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A FRAMEWORK FOR COMPETENCY BASED CURRICULUM DESIGN FOR IT COURSES

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Abstract

In recent years, universities are constantly facing assaults by certificate and training institutes on their capability to produce high quality graduates who can meet and adapt to the needs of industry. A good curriculum – the structure of the courses, the syllabus and the assessment – is an essential requirement for ensuring the quality of any academic program. The challenge is thus, to identify the core competencies that a student is required to achieve after completion of the course, and the subsequent designing of the syllabi to acquire these competencies.
In the competency based model, a proscribed competency should be the instructional goal - and the curriculum presentation and evaluation strategies need to be targeted towards acquiring this specific goal. This differs from the traditional methodology which focuses on imparting a generalized knowledge base that might prove useful in the future. The issue that needs to be addressed is thus, the design of a curriculum that is flexible, yet targeted towards the learner acquiring the necessary "knowledge base" for sustainable employment. This kind of a framework results in multiple entry and exit points into the system and can be flexible enough to accommodate inter-disciplinary students.

Keywords:

Curriculum design, competencies, conceptual mapping, education in IT courses, Data Management Systems, IT professional skills

1. THE BACKGROUND.

Traditional educational institutions who do not address the problem of adapting curriculum design towards the needs of the industry have been witnessing a significant decline in student enrollment, especially in IT related programs. It is a well known fact that students graduating from traditional models of academic teaching programs and institutions may be inadequately equipped for the flexibility and continuously evolving technological developments that the IT industry currently requires. Since employers look for candidates that are "industry ready" at the time they join the organization, the curriculum design for professional courses should focus on a student acquiring relevant competencies in their respective areas that make them "employable" at the time of recruitment. This paper proposes a general framework for curriculum design in courses related to IT which can be readily customized for an individual student.
Webster's Dictionary defines an occupation as "the principle business of one's life" while a job is "hire for a given service or period". A graduate academic program in an educational institution as opposed to a certification from a training institute must focus on the former rather than the latter. A good curriculum with a focus on "Learning for Life" is an essential requirement for ensuring the quality of any academic program. The most important stakeholders in an educational context being the students and potential employers, the goal of an effective academic program should primarily be industry relevance, adaptability and flexibility, rather than an acquisition of a knowledge base that might be used in future. After all, the predominant reason why students go to educational institutions is to acquire or enhance their knowledge and skills for employment or promotions. For this, we first need to identify the core competencies that a student would require for his job profile and subsequently design the syllabi ,the assessment and evaluation strategies to achieve these competencies.
This paper is primarily divided into five sections. Section I introduced the problem currently faced by academic institutions. Section II takes a look at some of the relevant articles and work in this area. Section

III explains the proposed framework for a competency based curriculum design in the field of IT, while Section IV uses the framework for designing a curriculum for a course in Data Management. Section V concludes with the future enhancements to the conceptual design and framework.

2. RELATED WORK.

Competency is defined as having the necessary skill or knowledge to perform a task successfully. Johnson [3] further adds," competency is a requisite ability and quality of a student within an academic program, the achievement of which indicates the students capability or qualification in the area of competency." The "education" imparted to a student, besides imbibing the requisite personality traits, must ensure the attainment of the "knowledge" and the "know-how" required for sustainable employment in the industry. An efficient method of learning, irrespective of the mode being classroom delivery or an e-learning program, must have a procedural and analytical methodology as its paradigm. This enhances the student's capacity in analogizing and propagating the skill set he has obtained.

In the competency based model, a proscribed competency is the instructional goal - and the curriculum presentation, learner guidance, practice and evaluation strategies should be targeted towards acquiring this particular goal. Since knowledge is attained at different levels, learning modules should be constructed so as to take the learner from an elementary knowledge base of information and concepts to a more advanced level of synthesis and evaluation. Some occupational analyses systems define levels of skills within occupations as entry level, mid level and fully qualified [1].

Mapping of concepts to competencies as a tool for curriculum design and assessment in academic programs has been studied earlier [7],[6]. The studies all conclude that concept mapping principles in the curricular planning process resulted in course content being more accessible and easily integrated by students.

While designing instructional transactions in the competency-based model, although each competency should be individually testable, the time frame that a learner requires to achieve this competency can be made flexible. The learner should be able to opt for different "competencies" across various subjects (providing a flexibility towards a multidisciplinary approach to curriculum design) to suit a particular job profile. A grade that the student obtains after assessment can be a measure of his/her level of competency. Assessment of occupational standards must include both - knowledge and performance assessment [1]. The authors also make a mention that quality curriculum can only be created by linking curriculum design and assessments to the needs of the workplace.

A similar outlook can be found in [7]. When a curriculum is first developed, its designers must articulate intended learning outcomes that align with competencies. Designers create a framework of educational experiences, to include courses and lessons, which facilitate learning leading to successful performance of the intended learning outcomes. Chaatra [4] which is a student monitoring and learner modeling system talks about the difficulty in identifying concepts and mapping of these concepts to adequate assessment. The focus is on building learner profiles and not in formulating conceptual content mapped to a pre-defined competency.

3. THE FRAMEWORK.

Learning goals are normally articulated by either experienced faculty in the institution or by organizations external to the institution, such as specialized accrediting agencies or professional associations. Occupational standards, or employment specifications, must be defined by employers following procedures agreed with all stakeholders [1]. Consequently, these learning goals and curriculum content must be aligned at three points:

i) The competencies that the learning outcomes would be aligned to.

ii) Creation of the framework to include training material required to facilitate learning leading to these learning goals.

iii) Continual up gradation of the designed framework to ensure its relevance to the current needs of the stakeholders

Most organizations, while recruiting candidates, lay an emphasis on the soft skills of the professional, and many technically savvy candidates fail to procure jobs if they do not have the required personality traits commensurate with the job. A professionally designed curriculum would require inculcating two main types of competencies:

(i) Professional competencies which relate to the “knowledge base” required and the ability to use this knowledge in the related work area..

