentations

Assessment Pattern (Written Tests)

<table>
<thead>
<tr>
<th>Bloom’s Level</th>
<th>Test 1</th>
<th>Test 2</th>
<th>Test 3/FE(Final Examinations)</th>
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</thead>
<tbody>
<tr>
<td>Remember</td>
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<tr>
<td>Understand</td>
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<td>Apply</td>
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<td>Evaluate</td>
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<tr>
<td>Create</td>
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</tr>
</tbody>
</table>

Table 4.1: Bloom’s Levels Classification
Exercise

- Identify the assessment pattern for the course keeping in mind resources, technologies, number of students in the class etc.

4.2.1 Demand Driven learning model

e-learning models have evolved from classroom replication towards models that integrate technology and pedagogical issues. E-learning models emphasize the role of technology in providing content i.e. informational, delivery i.e. access and electronic services. E-learning went through a hyper cycle triggered by technology expectations when the realities of e-learning become clear. Educator and learners not adopted e-learning as expected and desired learning outcomes are not being achieved.

The demand driven learning model was developed in Canada as a collaborative effort between academics and experts from private and public industries. This model is based on the technology learning management system vendors model of technology, content and services. The primary purpose of this model is to encourage academics to take a proactive role in the development and use of technology in delivery and services. Content should be comprehensive, authentic. As importance of investing in ICT infrastructure to support content, delivery and services. This model also highlights the importance of realizing the changing needs of learners and their employers and the pedagogical changes that must be made to content and services to meet these needs.

4.2.2 Instructional design and Community of Inquiry model

Most crucial prerequisites for successful implementation of e-learning is the need for careful consideration of the underlying pedagogy. Conard define effective e-learning as “the integration of instructional practices and internet capabilities to direct a learner toward a specific level of proficiency in a specified competency.”

Instructional values can be added by

- Customizing content for need of learners
- Presenting outcomes based on learning objectives
- Logical sequencing material to reinforce the objectives

The community of inquiry model has three elements that must be considered when planning and delivering e-learning experience and these are cognitive presence, social presence and teaching presence.
4.2.3 Modal e-learning model

Modal e-learning model describe how technology would achieve each of these functional stages. This section considers a range of e-learning approaches in relation to three pedagogical perspectives that are instructional system design, constructivist and communities of practices. E-learning list is by no means exhaustive and provides starting point for deeper reflection of how pedagogy can be mapped to teaching and learning practices when using technology enhanced tools and system. Most exhibit features from more than one perspectives. The candidates range from broad range teaching frameworks, within which e-learning is assigned functional roles, to technically oriented accounts which focus primarily on tools. It is possible to consider e-learning models in broader classes and to map these onto our pedagogical strands. When mapping onto e-learning models we have found it helpful to classify the cognitive/constructivist into further division. This distinction is between those approaches which focus on individual dialogue between teacher and learner and those that support group learning. Thus, for any e-learning approach following questions are most important

- Is the model characterized by an analysis of the learning outcomes in subject matter units
- Is the model characterized by active ownership of learning and teaching activities
- Is the model characterized by active discussion across group of learners
- Is the model characterized by a focus on the development of real world practice

Of course, these are very high level categories and there will be several e-learning models that will be characterized by each of them.

4.2.4 DIY (Do-IT-Yourself) Model

The DIY e-learning model assumes that if we want to utilize e-learning in our teaching practice, we do it ourselves. DIY consist of following phases.

FIND OUT: there are many e-learning tools freely available, for this we must join some e-learning network, explore the internet to know where to find them and what they are good for.
CHOOSE: we select tools to suit our purpose and student needs and we select the basis that it is small, doable and horses for courses.

LEARN: we find people who already know and have used tools, seek mentors and participate where possible in professional development sessions.

EXPERIMENT: we need time to adapt and experiment with tools to make mistakes and move on to something else if it doesn’t work as we want it to be.

CONVERT: we use our pre-existing resource materials where possible and convert them into a form that fits the e-learning tool.

SHARE: we don’t re-invent wheel. We share our resources and our knowledge with other trade teachers who discovers the e-learning pathway.

REUSE: once we have a resource that’s suitable, we store and archive it, so that it can be used at any stage in future if relevant.

REVIEW: we work in an ever-changing digital and trade environment, where today’s solution may not be tomorrow.

4.2.5 E-learning Maturity Model (eMM Model)

The E-learning Maturity Model is a quality improvement framework for supporting change and improving the quality of e-learning. This model tell show the capability analysis can go beyond benchmarking and provide a framework for supporting change and improving the quality of e-learning. eMM model was developed in New Zealand based on two complementary models, the capability maturity model (CMM) from the software engineering institute (SEI 2002) and SPICE (software process improvement and capability enhancement) and the progression from an immature, adhoc software process to mature, well managed software process.

CMM proposed that organizations matured from ad-hoc process through to a culture of continuous improvement in five steps. As organizations moved up the levels, it was contended that they would become more capable and ultimately more successful. An approach is that it does not impose any requirement that organizations used particular technologies or development methodologies, but rather that they explicitly understood what they were doing and why. The benefit of moving through levels is that the organizations, through defined and managed processes, better understand what it is doing and where to focus resources to improve and refine on successful developments.
4.2.6 Technology Content and Service Model

This model is used when learning has to be imparted with the combination of services, content and technology. The model is adapted from e-learning technology, content and services which is developed by author named Paul Henry. The model comprised of three elements

- Service to customer
- Content/ material
- Technology

The main focus is on use of technology, to create convenient virtual learning environment. Main emphasis is on technology and overlap of the circles to be maximum so as to be providing the maximum benefit of e-learning.

