Chapter 2: Literature Review

In the previous chapter, the general impact of technology in the digital age on the education and learning was discussed along with how it has impacted the society, different professions (like administration) and the outlook of people towards knowledge at large. In this chapter, based on survey of literature, we discuss how this growth spurt in technology has contributed towards different types of learning that have evolved in last few decades and how they are now a major part of our learning system. To start with, a review of existing learning theories and philosophies of education is touched upon briefly in relation with inclusive education. Then there is discussion based on literature review on each of Distance Learning, Computers in Education and e-learning followed by details of data analysis. The chapter also includes discussion based on literature review, sections on Educational Data Mining, Decision Trees and recommender systems.

2.1 Introduction

As discussed in previous chapter, conventional education system consists of classroom learning adapted with textbooks and blackboards etc. In most countries, classroom teaching involves a teacher managing a class of multiple students. In countries like India, one teacher might be teaching a class of sixty or even more students coming from varied backgrounds with different needs and different learning curves. A poor teacher-to-student ratio can lead to student’s individual need not being met in the conventional classroom. In such a system all students are expected to move at a similar place to follow with rest of the class and with the same old medium of instruction which is not personalized. Based on psychological studies [22, 23], we know that every student has a different learning curve and different pace. This is a very restrictive path for our education system, when in modern times we expect to raise literacy levels and create better skilled & empowered students through our education system. Moreover, in developing and under developed nations a large population does not even have
access to conventional classroom based education due to geographical or socio-economic reasons. This presents us with a huge opportunity to radically influence the education in India.

In the first part of this chapter we will provide an overview of education and pedagogy. After that we will review two new forms of learning methods that have come to supplement our traditional forms of learning over the last few decades: distance education and e-Learning. These have impacted the reach and the format of our information delivery compared to traditional education systems and we will discuss that in detail. In light of these two topics it is also important to discuss learning management systems (LMSs) and their wide usage in higher education.

Apart from the accessibility and the format for information and education, educators have realized that there are many other ways in which technology and its tools can be used for development of better learning systems. We already have a lot of historical data available which can be analysed to enhance our current education system and for design of more effective education systems. With the new methods of data mining and analysis available to us, we can redefine and redesign our education approach. In this regard, we will review the academic disciplines like statistics, data mining and educational data mining (EDM). As outlined in the introduction we have focused the case study data analysis on disabled students enrolled in IGNOU, hence, we will briefly touch on assistive technology and adaptive educational hypermedia.

2.2 Education

Education means to train, lead and raise or ‘bring up’ (Latin meaning) [24]. It is an act of teaching, training or drawing out hidden virtue/talent. Various agencies of education are school, state (rules, law, policies of Government, family, religion, community etc.). To
emphasize the importance of inclusive education, values & aims of education and their relation to life & society are stated below:

- **Inclusive aim of education:** Child should learn adjustment and ‘embrace all’ approach. Good of individual will lead to good of society.
- **Comprehensive aim:** Pupil must gain knowledge, learn culture & character, achieve some vocation, learn harmony, become a good and responsible citizen, earn a good living, develop physically, learn self-expression, experience joy & emotions, social development (from ‘I’ to ‘We’).
- **National, international and intercultural understanding:** social and democratic development.

According to UNESCO (United Nations Educational, Scientific and Cultural Organization) [25], inclusive education is seen as “a process of addressing and responding to the diversity of needs of all learners through increasing participation in learning, cultures and communities, and reducing exclusion from education and from within education.”

### 2.2.1 Pedagogy and teaching methods

Various teaching methods exist based on learning theories and philosophies. These methods are explained by teacher to students or they learn it over prolonged exposure and use.

- **Lecture method:** Teacher gives spoken explanation. Visual aids can be shown, which must be explained at the same time. Lecture method is an example of Teacher Controlled Instruction (TCI).
- **Demonstration method:** Teacher teaches through examples or experiments using a visual aid well supported with reasoning. This method is interesting and connectible or relatable. Demonstration method is scientific and activity & observation based.
• Collaboration method: These methods are conversation based to promote team work, leadership skills and presentation abilities. Here students can debate and discuss topics, do projects by collecting data from reliable sources for analysis. Collaboration method is an example Learner Controlled Instruction (LCI).

• Group controlled method: In Group Controlled Instruction (GCI) method students participate in the teaching process, to gain self-confidence and improve speaking and communication skills. They choose a topic to speak about and master it on their own. Then they teach it to other students. This method sometimes appears to be decreasing the burden of teacher but it actually increases the workload of a genuine teacher and student. It can also become learning by teaching.

2.2.2 Theories of philosophy in relation with inclusive education

Theories of philosophies which stress upon Inclusive Education:

• Idealism: This philosophy advocates adjustment. Inclusion of variety/diversity in the same class requires patience. It can be time consuming as well. But it can bring up self-realization. It stresses up on all types of education like arts & science. Role of teacher is important here to make peace and teach students that spiritualism is above all other qualities. Plato, Socrates, Descartes, Aurobindo Ghosh believed in Idealism.

