CHAPTER-1 INTRODUCTION

To enable persons with disabilities to live independently and participate fully in all aspects of life, States Parties shall take appropriate measures to ensure the persons with disabilities access, on an equal basis with others, to the physical environment, to transportation, to information and communications, including information and communications technologies and system.

-Article 9 of the U.N Convention on the Rights of Persons with Disabilities

The freedom of expression and access to information is a basic human right. The right to information and knowledge is a fundamental right of every person including the differently abled persons. Limited access to Information and Communication Technologies impacts all the people but differently abled persons are affected more adversely.

Over the past few decades, Information and Communication Technology (ICT) has fundamentally changed almost every aspect of our lives. The impact of information and communication technologies has transformed the entire universe into a new dimensional structure and the age-old barriers of distance and time have almost vanished. Now a days ICTs are playing an important role in facilitating the socio-economic, political inclusion, daily lives and mainstreaming of differently abled persons as ICTs can enable them to access various services like education, telecommunication facilities, public services, health services, government, information, employment opportunities, communication etc and most importantly, to achieve self reliance in spite of their particular disability.

In present scenario, Information and Communications Technology and assistive technology provides new opportunities for everyone, but these opportunities are specifically more significant for differently abled persons, who use assistive technologies for their daily activities to a higher extent than people in general. Today's assistive technology, which is adapted to everyone's abilities, means that disabled end users are able to participate in all aspects of social life on more equal terms than ever before. It is vital that people are able to benefit on an equal basis from the rapid development of ICT, to enable them to partake in an inclusive and barrier-free information society **(Eid, 2015).**

ICT refers to equipment and services related to broadcasting, computing, and telecommunications, all of which process, store and transmit information through computer

and communications systems **(UNESCO, 2014).** ICT is a combination of network of software and hardware as well as a convergence of information, communication and technology. They are technological tools and resources used to communicate, create, organize, disseminate, store, retrieve and manage information and learning **(Obi, 2002).**

ICT includes all technical means that are used for handling information and facilitating communication, including computers, network hardware, communication lines and all the necessary software. In other words, ICT is comprised of information technology, telephony, electronic media, and all types of process and transfer of audio and video signals, and all control and managing functions based on network technologies **(Celebic & Rendulic, 2011).** The World Bank defines ICTs as "the set of activities which facilitate by electronic means the processing, transmission and display of information" **(Rodriguez & Wilson, 2000).**

Assistive technology is an umbrella term that includes assistive, adaptive, and rehabilitative devices for people with disabilities and also includes the process used in selecting, locating, and using them. Assistive technology promotes greater independence by enabling people to perform tasks that they were formerly unable to accomplish, or had great difficulty accomplishing, by providing enhancements to, or changing methods of interacting with, the technology needed to accomplish such tasks **(Wikipedia, 2016).**

Assistive device is a device that is designed, made, used, or adapted to assist persons with disabilities in performing various tasks such as daily activities, communicating, academic work moving, lifting and enhance overall wellbeing. Well designed assistive devices for differently abled promotes greater independence, improves quality of life by enabling them to perform tasks more easily by creating barrier free environment.

The assistive technology plays an important role in the lives of the people with disabilities as it enhances information access and allows the user to accomplish their tasks in a more refined manner independently. The concept of assistive/adaptive technology and its role and importance in the access of information for the people with disabilities in the digital environment has been studied. There are thousands of computer based assistive aids and devices available today for the disabled and libraries are using these resources to provide services to their disabled community **(Sanaman& Kumar, 2014)**.

With the ingress of information and communications technology (ICT), new prospects are developing for differently abled persons. Despite of enormous challenges, serious efforts are being initiated to implement the use of ICT to overcome barriers faced by differently abled persons. The information society exhibit at once significant opportunities, but on the other hand plausible new obstacles are major threat for the social inclusion of differently abled persons. ICT and Assistive devices used by visually impaired includes mobile phones, screen reader, JAWS software, Braille, computer, laptop, tactile material, radio, tape recorder, abacus, white cane, smart cane, talking books, kurzweil reading books, text to speech software, dictation devices and description etc. The main purpose of providing accessibility mobile phones, computers and laptop to visually impaired, persons is to provide the best possible sight enhancement or sight substitution mechanism. At present, mobile phones are important source of communication for everyone but for visually impaired, mobile phones with screen reader; JAWS software facility or any speech software provides translated access to text and graphics, which is helpful in creating barrier free environment. Likewise computers and laptop are used for academics and for recreation by visually impaired students. Braille technology is one of the most used ICT devices by visually impaired. Tactile output which purely is text based, produced by Braille display using a special keyboard.