(ii) Personal competencies which represent a set of skills, attitudes and values that enable the professional to work efficiently and adapt to his present environment.

Although the core fundamental conceptual knowledge in IT remains the same, the technological advances are varied and rapidly changing. While designing a curriculum for an IT related course, knowledge about a particular software or tool is not sufficient. The knowledge that is needed is about modeling the problem itself first (the domain knowledge and the analytical knowledge), thinking which IT tool to use and how, and then applying a combination of them all. IT professionals are asked to master new skills that did not exist a few years ago while still performing old skills. Hence the skill set that the learner acquires must be what the industry is currently requires. The curriculum design must be flexible enough to take this into account. [8] does a relevant study that brings out the issue of applicability of knowledge that students receive when a course is done in a traditional manner in most educational institutions. The content delivery of most of the IT courses is done through review / demonstration of the tool itself (i.e. functionalities, menus@) which directly followed contemporary literature approach on the subjects. Such an approach to lecturing does not deliver the value it should. The most important knowledge - that of finding the right feature of a tool to solve a specific problem - is missing.

Facing such pressures and trends, the competency concept should arguably be the foundation for the new curriculum design.Accordingly, the four fundamental components of a systematic instructional design process that must be taken into account are [9].

(i)Learners - For who is the program developed?

(ii)Objectives - What do you expect the learner to achieve finally?

(iii)Instructional Strategies - How are you going to make learners meet their objectives?

(iv)Evaluation Procedures - How do you determine whether learning objectives are met?

The conceptual knowledge requirements need to be formulated for the different levels of learning, and the assessment should be targeted at finding the competency level of the learner at the Knowledge Level Base -- Entry level, Intermediate level or Advanced level -- he/she is currently pursuing. The Grading should be centered on finding how much the learner knows and is capable of performing at each learning outcome. The scales could accordingly reflect

0: Cannot perform the sub-competency (implying a repeat of the Learning Process)

1: Can perform the sub-competency but needs guidance

2: Can perform the sub-competency efficiently.

Rating the level of competency is not only for qualification but also helps in stimulating the students need for further improvement if desired. This approach is different from the Traditional Method of Instruction delivery and assessment, where learning material is accessed at definite points in time and the final assessment done at the end of the learning cycle. The traditional method is restrictive as a student cannot retake an assessment to improve his performance in a particular learning outcome. There are no multiple entry and exit points in this system and the grade earned once lasts for a lifetime.

The course curriculum is best visualised in a conceptual mapping diagram which shows the flow and dependencies of concepts.In addition, curriculum mapping can also serve as a device to tie assessment plans to the overall structure of the course, ensuring that student learning is effectively assessed at unit boundaries. Finally, as faculty revise courses and lessons, curriculum mapping can reveal which concepts need pruning from the map and which need additional emphasis – without having to wait for the reprints of standard textbooks!!

A general framework for curriculum design is in the field of IT must consider filtering of concepts in the Instructional /Learning Material as

Information (which does not require learner guidance or practice and can be assigned to students as self study material)

Instructional Material: Instruction differs from Information in the sense that it does require presentation and practice. It may consist of facts and knowledge that need to be assimilated. The learning material presented here should emphasize a procedural method of learning, where guidance and explanations are provided, and will enhance the student’s ability to predict, abstract and discover. Although a student could

learn through “raw discovery” and finally attain the needed skill to perform the required task, this is not an efficient method of learning, as the student may not be able to analogize (perform a similar process) or propagate (acquire one set of skills in the context of another) the skill.

The Instructional Material needs to be looked at in three different, yet complementary aspects to achieve the required conceptual base for a particular competency. The concepts need to be arranged in a hierarchy that can capture the pre-requisites of a particular concept. A complete concept can be tested only if its pre-requisite has been assessed.

The Instructional Material consists of

(i)Knowledge - theoretical concepts that must be covered in a pre-requisite order, and for which learner material and guidance needs to be provided

(ii)Know –How - assignments and practice to consolidate the concepts learned.

(iii)Skills - It is necessary to segregate this due to the rapid technological advances and the industrial requirements. Here, we select a subset of the current technologically viable skill set that the learner needs to acquire while performing the practice and will enhance his particular domain expertise.

Further, when identifying these concepts, the granularity is important – it should not lead to a diverged focus on the part of the learner or leave the learner disoriented.

A further refinement of these steps for a Competency Based Curriculum design would involve –

(i) Identification of the job opportunities and duties involved for that job.

(ii) Identify the competencies required to perform the job effectively (professional and personal).

(iii) Identify the knowledge, know-how and current skills required to achieve these competencies.

(iv) Identify corresponding subject concepts (theory) to acquire the knowledge required.

(v) Identify assignments (practical) that enhance the “know-how” of the subject.

(vi) Identify the skill set (the means) required to perform the practical.

(vii) Identify text and reference materials whose subject objectives match the knowledge required in (v), (vi) and (vii) above.

(viii)Design assessments that can check a candidate’s knowledge at various learning levels for a given competency.

4. DESIGNING A CURRICULUM FOR DATA MANAGEMENT.

Virtually every area of management uses databases: marketing professionals to analyze sales data, accountants to generate bills and sales reports. While databases are often created and maintained by information technology professionals, in this era, where IT has percolated in all aspects of business, all professionals would need to manipulate their own data. It is now mandatory that students understand how data management systems are used to design, build and run modern database applications.

A student of IT, at the end should be able to evaluate a business situation and build a database application for it. An interdisciplinary student would need to know how to extract data from a database and present the data effectively. Thus for different categories of learners , for the same domain, the material presented and the assessment level would depend on the duties that the person would be required to perform.

The Model curriculum guidelines for Under Graduate programs [2] recommends that students in any discipline of study require working knowledge in at least the areas of word processing, spreadsheets, Internet access, database management and external database retrieval. Students offering a minor in Information Systems must necessarily undergo a course in database design and information retrieval (among other courses). According to [5] outside of programming, competency is highly prized in operating systems, networking and web management, database design and SQL, systems implementation and testing

For a strong yet flexible curriculum, the pre-requisites in a domain for a particular concept needs to be determined ,and the organization of the concepts itself be such that a student, depending on objective of learning the domain, chooses his own conceptual requirements. Further, the determination of the learning activities and assimilated knowledge of a student should be determined at every learning step. The student should thus be guided through the learning of elementary material to a mastery of the subject through a continuous evaluation and feedback mechanism. The transfer to a new learning material should only be done after the previous material (pre-requisite) has been successfully mastered.