• Realism: This school thought that an all-inclusive approach should be developed. Science is ‘real’ and practical subject, therefore it should be taught to every person. School should be a mirror of society, so it must include students of all kinds. Noted people who believed in this school of Realism were Montaigne and Locke.

• Naturalism: This idea is about adaptation to supreme control i.e. nature. People need more than home care. So another such place should be educational institution. This ideology is child centred. It is about freedom and training of senses which is required
for all kinds- normal or differently abled. Philosophers like Aristotle, Rousseau, Bernard Shaw, and Lamark advocated Naturalism.

- **Pragmatism**: This system advocated student’s interest. Students should be able to follow their own interests and still earn a living. Education was thought of as a social process. Implementation of education is a responsibility of Government. John Dewey, Kilpatrick advocated Pragmatism.

### 2.2.3 Indian thinkers & inclusive education

Many of the well renowned Indian thinkers have believed in Inclusive Education, as listed:

- **Ravindra Nath Tagore**: Education should develop all the faculties (senses) of a child. Curriculum should be flexible as per the needs and capabilities of various types of students. Teacher must create conducive environment.
  - Tagore played key role in Indian renaissance & reformation.
- **Mahatma Gandhi**: He believed in full & perfect development of child. He advocated idealism, pragmatism and naturalism.
- **Shri Aurobindo Ghosh**: He said that goal of education is to satisfy present and future needs. He was an advocator of idealism.
- **Swami Vivekanand**: Learning should be about reaching perfection. He believed in idealism.

### 2.2.4 Learning Theories

Learning is change in behaviour. Learning theories[26] can be divided into two main groups.

- **Behaviourist/Connectionist**: Here, the motivation is stimulus and response (food, pleasure, success, fear).
Trial and Error by Thorndike, Classical Conditioning by Pavlov, Theory of Conditioning by John Watson, Continuity theory by Guthrie, Drive/need reduction theory by Hull, Operant Conditioning by Skinner.

Figure 6: Behaviourism

- Cognitive: Here, role of purpose, insight, memory, understanding, reasoning are key factors.
  - Gestalt psychology, Field theory by Lewin, Sign Learning by Tolman, Insightful learning, Kohler, Neuropsychological theory by Hebb, Gagne, Social learning theory by Bandura, Theory of experimental learning by Carl Rogers.

There are other schools of psychology: humanistic, structuralism, functionalism, transpersonal etc. Humanistic Psychology is about considering human a human with free will, freedom, values, goals, capable of adaptations & personal fulfilment which also suits for personalized instruction (PI). Other theories are not relevant to our work.

### 2.2.5 Inclusive education

Various learning theories have also advocated inclusive education.

- Behavioural approach: Teacher should prepare a conducive environment and reinforcement is required to encourage and promote learning.
- Multi-sensory approach using technology: educational technology, Computer Assisted Instruction (CAI), e-Learning – all of these are practical and teaching aid based methods.
- Content: Definitions, reword or rewrite difficult parts, hints for problem solving, replace map, diagram or video with audio and vice-versa – these features make basis
for adaptations in e-Learning contents, online learning portals, pedagogy and assistive technology.

**Educational Psychology**

Psychology is the study of behaviour. It is also called ‘science of mind’. In respect of various fields and subjects, psychology is divided into various domains- educational psychology, criminal psychology, clinical psychology etc. The idea Season of Birth comes from Educational Psychology domain. Educational Psychology can help us understand a learner better and it includes many other tools including assessment. Human behaviour and psychology is a complex subject and is studied under various departments and disciplines. Educational Psychology is the study of psychology of learners in educational settings.

### 2.3 Distance education

Distance education or distance learning is education platform which comprises of teaching methods and technology which delivers knowledge or information to students typically not physically present in a classroom usually on an individual basis. It has been described as "a process to create and provide access to learning when the source of information and the learners are separated by time and distance, or both”[27]. Some distance education courses might require an on-site/physical presence for certain exercises or examination and they can be classified or referred to hybrid or blended courses of study. In this section, we discuss the history and development of distance education.

#### 2.3.1 History and development

Distance education goes back a long way to as early as 1728, when a teacher in Boston gave an advertisement in the Boston Gazette seeking students for lessons to be sent weekly through mail [28].
Modern distance education initially relied on the development of postal services in the 19th and 20th century and has been practiced at least since Isaac Pitman taught shorthand in Great Britain via correspondence in the 1840s [29]. The University of London claims to be the first university to offer distance learning degrees, establishing its External Programme in 1858. This program is now known as the University of London International Programmes and includes Postgraduate, Undergraduate and Diploma degrees created by colleges such as the London School of Economics, Royal Holloway and Goldsmiths [30]. In the United States William Rainey Harper, first president of the University of Chicago developed the concept of extended education, whereby the research university had satellite colleges of education in the wider community, and in 1892 he also encouraged the concept of correspondence school courses to further promote education, an idea that was put into practice by Columbia University [31]. In Australia, the University of Queensland established its Department of Correspondence Studies in 1911 [32]. In India for entrance examination preparation brilliant tutorials was very popular with their distance/hybrid learning program in 1990s and in early 2000s [33].