ICT and assistive devices help persons with hearing impairment to live independently. In the era of technological advancement, many communication and assistive devices are available for persons with hearing, speech, voice and language impairment to communicate freely at home, work and leisure. ICT and Assistive devices used by hearing impaired includes hearing aids, speech trainer, interactive video disk, loop induction system, voice carry over telephones, closed captioning TV, Cochlear implant, wheelchair, walker, computer, laptop etc.

People who are deaf or hard of hearing utilize a variety of assistive technologies that provide them with improved accessibility in numerous environments. Most devices either provide amplified sound or alternate ways to access information through vision or vibration. These technologies can be grouped into three general categories: hearing technology; alerting devices; and communication supports. Within each main category there may be subcategories based on different purposes or intended audiences when utilizing the

technology. The overall goal of all of these devices is improved accessibility to information, most people gain through their hearing (**Heckendorf, 2009)**.

Information and communication technology enables persons with locomotor disability to compensate for the impairments they experience. The information and communication technology promotes greater independence by reducing physical, social and economic barrier. ICT and Assistive devices used by locomotor impaired include tricycle, crutch, prosthetic device, orthotic device, mobile phones, computers, laptop, radio, television, tape recorder etc. Wheelchair and tricycle is the most preferred assistive device by persons with locomotor disability as the only source of transportation. Tricycles are the preferred mobility aid because it offers long-distance travel capability at a lower price compared to wheelchairs. Providing access of wheelchairs that are appropriate for the purpose not only enhances mobility but begins a process of opening up a world of education, employment and social life.

More than one billion people in the World live with some form of disability, of whom nearly 200 million experience considerable difficulties in functioning. In coming years, disability will be a major concern because its prevalence is increasing rapidly. The main reason of higher prevalence of disability is aging population because older people are more prone to be disabled. Health conditions of people is also one of the major concerns such as cancer, diabetes, mental health disorder; cardiovascular disease etc. may lead to disability. India has one of the largest disabled population in the World. As per census 2011, 26.8 million people (2.21%) are affected by some form of disability. Proportion of disability is higher among males (55.9%) as compared to women (44.1%). Table 1 presents the data of disabled population by type of disability according to census 2011. From the table, it is clear that 18.8 % people are affected with visual impairment of which 17.6% are male and 20.2% are female. 18.9 % are affected with hearing impairment and 20.3 % are suffering from locomotor impairment. People with such kind of impairment should be encouraged to live an independent life. Although many programs and policies have been introduced by Government but these are not fulfilling their needs. Government should launch such kind of schemes that provides equal opportunity, effective access to information and rehabilitation measures to differently abled persons who constitute a valuable human resource for the country.

In the developing countries, approximately eighty percent people, live with some form of disability. Disability is both a cause and a consequence of poverty: poor people are more likely to become disabled, and people with disabilities are among the poorest and most vulnerable groups of the global population **(Luis Gallegos, 2013).**

The term 'Differently abled' was first proposed in the 1980s as an alternative to **disabled, handicapped,** etc. on the grounds that it gave a more positive message and so avoided discrimination towards people with disabilities. The term has gained little currency, however, and has been criticized as both over-euphemistic and condescending. The accepted term in general use is still disabled **(Oxford Dictionaries, 1980)**.

Table 1. Disabled Population by Type of Disability (%) India: 2011

Proportion of Disabled Population by type of Disability India: 2011			
Type of Disability	**Persons**	**Males**	**Females**
Total	100.0	100.0	100.0
In Seeing	18.8	17.6	20.2
In Hearing	18.9	17.9	20.2
In Speech	7.5	7.5	7.4
In Movement	20.3	22.5	17.5
Mental Retardation	5.6	5.8	5.4
Mental Illness	2.7	2.8	2.6
Any Other	18.4	18.2	18.6
Multiple Disability	7.9	7.8	8.1

Source: C-Series, Table C-20, Census of India

The **American Heritage Dictionary of English Language** defined the term *differently abled* as a substitute for *disabled or handicapped. Differently abled* emphasizes the fact that many people with disabilities are quite capable of accomplishing a particular task or performing a particular function, only in a manner that is different from or takes more time than that of people without the disability. On the other hand, the word *differently abled* is often criticized as an awkward euphemism and in some cases may be taken as offensively condescending by disabled people themselves. Like *challenged,* it is used most frequently in academic, government, and social service environments; its use outside those contexts may be problematic.