Students desirous of pursuing careers in IT should be vibrant, have vast domain knowledge and be able to keep pace with the rapid advances in technology. Some Personality Traits they may be required to possess would be

- (i) An ability to work with clients and customers (ii) Ability to make sound, well-informed, and objective decisions and a commitment to accomplish a goals.(iii)Is open to change, has good communication and technical writing , and interpersonal skills. (iv)Is creative, has a capacity for problem solving and reasoning and can make informed decisions quickly.

Although personality traits are important in recruiting a candidate, and an academically sound curriculum would not be complete if not designed to inculcate the required personality traits in the students, the perspective of this paper is to arrive at competencies in the design of syllabi for a course in Data Management.

Before arriving at the competencies required in the field of Data Management, let us take a look at some of the typical career opportunities that this domain could potentially provide.

Some Career opportunities and their envisaged duties in the field of Data Management

Data Analyst

A Data Analyst is directly involved with project work, gathering data requirements and definitions, and mapping data elements (source to target data transformations). They also create and maintain detailed data models, typically at the logical level, to hand off to the DBA.

DataBase Designer

A DataBase Designer is directly responsible for the Design and Creation of the entire Conceptual and Physical Design including the Data constraints, required for the Organization.

Application Developer

An Application Developer is expected to assist in designing, developing and maintenance of application software and provide system and database support.

DataBase Administrator

The DBA is the technical specialist who is responsible for every stage of the application development life cycle.

The course curriculum is designed keeping in mind the DataBase Administrator whose posting is at the top of a career chart in Data Management. Since the job duties of a DBA would primarily involve - i)Design of the database and Defining the storage structure and access methods (ii) Maintain the database and perform required performance tuning (iii) Protection of the data and Granting authorization for data access to various users and (iv) Routine maintenance – of metadata, disk space usage, recovery of data, usage profiles etc. - the competencies the DBA would be required to acquire would be:

Analysis : Accessing clients requirements , Performing job and cost estimations (of man hours, hardware and software requirements) and feasibility report generation

Design : Conceptual Designing - Evaluating and Choosing a suitable data modeling methodology , Organizing the data that needs to be stored in the database .Physical level design - Defining appropriate storage and access structures for the data and the catalogs, Data clustering and partitioning

Control : Creating users and Defining the roles that they will need, Protection ,Backup and Recovery mechanisms of the data, Performance Monitoring and Tuning, Methods of Concurrency handling

Data Manipulation : Extracting data using a query language and a host language ,Creating an active database, Optimizing queries, Importing and Exporting data

Data integration and Presentation : Effective design of forms and reports. Extracting data from various sources and creating visual representations of the data, Visual representation of data

General Administration : Installation , Configuring and upgrading the software, Loading the data, User training, Resolving conflicts, Defining user interface and programming standards ,Usage profiling and accounting

The curriculum design in a Data management course would thus require having consolidated syllabi that encompasses the entire knowledge base required by the DBA. The syllabus is structured in modules which can be taught at the three learning levels – Elementary Level (EL), Intermediate Level (IL) and Advanced Level (AL). For the job opportunities .The appropriate learning level of each of these modules is then used

to design curriculum for various job opportunities which shows the flexibility of this framework to incorporate multiple entry and exit points into the system.

Figure 2- A chart showing competency level modules required for various careers in Data Management

FDM – Fundamentals in Data Management
DBE – Data Base Environment
DMR – Data Manipulation and Retrieval
EDBP – Enterprise Data Base Processing
DS - Data Storage
PDBD – Physical Data Base Design
GDBA – General Data Base Administration
DBC – Data Base Control
DBAT – Data Base and Application Tuning
EL – Elementary Level
IL – Intermediate Level
AL – Advanced Level
L1 , L2 , L3 - Levels of the Concepts in the Module

AUDIENCE	Naïve End Users	Interdisciplinary Students , Sophisticated End Users , UG Teachers	DataBase Designers, DB Architects, Application Developers, Programmer Analysts	Data Administrators	DataBase Administrators
KNOWLEDGE BASE	Module 1 (Overview of DM) Part A FDM – EL (L1) Module 3 (Application Dev) Part A DMR – EL (L1)	Module 1 (Overview of DM) Part A FDM –EL (L1) Part B DBE – EL (L1) Module 2 (Application Dev) Part A Analysis – EL (L1) Part B Design – EL (L1) Module 3 (Using the DB) Part A DMR – EL (L1) Part B EDBP- EL (L1)	Module 1 (Overview of DM) Part A FDM – IL (L1, L2) Part B DBE – IL (L1 , L2) DS – IL (L1) Module 2 (Application Dev) Part A Analysis – IL (L1, L2) Part B Design – IL (L1, L2) PDB –IL (L1) Module 3 (Using the DB) Part A DMR – IL (L1, L2) Part B EDBP – IL (L1, L2)	Module 1 (Overview of DM) Part A FDM – AL (L1, L2 ,L3) Part B DBE – AL (L1 , L2, L3) DS – AL (L1,L2) Module 4 (DataBase Administration) Part A GDBA – AL	Module 1 (Overview of DM) Part A FDM – AL (L1, L2,L3) Part B DBE – AL (L1 , L2, L3) DS – AL (L1, L2) Module 2 (Application Dev) Part A Analysis – AL (L1, L2, L3) Part B Design – AL (L1, L2 ,L3) PDBDesign – AL (L1, L2) Module 3 (Using the DB) Part A DMR – AL (L1, L2 ,L3) Part B EDBP – AL (L1, L2, L3) Module 4 (DataBase Administration) Part A GDBA – AL Part B DBC- AL Part C DBAT - AL

