Chapter – 4

Discussions and Findings
CHAPTER- 4

DISCUSSIONS AND FINDINGS

This chapter demonstrates the knowledge management framework proposed in above chapter 3 in the context of IT education. It also includes another framework to implement a knowledge management system for curriculum development which details the technical aspects. This chapter addresses the techniques suitable for acquiring and representing knowledge required for curriculum development. It also details what data, information and knowledge will be required for the Knowledge Management System for Curriculum Development. This chapter concludes with conclusions including theoretical contributions, practical implications and recommendations for future research.

4.1 DEMONSTRATION OF THE PROPOSED FRAMEWORK

This section will demonstrate the proposed framework in context of IT education. It illustrates the nature of knowledge repositories as well as demonstrates sample outcomes resulting from manual implementation of the framework of each phase.

The nature of knowledge repositories (shown in abstract view of the framework in fig. 3.2) is demonstrated below trough sections 4.1.1 to section 4.1.11:

4.1.1 Modularized Subject Material

Subject matter will be stored in repositories categorized domain-wise, subject-wise and topic-wise in the form of modules for small sub-topics within the topics. For example, for the subject ‘Fundamentals of Computers’, under topics like Processor, Memory, Peripheral devices, Operating systems, Networking etc., each will have subtopics as modules. For example, ‘Networking’ topic will have modules like Communication fundamentals, Types of networks, Topologies, OSI model, Protocols, Networking devices etc. The subtopic ‘Communication Fundamentals’ will further
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have subtopics as Definitions, Communication System - Components, Communication Modes – Simplex, Half Duplex, Full Duplex, Transmission speed - concept of bandwidth and different bands, Communication Media- Twisted pair wire, Coaxial cable, Microwave, Communication satellite, Optical fibers etc. Such modularized subject material will help in considering or selecting small modules while selecting course contents.

4.1.2 References of web resources, books, journals
This will serve as a directory of resources which can be viewed in various ways as required by the user e.g. in alphabetical order, chronological publications / editions, or searched for particular discipline, subject, topic etc.

4.1.3 Curricula and modularized contents
Curricula of various programmes and courses of the same institution (for which the repository is built) and from other institutions like universities from various states and countries, private and autonomous institutions, professional training courses, model curricula from various bodies like ACM, IEEE, UGC, AICTE etc. can be maintained in the repository. This will also help to reach global standards / benchmarking or accommodate local needs as per requirement. These curricula can be captured by scanning or downloading from internet and stored by classifying in required manner and decomposing contents into modules and other components separately.

Curricula can be maintained classified domain-wise, discipline-wise, subject-wise etc. The usual way of classifying the domains Information Technology and Computer Science was studied through system followed by various departments of education or Computer Science (Stephen Petrina, 2007) and is illustrated as follows (Fig. 4.1):
Fig. 4.1: Classification of the domain of IT and Computer Science
(Source: Stephen Petrina, 2007)

4.1.4 Concept Maps
A concept map is shown in section 4.3. Concept maps will be useful in deciding depth and width of the contents of curriculum.

4.1.5 Teaching, Learning Methodologies
The teaching learning methodologies suggested by academicians, researchers and captured from teachers through their experience can be stored in the repository along with their purpose or context in which they are suitable. These can be used as reference to suggest methodologies to be included in the curriculum as well as for teachers to prepare for implementation of the curriculum.
As an illustration, following is a list of some of the teaching methods suggested by the Center for Teaching and Learning (web: The University of North Carolina USA, 2014) which are grouped in different categories depending on requirement/application by this researcher. All the methods are listed in Appendix ‘C’. Some of these methods may be applicable for particular disciplines. Thus they can be chosen depending on purpose or applicability and discipline.

**Group 1:** For concepts that need to be taught can be delivered through following activities: Lecture, Class discussion, Oral questions, Lecture-demonstration.

**Group 2:** For concepts that should be learned by students through different activities/experiences: Discussion groups among students, Presentation by students, Student reports by individuals or in groups, 4. Group Discussions, Debates by students, Forums, Bulletin Boards.

**Group 3:** For concepts to be emphasized through written assignments (e.g. description or application of concepts): Textbook assignments, Writing journals, monographs, etc., Assignments to encourage reading of supplementary books, Term papers.

**Group 4:** For extra inputs: Guest lectures, Panel discussions, Seminars / Workshops, Conferences, Industrial Visits.

**Group 5:** For learning through practical experience: Experiments by students, Field Work, Internship, Project (Individual or Group).

**Group 6:** For learning through research: Reports on published research studies, Library research on topics or problems, Problem solving or Case Studies, Surveys and their analysis.

**Group 7:** For learning through other activities: Construction of summaries by students, Student construction of diagrams, charts, or graphs, Crossword puzzles, Construction of vocabulary lists, Models, Gaming and simulation, Drama, role playing, Interviews
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A bank of teaching styles with their applicability and effectiveness can be maintained in the repository which can be helpful for teachers’ preparation. Experiences of teachers with such methods can be added to as and when they are captured. This will help new teachers.

The George Washington University has listed some teaching techniques on its website (web: classroom assessment techniques, 2014). These techniques, can be useful to judge the effectiveness of the classroom sessions and accordingly methods can be chosen. As an illustration, two techniques named as ‘chain notes’ and ‘one-sentence summary’ are described below and all are included in Appendix ‘D’.

1) Chain Notes: One question is written by the teacher and enclosed in an envelope. Students circulate this envelope among them in the class. When a student receives the envelope, he/she places a response to the question in the envelope and then passes to the next student. The teacher goes through the student responses. In order to detect the response patterns, teacher determines criteria for categorizing. Patterns of responses are discussed with the students, which leads to better teaching and learning. In this technique, time required for preparation, conducting as well as analysis is small.

2) One-sentence summary: This technique is useful when teacher wants to know whether students can select or summarize only the important features of an idea. Students are asked to summarize knowledge of a topic or concept through a single sentence. This may have the nature as "answering questions like who does what to whom, when, where, how, and why". The teacher evaluates quality of these summaries. This helps the teacher to know whether students have understood the topic to extract essential concepts and their interrelationships. Then teacher shares his/her observations with the students. In this technique, time required for preparation is small but in class and analysis is medium.

Learning Styles / Methodologies :
Depending on the type / level of students and type of course contents, recommending proper learning styles will help student achieve learning outcomes effectively. As an
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illustration, following is a brief description of certain learning styles (Stephen Petriana, 2007) which can be added in the repository:

1) **Cooperative learning** is a methodology which is helpful to develop comfort and confidence in those students who may be reluctant to present their ideas in a large group. Dyads (two), triads (three) or small group discussions enable students to cooperate in activities and projects.

Guidelines for Cooperative Learning:

- Divide the students into subgroups of four to six. Make sure the students are seated next to each other to facilitate interaction.
- Clearly state the problem or issue that they are supposed to address. Write it on the board, provide handouts, refer to website or use an overhead projector to ensure that the students understand what is to be addressed.
- Let the group members select a member for tracking the progress of the group.
- Discuss approaches to the issue and raise questions.
- Let participants handle the issue for given time period. Teacher can assist groups as necessary.
- It is useful for group assessment on a particular project or design, to evaluate the group effectiveness.

2) **Debriefing** is a used to provide a means to transfer knowledge or emotions resulting from an experience. Its effectiveness depends on skills of the facilitator to interpret the experience. For some experiences, it may become easy by asking students’ reactions about an event or experience. For some experiences it may require a formal approach following a framework.

4.1.6 **Assessment Methodologies**

Maintenance of patterns of assessment in the repository will help to select assessment methodologies to be included in the curriculum to measure the learning outcomes.
Matching Learning Outcomes to Assessment Types -
University College, Dublin, has listed on its website, assessment types linked with nature of learning outcomes as follows. As a sample, three examples are given below and all are included in Appendix ‘E’.

i) If the intended learning outcomes are “To think critically and make judgment”, the students are expected to develop arguments, judgment, evaluation or reflection. Some examples of assessment methods in this case are essay, report and book review.

ii) If the expected learning outcomes are “Performing procedures and demonstrating techniques”, students may be required to use equipment and take readings, follow laboratory procedures, protocols and instructions. Assessment methodologies applicable in this case are demonstration, lab report, making a video, script or poster.

iii) If the learning outcome “Communicating” is to be assessed, students should have written, oral, visual and technical skills. Appropriate assessment methods in this case are presentations, discussions, role plays, debates and group work.