Disability is generally defined as a physical, mental, or psychological condition that limits a person's activities. Earlier, it was interpreted according to a medical model. Disability was linked to various medical conditions, and was viewed as a problem residing solely in the affected individual. Disability was seen solely as the result of an individual's inability to function **(Mont, 2007).**

Disability is the consequence of an impairment that may be physical, cognitive, intellectual, mental, sensory, and developmental or some combination of these results in restrictions on an individual's ability to participate in what is considered normal in their everyday society, a disability may be present from birth or occur during a person's lifetime **(Wikipedia, 2016).**

WHO defines disability as it is an umbrella term, covering impairments, activity limitations, and participation restrictions. Impairment is a problem in body function or structure; an activity limitation is a difficulty encountered by an individual in executing a task or action; while a participation restriction is a problem experienced by an individual in involvement in life situations. Thus, disability is a complex phenomenon, reflecting an interaction between features of a person's body and features of the society in which he or she lives **(WHO, 2016).**

In 1980, World Health Organization (WHO) has suggested definitions of disability, impairment and handicapped. **Disability** is defined as "any restriction or lack (resulting from an impairment) of the ability to perform an activity in the manner or within the range considered normal for a human being". **Impairment** is defined as a loss or abnormality of psychological, physiological, or anatomical structure or function. **Handicapped** is defined as a disadvantage for a given individual, resulting from impairment or a disability, that limits or prevents the fulfillment of a role that is normal (depending on age, sex, and social and culture factors) for that individual.

Types of Impairment

In 1980, World Health Organization has suggested following types of impairment.

Visual Impairment: In medical terms, visual impairment can be defined as a total loss of, or reduced ability to, perceive light and color. The classic definition of blindness is a visual acuity of 6/60 or less in the better eye with optimum correction, or visual acuity of better than 6/60 if the widest diameter of field of vision subtends an angle no larger than 20 degrees. This means that a blind person must be at 6 meters in order to see something that a

person with normal sight can see at 60 meters, or that the field of vision is so restricted that only a very limited area can be seen at one time.

Hearing Impairment: Hearing impairment implies a total or partial loss of the ability to perceive acoustic information. The impairment may affect the full range of hearing, or be limited to only parts of the auditory spectrum, which for speech perception is the region between 250 and 4000 Hz. The term deaf is used to describe people with profound hearing losses while hard of hearing is used for those with mild to severe hearing losses. Hearing loss is expressed in decibel (Db) relative to an audiometric cero which is a standardized normal threshold of hearing. Deafness is usually defined as an average hearing loss of more than 92 Db in the speech area. A person with a hearing loss of 70-90 Db is severely hard of hearing. A person with a hearing loss of 50-60 Db is considered moderately hard of hearing **(Davis, 1970).** Measured loss of less than 20 Db is considered normal acuity.

Locomotor Impairment: Locomotor impairment means impairment of the bones, joints, muscles leading to substantial restriction of the movement of the limb or any form of cerebral palsy. Symptoms are paralysis, unsteady movements of limbs poor muscle control, loss of limbs.

Speech Impairment: Speech impairment refers to any reduction in a person's ability to use speech in a functional and intelligible way. The impairment may influence speech in a general way, or only certain aspects of it, such as fluency or voice volume. Speech impairment may be due to a number of different factors. It may or may not be linked with difficulties in speech perception or comprehension. Speech impairment may be caused by developmental problems as in the case of moderate to severe developmental language disorder **(dysphasia),** or by distorted speech due to lack of muscular control **(dysarthria)**. It may be an acquired impairment, for example loss of expressive language skills **(expressive aphasia)** caused by a stroke or brain tumour, or speech impairment after removal of the larynx (laryngectomy). Acquired disorders are more prevalent with advancing age. When speech impairment is caused by reduced muscular control **(apraxia),** it is often accompanied by reduced muscular control of the arms. Low volume is often apparent in people who have had laryngectomy and who must speak in a "whispering" voice.