From 1964 to 1968, the Carnegie Foundation funded Wedemeyer's Articulated Instructional Media Project (AIM) which brought in a variety of communications technologies aimed at providing learning to an off-campus population. According to Moore's recounting, AIM impressed the UK which imported these ideas when establishing in 1969 The Open University, which initially relied on radio and television broadcasts for much of its delivery [34]. Athabasca University, Canada's Open University, was created in 1970 and followed a similar pattern [35]. Now there are many similar institutions around the world, often with the name Open University (in English or in the local language). All "open universities" use distance education technologies as delivery methodologies and some have grown to enrol a very large student base with more than 100,000 students. IGNOU is the
largest Open University in India and offers various programs which will be listed in Appendix A: List of IGNOU Programs.

Over the years various developments in the field of computers and internet has really had an accelerating impact on this field by making the process and format of distribution much easier and faster. Now there are Universities where the entire educational offerings are conducted online [36], hence known as virtual university.

Today, there are many private and public, non-profit and for-profit institutions worldwide offering distance education courses from the most basic instruction through to the highest levels of degree and doctoral programs. Levels of accreditation vary: some of the institutions receive little outside oversight, and some may be fraudulent diploma mills, although in many jurisdictions, an institution may not use terms such as "university" without accreditation and authorization, often overseen by the national government.

2.3.2 Technologies used in delivery

The types of available technologies used to enable distance education are divided into two groups: synchronous learning and asynchronous learning.

![Distance learning technologies diagram](image)

**Figure 8: Typical approaches used for delivery of distance learning**

**Synchronous Learning**

Synchronous learning technology is a mode of delivery where all participants are "present" at the same time. It resembles traditional classroom teaching methods despite the
participants being located remotely. It requires a timetable to be organized. Web conferencing, videoconferencing, Educational television, Instructional television are examples of synchronous technology, as are Direct-Broadcast Satellite (DBS), internet radio, live streaming, telephone, and web-based Voice over Internet Protocol (VoIP) [37].

**Asynchronous Learning**

The asynchronous learning mode of delivery is where participants access course materials on their own schedule and so is more flexible. Students are not required to be together at the same time. Mail correspondence, which is the oldest form of distance education, is an asynchronous delivery technology and others include message board forums, e-mail, video and audio recordings, print materials, voicemail and fax [37]. The two methods can be combined in the delivery of one course.

Other technology methods used in the delivery of distance education include online Three-Dimensional (3D) virtual worlds. A popular 3D virtual world, Active Worlds, is used for synchronous and asynchronous learning. Active Worlds provides opportunities for students to work collaboratively [38].

### 2.3.3 Benefits of Distance Learning

Distance education has some obvious advantages when it comes to spreading the reach of education in a hugely populated country like India. Some of the obvious benefits are listed below.

- Expanding outreach and access distance education can assist in meeting the demand for education and training demand from the general populace and businesses, especially because it offers the possibility of a flexibility to accommodate the many time-constraints imposed by personal responsibilities and commitments.
• Alleviate capacity constraints: being mostly or entirely conducted off-site, the system reduces the demand on institutional infrastructure such as buildings and also reduces the pressure on the system to improve the student/teacher ratio.

• Promote lifetime learning and earning: an increasing acceptance from the population of the value of lifelong learning, beyond the normal schooling age, and institutions can benefit financially from this by adopting distance education.

2.4 Computer in Education

MS-office simplified data processing. CD-ROMs made education electronic. But it was only after internet that education became what we see today i.e. Web Based Education (WBE). Virtual communities supported by social networking websites and independent educational websites belonging to institutions engage learner in online world [38]. Tools for communication (chat, e-mail), comprehensive knowledge (wiki, blog), and learning with entertainment (virtual learning environments, games, virtual field trips) and class room learning (power point slide show, videos, audios, digital white boards, electronic projectors) are now available in educational institutions. Computers and available software can be used on education from basic data processing, presenting & communication all the way to using them to build platforms for recommender systems. Large student: teacher ratio leads to even lesser interactions. E-Learning can solve such problems and also provide customization & personalization of content.
2.5 E-Learning

This section is about E-learning, its history, development and approaches. E-learning is defined as electronically supported teaching and learning. In a broad sense, E-learning encompasses of enabling knowledge increase or education instruction delivery with the aid of any electronic media such as networks (internet, intranet and extranet), TV, satellite and radio broadcast, audio/video tapes and cassettes, CDs and DVDs etc. E-learning can be used to describe in-classroom or out of classroom learning. E-learning applications and processes include Web-based learning (WBL), computer-based learning (CBL), virtual education opportunities and digital collaboration. E-learning content can be customized according to the needs of the student or the program to be self-paced as per the student or instructor-led in the form and includes media in the form of text, images, video or audio.