(Adapted from Nightingale et al., 1996)

Guidelines for choosing the teaching / learning / assessment methodologies can also be stored in the repository. For example, for choosing the most appropriate assessment type, questions given in Appendix ‘F’ can help to choose the most appropriate methods. (These are adapted from a section in “500 Tips on Assessment” given by Sally Brown et al, 1996). Some questions may be applicable to certain disciplines only.

4.1.7 Question Banks

Nature of some courses may be such that the curriculum should include some list of experiments or practical experiences which a student should go through as a part of learning that topic. Maintaining a bank of such assignments in the repository will make the system suggest assignments depending on the topic in the curriculum. Other assignments can be based on theory, surveys, research problems, projects etc. The ready reference of such assignments will also help teachers to select questions to carry
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out measurement of learning outcomes while implementing the curriculum. Question banks can be classified domain/discipline wise, subject-wise and topic/subtopic wise, so that they can be searched and retrieved as per requirement of assignments on the topic.

Following is the illustration of a question bank, for ‘C programming’ experiments

**Laboratory Experiments in ‘C Programming’ grouped topic-wise:**

I. Use of simple Loops and arithmetic operations in C
   1) Program to display whether inputted number is Armstrong number or not.
   2) Program to display all numbers divisible by 7 between 1 and 100.
   3) Program to input any number and display digits which are absent in given number.
   4) Program to input any five digit number and display its last and first digit.

II. Use of nested loops in C
   5) Program to display all prime numbers between 1 and 500.
   6) Program to display sum of digits of a given numbers upto a single digit.
   7) Program to convert rupees into thousands, hundreds and rupees.
   8) Display following pyramid
      (i) 1 1 1 1 1 1
           2 2 2 2 2
           3 3 3 3
           4 4 4
           5 5
           6
      (ii) 1
           2 1 2
           3 2 1 2 3
           4 3 2 1 2 3 4
           5 5
           6
   9) Program to calculate LCM and GCD of two numbers.
   10) Program to calculate prime factors of a given number.
   11) Program to input any decimal number and convert it into various bases.
   12) Program to check whether inputted number is a palindrome.
   13) Program to calculate 1/1!+2/2!+…….+n/n!
   14) Read a line of characters from the user and count no of lines, words, spaces, tabs and characters in it.
15) Determine whether a number \( n \), accepted from user is the sum of all of its divisors. (\( n \) is sum of all \( x \) where \( 1 \leq x < n \), and \( x \) divides \( n \).

16) Program to calculate \( ^nC_m \).

### III. Use of recursion in C

17) Program to display GCD using recursion.
18) Program to calculate Fibonacci series using recursion.
19) Program to calculate \( n! \) using recursion.
20) If \( a \) is an array of \( n \) elements then write recursive function to display powerset of \( a \).

### IV. Use of arrays and sorting techniques

21) Program to display all array elements in ascending order using selection sort.
22) Program to display all array elements in descending order using bubble sort.
23) Program to calculate largest and second largest from a set of \( n \) numbers.
24) Program to perform various operations on matrix (addition, subtraction, multiplication, norm of matrix, saddle point, magic square, inverse, transpose)
25) Program to display students list in ascending order.

### V. Use of strings, files and structures

26) Program to perform various string operations (find length, checking palindrome, copy one into another, comparing strings, find substring using user defined functions)
27) Display marksheet of student using structure.
28) Program to display bazaar bill of any customer.
29) Program to copy contents of one file into another.
30) Program to display contents of a file in uppercase letters.
4.1.8 Documents, reports, files and databases

Following are the examples of each which can be represented in the knowledge repository.

Documents:

As suggested by one of the experts during interviews, there should be a ‘Theme Paper’ existing in the knowledge repository for each course. This paper will help as guidelines for framing the curriculum of that course. It will contain expectations from the course, purpose, relationship or relevance with other courses, real life applications, benchmarking standards etc. These ‘theme papers’ can be stored in the repositories and should be referred before writing the curriculum of that course. Documents depicting best practices can also be stored in the repository.

Another Example of document for an institute’s vision, mission and goals (since curriculum should reflect them):

(Source: Student Handbook, IMED, Bharati Vidyapeeth, Pune)

Vision

"Be a global leader in Innovative Management and Information Technology Education"

Mission statement

"Enable advancement of professionalism by adopting latest educational systems for delivery of Management and Information Technology education".

The Goals of the Institute are:

- To impart quality education in the areas of Management and Information technology
- To update teaching learning processes to meet the challenges of change
- To involve industry experts and professionals to impart application oriented knowledge.
- To encourage consultancy, research, and extension activities
- To help the students for advancement in career.
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- To maintain academic excellence by developing talent and skills among students.
- To promote quality consciousness among staff and students.

Example of a Report:
A report on expectations of knowledge/skills by recruiters for various positions in some academic year may consist of following fields:

- Name of the organization, contact details, position, expected qualification and conditions, nature of job, knowledge, skills expected, number of students applied, students selected etc.

Example of a database:
A database of alumni will consist of fields like name, address, email id, contact number, name of the organization, designation, batch and programme passed out.

4.1.9 Expert Profiles and Knowledge Maps
Expert profiles can be thought of as a directory containing the details, skills and expertise of people knowledgeable in various domains. These can be stored by describing the experts’ domain area, specialization, education, work experience, contact information.

A sample profile may take a form as follows:

Current : Professor and Head of the Department, Dept. of Information Technology, University of Pune.
Past : Professor at College of Engineering, Pune, Manager at Wipro, Bangalore
Education : B.E.(Comp.Sc.), University of Pune, Ph.D.
Summary : Experienced in teaching subjects like C, C++, Java, C#. Worked on Board of studies of various institutions like University of Pune, Bharati Vidyapeeth etc.
This will have link to the detailed bio-data of the concerned expert whenever required by the user. Thus it is knowledge about where the knowledge resides (metadata) and can be thought as potential knowledge. Required knowledge or the individual possessing that knowledge can be easily located through categorization of these profiles and organizational knowledge maps. Though knowledge map does not store knowledge, it points to people who own it facilitating knowledge exchange.

4.1.10 Stakeholders feedbacks

Various questionnaires or formats to take feedback about curriculum from various stakeholders can be stored in the repository so that a questionnaire can be selected suitable for course in consideration and the stakeholder. Data collected through such questionnaires, interviews or meetings with stakeholders will be stored with analysis and used for updating curricula.

For example, some potential questions for students feedback can be:

- Which skills have you developed through the course?
- What opportunities were given to develop the skills?
- Which other opportunities would have developed these skills?
- What other skills would have been beneficial for you?
- How can those other skills be developed? (Peter Wolf et al, 2006)

Potential questions for evaluation of programme content can be:

- Do you think that all necessary learning objectives and competencies are included in the curriculum?
- Is the time allocated to each course sufficient, excessive, or inadequate?
- Are there areas of the curriculum (i.e. specific courses or learning objectives) that need to be revised, removed or added to the program? Please specify, providing a rationale where necessary.
- Do you feel that there is a proper balance between theory (i.e. classroom) and practice (i.e. lab/ shop/fieldwork) in the program/course?
- Are the textbooks and other resources listed adequate for program/course delivery?
- Is program content/learning activities consistent with industry practices? (web: Department of Education, Labrador, 2014)
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Some questions may be asked to give ratings to different criteria:

- In understanding theoretical concepts, do you find that your lab work is:
  - extremely useful
  - useful
  - not very useful
  - not at all useful

4.1.11 Cases with lessons learned

Incidences in the history of the institution which may have resulted in updating the contents of the curriculum or changing the way of teaching/learning or assessment of students may be stored in the repository as references to deal with such situations. These can be stored in the form of description of situation, its interpretation or analysis and action taken. These will act as lessons for the future in the sense that if similar situation arises, it is known that which decisions worked or failed. For example, in case of failure of considerable number of students in a course, decision taken was to provide that course as a remedial course for the next semester, evaluating students in some different way and it proved successful. For similar situation in future, the knowledge management system will find a match in the cases in the repository and suggest solution.

Search and retrieval of knowledge within each repository mentioned in Fig. 3.2, will be efficient, if content of the repositories is structured by using appropriate taxonomy. Section 4.4 shows how data, information and knowledge in this context will be stored and classified.