4.2.7 Demand and supply model

In economic terms, diffusion represent the equilibrium between what the market offer (supply) and what consumer want and need(demand). In the case of a supplier led market, demand lags behind supply of products and services. If the innovation is successful, demand will increase as the advantage of the product are identified and equilibrium is achieved over time as both demand and supply adjust to meet business needs, supplier cost and buyers willingness to pay.

e.g. Maruti Automobile Insurance system(MAIS): Maruti Udyog Limited (MUL) is using the internal and external influences collected from their customers to check the advantages and barriers to enhance their customers benefits like hassle free 24/7 availability of enterprise data, insurance sales-cycle analysis, integration to back office accounting system etc. The suggestion for MUL is to use some methods to check the advantages of the internal and external influences which derives them to the adoption of e-learning at firm’s level.

Gurukul Online Learning solution(GOLS) : GOLS is using innovation which they gathered from internal and external influences to make complete use of the e-learning process. They are also checking the advantages and barriers of the outcome of their survey to enhance their e-learning activity. The solutions for university education and academic industry open new avenues to students while introducing them to a stimulating new world of learning and knowledge. This dynamic tool when used successfully
expands talent and further improves the abilities of individual students. The suggestion is
to establish a learning environment that facilitates accessibility, reliability and relevance
for students that equips them with much needed skill sets.

4.2.8 Competency based model (problem, activation, demonstration, application and integration)

What are Learning Units?
■ A Course is organized as Modules and Units as identified by the Concept Map
■ One semester course will have 15 to 40 Units
■ A unit deals with a group of related concepts. Related factual knowledge and
procedural knowledge are also the concern of the unit.
■ A Learning Unit identifies and elaborates the (factual, conceptual and procedural)
knowledge, activities the learner is required to do, assessment for learning, assessment of
learning, and learning resources as identified by the Instructor

Structure of Units
■ Unit summary
■ Instructional Material
■ Learning Material (Readings and Activities)
■ Instructional Objectives

Readings and Activities
■ Readings and activities are identified or created for the learner (not for the
teacher)

Reading
■ Text
■ Multimedia material (videos, audio files, text with graphics, text with animations)
■ Simulations
■ Cases
■ Links to Learning Objects
■ Annotated references and Internet links
■ Worked out problems
■ Problems to be worked out
■ Reports to be written along with rubrics
Assessment instruments for learning
- Simulation exercises
- Drawings to be drawn
- Programming to be done
- Etc.

Instruction Material
- Refers to all the plans and materials an instructor uses to facilitate learning
- All communications with students (Course description, how it is conducted and assessed, schedules etc.)
- How classroom sessions are conducted
- Presentations in the classroom
- Plans for instructional activities (description, rubrics, processes, evaluation and feedback)

First Principles of Learning
- Learning from a given program will be facilitated in direct proportion to its implementation of first principles.
- First principles of instruction can be implemented in any delivery system or using any instructional architecture
- First principles of instruction are design oriented rather than learning oriented. They relate to creating learning environments and products rather than describing how learners acquire knowledge and skill from these environments or products
- Learning is facilitated when learners are engaged in solving real-world problems.
- Learning is facilitated when existing knowledge is activated as a foundation for new knowledge.
- Learning is facilitated when new knowledge is demonstrated to the learner.
- Learning is facilitated when new knowledge is applied by the learner.
- Learning is facilitated when new knowledge is integrated into the learner's world.
- Learning is facilitated when learners are engaged in solving real-world problems.
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Learning is facilitated when new knowledge is integrated into the learner's world.

- Learning is facilitated when learners are engaged in solving real-world problems.
- Learning is facilitated when learners are shown the task that they will be able to do or the problem they will be able to solve as a result of completing a unit, module or course.
- Learning is facilitated when learners are engaged at the problem or task level not just the operation or action level.
- Learning is facilitated when learners solve a progression of problems that are explicitly compared to one another.

**Problem solving**

Learning to solve a problem involves four levels of instruction:

- problem
- tasks required to solve the problem
- operations that comprise the tasks
- actions that comprise the operations

Effective instruction must engage students in all four levels of performance: the action-level, the operation-level, the task-level, and the problem level.
Design of Generalized E-Learning Model

Activation
Learning is facilitated when relevant previous experience is activated.

- Learners are directed to recall, relate, describe, or apply knowledge from relevant past experience that can be used as a foundation for the new knowledge.
- Learners are provided relevant experience that can be used as a foundation for the new knowledge.
- Learners are given the opportunity to demonstrate their previously acquired knowledge or skill

Demonstration
Learning is facilitated when the instruction demonstrates what is to be learned rather than merely telling information about what is to be learned. …

- Learning is facilitated when the demonstration is consistent with the learning goal: (a) examples and non-examples for concepts, (b) demonstrations for procedures, (c) visualizations for processes, and (e) modeling for behavior.
- Learning is facilitated when learners are provided appropriate learner guidance including some of the following: (a) learners are directed to relevant information, (b) multiple representations are used for the demonstrations, or (c) multiple demonstrations are explicitly compared.

Application
Learning is facilitated when learners are required to use their new knowledge or skill to solve problems.

- Learning is facilitated when the application (practice) and the post test are consistent with the stated or implied objectives.
- Learning is facilitated when learners are guided in their problem solving by appropriate feedback and coaching, including error detection and correction, and when this coaching is gradually withdrawn.
- Learning is facilitated when learners are required to solve a sequence of varied problems.

Integration
Learning is facilitated when learners are encouraged to integrate (transfer) the new knowledge or skill into their everyday life.
Design of Generalized E-Learning Model

- Learning is facilitated when learners are given an opportunity to publicly demonstrate their new knowledge or skill.
- Learning is facilitated when learners can reflect-on, discuss, and defend their new knowledge or skill.
- Learning is facilitated when learners can create, invent, and explore new and personal ways to use their new knowledge or skills.