E-learning is defined as the acquisition and use of knowledge which is distributed and facilitated primarily by electronic means [39]. Instructions delivered via all electronic media including the internet, intranet, extranet, satellite broadcasts, audio/video, interactive TV, and CD-ROM [40]; Learning facilitated by internet and www technologies, delivered via end-user computing that creates connectivity between people and information and creates opportunities for social learning approaches [41]; Distance education using the internet and/or other information technologies [42]. In a similar way, m-learning or mobile learning
is learning using mobile devices. Smart phones run application software called app. We will discuss these in Chapter 6.

As the world of communication technology has evolved significantly in the last few decades, it is imperative to see its effect on education and learning which is usually imparted through different modes of communications. It makes little or no sense to use e-Learning or computer based learning (CBL) to simulate traditional approaches because then we would be binding ourselves by pre-existing limitations, whereas clearly we have an opportunity to transform and influence all forms of learning in the twenty first century.

e-Learning is much more and hence very different compared to just an online distance education system. Any program or tool that uses information and communication technology as a means for or to aid a learning process falls in the category of e-Learning. E-Learning has the following three characteristics[43]:

1. Network: Knowledge can be updated in time, and meanwhile ensuring knowledge consistency.

2. Personalization: The terminals can be computers or mobile telephones. Learners can arrange personal progress according to his (her) time, can decide the appropriate content he (her) need.

3. Trackability: All learning activities can be recorded as the basis for the assessment of the learning result and the analysis of training needs.

2.5.1 History of e-Learning

In the early 1960s, Stanford University psychology professors Patrick Suppes and Richard C. Atkinson experimented with using computers to teach math and reading to young children in elementary schools in East Palo Alto, California[44]. Early e-Learning systems were usually designed to replicate classroom teaching styles to transfer knowledge, as opposed to systems developed later on, which encouraged the shared development of
knowledge and are much more interactive. As early as 1993, William D. Graziadei described an online computer-delivered lecture, tutorial and assessment project using electronic mail[45]. He published his work in a paper in 1997 where he discussed developing an overall strategy for technology-based course development and management for an educational system[46]. Even at that early stage he recognized that an e-Learning product or tool would have to be easy to use and maintain, portable, replicable, scalable, affordable, and have some long term success. Today a wide variety of technologies are used in e-Learning platforms like slide sharing, blogs, online forums, collaborative software programs etc.

2.5.2 Approaches to E-Learning

E-Learning approaches and services have come a long way since computers were first used in schools or education. Now the world is moving towards blended learning where the computer based activities are integrated with classroom based teaching methods to lend a more collaborative and evolved platform. The vast field has grown from students just using computers and/or the Internet for learning, through study aids, such as PowerPoint slides, video lectures tutorials etc. leading to even enabling different forms of distance learning. Typically E-Learning can also be classified as blended or distributed learning where blended learning takes more of an approach of using e-Learning tools and services along with conventional classroom teaching techniques to create a blended platform. Distributed learning on the other hand can rely on hybrid learning or use of fully online based learning for knowledge transfer. Lack of awareness, poor network, poor quality, digital divide, lack of interest and language are most common problems faced in an e-learning scenario.
Additionally E-learning has also been classified based on method of delivery and instruction used as shown in Figure 11, followed by explanation.

**Computer-based learning**

Computer-based learning, (CBL) is a learning platform using computers as a key component. This could involve using computers in classroom as well as using computers for teaching and lecturing purposes. Computers are playing an ever increasing role in higher education.

The evolution to include computer-supported collaborative learning, in addition to data management, has been realized. The type of computers has changed over the years from cumbersome, slow devices taking up much space in the classroom, home, and office to
laptops and handheld devices that are more portable in form and size and this minimalization of technology devices will continue.

**Computer-based training**

Computer-based trainings (CBTs) are self-paced learning activities accessible via a computer designed to help the user learn particular content. CBTs typically present content in a linear fashion similar to reading a paper book or manual. Because of this linear design, they are typically used for static processes/courses such as software or hardware manuals and not for dynamic interactions with a student. This could be as simple as providing study material to the user in form of pdfs to complex platforms where user has to finish reviewing a certain portion of the content before they can move on to the next.

Computer-Based Training is often used interchangeably with Web-based training (WBT) with the primary difference being the delivery method. Where CBTs are typically delivered via CD-ROM, WBTs are delivered via the Internet using a web browser. Typically CBTs and WBTs have assessments at the end in form of multiple choice questions, or other assessments that can be easily scored by a computer such as drag-and-drop, radio button, simulation or other interactive means. Assessments are easily scored and recorded via online software, providing immediate end-user feedback and completion status. Users are often able to print completion records in the form of certificates.