In the next sections 4.1.12 through 4.1.17, frameworks representing each of the six phases in curriculum development process are illustrated. Since these frameworks involve representation of actual knowledge that may be retrieved from the system and possible actions on the retrieved information. The frameworks are illustrated by example under the assumption that the required information is available in the repositories. Based on the retrieval of this information or knowledge, actions such as discussions, analysis, interpretations etc. are simple illustrative representations to show some sample outcomes which may be in practice, in the form of various reports or documents. Thus the illustration is based on some assumptions and cannot show the actual results as when a KM system based on this framework is implemented.
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This illustration demonstrates a curriculum revision exercise for a course on Database Management Systems (DBMS) at the Post Graduate level in Computer Applications. The outcomes of each phase will facilitate the decision making regarding the curriculum like adding, deleting or modifying the contents. The curriculum is given in Appendix G.

4.1.12 Framework for Phase I : Gap Analysis

Referring to framework given in Fig 3.3, similar curricula i.e. curricula of same subject were retrieved from the stored curricula of different institutions. The curriculum was compared with these ten different curricula. The comparison report identified similarities with other curricula by stating frequency of repetition of topics from this curriculum in the other curricula. It also identified topics repeated in other curricula which are not part of given curriculum. Some keywords in the curriculum were searched (with their context) for occurrence in other curricula (This can be done using text mining tool and search engine).

Comparison Report of Curricula

<table>
<thead>
<tr>
<th>Topics existing in given curriculum</th>
<th>Appearing in other matching curricula (10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Database versus file systems</td>
<td>6 (60%)</td>
</tr>
<tr>
<td>Three-tier Architecture</td>
<td>7 (70%)</td>
</tr>
<tr>
<td>Hierarchical and Network models</td>
<td>6 (60%)</td>
</tr>
<tr>
<td>ER Model, Relational model</td>
<td>10 (100%)</td>
</tr>
<tr>
<td>Relational Algebra</td>
<td>5 (50%)</td>
</tr>
<tr>
<td>RDBMS, Codd’s Rules</td>
<td>7 (70%)</td>
</tr>
<tr>
<td>Normalization, Functional dependencies</td>
<td>8 (80%)</td>
</tr>
<tr>
<td>First, Second, Third, Boyce-Codd Normal Forms / (1NF, 2NF, 3NF, BCNF)</td>
<td>8 (80%)</td>
</tr>
<tr>
<td>Transaction, ACID, Serializability, Timestamp</td>
<td>7 (70%)</td>
</tr>
<tr>
<td>Concurrency, Multiple Version Technique, Deadlocks</td>
<td>7 (70%)</td>
</tr>
<tr>
<td>Backup, Recovery, Log based, checkpoints, shadow paging</td>
<td>6 (60%)</td>
</tr>
</tbody>
</table>
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#### Table 3.18: Comparison Report of Curricula

<table>
<thead>
<tr>
<th>Topics existing in given curriculum</th>
<th>Appearing in other matching curricula (10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>File structure/ organization</td>
<td>4 (40%)</td>
</tr>
<tr>
<td>Hashing, B Tree Index file</td>
<td>3 (30%)</td>
</tr>
<tr>
<td>Data Security, masking, encryption, decryption, user privileges</td>
<td>6 (60%)</td>
</tr>
<tr>
<td>Security implementation, Security standards</td>
<td>2 (20%)</td>
</tr>
<tr>
<td>Data Quality- management, principles, audit, improvement</td>
<td>1 (10%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Topics not existing in given curriculum</th>
<th>Appearing in other matching curricula</th>
</tr>
</thead>
<tbody>
<tr>
<td>4NF, 5NF, 6NF</td>
<td>2 (20%)</td>
</tr>
<tr>
<td>Query Processing and Query Optimization</td>
<td>3 (30%)</td>
</tr>
<tr>
<td>SQL Concepts, DDL, DML, DCL</td>
<td>8 (80%)</td>
</tr>
<tr>
<td>Distributed databases</td>
<td>3 (30%)</td>
</tr>
</tbody>
</table>

#### Assessment of Professional Needs

Discussion with Professional Experts suggested by the KM system may result into following remarks about professional needs in this domain: “The concept of distributed data bases, dealing with multimedia databases, XML standards for data representation should be included to serve the professional expectations.”

While gathering current developments in the domain, discussion with subject experts and other references, may lead to the following conclusion: “Open source DBMS, Mobile database suits to serve the demand for access through mobile devices, choosing a cloud data store for big data, should be added as latest trends in DBMS.”

#### List of Content Requirements

From the comparison of the curriculum with other curricula, professional needs and current trends in the domain, the broad content requirements for this subject are listed as follows:
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- Database versus file systems, Three-tier Architecture
- Hierarchical, Network, Relational models, ER Model
- Relational Algebra
- RDBMS, Codd’s Rules
- Normalization, Functional dependencies, First, Second, Third, Boyce-Codd Normal Forms
- Transaction, ACID, Serializability, Timestamp
- Concurrency, Multiple Version Technique, Deadlocks
- Backup, Recovery, Log based, checkpoints, shadow paging
- Data Security, masking, encryption, decryption, user privileges
- Distributed databases, Multimedia databases, Open source DBMS,
- Mobile database for access through mobile devices, Cloud database, Concept of big data and NoSQL

Changes in teaching/ learning/ assessment methods required if any
Since Teaching, Learning and Assessment Methods are not given in the curriculum, discussion with academic experts may lead to the following remark: “Suitable teaching, learning methods taking into account trends in teaching database concepts should be added in the curriculum. Assessment methods be provided to bring clarity to students as well as teachers about how the students will be assessed.”

Report on interpretation of feedbacks
Feedback of the past recruiters implies there should be emphasis on giving hands on practical experience to students, with real world exercises. Real life organizational case studies to design database structures are recommended. Feedback of past students states that they had difficulties in understanding ‘Relational Algebra’ because of lack of mathematical background. Hence the teaching approach for this unit should introduce related mathematical concepts first.

The above outcomes of the Phase-I, Gap Analysis will help the curriculum developers to take a decision on whether to revise the existing curriculum or introduce new curriculum. Based on these outcomes it may be decided to modify the curriculum.
With this decision, illustration of the next phase, Phase II- Planning of Resources may take the following form:

**4.1.13 Framework for Phase II : Planning of Resources**

An illustration of committees for curriculum development and their responsibilities would be as follows:

**Formation of Teams / Committees**

(The experts’ profiles available in the repositories may help to select the members suitable for the particular tasks in the committees)

Academic Advisory Team ..... List of members
This includes individuals and faculty with knowledge and expertise in the specific field. It will include expertise in learning technologies, curriculum development, teaching/learning, and assessment/evaluation.

Subject Experts ..... List of members
Teachers teaching the concerned subject/course, researchers in that area, academicians qualified or experienced in that domain can be included.

Professional Representatives ..... List of members
Experts outside the institution like other academicians, consultants, persons from industry may be included.

Writing Team ..... List of members
Members can be selected considering the domain area/ subject expertise, curriculum development expertise and teaching or professional experience. They should have highly developed written and verbal communication skills.

Evaluation Team ..... List of members
The members should be Curriculum Content Specialists having experience and expertise as teacher or trainer in college or university, business or industry training program, or other institution. They should be experienced in the measurement of student progress and outcomes.
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Allocation of responsibilities
Academic Advisory Team: The role of Academic Advisory Team is to meet on a regular basis to provide curriculum and subject matter expertise to ensure continuous development and improvement of the program. The Committee is responsible to ensure that curriculum meets the expectations of stakeholders. It should see that the curriculum is comprehensive and fulfils the mission, goals and objectives of the institution and programme. This committee shall develop policies and procedures for developing and evaluating the curriculum.

Professional Representatives: Their role is to assess need of various topics in the curriculum by identifying topic area and its associated application and practice in the workplace. They should ensure essential Employability Skill Outcomes in the curriculum.

Subject Experts Team: The team can be headed by a senior person who will allocate responsibilities of various topics in the curriculum to the concerned experts.

Curriculum Writing team: It should review the course content, identify comparable courses, and authorize courses for transferring to students. Writing of the curriculum should be in accordance with the guidelines or parameters established. The writing team should be supported by a panel of experts or advisory group associated with the subject to provide advice on draft materials at key stages in the development process.

Evaluation Team: Program curriculum of existing programs will be reviewed annually to ensure it remains operationally meaningful, relevant, and to ensure its use in the day-to-day teaching and learning of program by faculty and students is meeting the occupational requirements of the program graduates. The team will ensure compliance with standards related to curriculum.