The DBA would require to undergo Modules 1, 2, 3 and 4 of the Advanced Level of the curriculum shown below to achieve competencies in all areas listed above (detailed module content shown in the Appendix)

Data Management curriculum designed at 3 levels:

Elementary Level:

Data Management - Elementary Level (required by all in any domain)

Competencies

- Choose an appropriate Data Management tool for their application to be designed
- Analyze requirements of a domain
- Design and create a database for a small domain
- Populating the database
- Manipulating data in the database
- Accessing the Database from a client application

Module 1

An overview of Data Management (Elementary level)

Part A: Fundamentals of Data Management: Basic Concepts - Elementary Level (Level 1) (Information)

Part B: The DataBase Environment: An Introduction - Elementary Level (Level 1) (Information)

Module 2

Application Development Process (Elementary level)

Part A: Analysis: Basic Systems Analysis Concepts - Elementary Level (Level 1) (Information/Instruction Material)

Part B: Design: Elementary Concepts of Conceptual and Logical DB Design - Elementary Level (Level 1) (Instructional Material) includes Concepts, Practice, Skills

Module 3

Using the DataBase (Elementary level)

Part A: Data Manipulation and Retrieval: Basic Concepts - Elementary Level (Level 1) (Instructional Material)

Part B: Enterprise DataBase Processing: The Basics - Elementary Level (Level 1) (Instructional Material)

Intermediate Level:

Data Management - Intermediate Level (Application Developers, DataBase Designers, Data Analyst, Data Architect)

Competencies

- Choosing an appropriate hardware and software platform for an application
- Installation , Configuring and upgrading the software
- Analyzing Clients Requirements
- Creating appropriate documentation
- Designing a DataBase
- Creating and Deploying an application on Client/Server platforms
- Maintaining DataBase Security
- Performance Tuning of the DataBase

` Module 1

An overview of Data Management (Intermediate level)

Part A: (I) a. Fundamentals of Data Management - Elementary level (Information)

b. Beyond the Basics - (Intermediate level) (Level 2): (Information)

Part B: (I) a. The DataBase Environment: An Introduction - Elementary Level (Information)

b. Beyond Basics - (Intermediate level) (Level 2): (Information)

(II) Data Storage - Intermediate Level (Level 1) (Information)

Module 2

Application Development Process (Intermediate level)

Part A: (I) Analysis

a. Basic Systems Analysis Concepts - Elementary Level
b. Systems Analysis for Large Application Domains - (Intermediate level) (Level 2): (Information/ Instruction)

Part B: (I) Design
a. Elementary Conceptual and Logical DB Design – Elementary Level
b. Conceptual Systems Design for Large Application Domains – (Intermediate Level) (Level 2) (Instructional Material)

(II) Physical DB Design: Basic Design Issues - (Intermediate level) (Level 1): (Information)

Module 3

Using the DataBase (Intermediate level) (Instructional Material)

Part A: (I) a. Data Manipulation and Retrieval - Basic Concepts – Elementary Level
b. Enhanced DataBase Manipulation and Retrieval- (Intermediate level) (Level 2): (Information/Instruction)

Part B: (I) a. Enterprise DataBase Processing : The Basics – Elementary Level
b. Enhanced Enterprise DataBase Processing Features - (Intermediate level) (Level 2): (Instructional Material)

Advanced Level:

Data Management - Advanced Level (Data administrator, Data Base Administrators, DataBase Technology Experts , DataBase Consultants)

Data and Database administration activities occur throughout the database development process. A Data administrator normally plays a stronger role in the overall planning of data resources and in the initial stages of database development. A Database Administrator plays a stronger role during the physical database design , implementation and operation .

Competencies of Data Administrator

- Manage the corporate rules and methodologies
- Establish long range plans for the organization pertaining to the data management of the organization.
- Define standards in application development
- Manage Configuration Control and Documentation
- Create Usage profiles and accounting
- Manage responsibility for data, metadata and policies about data use
- Choosing an appropriate hardware and software platform for an application
- Installation , Configuring and upgrading the software
- Handling User Training requirements
- Plan Growth and change

Competencies of DataBase Administrator

- Analyzing Clients Requirements
- Creating appropriate documentation at various stages of the SDLC
- Designing an Enterprise DataBase at the Logical and Physical Levels
- Populating the DataBase from heterogeneous data sources
- Creating and Deploying an application on Multi-tiered Architectural platforms
- Manage System Catalogs
- Maintaining DataBase Security , Privacy and Integrity
- Routine maintenance – of metadata , disk space usage, recovery of data , usage profiles
- Specify Test procedures
- Establish procedures for Backup and Recovery of the DataBase
- Performance Tuning and Monitoring of the DataBase
- Setting up the application development environment
- Creating Users and Roles
- Configuring the Devices and the Database
- Troubleshooting and Resolving conflicts

Module 1

An overview of Data Management (Advanced level)

Part A: (I) a. Fundamentals of Data Management - Basic Concepts - Elementary Level
b. Beyond the Basics - Intermediate Level
c. Advanced Concepts – (Advanced Level) (Level 3) (Information)
Part B: (I) a. The DataBase Environment: An Introduction - Elementary Level
b. Beyond Basics- Intermediate Level
c. The Enterprise DB Environment – (Advanced Level) (Level 3) (Information)
(II) a. Data Storage: An Overview – Intermediate Level
b. Advanced Data Storage Concepts – (Advanced Level) (Level 2) (Information)

Module 2

Application Development Process (Advanced level)

Part A: (I) Analysis
a. Basic Systems Analysis Concepts – Elementary Level
b. Systems Analysis for Large Application Domains – Intermediate Level
c. Advanced Concepts in Systems Analysis - (Advanced Level) (Level 3) (Information/Instruction)
Part B: Design
(I) a. Elementary Conceptual and Logical DB Design - Elementary Level
b. Conceptual Systems Design for Large Application Domains – Intermediate Level
c. Advanced Concepts for Conceptual Design of Enterprise DataBases (Advanced Level) (Level 3) (Instructional Material)
(II) Physical DB Design
a. Basic Design Issues – Intermediate Level (Level 1)
b. Advanced Design Issues – (Advanced Level) (Level 2)