Impairment of Language Comprehension: This category contains a loss of, or a reduction in, the ability to understand language. The disability may imply only an impairment of

language, or it may be associated with a more general intellectual impairment. Several disorders of the central nervous system may include impairment of language comprehension. In some conditions, like severe developmental language disorder (receptive dysphasia), only the language function is affected, while other conditions may influence most intellectual functions. This may, for example, be the case for people with autism.

Intellectual Impairment: People with reduced intellectual ability constitute a very diverse group with a range of sensory, motor and cognitive impairment; most impairment, including visual and auditory impairment have a higher incidence in the group that is called intellectually impaired. One common trait is that they tend to do things slower than other people, another that they have reduced comprehension of instructions and language in general. For the purpose of adapting telecommunication equipment and services, the best strategy may be to consider intellectual impaired people as having multiple impairments

Reading Impairment: Dyslexia is a disorder manifested by difficulty in learning to read despite conventional instruction, adequate intelligence, and socio-cultural opportunity. It is dependent on fundamental cognitive disabilities, which are frequently of constitutional origin **(Critchley, 1970).** The reading impairment may or may not be associated with other language disorders, such as developmental dysphasia and anarthria due to cerebral palsy. Severe reading disorder may also be an acquired condition similar to aphasia, and is then usually called alexia. A lack of reading skills will be a handicap in a wide range of social and professional situations. In particular, it will influence the person's ability to obtain information.

The ICT opportunity for differently abled persons can be better assessed by analysing how each type of ICT and assistive technology contributes to the various dimensions involved in the social and economic upliftment of persons with disabilities. Making information and communication technology accessible, affordable, available, adaptable, acceptable and of appropriate quality requires efficient use of often limited resources. In the line of above, the use of Information and Communication Technologies (ICT) allow the removal of many of the remaining obstacles faced by differently abled persons. With ICT increasingly integrated into every aspect of the modern world, these pervasive technologies have become a positive force of transformation. ICT and assistive technologies are already providing access to key public services, with widespread implications for social progress and

economic development aimed to eradicate poverty, promoting inclusive societies and sustainable development. Accessibility of ICT have the potential to provide differently abled persons exotic levels of access to education, employment, public services as well as the opportunity to participate in the economic, cultural and social life of their communities.

Thus ICT provides great opportunities to improve quality of life of people and access an abundance of information using multiple information resources and viewing information from multiple perspectives, thus fostering the independence, improves social participation, and may reduce care and support costs. To ensure that ICT devices are appropriate, they need to suit both environment and user and be accompanied by adequate follow-up.

RATIONALE OF THE STUDY

Persons with disabilities who generally refer to differently abled persons are among the most stigmatized and excluded groups of people around the world. They are likely to have less education, poorer health, less employment opportunity and are more likely to live in poverty and deal with greater inequalities than persons without disabilities.

Over the last several years, ICT have become an integral part of daily life, affecting the way people work, learn, shop, recreate, and communicate with others. At the same time, these technologies hold great promise for people with disabilities since they have the potential to eliminate (or at least reduce) many of the disabling barriers that impair or completely prevent them from participating in many activities. Differently abled persons face wide range of difficulties including lack of employment, limited access to information, health care services, education and many more in their day to day life. Due to various kinds of limitations, differently abled people may not be able to use ICT effectively as used by normal people. For example; visually impaired persons face difficulties like in handling mobile phones, laptop and computers due to JWAS (Job Access with Speech) software and screen reader which sometime slows down the systems. They also face problem in using smart cane, this device is unable to detect exact direction of obstacle. Persons with hearing impairment also face many problems in hearing aids, sometimes it creates more noise and sometimes they are unable to participate in conferencing because it lacks captioning. As far as persons with locomotor disability are concerned, they face problems in using wheelchair, tricycle, crutches, elbow sticks etc.

One of the most important requirements for differently abled persons to flourish is their access to assistive technology and information and communication technologies. With the help of user friendly, ICT related and assistive technologies, barrier free environment can be created for differently abled. Assistive technologies usually refer to those products, devices or equipments which are used to increase or improve the functional capacities of individuals with disabilities. Assistive technology is one of the important elements to advance inclusion of differently abled persons together with additional supports such as accessibility of information, availability of assistive devices, personal assistance, transportation facilities, sign language interpreters and removal of barriers. When differently abled persons are given opportunities to flourish as any normal person, they have the potential to lead fulfilling lives and to contribute to the social, cultural and economic vitality of their communities. Yet surviving and thriving can be especially difficult for differently abled persons. All too often they are isolated and excluded, cut off from health, education and social services, and with limited opportunities to participate in family and community life. This frequently impacts on their future, employment, opportunities and participation in civic life.