List of resources available and required
The resources like web references, books, journals and other documents related to the course under consideration (DBMS) are listed by the members of committees formed as above. It is checked for the resources available and then recommendations for
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required resources like journals to be subscribed or books to be purchased etc. are listed.

Resources available

Books:

1) Database Systems Concepts- Korth, Tata McGra Hill
2) Introduction to Database Management- C.G Date
3) Database Management System- Alexix Leon, Leon Press
4) Fundamentals of Database System- R. Elmasri, S. Nawathe, Pearson Education
5) Database Management Systems- Raghu Ramkrishnan

Journals:

1) International Journal of Database Management Systems
2) Journal of Database Management
3) Computer Science and Information Systems
4) Australasian Journal of Information Systems
5) Journal of Advances in Information Technology
6) Journal of Research and Practice in Information Technology
7) Journal of Information Systems and Technology Management

Web Resources

- Web Resource : www.tutorialspoint.com/dbms

  Contents:
  ✓ DBMS Overview, Architecture, Data Models, Schemas, Data independence
  ✓ Entity Relationship Model: Basic Concepts, ER Diagrams, Generalization, Aggregation
  ✓ Relational Model: Basic Concepts, Codd's Rules, Relational Algebra, convert ER to Relational Model, Normalization
  ✓ Storage and File Structure: File Structure, Storage, Indexing, Hashing
  ✓ Transaction, Concurrency, Backup and Recovery: Transaction, Concurrency Control, Deadlock, Data Backup, Data Recovery
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- Web Resource: http://www.studytonight.com/dbms
  Study material available here can be collected and stored for further use since it contains concepts as well as tests on various topics. It has also a facility to ask questions and to discuss with other users and authors.

  Contents:
  ✓ Overview of DBMS
  ✓ Database Architecture
  ✓ Database Models
  ✓ RDBMS Concept
  ✓ Codd's rules
  ✓ Database keys
  ✓ Normalization
  ✓ ER-Diagrams
  ✓ Generalization and Specialization

  Contents:
  ✓ DBMS: Introduction, Advantages
  ✓ Data Models: E-R Model, E-R Diagram, OOriented Model, Relational Model, Network Model, Hierarchical Model
  ✓ DBMS: Languages, Codd's 12 Rules for RDBMS, DBA
  ✓ DBMS Types
  ✓ Normalization

Resources required

Books:
1) An Introduction to Database Systems - Bipin Desai
2) Principles of Database Systems - J.D. Ullman

Journals:
1) International Journal of Intelligent Information and Database Systems
2) Journal of Advanced Database Management and Systems
3) Information Retrieval Journal
4) Knowledge and Information Systems
Web Resources

1) Serebra Learning Corporation (http://www.training-classes.com/programs/01/73) –
   This web resource provides training through a combination learning management system (LMS) and a curriculum catalog for various courses. This online training will be useful for faculty as well as teachers. The following modules need to be acquired from http://www.training-classes.com/programs/01/73/:

   Modules from Oracle 10g Training from Serebra Learning Corporation useful for this course:
   • Managing Storage and System Resources in Oracle 10g
   • Oracle Database 10g Managing Backup and Recovery Release 2
   • Oracle Database 10g Miscellaneous New Features

2) http://www.databasejournal.com:
   This site contains Database Management & Programming News, Articles & Tutorials for Database Administrators.

3) http://www.dbta.com:
   The site gives information about the quarterly magazine “Database Trends and Applications” and information about its subscription. This is a magazine related to the domain of data and information management, data science and big data. Subscription of this magazine will help to know recent trends in databases. In addition, this website provides its users white papers, arranges webinars and other learning opportunities in the domain.

4) http://adbc.kennesaw.edu:
   This is a site containing animated database courseware, follows interactive approach for teaching the database concepts. It is an interactive tutoring from Kennesaw State University for database design and SQL exercises. This site needs Flash Plug-in and Java Virtual Machine for the modules in it.
4.1.14 Framework for Phase III : Establishing Goals and Objectives

Formulation of goals of the programme (if applicable)
In the illustration taken, since a course curriculum is being prepared and not a programme curriculum, this is not applicable.

Objectives and learning outcomes of the course
By studying objectives and learning outcomes of similar curricula of other programmes/ institutions and local needs, objectives were formulated as follows:

Objectives common in most of the curricula:
The course aims to impart knowledge of the concepts related to Database models, E-R modeling, SQL to create, update, modify and query a database. To familiarize students with various integrity constraints, Normalization, Data recovery, data security.

Objectives included in few curricula:
Understand Relational Algebra, Oracle Architecture, Data Security Standards and methods, concurrent use of database, Introduce concepts of Object Oriented DBMS, Distributed databases, Physical database design and performance tuning.

Learning outcomes common in some curricula (In some curricula, learning outcomes are not included) :
At the end of this course, student should be able to understand concepts of Database Management, data models, write PL/SQL queries with oracle, choose appropriate data types and design the database schema for storage of data in database, practical experience with real world exercises, backup data from database.

For the course under consideration, objectives and learning outcomes were framed as follows:

Objectives :

1) To provide a sound introduction to the discipline of database management.
2) To train students in data modeling and design of database.
3) To understand operations on databases and management of database.
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4) The course also aims to impart knowledge about database transactions, concurrency control, data security and latest trends in database technologies.

Learning outcomes:
At the end of the course, student should be able to

1) Describe and appreciate the need of database management, Understand the concepts of database technologies and effectively explain users and designers of databases with their roles.

2) Know various database models, suggest model as per requirements of a database, effectively design ER model, relational database following normalization with exposure to real world exercises, design the database schema by choosing suitable data types for efficient storage.

3) Apply relational algebra to explain various database operations.

4) Illustrate database transactions and concurrent operations.

5) Design effective strategies for managing backup and recovery, data security and privacy, fraud detection and audit control. Implement data security, backup and recovery of a database.

6) Develop insights into future data management tools and techniques. Have conceptual knowledge of new developments and trends in databases.

Establishment of feasibility of achieving and measuring learning outcomes
The learning outcomes listed above can be achieved and measured in following ways:

- Classroom lectures accompanied with ICT tools to deliver theoretical knowledge.
- Written exams with descriptive pattern to test knowledge of database concepts, data models, relational algebra etc., Objective type exams to test the fundamentals.
- Presentations and group discussions on recent trends in database technologies.
- Practical demonstration and implementation of various database utilities like backup and recovery.
- Exposure to real world exercises can be achieved through small real life project exercises which will cover ER Modeling, normalization, relational database design, integrity constraints specifications etc. These exercises can be
acquired through web resources, journals, books, question bank maintained in the KM system etc.

Thus it is found that the learning outcomes are feasible to achieve and measure.

**Description of prerequisites if any**

By studying pre-requisites of similar courses and objectives, the pre-requisites are formulated as follows:

- Knowledge of Fundamentals of Computers, Knowledge of any programming language.

**4.1.15 Framework for Phase IV: Selection and Organization of Contents**

Considering the objectives in previous phase and referring to subject material, broad topics to cover each objective were listed. Comparing with the topics in other similar curricula, though it was found that topics like SQL, PL/SQL are covered in many curricula, the programme structure for this programme contains two courses on DBMS where one is intended to introduce DBMS theory while the other to cover Oracle as its implementation and hence will cover SQL and PL/SQL. Hence in this theoretical course on DBMS, SQL and PL/SQL are not introduced.

**Listing of Major Topics**

Major topics found in most of the curricula and selected:

- Database System Concepts, Data Models, ER Model, Relational Model, Normalization, Relational Algebra, Transactions, Concurrency control, backup and recovery techniques, security and privacy of data, database administration.
- Major topics essential considering latest trends and experts’ recommendations:
  - Distributed, Multimedia and Mobile databases, Open source DBMS, Cloud database, Concept of big data and NoSQL.
- Considering the listing of major topics above and local needs, major topics were finalized as follows:
  - Database System Concepts, Data Models, ER Model, Relational Model, Normalization, Relational Algebra, Transactions, Concurrency control, backup and recovery techniques, security and privacy of data, database administration,
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Concepts of - distributed and Multimedia databases, Open source DBMS, Cloud database, big data and NoSQL.

Listing of subtopics belonging to each major topic and time allocation

Database System Concepts (3L):
Database approach, characteristics, advantages over file processing systems and disadvantages of DBMS, DBMS users, actors, administrators, designers etc., database architecture- levels of abstraction, schema and instance.