CBTs provide learning stimulus beyond traditional learning methodology from textbook, manual, or classroom-based instruction. For example, CBTs offer user-friendly solutions for satisfying continuing education requirements. Instead of limiting students to attending courses or reading printed manuals, students are able to acquire knowledge and skills through methods that are much more conducive to individual learning preferences. For example, CBTs offer visual learning benefits through animation or video, not typically offered by any other means. CBTs can be a good alternative to printed learning materials.
since rich media, including videos or animations, can easily be embedded to enhance the learning. Another advantage to CBTs is that they can be easily distributed to a wide audience at a relatively low cost once the initial development is completed.

However, CBTs pose some learning challenges as well. Typically the creation of effective CBTs requires enormous resources. The software for developing CBTs is often more complex than a subject matter expert or teacher is able to use. In addition, the lack of human interaction can limit both the type of content that can be presented as well as the type of assessment that can be performed. Many learning organizations are beginning to use smaller CBT/WBT activities as part of a broader online learning program which may include online discussion or other interactive elements. Studies show that this also helps people retain more information in less time and with lower cost[47].

**Computer-supported collaborative learning (CSCL)**

Computer-supported collaborative learning (CSCL) implements innovations to improve teaching and learning with the help of modern information and communication technology. Most recent developments in CSCL have been called E-Learning 2.0, where the concept of collaborative or group learning whereby instructional methods are designed to encourage or require students to work together has been leveraged [48]. This model is very different from traditional direct transfer model in which the instructor is assumed to be the distributor of knowledge and skills.

**Technology-enhanced learning (TEL)**

Technology enhanced learning (TEL) has the goal to provide socio-technical innovations for e-Learning practices, regarding individuals and organizations, independent of time, place and pace. The field of TEL therefore applies to the support of any learning activity through technology.
In all these different types of services, we need to ensure that we focus on the aspect of motivation success and improving the efficiency and cost effectiveness of e-Learning services. Also providing information on motivation for developing these services and feedback can help educators, psychologists, and technologists develop insights to help students perform better academically.

**Learning Management Systems**

Learning Management Systems (LMS) refer to software that primarily acts as an electronic registrar by electronically performing various enrolment and related tasks. Its examples are Moodle, Blackboard and WebCT. LMSs were originally designed for workplace learning environments, and specifically perform some or all of the following tasks [43]:

![Figure 12: Various modules for various tasks in an LMS](image)

**Content Management Systems**

Content Management Systems (CMSs) on the other hand are online systems that were originally designed to support classroom learning in academic settings, such as universities and high schools. WordPress is a CMS.
Concept Learning Systems

Thinking on the lines of chemistry (solid, liquid, gas, semi-solid), there is a classification procedure which can cope with a situation where the only possible response is ‘yes’, ‘no’ or ‘may be’, i.e. discrete fuzzy. J. R. Quinlan in[49] described a family of inductive-Learning systems which produce decision trees, all derived from CLS (Concept Learning Systems). It is a non-procedural representation of concepts. This technique can also be found in games where people have to guess an object ‘A’ based on properties (attributes $a_1, a_2, \ldots a_n$) described by a host.

Keeping humanistic psychology in mind, we need to remember that students have their some choices and responsibilities [26].

2.6 Adaptive Educational Hypermedia (AEH)

Hypermedia material support linking to various media like text, graphics, audio, video, presentations and animations. Educational Hypermedia materials are based on the concerns of instructional design-learners, goals of instruction, teaching strategies, appropriate
They allow cognitive flexibility and promote higher order learning. Educational Hypermedia (EH) involves learner elements (computer skills, content knowledge, self-efficacy, learner control, task control & task type) and site elements (content, presentation, navigation, task type, links & nodes). By attending to these elements, Educational Hypermedia designers can meet the needs of learning. The navigation can be made 3-layered: nonlinear (linear with branching), guided (paths, guidelines) and self-directed (navigation cues and obvious links to promote exploration of web).

An adaptive educational hypermedia system are given a presentation that is adapted specifically to knowledge of the subject [51, 52] and a suggested set of most relevant links to proceed further [53, 54] with Adaptive Learning Environments. (ALEs) offer support for the learning process through adaptive guidance and perhaps also personalized learning material (content) [55].

<table>
<thead>
<tr>
<th><strong>Regular educational hypermedia</strong></th>
<th><strong>Adaptive educational hypermedia</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>Design and structure the knowledge space</td>
</tr>
<tr>
<td></td>
<td>Design a generic user model</td>
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<tr>
<td></td>
<td>Design a set of learning goals</td>
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<tr>
<td>Design and structure the hyperspace of educational material</td>
<td>Design and structure the hyperspace of educational material</td>
</tr>
<tr>
<td></td>
<td>Design connections between the knowledge space and the hyperspace of educational material</td>
</tr>
<tr>
<td><strong>Authoring</strong></td>
<td></td>
</tr>
<tr>
<td>Create page content</td>
<td>Create page content</td>
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<tr>
<td>Define links between pages</td>
<td>Define links between pages</td>
</tr>
<tr>
<td></td>
<td>Create some description of each knowledge element</td>
</tr>
<tr>
<td></td>
<td>Define links between knowledge elements</td>
</tr>
<tr>
<td></td>
<td>Define links between knowledge elements and pages with educational material</td>
</tr>
</tbody>
</table>