In the line of above, ICT offer great opportunities for differently abled persons for social inclusion because it has the potential to overcome many of the disabling obstacles that completely prevent people from their daily living activities as learning, working, shopping, banking, being entertained, and communicating with others. ICT applications are very helpful in improving their quality of life. Some people are affected with severe form of disability, so they are unable to attend to school, college and are being deprived of education. In the above said conditions, ICT plays an important role they can access education from home and can communicate with other with the help of communication technology. ICT provides many new ways to reduce barriers in accessibility and provide differently abled the opportunities to exchange knowledge and information, and to communicate in effective manner. ICT tools and applications are paving the way for differently abled persons to access educational materials and resources in different formats and to engage in the same.

Differently abled persons can be empowered by implementation of right policies, programs and accessibility of information and knowledge through information and communication

technologies. In this turn, information and communication technology accessible, available, affordable, acceptable, adaptable and of appropriate quality requires efficient use of often limited resources. The successful application of ICT and assistive technology can make physical and social environments more accessible, classrooms more inclusive, teaching and learning content and techniques more in tune with learners' needs. Hence, the present study is focused on "A Study on ICT enabled devices used by differently abled: An exploratory research" with the following major objectives of the study:

1. To explore the ICT enabled and assistive devices available for differently abled through market and institutional survey.
2. To validate and standardize the schedule for assessing accessibility, purpose and barriers in using ICT and assistive devices.
3. To assess the utilization of ICT enabled and assistive devices for differently abled.
4. To assess the purpose of using various ICT enabled and assistive devices by differently abled.
5. To identify the barriers in the usage of ICT enabled and assistive devices by differently abled.
6. To develop and test the prototype of the identified device for the differently abled through customization.

CHAPTER-2 REVIEW OF LITERATURE

Review of related literature is conducted to enable the researcher to get a clear understanding about the specific field of study. It also helps the researcher to have an insight into the tested methods, procedures and interpretations of similar studies conducted elsewhere. Considerable amount of literature is available regarding the application of Information Communication Technology (ICT) for persons with disability but studies are relatively few regarding ICT enabled and assistive devices for differently abled. An attempt is made in this chapter to present a survey of the literature available in India and abroad under the subheadings listed below.

2.1. Concept of ICT and Assistive Device

2.2. Differently Abled

2.3. Theoretical Perspective

2.4. ICT enabled and Assistive Devices for differently abled

2.5. Assessment of utilization of ICT enabled and assistive devices for differently abled

2.6. Barriers in the usage of various ICT and assistive devices faced by differently abled

2.7. Customization of ICT enabled and assistive devices for differently abled

2.1. BASIC CONCEPT OF ICT

ICT can be defined as "technologies that enable the handling of information and facilitate different forms of communication between human factors, human beings and electronic systems". Overall, ICT is grouped together under two categories: the 'traditional' and the 'new'. Traditional ICTs are non-electronic media such as print and analogue technologies, including books and newspapers, radio, television, fixed-line telephones and facsimile machines. New ICTs consists of computers and the data processing applications accessible through their use: email, the internet, word-processing, mobile phones, wireless technologies and other data processing applications **(Ngenge, 2003).**

The term 'ICT' includes any communication device or application, encompassing: radio, television, cellular phones, computer and network hardware and software, satellite systems and so on, as well as the various services and applications associated with them, such as videoconferencing and distance learning. ICTs are often spoken in a particular context, such as ICTs in education, health care or libraries. The importance of ICTs lies less

in the technology itself than in its ability to create greater access to information and communication in underserved populations **(Kude, 2016)**.