Data Models (10 L):
- Hierarchical Model, Network Model, Relational Model and their comparisons.
- ER Model- Concept of entity, attributes, relationship, degree and cardinality of relationship. Extended ER model- Strong and weak entities, superclass and subclass entity types, aggregation, specialization, generalization.
- Relational Model- Concept of domain, tuple, relationship, keys. Converting ER diagrams into tables (database design), integrity constraints.
- Practical exposure to ER modeling and relational model through project and assignments.

Normalization (3L):
Functional dependencies, Normal Forms (1NF, 2NF, 3NF, BCNF) with examples and case studies, Decomposition.

Unit 3: Relational Algebra and RDBMS(7L):
Keys (composite, candidate, primary, secondary) Foreign, Integrity Rules, Relational Set Operators- Union, Intersect, Difference, Product, Select, Project, ,Divide, Assignment. Set Operators Join, Outer Join, Inner Join, with example, Relationship within the Relational Database (1:M,1:1,M:N) with example. Problems and Reduction of M:N with example. Concept of RDBMS, Codd’s Rules, Examples of RDBMS that implements some Codd’s rules.
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Unit 4: Transactions, Concurrency Control and recovery techniques – (9L)

Unit 5: Data security and its management (7L):
Basic data security principles – user privileges, data masking, encryption and decryption. Data Security Implementation, ITCS304 (security standard) revalidation of user, role, privileges. Data administration, Role and responsibility of DBA, creating / deleting / updating table space, database monitoring, user management, Lab exercises.

Unit 6: Recent Trends in Database Management (6L):
Introduction to distributed databases, multimedia databases, Open source DBMS, cloud database, Concept of big data and NoSQL

Once the draft syllabus is uploaded in the system, it will give alerts for the overlapping topics if any, in different courses of the same programme. It was observed that in the programme structure that the course ‘Object Oriented Analysis and Design’ at semester II, includes ‘object oriented database model’. Hence this model was removed from the existing contents to avoid repetition of the topic in two courses.

Description of Teaching/Learning and assessment methodologies
This curriculum will be implemented with 3 lectures and 2 tutorial sessions of one hour duration each, per week. Tutorials will include lab sessions, presentations, projects and practical assignments. By means of interactive lectures, fundamentals, theoretical portion will be covered. In tutorials, computer lab sessions will be used to demonstrate and assess topics related to database administration- commands for creating / deleting / updating table space, database monitoring, user privileges and management, using backup and recovery techniques etc. Students will be assessed through demonstrations or group presentations by them on projects and practical/ real
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world exercises solved by them for data modeling, database design, normalization, decomposition etc. Guest lectures from practicing professionals will give inputs to the students on recent trends and practices in database management. Students can be assessed on the basis of Term Papers written by them for the recent developments in databases.

The students will be assessed through continuous evaluation system throughout the semester. This will include class tests, quizzes, case studies, assignments, practical exercises, project and computer lab tests. Assessment through exams will include written exams at mid-term, end-term, university level final exam.

List of Resources and reference material

Books are selected by finding reference material listed in majority of the curricula and by confirming coverage of topics from curriculum in the book.

Books:
4) Oracle – The complete reference – TMH /oracle press
5) Lee Chao, Cloud Database Development and Management, CRC Press

Journals and Magazines:
2) Magazine (Quarterly)- Database Trends and Applications, publisher DBTA, Unisphere Media

Web Resources:
1) http://www.studytonight.com/dbms
Other resources:

1) Computer lab facility with networking and a client server based DBMS Software (Oracle),
2) ICT facilities with a means of demonstration like LCD projector.

Draft Curriculum

1) The draft curriculum is ready as above i.e. combination of:
2) Objectives and learning outcomes of the course, pre-requisites,
3) Listing of subtopics belonging to each major topic and time allocation,
4) Description of Teaching/Learning and assessment methodologies,
5) List of Resources and reference material (All listed above)

(This draft curriculum should be sent to various experts for review and then finalized)

4.1.16 Framework for Phase V : Preparing for Implementation

Study material or teaching material to deliver the curriculum is prepared by retrieving material from the resources listed in the system pertaining to the contents of the curriculum. This phase also involves preparation of measuring the learning outcomes. For this purpose, lists of assignments, case studies, practical assignments, projects etc. are prepared by selecting from the related question banks stored in the system.

Following is an illustration:

List of assignments for the topic “Database Systems Concepts”

1) Describe the disadvantages of Traditional File Processing Systems.
2) Explain Database Approach and its advantages
3) State the role of following people involved in Database development team – Systems analyst, database analyst, programmer, database and data administrator, other users of DBMS.
4) Explain three-layer architecture for database development (conceptual, external, internal)
5) Explain the following concepts with examples
   a) Data
   b) Information
c) Database

d) Database Management System (DBMS)

e) Metadata

f) Redundancy

g) Consistency / Integrity of data

h) Constraints

i) Data Independence (Logical & Physical)

j) Schema and Instances

4.1.17 Framework for Phase VI: Evaluation and Feedback

Analysed Feedbacks from Stakeholders

Feedback from stakeholders like students, teachers, professional experts, academic experts, subject experts should be analysed. A sample feedback analysis of students’ level of satisfaction in each unit of the curriculum, with reference to the aspects like adequacy, usefulness, relevance with practice, ease in understanding, may appear as given below (Fig. 4.2):

![Graph showing feedback analysis](image)

**Fig. 4.2: Example of Analysed Feedback on Curriculum**

The feedback in the form of five point scale for each unit of syllabus on the four criteria is converted into average of all students for that criteria of the unit during analysis. The graphical representation can reveal that though Unit 3 is adequate in its
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contents, it is not that much useful, relevant or easy to understand for the students. It can also be interpreted as Unit 6 is not adequate enough in contents as it has score of 62% in terms of adequacy. Rest of the criteria have average score of about 80 to 90% for every unit which can be interpreted as students are satisfied in those respects.

Similarly feedbacks from professionals, alumni, academicians can be procured and analysed. Suggestions given by the stakeholders can be summarized for the ease of interpretation.

Suggestions for Improvement
In the evaluation of previous existing curriculum, some stakeholders have given following suggestions:

- Student should be assessed with more weightage to practical based evaluation like computer lab work, practical exercises for data modeling etc., project and presentations.
- Curriculum should include latest trends in database technologies.
- Curriculum should emphasize on solution to practical problems and providing hands on with respect to database operations.

Lessons Learned
A lesson learned searched on the category ‘Assessment methodologies’ and subcategory ‘project’ may reveal (based in the experience quoted therein) that it is difficult to assess students in group projects and became easier when role and contribution of each individual in the project is defined in the earlier stage of the project.

4.2 REALIZATION OF THE FRAMEWORK AS AN IT APPLICATION

In order to build a knowledge management system for curriculum development using the above frameworks (introduced in section 3.2), some implementation specific guidelines are given below along with a framework. This framework is the modified
version of the first framework used for pilot study. (The framework and questionnaire used for pilot study is given in Appendix B)

Organising the knowledge will involve various operations like indexing, linking, adding context, associating keywords, synonyms, metadata etc. so that it becomes convenient for retrieval.

Knowledge dissemination will be achieved through the portals for different users, using the networking technologies or intranet of the organization.

**Fig. 4.3: Realization of the framework as an IT application**

**Components of the framework**
The CDKMS components (Fig. 4.3) should have the features as mentioned below

**CDKMS Portal**
The KM portal will provide different interfaces to various users of the CDKMS which will allow browsing and searching the required knowledge from the repositories. The interfaces will hide the internal complications and details from the user and make the retrieval easy for the user.
The CDKMS will have several users like curriculum developers, knowledge developers, faculty, students, experts who will be provided individual interfaces suitable to their tasks and rights to access the knowledge.

The CDKMS portal will also be responsible for generating alerts and messages related to new arrivals in the repositories concerned with users belonging to the concerned area, e.g. new faculty development opportunity, conferences, newly added research papers, books, references, notices to students, faculty etc. The portal will act as gateway for dissemination of knowledge for use using the underlying networking technologies, groupware and collaboration tools.

**Interfaces for Different Users :**

Requirements of various users of the system will be different. Hence they will have user rights for accessing their required information only and the interface accordingly. The knowledge will get distributed and utilized through the interfaces designed for various users.