Table 1: Design and authoring steps in the process of creating regular and adaptive educational hypermedia system[56].
Earlier Educational tools like WebCT, Blackboard followed ‘One size fits all’ – inflexible approach. They were drill & repetition based. Adaptive Educational Hypermedia (AEH) are flexible, adaptation, customized to provide appropriate lesson for each student (individualism) e.g. AHA! [57], WHURLE, MOT (My Online Teacher), TANGOW, Interbook, and Firefly [58-62].

Questions of adaptation [63]

The core of adaptation is defined by posing and answering six major questions:

- What can we adapt? (What?)
- What can we adapt to? (To What?)
- Why do we need adaptation? (Why?)
- Where can we apply adaptation? (Where?)
- When can we apply adaptation? (When?)
- How do we adapt? (How?)

In the context of disability, we need to adapt our content and presentations as per their need, so that they are able to learn as independent of other students as possible. We can apply adaptations to our learning material – documents, audios, videos & graphics.

2.7 Assistive Technology

New innovations and growth in technology consider need of disabled learners. Certain specified standards are incorporated in to existing conventional technology to make educational technology accessible. Use of adaptive method can simplify the task further. Assistive Technology (AT) refers to development of those devices which can be used to enable or partially enable a disabled or differently abled person, perform daily living activities at home, outside like market, institution and workplace etc. This will be discussed in detail in sixth chapter.
2.8 Adaptive methods and techniques

Adaptive learning systems offer students a range of appropriate learning options based on the learners’ characteristics. It is, therefore, necessary for such systems to maintain a hyperspace and knowledge space that consists of a large volume of domain and pedagogical knowledge, learner information, and adaptation rules.

The architecture of any adaptive system dedicated to learning is mainly composed of a learning model and a domain model. The first one allows taking into account the different characteristics of the user: his information, needs, preferences, objectives, competences, knowledge, etc. These diverse parameters can be acquired by some questionnaires and a survey from the interactions of the learner with the computer system. The second model, also known as "the domain of knowledge" or "the model of knowledge", has the objective of determining the pertinent concepts and their relations, and providing a global structure of the field of learning (or course) [64].

2.9 Data Analysis

In view of the fact that real world implementations have high complexities, it is difficult to capture human behaviour. It is learned and passed on in complex loops which may not be completely visible but also beyond our comprehension. Understanding brain or learning mechanisms is a similar puzzle which psychologists, scientist from various domains and mathematicians try to solve. According to various surveys, papers, chapters, books and reports MS- Excel is a very good and popular data mining tool [65-68], hence we used as the preferred tool for data mining and analysis in this research work.

A data mining research is generally based on data of various types: text, images, audio and some technique(s) or algorithms. The datasets in the present research came from enrolment forms filled by disabled learners. The alphanumeric data contained too many errors which have been corrected wherever possible. Records and fields had to be ignored if
they are scarcely used or unused. DM can be visualized as a confluence of multiple disciplines where the background knowledge pertaining to the area of study is processed using tools pertaining to other disciplines such as – information science, database technology, statistics, machine learning & other related fields. Information Science is study of existing literature. ‘Area of Study’ is ‘Education’ in the current research.

Figure 14: Data mining as a confluence of various disciplines

Understanding of focus area – Education is necessary to remain unbiased. Education consists of following main parts:

- Philosophy
- Psychology
- Administration
- Curriculum (including teaching methods)
- Computers in Education (including e-Learning, EDM)
- Assessment
- SUPW, CCA & SPORTS
2.10 Statistics

Statistics is a mathematical science pertaining to the collection, analysis, interpretation or explanation, and presentation of data. It is a name for the body of scientific methods which are meant for the collection, analysis and interpretation of numerical data. It is used to measure, compare and understand numerical data arising in any form of sphere of human experience – to be precise, numerical data which arise from a host of uncontrolled, and mostly unknown, causes acting together [69, 70].

Probability theory is the branch of mathematics concerned with analysis of random phenomena. The central objects of probability theory are random variables, stochastic processes/random process, and events: mathematical abstractions of non-deterministic events or measured quantities that may either be single occurrences or evolve over time in an apparently random fashion. Although an individual coin toss or the roll of a die is a random
event, if repeated many times the sequence of random events will exhibit certain statistical patterns, which can be studied and predicted. No randomness is involved in the development of future states of the system. Deterministic models thus produce the same output for a given starting condition.

Different samples have different statistics. This is called sampling fluctuation. Events are outcomes or results of an experiment like – casting a dice, tossing a coin, drawing a card from an urn of playing cards. These events may be mutually exclusive, exhaustive or independent.