UNDP(United Nations Development Programme) defines ICT as is basically information-handling tools- a varied set of goods, applications and services that are used to produce, store, process, distribute and exchange information. They include the 'old' ICTs of radio, television and telephone, and the 'new' ICTs of computers, satellite and wireless technology and the Internet. These different tools are now able to work together, and combine to form our 'networked world' – a massive infrastructure of interconnected telephone services, standardized computing hardware, the internet, radio and television, which reaches into every corner of the globe **(Nwokeafor & Okeke, 1992).**

2.1.1. ASSISTIVE DEVICE

Assistive devices and technologies are those whose primary purpose is to maintain or improve an individual's functioning and independence to facilitate participation and to enhance overall wellbeing. They can also help prevent impairments and secondary health conditions. Examples of assistive devices and technologies include wheelchairs, prostheses, hearings aids, visual aids, and specialized computer software and hardware that increase mobility, hearing, vision, or communication capacities. In many low-income and middle-income countries, only 5-15% of people who require assistive devices and technologies have access to them **(WHO, 2016).**

2.2. DIFFERENTLY ABLED

Differently abled or disability is defined as limitation of a person's ability to carry out the activities of daily living, to the extent that he or she may need help in doing so **(Singit, 2011)**.

The American Disabilities Act of 1990 defines disability, as 'physical or a mental impairment that substantially limits one or more of life abilities'. Such impairment may include physical, sensory and cognitive or intellectual impairment. Mental disorders, such as psychiatric or psychosocial disability or various types of diseases such as TB, HIV, stroke, spinal cord injuries, Arthritis, Alzheimer may be also considered as disabilities.

Disability is defined as a "restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range of considered normal for a human being" – a functional limitation or activity restriction by an impairment. A disability may occur during a person's lifetime or exist from birth.

The definition of 'disabled person' according to the **Declaration on the Rights of the Disabled** Persons proclaimed by the United Nations Assembly on December 9, 1975 is: "any person unable to ensure by himself, wholly or partially, the necessities of a normal individual and/or social life, as a result of deficiency, either congenital or not, in his or her physical or mental capabilities **(WHO, 2011)**."

2.3. THEORETICAL PERSPECTIVE

The term 'Information and Communication Technology' has been used by academic researchers since the **1980s**, and the term ICT became popular after it was used in a report to the UK government by **Dennis Stevenson in 1997** and in the revised **National Curriculum for England, Wales and Northern Ireland in 2000.** But in 2012, the Royal Society recommended that the term ICT should no longer be used in British schools "as it has attracted too many negative connotations", and with effect from 2014 the National Curriculum was changed to use the word computing reflecting the addition of computer programming to the curriculum. A leading group of universities consider ICT to be a soft subject and advise students against studying A-level ICT, preferring instead A-level Computer Science **(Wikipedia, 2015).**

According to **UNESCO (2002)** information and communication technology (ICT) may be regarded as the combination of 'Informatics technology' with other related technology, specifically communication technology.

The various kinds of ICT products available and having relevance to education, such as teleconferencing, email, audio conferencing, television lessons, radio broadcasts, interactive radio counseling, interactive voice response system, audiocassettes and CD ROMs etc have been used in education for different purposes **(Olakulehin, 2007).** In the context of use of Information and Communication Technologies (ICT) for differently abled will make their life barrier free and improve the quality of life. Accessible ICT have the potential to provide persons with disabilities unprecedented levels of access to education, skills training and

employment, as well as the opportunity to participate in the economic, cultural and social life of their communities.

2.3.1. Theoretical Approach to disability

In recent time, there has been increased emphasis on the social model of disability rather than the medical model. The theoretical model that underpins a programme or organization influences the way services are provided and the type of interventions that are implemented **(WHO, 2002).**

Medical model

The medical model has two basic features: **first,** the alleged causes of the disability are medical in nature. A medical orientation means that disability is spoken of in terms of 'disease' in this model. Thus, persons with disability become objects of medical care, and their reality is examined and explained through a 'medicalized' and 'medicalizing' prism. **Second,** persons with disability do have something to contribute to society, but only insofar as they have been rehabilitated or normalized and have been integrated as much as possible with people of normal abilities **(Toboso, 2011).**

The Social Model

The social model of disability, on the other hand, sees disability as a socially-created problem and not at all an attribute of an individual. On the social model, disability demands a political response, since the problem is created by an unaccommodating physical environment brought about by attitudes and other features of the social environment **(WHO, 2002).**

Bio-psychosocial Model

On their own the medical and social models are partially valid but not adequate so a synthesis of both models is the most useful approach. The latest International Classification and Functioning from the World Health Organization is based on the bio psychosocial model which is an integration of the medical and social models and provides a coherent view of different perspectives of health: biological, individual and social **(WHO, 2002)**.