**Interface for Curriculum Developers**

This interface should have support and menu for the following functionalities:

**Design new Curriculum:**

This option should provide support for adding new curriculum or modifying existing curriculum. In case of modifying, it should retrieve the requested curriculum, in case of new addition it should provide a template based on the components of the curriculum like objectives, Contents, Teaching Learning Methodologies, Resources, Learning Outcomes, Ways of evaluating learning outcomes. Then in both cases it should extract and recommend material with the concerned area from other curricula, documents available with the concerned subject etc (e.g. topics occurring frequently in concerned curricula, topics appearing in combination etc). It should also guide about steps to take like experts to be contacted, references of the concerned websites, books, journals etc. guidelines to be considered, by referring to the knowledge maps in the system. The Draft of the curriculum being designed should be sharable among the group of people who are developing that curriculum so that inputs received are
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reviewed. The system should also give alert if any topic is also included in some other course of the same programme, so that repetition of topics can be avoided.

A template presented to the curriculum developer by the system, for new course may take the following form (The questions given will guide for deciding contents):

**Curriculum Development Proforma**

Programme: ________, Year/Semester/Trimester/Module: ________ Level: UG/PG

Course Title: ………

Pre-requisites or Co-requisites if any: …………

- What background students must have?
- Which concepts/portion/course/module they must have undergone before this course/module or in parallel?

Goals and Objectives of the course: …………..

- What is the purpose of this course?
- After completion of the course, what the student will learn or what they will know or able to do? (brief)

Contents: ………

- In order to achieve the objectives, what subject matter (theoretical concepts, applications, ideas, interpretations etc.) should be included?
- What skills and competencies in the discipline need to be developed into the students by the end of each topic?
- What will be the appropriate proportion of breadth and depth of topics, knowledge and skills to be developed, processes and values to be inculcated for proper balance of these in the contents. To what extent the students of the given level can learn in the time available?
Teaching/Learning Methodologies: ………..

- How can different units of the content to be presented to the learners in effective manner?
- Identify delivery methods, learning styles, application of various media best suitable.

Learning Resources: ……..

- List the support materials and other resources that will be required. Books, journals, web resources, equipments, hardware and software required if any etc.

Learning Outcomes: ……..

- What will the learners be able to do on completion of the course? (Lists of conceptual and practical abilities)

Ways of evaluating learning outcomes (Assessment methods): ………..

- What are the ways of ensuring and measuring that learning outcomes have been achieved?
- What will be the methods and at what stages?
- Include lists of experiments or practical/field work if any to be done by the students.

Other Curricula: This should support navigation and retrieval from curricula of other institutions, present curricula and in the past, classified and indexed on different criteria like level-wise (UG/PG etc), discipline-wise, in chronological order etc. so that retrieval as per user requirement is efficient.

Subject Material: Subject-wise material updated frequently with additions in research, technological advancements, professional trends and accessible in small pieces as per required context, supported by concept maps, will be very helpful in selecting topics for the contents of curriculum. Searching on keywords, synonyms, context will lead to efficient retrieval.
Modularised Curricula: If present and past curricula of the institution are maintained in hierarchical manner to represent broad topics divided into smaller topics at lower levels, even the smallest piece of content can be added, removed, modified, retrieved and used to combine with other topics at any level of hierarchy to design other curricula and interdisciplinary curricula.

Profiles of Experts: This option should guide the curriculum developer about whom to approach for seeking advice or expertise during the curriculum design. It should provide way to contact academic experts, professional experts, subject experts and provide information about their domains, experience, contact details etc. Corporate relationships, guest speakers will be useful in finding current trends and professional requirements in related field. Knowledge maps in the repositories will help in finding experts and expertise.

Guidelines by bodies: Various governing bodies like universities, accrediting bodies, academic bodies, government, management may have provided guidelines, rules and regulations or constraints about curriculum. For example, a constraint like making inclusion of certain course or module mandatory or providing model curricula, guidelines about student evaluations etc. must be brought into notice of the curriculum developer depending on context.

References: Index of reference material or sources available outside the system in the form of websites, books, journals, white papers etc. will help in accessing this material. The portal should provide corresponding links and access to internet to seek web information.

Stakeholders Feedbacks: Analysis of feedbacks about curricula from different stakeholders like students, alumni, faculty, employers, professionals, experts should be facilitated.

Similarly interfaces for other users i.e. faculty, students and experts will have functionalities suitable to their needs, as stated in the framework.
Knowledge Repositories:
According to Wikipedia, “A knowledge repository is a computerized system that systematically captures, organizes and categorizes an organization's knowledge. The repository can be searched and data can be quickly retrieved. The nature of the repository only changes to contain / manage the type of knowledge it holds. A repository (as opposed to an archive) is designed to get knowledge out. It should therefore have some rules of structure, classification, taxonomy, record management etc. to facilitate user engagement”.

The Curriculum Development Knowledge Management System (CDKMS) will have repositories for experts’ profiles, curricula, rules and guidelines by various bodies, modularized contents and subject material, references, feedbacks, teaching methodologies, evaluation techniques, assignments, question banks, project banks etc. The CDKMS repository, along with other knowledge structures, will have topic maps as a means to store the contents of various subjects in hierarchical manner to represent broad concepts further divided into smaller categories at lower levels. Due to this, even the smallest piece of content can be retrieved and used to combine with other topics at any level of hierarchy to design the curriculum content with lot of flexibility.

Administrators: They are the technical persons who will use authoring tool to update the repositories, modify their structures, add new data structures etc.

Archive: The repositories need to be updated time to time so that they serve the latest knowledge. Knowledge repositories must be managed since they grow. This management involves deleting obsolete content, archiving less active but potentially useful context and reorganizing the remaining.

Query Generator: It will build the search query as per the requirement of search given by the user and pass it to the search engine.

Search Engine: Search engine will retrieve the information as the result of the query and pass it back to the query generator which will give the result in proper format to the user.
Tools:
Various IT tools will be used in the KM system. “A KM system is a kind of IT system that stores and retrieves knowledge, improves collaboration, locates knowledge sources, mines repositories for hidden knowledge, captures and uses knowledge or enhances the KM process” (web: Knowledge Management Tools, 2016). Hence it may use IT tools for document management or content management, collaboration tools, searching tools, knowledge base, data mining or text mining, decision support system etc. Following description will give insight into such tools:

Content Management and Document Management
A content management system manages digital information by combining processes and technologies together. It can accommodate various types of content like electronic documents, web pages, audio, video and other multimedia files. On the other hand, document management systems are restricted to manage data in the form of structured documents and files like word processing documents, spreadsheets, presentations, PDF files and other standard formats.

A content/document management system automates and streamlines all workflows related to document management comprising of creation, sharing and transfer of the documents. The centralized repository stores digital content or files in categorized manner. This central repository enables employees or users to access or edit documents easily depending on the permission levels. Thus information is available to authorized users, inside and outside the organization, through a network or the web. Thus, content management systems offers centralized control and administration of organizational digital information. It gives other benefits like efficient updates of contents resulting in better content accuracy, consistency and timeliness, content reusability, enhanced collaboration due to rapid information access and sharing, elimination of paper waste and hard-copy storage.

A study by leading analyst firm ‘Deloitte Consulting’ claims that “a content management system can cut labour costs by about 50% by minimizing the time needed to author, design, and publish both online and printed documents”.

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Content management software (CMS) platforms streamline and standardize the document life cycle (i.e. creation, cataloguing, delivery, electronic storage, destruction) editing, sharing and databasing of all the content needed for the Institution. CMS can be in the form of an intranet or extranet of information and files which are easily searchable and accessible by anyone in the organization.

The commonalities in content management and document management systems are that both are based on fully centralized control on administration and storage of information. A network-based or web-based repository enables easy retrieval of information, enhance collaboration and help manage organization-wide content. Multiple users can work together from different locations on the same document simultaneously. Since organizational information is vital, these systems should have powerful security features so that unauthorized access and use of information is prevented.

**Difference Between Document Management and Content Management**

Content management systems are different from document management systems in one aspect – the type of information they manage. Purpose of document management systems which manage data in structured documents is mainly to digitize and archive files. They track the documents through their lifecycle, as they are created, updated and archived. They are supported with advanced imaging and scanning facilities (to digitize hard copy documents), which may not be present in content management systems.

On the other hand, content management systems deal with the logical organization of information. It provides improved accessibility to various types of structured and unstructured documents covering a broader range of digital assets including raw data collected from internet sources.

**Databases and Data Warehouses**

A knowledge management system may retrieve data available in various databases of the organization. For example, some data of students about their performances in various types of assessments on various topics may be useful for analysing suitability of assessment methods or suitability of topics in the curriculum for particular course.
Database Management and Data Mining may be useful for extracting knowledge out of such data.