Module 3

Using the DataBase (Advanced Level)

Part A: (I) a. Data Manipulation and Retrieval: Basic Concepts – Elementary Level
b. Enhanced DataBase Manipulation and Retrieval – Intermediate Level (Level 2)
c. Advanced Concepts in DataBase Manipulation – (Advance Level) (Level 3) (Instructional Material)
Part B: (I) a. Enterprise DataBase Processing: The Basics – Elementary Level
b. Enhanced Enterprise DataBase Processing Features – Intermediate Level
c. Advanced Enterprise DataBase Processing – (Advanced Level) (Level 3) (Instructional Material)

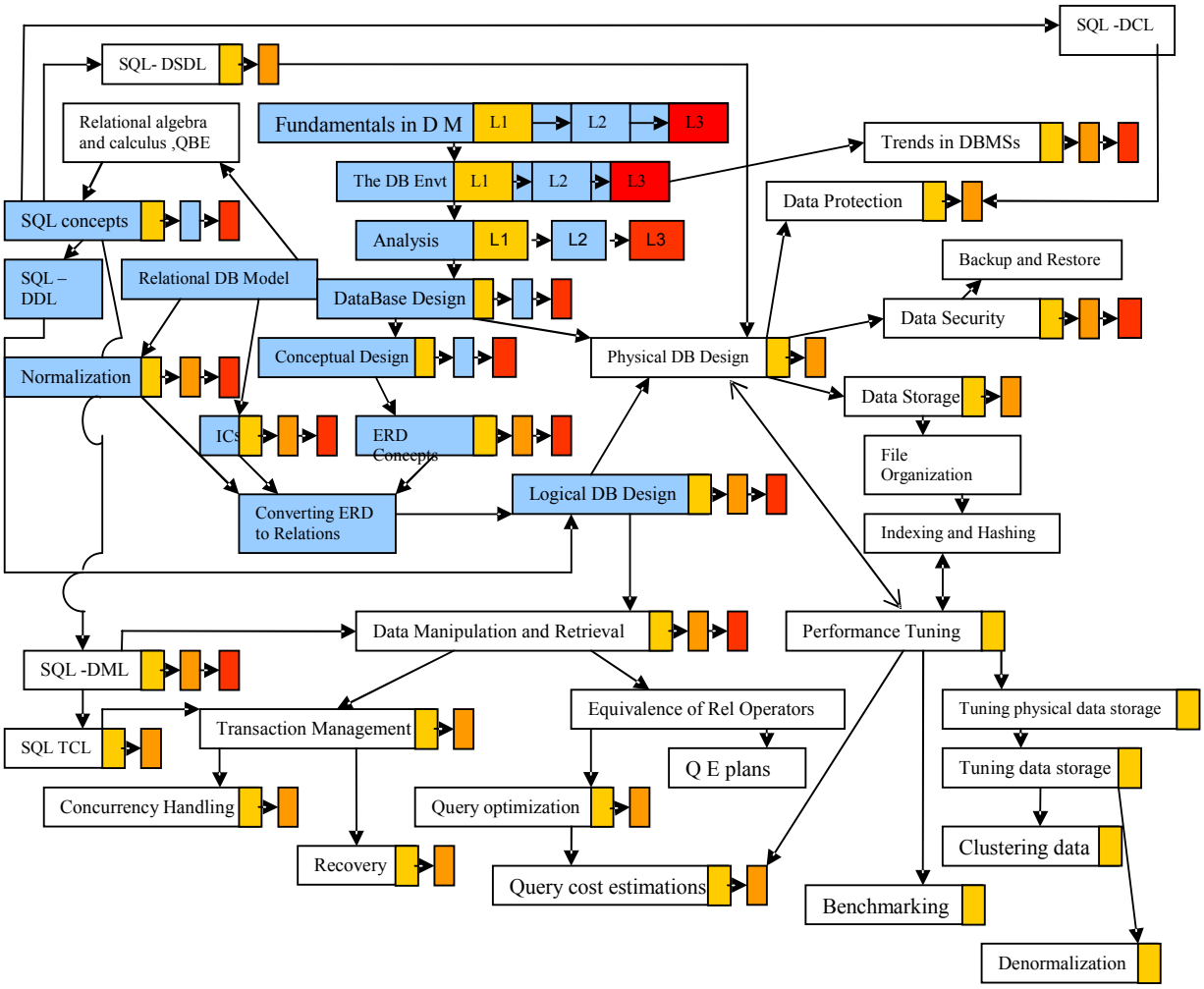
Module 4

DataBase Administration

Part A: DataBase Control – Advanced Level (Level 1) (Instructional Material)
Part B: DataBase and Application Tuning – Advanced Level (Level 1) (Instructional Material)
Part C: General Administration – Advanced Level (Level 1) (Instructional Material)

A conceptual mapping that maps the concepts in a diagrammatic way showing the organization, pre-requisites and relationships between the various concepts (conforming to the way learning takes place) would be an appropriate way to visualize the curriculum .This can not only aid in preparing the guiding material for presentations and assignments, but allows for a continuous and effective assessment for a particular competency in incremental stages of conceptual knowledge. The structure and organization of course material is important as it prevents disorientation for a learner. A learner can see the linkages and relationships between the concepts and can proceed in an organized manner.
These concepts and the pre-requisites needed are easily traced when the curriculum is represented in a diagram that shows the conceptual mapping. In the following figure, this is shown by color coding the block in blue.

Figure 3 - A diagram showing the concepts mapping with different knowledge levels for Data Management



5. CONCLUSION AND FUTURE ENHANCEMENTS.

To provide quality education to professionals it is critical to have a curriculum design framework that reflects the current competency standards of the field. There is a need to define a finer level of granularity for each concept and to translate these learning objectives into a learning plan - describe teaching approaches and material aimed at developing each competency and assessment targets with an emphasis on knowledge application.