International Classification of Functioning, Disability and Health

In the ICF, the term functioning refers to all body functions, activities and participation, while disability is similarly an umbrella term for impairments, activity limitations and participation restrictions. In ICF disability and functioning are viewed as outcomes of

interactions between health conditions (diseases, disorders and injuries) and contextual factors **(WHO, 2002).**

2.4. ICT ENABLED AND ASSISTIVE DEVICES FOR DIFFERENTLY ABLED

Nanda and Ramesh (2012) conducted a study on "Assessment of Information and Communication Technology (ICT) Literacy among Teachers and Practitioners in the Field of Disability i.e Visual, Hearing and Speech Language, Mental retardation, and Locomotors disability" with the objective to assess the Information and Communication Technology (ICT) Literacy such as general ICT skills and specially oriented Assistive devices for students with disability in the state of Odisha. A total of 335 respondents were selected for conducting this research. Among 335 respondents, 75 professionals were working for visual Impaired, 104 professionals (teachers and Speech Language pathologists) were working for Hearing Impaired, 58 professionals were working for Mental Retarded children, and 98 professionals (Physiotherapists, Occupational Therapists, Orthotists and Prosthetists) were working for Loco-motor Disability. Tools adopted for this research was questionnaire methods with multiple choice questions. The finding of the research emphasizes that ICT provides an effective mode of communication with professionals and they are well acquainted with the assistive technologies in some extent. The results showed that 87% respondents were computer literate. The practitioners have good computer skills in the field of Internet, E-mail, MS Office, and WWW than the teachers. Only 28% respondents were Skillful in using Software programs. There was a mixed response regarding use of different Assistive technology and devices for the students with disabilities. Most of the respondents refer text books, reference books, newspapers, magazines, and dictionaries to meet their information needs.

USOF, (2011). ICTs can play an important role in facilitating the socio-economic and political inclusion and mainstreaming of Persons with Disabilities (PWDs) as ICTs can enable them to access various services (health, education, government services etc), information, employment opportunities etc and most importantly, to communicate effectively in spite of their particular disability. However for ICTs to play this role, the ICT services must be available, affordable and be truly "accessible". According to the ITU (International Telecommunication Union) tool kit on e-accessibility, accessibility is a

measure of the extent to which a product or service can be used by a person with a disability as effectively as it can be used by a person without that disability.

Vicente & Lopez (2010) stated that over the last several years, ICT have become an integral part of daily life, affecting the way people work, learn, shop, recreate, and communicate with others. At the same time, these technologies hold great promise for people with disabilities since they have the potential to eliminate (or at least reduce) many of the disabling barriers that impair or completely prevent them from participating in many activities.

2.4.1. ICT Enabled and Assistive Devices for Persons with Visual Impairment

Lucky and Achebe (2013) conducted a study on "Information Service Delivery to the Visually Impaired: A Case Study of Hope for the Blind Foundation Wusasa, Zaria (Nigeria)". They aimed to investigate the information service delivery to the visually impaired. In the present study, seventy respondents were participated in the data gathering process. The questionnaire method was adopted for collecting data from the respondents. About 50 questionnaire were distributed out all were returned. It was found that with the help of ICT, the visually impaired have been rendered special attention to fully participate in the world by providing them with best possible support necessary to bridge gaps between accessibility and literacy. More importantly career in science are now within the reach of the visually impaired and some of them have become successful in information service.

Eskay & Chima (2013) studied the "Impact of Library and Information Service Delivery for the Blind and Physically Challenged in University of Nigeria Nsukka Library". They investigated the evolution of library services for the blind people and physically challenged in Nigerian universities with particular reference to the University of Nigeria, Nsukka (UNN), meeting the needs of persons with visually impaired through assistive technologies such as Screen reader, Braille translation software, Braille writing equipment, Closed – circuit television (CCTV), and Braille embosser and scanners. They found that the loss of vision seriously inhibits persons with visual impairment from accessing very useful information, especially those available in print. The blind also have their hobby reading needs, vocational reading needs, and recreational reading needs, just as the sighted do. It is time that the library profession in Nigeria paid close attention to these individuals and made provisions for their reading needs and welcomed them into the regular library community.