If properly designed and implemented, data warehousing makes decision making process faster. This can be achieved through tools like data mining, data visualization and Online Analytical Processing (OLAP).

**Data Mining and Text Mining**

Data mining tools and techniques are useful to identify patterns from huge data, that may lead to new insights. Data mining is used to create usable knowledge or information from data warehousing. This technique is more suited for heterogeneous databases. Exploring hidden patterns is knowledge discovery and this aspect falls within the KM discipline.

Data mining uses various tools like symbolic methods and statistical analysis. Symbolic methods identify patterns to find structure. Statistical methods measure and plot important characteristics, which are then divided into classes and clusters. (web: Knowledge Management Tools, 2016)

Text is unstructured and difficult to process algorithmically than data stored in databases. But text is largely used for formal exchange of information. “Text mining is the process of analyzing text to extract information that is useful for particular purposes”. (web: Knowledge Management Tools, 2016)

In the proposed framework, text mining will be useful at various stages in identifying text patterns that appear in curricula of various institutions about a topic. For example, it will reveal that a particular topic is included in many curricula, so that it may be decided to be included in the curriculum being designed.

**Decision Support Systems**

“A decision support system is a computer system designed to provide assistance in determining and evaluating alternative courses of action” (web: Business Directory, 2014). Thus a decision support system

1) gets data from the routine transactions of a firm,
2) analyses it using statistical tools to extract relevant information, and
3) applies rules based on decision theory to narrow down the range of choices.

It facilitates 'what if' analysis and does not replace a manager’s judgment i.e. it evaluates the various alternatives which help manager to take decision.

Data driven Decision Support Systems usually access and manipulate data from a data warehouse. They use Online Analytical Processing as a tool to apply data mining. Though they help in decision-making to solve problems, they don’t replace human control and hence it is not a form of artificial intelligence. These systems answer queries that the expert inputs.

The organization should investigate the decisions made with assistance of decision support system, compare them with KM activities, evaluate and then modify the said system if necessary.

**Database Management Systems**
This is the traditional IT tool usually present in any organization. A database management system facilitates retrieval of required information by means of queries on the databases. Databases of the organization belonging to different departments are part of the KM system of the organization since information can be retrieved from these databases and applied to convert into knowledge. Small scale data can be managed by the database management systems and can be helpful in routine type of queries. Thus explicit knowledge can be acquired through the database management systems.

**Groupware and Collaborative Tools**
Groupware refers to technology designed to help people collaborate. Wikipedia defines three categories for groupware viz. Communication tools, Conferencing tools and Collaborative management tools.

Communication tools are used to send messages and files, including email, wikis, web-publishing, file sharing, etc. Conferencing tools examples are chat, forums, audio and video conferencing etc. Collaborative management tools manage group activities
like workflow systems, project management systems, information management systems etc.

Groupware systems are integral part of a knowledge management system. If designed and implemented properly, they can enhance knowledge creation to a large extent with the help of collaborative management tools. They facilitate dissemination and sharing of explicit knowledge through publishing with communication tools. They also facilitate tacit knowledge transfer to some extent, by supporting socialization through tools like video conferencing.

**Internet and Intranet**

Internet and intranet are integral part of a knowledge management system. Being vast source of information and means of communication, internet plays the role of basic potential source of knowledge in a KM system.

“An intranet is a private network within an enterprise. It may be an integration of many interlinked local area networks leased lines in the wide area network” (web: Knowledge Management Tools, 2016). Usually, an intranet connects to the external internet also. Intranet provides the basic platform to share organizational information among employees. It also enables sharing of computing resources and facilitates working in groups. An intranet can also be used for teleconferences. A KM system is typically built upon the intranet of the organization as IT infrastructure.

**Search Engine**

A search engine is a tool that searches for the given contents in a web. Thus it fulfills the basic goal of knowledge management that “people should get the information they need, at the time they need it”. A KM system should provide ‘effective search’ and not just ‘finding’ the given stuff. Hence search engine should be configured to provide an efficient search solution which will reduce time of the users to get focused information. This will help knowledge managers to understand staff needs and other needs, staff getting what they are looking for and can increase the visibility of key information.
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A poor search giving unwanted information may lead to users’ frustration. Hence, efforts must be taken for effective searching. For this purpose, a search engine can be supported with a good quality taxonomy. This will allow a ‘guided navigation’ along with searching, and help users to find desired information faster resulting into a better understanding of the available knowledge.

Software for Knowledge Management

Various software platforms are available for different components of the knowledge management system which facilitate document management, content management, groupware tools, intranet solutions, searching tools, knowledge base, metadata creation etc. Following is the list of some software along with their features:

<table>
<thead>
<tr>
<th>Name of Software</th>
<th>Category</th>
<th>Modules available / Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshdesk</td>
<td>Online Customer Support Software &amp; Helpdesk Solution</td>
<td>Ticketing System, Knowledge Base, Community Forums, Live Chat Support Phone Support, Mobile In-app support</td>
</tr>
<tr>
<td>AnswerHub</td>
<td>Enterprise knowledge management and community platform</td>
<td>Create, organize and share (and even wikify) articles. Capture, comment, voting and tracking of ideas. Question and answer format. Best answers rise to the top. Reply to questions by email. Follow topics and get updates. Control who can see what. Monitor community activity like average time to answer. Option to segment content by team, vertical,</td>
</tr>
<tr>
<td>Name of Software</td>
<td>Category</td>
<td>Modules available / Features</td>
</tr>
<tr>
<td>------------------------</td>
<td>-----------------------------------------------</td>
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<tr>
<td></td>
<td></td>
<td>topic.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Advanced search. Advanced analytics view and community activity. Direct user to user messaging.</td>
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<tr>
<td></td>
<td></td>
<td>Reputation scoring, badges, and expert identification</td>
</tr>
<tr>
<td>Intelligence Bank</td>
<td>Manage documents and data online</td>
<td>Document Management, Audit Trail by User &amp; Files</td>
</tr>
<tr>
<td>Knowledge Management</td>
<td></td>
<td>Version Control, Read PDF's Online &amp; Offline</td>
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<td></td>
<td>Bulk Upload &amp; Download Files</td>
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<td></td>
<td></td>
<td>Playback Media Online &amp; Offline</td>
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<td></td>
<td>Custom Databases &amp; Forms, Granular Permissions</td>
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<td></td>
<td></td>
<td>Workflow, Team News Forum, Search Title, Description &amp; Contents, Live RSS Feeds, Encryption</td>
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<td></td>
<td>Mobile Friendly &amp; Dedicated iPad App</td>
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<td></td>
<td></td>
<td>Custom Reporting on Files, Databases &amp; Workflow Alerts, Review Dates</td>
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<td></td>
<td></td>
<td>Email Links to Non Registered Users, Metadata</td>
</tr>
<tr>
<td>Codesk</td>
<td>Social workspace and teamwork tools for small enterprises</td>
<td>Social feeds, Discussions, Task lists, Group work, Questions &amp; Answers, Blogs, Events, Files, Ideas, Goals, Profiles, Tags &amp; Folders, Messages, Announcements</td>
</tr>
<tr>
<td>IntelliEnterprise</td>
<td>Intranet software suite</td>
<td>Weblog API, OpenSearch API, Federated Search</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Let users collaborate in Communities with Blogs, Wikis, ..</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Re-use existing user information, LDAP, Single-Sign On</td>
</tr>
</tbody>
</table>
### Discussions and Findings

<table>
<thead>
<tr>
<th>Name of Software</th>
<th>Category</th>
<th>Modules available / Features</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>HTML5 Editor + Responsive Design Editor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Office documents, PDFs, webpages, images, videos, etc.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Search for metadata with Search Discovery</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gauges, Bar charts, Funnels, Pie charts, all HTML5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Graphical workflow designer to easily design processes</td>
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<tr>
<td></td>
<td></td>
<td>Databases, Fileshares, WebDAV, RSS, IFrame, SQL,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lifecycle management of content, Submit ideas and vote.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Recruiting requisition manager + Job tracker application</td>
</tr>
</tbody>
</table>

Table 3.19: List of Knowledge Management Software (web: capterra.com, 2016)