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APPENDIX

Module 1

An overview of Data Management (Elementary level)

Part A: Fundamentals of Data Management: Basic Concepts - Elementary Level (Level 1) (Information)

Differences between data, information, metadata. Data requirements at various levels in an organization .Evolution of data management applications .Various types of data and the various kinds of applications that manipulate it (files, spreadsheets, various kinds of DBMSs), their advantages and disadvantages. Various kinds of users of the system, the roles they play, and the effectiveness of information provided to each level of users in an organization

Part B : The DataBase Environment:- An Introduction Elementary Level (Level 1) (Information)

Range of DataBase applications.Advantage of a DBMS .Levels of Data Independence.Components of a DBMS

Goals and Objectives of a DBMS. DataBase languages and Interfaces. Growth in DBMSs (HDBMS, NDBMS, RDBMS, ORDBMS, OODBMS,multimedia DBMS) – the reason for evolution and the suitability of a DBMS for a particular application. Disadvantages of the DataBase approach. Roles of Database Personnel. Data Security.Knowledge of some leading commercial databases

Module 2

Application Development Process (Elementary level)

Part A : Analysis: Basic Systems Analysis Concepts - Elementary Level (Level 1) (Information)

Components of an Application. Application Development Life Cycle .Methods of Requirement Analysis (Instructional Material)

Three schema architecture for database modeling. Types of Data Models

Part B : Design: Elementary Concepts of Conceptual and Logical DB Design - Elementary Level (Level 1)

(Instructional Material)

Concepts: Importance of identifying the Individual and Community users views of the data .Conceptual Level Modeling : Various design methodologies and their use in appropriate situations (eg DFDs, ERDs, UML).Data Modeling using the Entity Relationship Model.Good Design Principles. Logical Database Design: Converting the ERD to the database schema in the DDL of the chosen DBMS. The Relational Data Model - properties .Integrity constraints on the data. Data Normalization – Basic Normal Forms. Converting the ERD to Normalized Tables.Effects of business rules on Normalized Data. The Data Dictionary. Using the DSDL and DDL of the DB Query Language to create the domains, relations and enforce the ICs on the data

Practice: A small case study in the relevant domain of the learner can be taken.The student should be asked to analyze the requirements of the client and create the conceptual design using the ERD.The ERD should then be used to create Normalized tables with relevant ICs defined on the data.The Logical Database should be defined using the DDL of the DBMS.SQL – DDL for creating, modifying , deleting tables and views. Inserting, modifying, deleting data in the tables. Adding ICS on the tables.

Skills: The DBMS chosen for implementation could be what the learner seeks to have expertise in (Oracle, DB2, Sybase, MySQL, Access, PostGress etc). Most DBMS and third-party vendors have their own design tools for conceptual designs (Visio, DeZign, Rational rose) SQL – DDL and DML (I/U/D). SQL – DSDL

Module 3

Using the DataBase (Elementary level)

Part A: Data Manipulation and Retrieval: Basic Concepts - Elementary Level (Level 1) (Instructional Material)

Concepts: Various ways of manipulating data – query languages, using programs to retrieve and save data. Queries - The form of a Basic SQL query, basic queries, computations in queries. Subtotaling and aggregate operators, queries using multiple tables, testing queries.

Issues with null values, view creation, retrieval of data using viewsMethods of populating the database

Practice: A varied set of SQL queries that start from creation and modification on tables and views, populating the tables, modifying the data in the tables. SQL – DML statements starting from elementary and moving towards more complex queries
Skills: Basic SQL – DDL and DML
Part B: Enterprise DataBase Processing: The Basics - Elementary Level (Level 1) (Instructional Material)
Concepts: Effective design of Forms and Reports, Menus and Form layout. Two and Three tiered architectures and their relevance to application design and development. Downloading data. Manipulating data in a remote database using a Form/Report.Concept of a Transaction and the importance of ensuring the ACID properties. Using the TCL statements of the DBMS. Database Protection and Application Security. Using the DCL of the DBMS to enforce privileges
Practice: Assignments that take the learner through creating and designing forms and reports for the presentation tier of an application. The focus should be on a Client/Server platform with a user-friendly interface. The interface designed should be the only means to manipulate the database on the server. Use of Form designing and Report generation tools. Using visualization tools to present the data effectively . Granting/Revoking privileges on data
Skills: The Designer of the commercial DBMS , third party vendor like .NET platforms ,ASP ,etc. SQL-DML , DCL , TCL.
The application that has been analyzed ,designed and created in modules 1 and 2 should be implemented by creating a User Friendly Interface to the DataBase

Intermediate Level:

` Module 1

An overview of Data Management (Intermediate level)

Part A : (I) a. Fundamentals of Data Management - Elementary level (Information)
b. Beyond the Basics - (Intermediate level) (Level 2): (Information)
Range of Data Management Applications .Information Systems Architecture. Advances in Data types and Applications (Spatial Databases , Temporal DataBases , Multimedia databases, Distributed Databases , Mobility and Personal databases). Current issues in security, privacy and piracy
Part B : (I) a. The DataBase Environment: An Introduction - Elementary Level (Information)
b. Beyond Basics - (Intermediate level) (Level 2): (Information)
DBMS Architecture. Various hardware and software available so as to make appropriate choices Various Costs of the DataBase approach (Installation , management, conversion ,training).Need for Backup and Recovery. Multi-tiered Application Environments.Role of Middleware.Client/Server connectivity Standards (ODBC,OLE,ADO,ASP,JDBC,JSP)
II) Data Storage - Intermediate Level (Level 1) (Information)
An Overview : Overview of Physical storage media. File Organization and Access methods. RAID levels. Organization of records of a relation in files. Clustering files. Data dictionary storage. Indexing and Hashing Methods and their comparisons

Module 2

Application Development Process (Intermediate level)