**Theoretical distributions**

These are ideal or model approximations. They are abstract & hypothetical shapes/entities. They may approximate to some situation that we encounter in real life. Some such distributions are: Binomial, Normal, Poisson distribution, Normal (Gaussian) distribution, Chi-Square etc.

### 2.11 Data Collection

The data can be collected from students’ use of interactive learning environments, computer-supported collaborative learning, evaluation, assessment or administrative data (web logs, library usage) from schools and universities. There are various challenges in the field of education like understanding choice of major, appropriate evaluation schemes, student drop out, retention, student unrest and crime (e.g. ragging), assessment of institution and educationists’ goals like quality, access, cost, social and cultural biases. Educational efficacy can be measured and predicted DM methods [71]. DM is a field which has originated from databases and Artificial Intelligence [21]. Understanding the current trends of our education system could point out towards the underlying issues and help us device an effective plan to address them.
2.12 Data Mining

Data mining (DM), or Knowledge Discovery in Databases (KDD), is the field of discovering novel and potentially useful information from large amounts of data [72]. It finds applications in the fields of artificial intelligence, numeric & combinatorial optimization, business, management, medicine, computer science, engineering etc. [73]. DM largely consists of analysing available sets of data to interpret, isolate the trends and patterns present in the data i.e. converting raw data into information. The trends obtained can be called as prediction or recommendations [74]. These can be used by educators, educational software developers, teachers, parents or students. Data mining research falls in the category of experimental research.

If the teachers and administrators have more knowledge about their students like their usage pattern, choices, login times, leave pattern, performance or working pattern etc. they may help the students more regarding their problems. This is where the field or concept of data mining comes in to the picture. Data mining is about finding interesting and useful patterns in the data.

Figure 16: Steps in data mining

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In Data Mining process, first the datasets are extracted and then cleaned i.e. checked for errors. Transformations are performed to derive other variables. Patterns are found and rules are interpreted.

2.13 DM using MS-Excel

Analysis of enrolment data may give us some useful insights about them. We may find answers to questions like – “Most disabled students are proffering which course?” Next question arises – “Is there enough support for disabled students in all the courses?” Overall MS-Excel turned out to be a good tool for data cleaning and for performing some iteration too.

Data cleaning [75] is easy after importing file from FoxPro to MS-Excel because every column can be viewed separately now. The values are standardized already and discrete verifiable from university website & prospectus. Records are matched to see that there is no repetition of a student’s enrolment number which is the primary key. Necessary transformation can be done e.g. to get age from date of birth.

2.14 Educational Data Mining (EDM)

Like technology helped in creating subjects – biotechnology, bioinformatics from biology; e-commerce from commerce, it created e-Learning and educational data mining as sub branches in the field of education. Education researchers and psychologists play the key role in the EDM community.

In the last few years EDM has emerged as a field of its own. The EDM community website [76] defines EDM as follows: “EDM is an emerging discipline, concerned with developing methods for exploring the unique types of data that come from educational settings, and using those methods to better understand students, and the settings which they learn in.”
Goal of EDM is guiding students in learning [77]. The measure in EDM is not money but achieving objectives of teaching (by teacher) by measuring learning (by student). The techniques for EDM are traditional DM techniques – classification, clustering association analysis, but not limited to them.

Educational data is hierarchical in nature. Educational data has a non-independence nature due to interactions and influences in students’ lives. Therefore, psychometric methods are required to analyse learning. One such example is formative evaluation where a program is evaluated while it is being developed. EDM can always address a few questions important for improving educational designs and decision making.

It is largely understood that EDM methods are often different from standard DM methods. This is because of the non-independence and multilevel hierarchy found in educational data. For the same reason, it is increasingly common to see the psychometrics models being used in EDM [78]. DM is a part of Data Analysis. The outcomes of data based research can be descriptive or actionable, this study includes both.

Figure 17 Error! Reference source not found. shows broad two possible dimensions of EDM research wherein utilizing the data from point of view of educators and also from those studying the management/administrative aspect of EDM is considered.
2.14.1 Data Sources

EDM data sources are rich and diverse (Figure 18). Some educational data repositories are:

- PSLC DataShop [79]
- UCI Machine Learning Repository (one University data set)

Various institutions can be contacted online to get data on a CD-ROM or as downloadable files on web /e-mail. Attributes / columns available for analysis is a policy matter of the institution or state. A Data Mining problem can be solved through Generalization. To achieve a high degree and accuracy of generalization, a data miner needs a large number of records and more resources in terms of access, time, permissions, teams, better software, machines and related facilities as shown in Figure 19. Over a longer period of time Agility in Data Analysis can be achieved through Software Re-Engineering. Real world implementations have high complexities.