### Some Open source software for knowledge management

<table>
<thead>
<tr>
<th>Name of Software</th>
<th>Category</th>
<th>Modules available / Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>eXo Platform</td>
<td>Open Source Enterprise Social Collaboration</td>
<td>Document Storage, Knowledge Management Idea Management, Rss feeds, Activity dashboard CRM Integration, Calendar Management Collaborative workspace</td>
</tr>
<tr>
<td>Name of Software</td>
<td>Category</td>
<td>Modules available / Features</td>
</tr>
<tr>
<td>------------------</td>
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</tr>
<tr>
<td>InfoAxon</td>
<td>Open source integration</td>
<td>Workflow based contextual knowledge management, Social Network Portals for any enterprise, knowledge management within established communities of practices, Ad Agency KM solution, Collaborative content management solution, Dynamic knowledge repositories that can easily be linked to websites, business system</td>
</tr>
<tr>
<td>XWiki</td>
<td>Open source collaborative platform</td>
<td>Allowing to develop knowledge bases, documentation, workspaces or websites. Features like Advanced Search, Cataloging / Categorization, Collaboration, Content Management, Data Management, Document Management, Discussion Boards, FAQ, Full Text Search</td>
</tr>
<tr>
<td>Bitrix24</td>
<td>Intranet solution for small and medium-sized businesses</td>
<td>Highly secure, designed for effective collaboration, communication, social networking, business process and knowledge management. Allows better knowledge continuity by moving data from network silos and local drives to a well-protected centralized repository. Wikis, blogs and forums ensure social-enabled knowledge bases for improved teamwork.</td>
</tr>
<tr>
<td>Smart Support</td>
<td>Internal &amp; external knowledge base</td>
<td>Powerful Search Engine, Easy-to-use dashboard for KB management, Workflows allow for</td>
</tr>
</tbody>
</table>
4.3 TECHNIQUES SUITABLE FOR ACQUIRING AND REPRESENTING KNOWLEDGE REQUIRED FOR CURRICULUM DEVELOPMENT

Various techniques used for capturing, representing and storing knowledge were studied and those suitable in this proposed system are discussed below.

Knowledge Capture

Explicit knowledge for curriculum development can be captured through documentation, files, databases and stored in repositories. Explicit knowledge will be in the form of curricula of various institutions and previous curricula, profiles of experts, professionals, faculty, subject-wise reference material, rules and guidelines by governing and accrediting bodies, students and alumni data etc. Paper documents can be scanned and stored in text form.

Tacit knowledge is difficult to capture and it has to be converted into explicit knowledge (which is called externalization) in order to store and reuse. Tacit knowledge can be captured and codified using various techniques discussed below. An organization can use its intranet (preferable) for storage and distribution of knowledge.

Tools commonly used for capturing and representing knowledge in business processes are

- Interviewing experts
Discussions and Findings

- Learning by observation
- Story telling
- Questionnaires or surveys
- Brainstorming
- Learning from others
- Participation
- Concept mapping
- Case based reasoning
- Knowledge maps
- Decision trees and Decision tables

This researcher has established application of following tools to capture knowledge in context of curriculum development.

Interviewing experts, Questionnaires or surveys, Brainstorming, Concept mapping, Case based reasoning, Knowledge maps, decision trees and decision tables.

**Experts’ Interview**

Curriculum experts from different departments belonging to different specializations can be interviewed and a common approach can be framed by analyzing and consolidating their views.

**Curriculum experts can be asked questions related to following aspects**:

In case of new programme or revising programme structure:

- How do they choose subjects/courses to be included in a particular programme (structure of programme) (e.g. objectives of the programme may be taken as base guidelines for framing the programme structure)
- How are the goals and objectives treated and explored to obtain information related to subjects?
- How do they come to know the professional demand or scope of a particular subject area so that it can be included in the structure?
In case of preparing contents of a subject/course:

- How do they decide objectives, learning outcomes of the course?
- How do they select contents (major topics and detailed topics/subtopics)?
- How do they identify latest trends, techniques, research in the concerned subject?
- Which factors help them decide whether the topic/subtopic is essential or outdated?
- How do they make use of available material? How should the material be preserved, classified and maintained (continuously updated) for future use?
- After implementing the curriculum, how can the research conducted, best practices, lessons learned, outcomes tracking, information related to teaching and learning be maintained to make it available for reuse?
- How can they collect and treat/analyse feedback from professionals, faculty, students, alumni etc?

Interviewing an expert can be supported by other tools to capture knowledge more efficiently e.g. Protocol Analysis which is a ‘think aloud’ knowledge capture method. The expert speaks out loud, whatever thoughts come to mind, while answering a question.

There are two approaches to data collection in protocol analysis: concurrent and retrospective. Concurrent protocols are generated when the problem solver verbalizes their thoughts, while working on specific tasks. Retrospective protocols conduct interviews with the problem solver after the problem solving process.

In both protocols the collected data can be used to reconstruct the problem solving process.

**Concept Mapping**

Concept Mapping will be suitable for organizing curriculum content knowledge. Various key concepts and ideas and their interrelationships in the curriculum content can be represented using nodes and links. For creating concept maps, a software tool
can be used to draw concepts, links and editing, deleting text related to labels, descriptions etc., display description of the concepts represented by nodes. The interrelationships will be helpful in deciding which related topics and subtopics should be included in the curriculum with consideration of other factors like scope, depth, time available and requirements of the concerned course.

The concept maps will also be useful in teaching curriculum content of a course. A topic can be represented by main concept and then related to other main concepts using Macro maps. Then each of the main concepts having child concepts related to subtopics can be represented by Micro maps. Concept maps arranged in the form of macro maps and micro maps will avoid complications. A concept map is illustrated in Fig. 4.4.

**Fig.4.4:** Example of Concept Map - Representation of concept Computer Memory

**Brainstorming**

Brainstorming consists of inviting two or more experts into a session in which discussions are carried out and opinions are considered or evaluated.
Discussions and Findings

At the time of designing curriculum, topics and subtopics to be included in the curriculum content can be decided by consensus among experts (e.g. members of board of studies). Objectives of the course can be given as initiation of brainstorming session.

In case of electronic (computer-aided) brainstorming, it can be asked to select topics (may be among provided material) and list priority-wise so that overall high priority topics can be selected for curriculum. A vote may be taken if required. The organization’s intranet can be used for electronic brainstorming.

Questionnaires and Surveys
To capture feedbacks from various stakeholders like students, alumni, faculty, employers, academic experts, professionals etc., questionnaires and surveys will be useful.

Knowledge Codification

Knowledge Maps
Using knowledge is the aim of knowledge maps and not capturing or storing. It is like a directory which helps in getting required knowledge by pointing to people, documents or repositories possessing that knowledge.

Knowledge maps will guide whom and where to approach while designing curricula belonging to various categories e.g. faculty, domain experts / academicians, professionals in the concerned domain. Thus they will be supported by databases of information or profile of these experts e.g. their contact details, availability, domain, expertise, competency etc.

The maps will point to various websites, books, journals to seek information about the concerned subject details, latest research, updates etc. The maps will also point to the stored classified documents related to detailed subject material, previous curricula, curricula of other institutions for the concerned subject, guidelines by management, government bodies, accrediting bodies etc. The maps can also be used to guide about teaching methodologies, evaluation techniques, assignments, question banks, project banks etc.
In a KM system, the documents, databases, repositories are usually available and shared on the organization’s intranet.

**Case Based Reasoning (CBR)**
- CBR is based on the idea of learning and acting from experience, with known cases serving as patterns for responses to similar new situations.
- Cases can be maintained for actions taken in certain situations so that it is helpful in taking decisions in similar situations. Following are the examples of some situations which may have occurred in past in an educational organization:
  - Action taken based on feedback from employers - e.g. some additional training provided to students or additional module included in curriculum on understanding of certain requirements by the employers.
  - Actions taken based on students’ placement information - e.g. revision of curriculum by seeing degradation in placements.
  - Difficulties faced by faculty while implementing particular curricula
  - Hurdles experienced by students while undergoing particular type of curricula or acquiring some skills.
  - Re-assessment of students or use of other evaluation techniques in case of considerable failures.

**Decision Trees and Decision Tables**
During interviews with experts if they tell any processes for some decision making where it is possible to frame into decision trees or decision tables, then these processes can be represented by these tools. For example if more than 75% professionals and subject experts recommend for some topic or subject to be essential in the curriculum or it is occurring frequently in other curricula, it can be included or reviewed for including in the curriculum.

The next chapter provides an insight to the actual data, information and knowledge in context with the repositories proposed in the framework along with conclusions and scope for further research.