Part A : (I) Analysis
a. Basic Systems Analysis Concepts - Elementary Level
b. Systems Analysis for Large Application Domains - (Intermediate level) (Level 2): (Information/ Instruction)
Current application architectural and development standards. Networking Environments. Various techniques for requirements gathering. Creation of feasibility study and other documentation reports. Techniques for Cost Benefit Analysis .Methods and tools used in project planning
Case Studies can be given for analysis
Part B : (I) Design
a. Elementary Conceptual and Logical DB Design – Elementary Level
b. Conceptual Systems Design for Large Application Domains - (Intermediate level) (Level 2) (Instructional Material)

Concepts: Multi –Tiered Database architectures. Data Modeling with the Extended ERD. Reduction of an EERD to a Relational SchemasHigher Normal Forms. Theory of Functional Dependencies. Decomposition using FDs. Creating Relational schemas using the synthesis approach. Problems with Null Values in a database. Requirement of External Level view to the database. Defining Roles and privileges on the data. Defining structural and operational constraints on the database

(II) Physical DB Design : Basic Design Issues - (Intermediate level) (Level 1): (Information)

Basic Design Issues : Importance of Data Volume and Usage analysis in the physical database design process. Designing Domains and Controlling data integrity. Using and Selecting indices. Optimizing for Query performance. Denormalization

Practice: Elementary Level Practice

Intermediate Level : A sufficiently complex application should be taken for analysis and design.The Conceptual Design should be arrived using the EERD.The EERD should then be used to create Normalized tables with relevant ICs defined on the data.The Logical Database should be defined using the DDL of the DBMS.DSDL statements of the DBMS should be used to create domains, complex ICs , indices on the database.SQL – DSDL for creating domains , semantic constraints , referential integrity constraints.Indices should be created on single, multiple attributes. SQL – DDL for creating, modifying , deleting tables. For creating and manipulating views. SQL- DML for Inserting, modifying, deleting data in the tables .Importing/ Exporting data to/from database SQL – DCL for defining roles, granting and revoking privileges

Skills: Elementary level Skills

Intermediate level: Advanced SQL. SQL - DCL

Module 3

Using the DataBase (Intermediate level) (Instructional Material)

Part A : (I) a. Data Manipulation and Retrieval - Basic Concepts – Elementary Level

b. Enhanced DataBase Manipulation and Retrieval- (Intermediate level) (Level 2): (Information/Instruction)

Concepts :Difference between Procedural and Non Procedural Languages. Relational Algebra and Calculus – its need and expressive power in formulating queries, the operations involved and their correspondence to SQL. Few examples using a query language based in RC (tuple and domain relational languages).Advanced queries - aggregate queries , inner and outer joins , nested queries , subqueries, correlated subqueries Data Warehouses and OLAP.Querying the Data dictionary.Creating and manipulating view and the associated problems.Data Manipulation using embedded SQLs, properties and usage of cursors, dynamic SQL, complex ICS .Triggers and active databases, stored procedures, packages ,error events, problems with triggers.Handling multiple users and concurrent access.

Practice: Elementary level pratice

Intermediate level : SQL statements to populate data in the database.Complex SQL statements that use set manipulation, aggregate operations, inner and outer joins.Nested and correlated subqueries. Statements to query the Data dictionary.Statements to create Assertions and Triggers. Writing dynamic SQLs and stored procedures.Creating a package

Skills: Elementary level skills

Intermediate level :Advanced SQL.Embedded SQL

Part B : (I) a. Enterprise DataBase Processing : The Basics – Elementary Level

b. Enhanced Enterprise DataBase Processing Features - (Intermediate level) (Level 2): (Instructional Material)

Concepts: Partitioning an Application for a tiered architecture. Using Middleware. Establishing Client/Server security .Ensuring Transaction Integrity .Concurrent management of transactions and anomalies that can arise .Concurrency based protocols – Lock and Time-stamp based. Transaction schedules, equivalent schedules, Serializablity, Recoverable and Cascading schedules. Sharing Enterprise data. Backup and Recovery of Data

Practice: Elementary level practice

Intermediate level :Creating Roles and Granting/revoking privileges .Using SQL statements at different transaction isolation levels. Using various locks on the data. Embedding SQL in programs. Using Cursors .Writing Triggers and stored procedures. Creating a

package. Using OLE, COM, ActiveX controls to access the database. Using the Service Provider to retrieve, update and manipulate remote data. Invoking stored procedures.

Skills: Elementary level skills

Intermediate level: Advanced SQL and TCL statements. Embedded SQL. Using a CLI,ADO , ASP , JSP.Multi – tiered application design and development and deployment

Advanced Level:

Module 1

An overview of Data Management (Advanced level)

Part A : (I) a. Fundamentals of Data Management - Basic Concepts - Elementary Level

b. Beyond the Basics - Intermediate Level

c. Advanced Concepts – (Advanced Level) (Level 3) (Information)

Various threats to Data Security and mechanisms to prevent them. Managing Data Quality. Semi-structured Data .Decision-Support systems.OLTP and OLAP systems.Data Warehousing and Data Mining

Part B : (I) a. The DataBase Environment : An Introduction - Elementary Level

b. Beyond Basics- Intermediate Level

c. The Enterprise DB Environment – (Advanced Level) (Level 3 (Information)

Data Dictionaries and Repositories. DataBase System Architectures. Application Migration.Transaction Processing Monitors. Transactional workflows. E-commerce .Long-Duration transactions .Main-Memory DataBases. Web Fundamentals and Web interfaces to DataBases. Semantic Object Model. Object-Based DataBases. ORDBMS. XML – Struture, Storage of XML Data , APIs to XML

(II) a. Data Storage: An Overview – Intermediate Level

b. Advanced Data Storage Concepts – (Advanced Level) (Level 2) (Information)

Multi-Key Access Files and Bitmap Indices.Clustering and Indexing.Advantages and Disadvantages of various RAID levels .Performance Benchmarks.Tuning the DataBase for Performance

Module 2

Application Development Process (Advanced level)

Part A : (I) Analysis

a. Basic Systems Analysis Concepts – Elementary Level

b. Systems Analysis for Large Application Domains – Intermediate Level

c. Advanced Concepts in Systems Analysis - (Advanced Level) (Level 3) (Information/Instruction)