![Figure 18: Diverse data sources for EDM](image-url)
2.14.2 Techniques in EDM

**Visualization in EDM**

Information Visualization (IV) is use of computers to generate interactive visual representations to explain and understand specific features of data. The basic principle of IV is to present data in a visual form and use human perceptual abilities for their interpretation. Visualizations improve comprehension. It allows recognition of essential features and helps making important inferences. Colour, form, movement and spatial position in IV generate good user interfaces too. ‘A picture is worth more than a thousand words’ (A Chinese proverb). Visualizations help form a mental image [80]. Computers help this activity and help plot – graphs, simulations, maps, structures. It helps in finding pattern (geometrical proof) and reduces repetition of search [81].

**Statistical analysis in EDM**

Data has to be prepared to employ statistical techniques on it. To start with, data is cleaned so that it remains accurate, relevant and a meaningful analysis can be performed.
Irrelevant records are removed and missing records are replaced. Variables can be transformed and discretized if possible. Relevant features are selected and irrelevant & redundant fields are removed. Graphs can be drawn then, and statistical measures can be calculated [81].

**Classification in EDM**

Classification techniques can be used to predict academic success, course outcomes. Approaches used for classification are: decision trees [82], Bayesian classifiers, neural networks, nearest neighbour classifiers, support vector machines, and linear regression. A discussion on decision trees is presented in chapter 6.

**Clustering in EDM**

Groups or clusters can be formed in dataset using clustering methods like k-means clustering, fuzzy c-means clustering, Kohonen Self-Organizing Maps, Generative Topographic Mapping. In education sector, e-Learning material can be clustered to organize and improve search. These involve understanding semantics & fuzzy logic. Students can be clustered as per their e-Learning behaviour i.e. browsing, learning strategy, usability preferences, performance similarities, navigation, ICT skill level, personal attributes and characteristics to improve online collaboration [83, 84].

**Association Rule Mining in EDM**

Deriving code or rules like If A & B then C. Association rule mining is in an early stage in EDM and more studies are needed [77, 82].

**Sequential Pattern Analysis in EDM**

Log files are utilized to study events. Detailed usage pattern are studied to see how students interact with learning material [83].
2.15 Decision Trees – ID3 to generate rule base

Decision Trees (DTs) are classification procedures in which each node specifies a particular feature of the object under consideration and the node’s branches represent the possible values of that feature. To classify an object the branches are traversed from the root node downward according to the values of the object on each of the features encountered. At each node is a feature to be tested and at the end of each branch will be a response classified as –ve, +ve [21].

2.16 Recommender Systems

Recommender System is a system that recommends items to users according to several criteria such as the user preferences, user history information and the context [85]. The goal of a recommender system is to generate meaningful recommendations to a collection of users for items or products that might interest them. Suggestions for books on Amazon, or movies on Netflix, are real-world examples of the operation of industry strength recommender systems [86].

The approaches to recommender systems can be broadly categorized as:

**Collaborative Filtering (CF):** In CF systems, a user is recommended items based on the past ratings of all users collectively. CF methods can be further subdivided into:

- **Neighbourhood-based or memory-based approaches:** Subsets of users are chosen based on their similarity to the active user, and a weighted combination of their ratings is used to produce predictions for this user e.g. entropy.

- **Model based approaches:** provides recommendations by estimating parameters of statistical models for user ratings e.g. classification.

These approaches treat all users and items as atomic units, where predictions are made without regard to the specific of individual users or items. However, one can make a better
personalized recommendation by knowing more about a user, such as demographic information.

**Content-based recommending**: These approaches recommend items that are similar in content to items the user has liked in the past, or matched to predefined attributes of the user. Recommendations are provided by comparing representations of content describing an item to representations of content that interests the user e.g. Decision Trees.

**Hybrid approaches**: These methods combine both collaborative and content-based approaches e.g. ID3

Other approaches can be demographic, knowledge based, community (peer) based [87].

### 2.16.1 Evaluation of a recommender system

Following question can be asked as survey or feedback [88]:

- **Reaction of user**: what they thought and felt (“Did I enjoy the recommendations I receive?”);
- **Learning**: the resulting increase in gaining new knowledge or capabilities (“Did I learn what I needed to and get some new ideas, with the help of the recommender?”);
- **Behaviour**: extent of how acquired knowledge and capability can be implemented/applied in real life (“Will I use the new information and ideas I was recommended?”);
- **Results**: the effects on the user’s performance in the learning or working environment (“Do the ideas and information I was recommended improve my effectiveness and results?”).

Educational Recommender Systems (ERS) can be used to predict student and teacher performance, drop-out, curriculum and demand for employment. Curriculum includes and needs and interests of student & society,
2.17 Summary

This chapter presents a detailed overview, based on literature review, of a multitude of topics related to this research. Relevant literature in respect of fundamentals of education, distance learning, e-Learning are reviewed. Data mining, statistics & EDM, decision trees are reviewed. Since the data used for this analysis is the enrolment data of disabled students enrolled in IGNOU, assistive technology and adaptive educational hypermedia, again through literature review, are also discussed. The utility of including all these tools and techniques will become clear in the chapters to follow.