Identifying Business Rules and their scope.Defining Structural Constraints and Operational Constraints on Business Rules

Identifying Strategic Planning Factors and Corporate Objectives. Enterprise Modeling. Alternative IS Development approaches

Matching User Needs to the IS Architecture. Creating the appropriate Documents and entering into contracts with the client

The Role of CASE and Repository.Installing and Configuring the DataBase

Part B : Design

(I) a. Elementary Conceptual and Logical DB Design _ Elementary Level

b. Conceptual Systems Design for Large Application Domains – Intermediate Level

c. Advanced Concepts for Conceptual Design of Enterprise DataBases (Advanced Level) (Level 3) (Instructional Material)

Concepts: Modeling Time-Dependant Data and Multiple Relationships .Modeling for GIS DataBases. Object-Oriented Modeling. Defining Discriminators for Class Hierarchies. Normalizing Summary Data. MultiValued and Join Dependencies. Decomposition using Multivalued Dependencies. DK Normal Form. Application Security and Access Controls. UML Designs. DataBase Design with semantic object models

(II) Physical DB Design

a. Basic Design Issues – Intermediate Level (Level 1)

b. Advanced Design Issues – (Advanced Level) (Level 2)

Optimizing for Query Performance. Indices on Multiple attributes. Managing Disk and other Resource Usage and Contention

Creating and Managing Data spaces for the Relations and Control Files. Creating Datafiles for Other Programs. Creating Users and Assigning Roles

Practice: Elementary Level Practice,Intermediate Level Practice

Advanced level

Creating Design Patterns. Creating the Data Repository .Using CASE Tools. Subdividing the Project. Designing Standard Interfaces and Test Cases. Creating the Project Plan and Schedules. Handling Version control and upgrades. Creating Integration plans

Designing Physical Records and Files. Creating DataBase Objects .Selecting indices

Skills: Elementary Level Skills, Intermediate Level Skills

Advanced Level

SQL - DSDL .Advanced SQL – DCL. Choosing RAID Levels for the Organization. Reorganizing DataBases

Using the Loader and Managing the Control Files. Using various methods of operations to Import/Export Data

Maintaining DataBase Statistics.Using DBA Tools

Module 3

Using the DataBase (Advanced Level)

Part A : (I) a. Data Manipulation and Retrieval : Basic Concepts – Elementary Level

b. Enhanced DataBase Manipulation and Retrieval – Intermediate Level (Level 2)

c. Advanced Concepts in DataBase Manipulation – (Advance Level) (Level 3)

(Instructional Material)

Concepts: Creating assertions and complex ICS. Managing an Active DataBase. Creating Stored Procedures that manipulate multiple tables

Packaging the Application. Query Equivalence and Query Cost Estimations. Query Evaluation Plans and strategies

Query Optimization. Using DBMS Built-in Packages. Error handling

Practice: Elementary Level Practice, Intermediate Level Practice

Advanced Level : Writing complex ICS and Assertions. Writing advanced Embedded SQL queries, Triggers , Stored procedures

Creating and Compiling Packages to handle complex business rules. Creating Datafiles for other programs. Using various Loading options . Using Various parameters in Import/Export. Manipulating data from heterogeneous sources. Advanced Transaction Control

Statements. Using various Locks for Concurrency handling .Handling Transactions at different Isolation levels

Skills: Elementary Level Skills, Intermediate Level Skills

Advanced Level: Embedded SQL. Advanced TCL

Part B : (I) a. Enterprise DataBase Processing : The Basics – Elementary Level

b. Enhanced Enterprise DataBase Processing Features – Intermediate Level

c. Advanced Enterprise DataBase Processing – (Advanced Level) (Level 3) (Instructional Material)

Concepts: Configuring the Data and Service providers. Establishing Client/Server Security. MiddleWare Technologies. Partitioning the Application and Deployment on Multi-Tiered Architectures. Markup Languages – HTML,DHTML,XML and their Use

JDBC,ASP,JSP. Sharing Enterprise Data. Building Internet DataBase Servers.Data WareHousing and Data Mining Techniques

Practice: Elementary Level Practice, Intermediate level practice

Advanced Level :Using various kinds of Cursors and Triggers. Creating and Manipulating DataBase Objects. Exception handling

Query Execution Enhancements. Partitioning the Application. Deploying the application on multiple tiers. Using Middleware

Distribution and Integration of Data .Managing Transactions using Middleware

Skills: Elementary Level Skills, Intermediate Level Skills

Advanced Level :Advanced SQL (SQL scripts, SQL creating SQL).SQL Functions. Advanced Embedded SQL. Using Middleware

Module 4
DataBase Administration

Part A : DataBase Control – Advanced Level (Level 1) (Instructional Material)

Concepts: Controlling Concurrent Access. Managing Data Quality. Create User accounts and Monitor Data Security. Recovery and Startup Procedures. Backing up Databases. Maintaining Data dictionaries and Repositories. DataBase Operation and Maintenance

Scheduling and Creating Alerts

Part B : DataBase and Application Tuning – Advanced Level (Level 1) (Instructional Material)

Concepts: Monitor Resources and Tune the DataBase for Performance. Data Partitioning and Clustering. Denormalizing tables

Query tracing and Optimizing

Part C : General Administration – Advanced Level (Level 1) (Instructional Material)

Concepts: Changing Roles of Data and DataBase Administrators. Installing , Configuring , Maintaining and Upgrading The DBMS

Planning for DataBases. Coordinate with DBMS vendors and plan for changes. Maintain DBMS Documentation and Information for developers. Troubleshooting

Practice: Reducing Wait situations and Reusing SQL statements. Installing and Configuring the DBMS. Creating the Application Environment

Startup and Shutdown the DB with various options. Handling Errors, exceptions and Troubleshooting. Creating Tablespaces, DB Objects ,Users ,Roles, Logs, RollBack segments . Maintaining and Querying metadata. Creating Materialized views. Using DBA tools

Performing Backup and Recovery procedures

Skills: Using DBA Tools and wizards