Handicapped people also faced barriers in accessing library services. History of the library and information services delivery for blind and physically challenged has revealed that in overseas it has been a normal practice.

USOF, (2011) focused on **"**ICT enabled services for disabled" and ensured that PWDs (Persons with disabilities) in rural India are able to effectively access telecommunications services is an important facet of bridging the digital divide. Given its mandate, USOF appreciates that special initiatives and schemes are required to this end. In fact USOF is aware that addressing the need of individual and public access to telecommunications services by PWDs in rural India will also benefit the significant proportion of rural Indians who are aged or illiterate and need assistive technologies (ATs) to enable meaningful ICT access. An example of the same would be text to speech technologies which would enable the visually impaired and illiterate, semiliterate to communicate and to access news, information and e-services in audio format. Similarly, speech to text ATs would benefit both PWDs and illiterate, semi-literate to communicate and could facilitate them to perform ICT enabled/related jobs. Keeping this in view, it has been decided to launch a scheme of pilot projects for enabling PWDs in rural areas to access ICTs and ICT enabled services.

Soderstrom and Ytterhus (2009) in their study "Use and Non-use of Assistive Technologies from the World of Information and Communication Technology by Visually Impaired Young People" investigated the symbolic values and use of assistive technologies from the world of information and communication technology (ICT) in the daily lives of 11 visually impaired young Norwegians. The study draws on a qualitative interview study with a purposeful sample of 11 visually impaired Norwegians aged between 15 and 18 years. Six of the participants (three girls and three boys) were partially sighted and five (all girls) were blind. These young people had all been allocated a personal computer and ICT assistive technologies by the public assistive technology centre and all attended a local public high school. The participants in the study were anonymously recruited through the assistive technology centers, other resource centers and user organizations. The interviews were semi-structured and all were carried out through face-to-face conversations about the significance of ICT in the everyday lives of the participants. Respondents were asked questions about personal concerns and experiences related to the use and perception of ICT and ICT assistive technologies, as well as questions about social relations, social contexts,

participation and identity. The result of the study indicates that majority of the respondents were simply using ICT assistive technology in school, at home or during leisure time with friends drew unwanted attention to their impairment. Most of the partially sighted participants chose not to use the ICT assistive technology and rejected using it. The finding of this study revealed that partially sighted young people have the possibility of accessing ICT without using assistive technology and their access and use may be considerably limited without

the assistive technology, with the result that they may become less efficient users of ICT. On contrast, young blind people do not have the luxury of rejecting ICT assistive technology if they want to participate in the community of their peers. The importance of this participation forces them to adopt the ICT assistive technology. Moreover, further research in this field needs to investigate how much barriers respondents faced while using ICT assistive technology and how ICT might become more easily adaptable to the requirements of individual users.

Puffelen (2009) in his study focused on the "Relationship between the ICT-related training offered to blind and visually impaired people and their actual, self-reported and demonstrated, competencies for online activities and information processing". Respondents were selected through the three national support organizations. The inclusion criteria were: a vision of < 0.3 and having received ICT training from these organizations in the past three years. All respondent's information was treated in accordance with the professional code of conduct for social researchers. Data was collected through telephone interviews with 142 respondents whose ages ranged from 55 to 87 and 73 young respondents with ages between 10 and 18 years. The result indicated remarkable differences between age groups in use, skills confidence and skills acquisition methods. The www is used by 97.3% of the young people against 71% of the elderly and the younger respondents perceived their skills, except for the use of email, higher than the elderly. The majority of the elderly respondents (71.4 %) learned to go online and using email from receiving computer training whereas 80.3% of the younger people learned these internet activities themselves.

Bocconi, et al. (2007) has conducted a study on "ICT educational tools and visually impaired students: different answers to different accessibility needs". They tackled the issue of the accessibility/usability of educational material by visually impaired students. While

examining a few educational products, the fact that different types of visual impairments have different needs and ask for different solutions has been underlined. A quick overview of the main provisions established by the Italian law in force has been taken and, as a result, it has been shown that they address a great majority of the needs of visually impaired users, establishing a significant number of "accessibility" features to be met. The idea of "usability" is, in fact, directly linked to the degree to which it "takes into account the human psychology and physiology of the users, and makes the process of using the system effective, efficient and satisfying". The finding of the study clearly revealed that that a great majority of the needs of visually impaired students is covered by the law provisions: alternative keyboard navigation is required in that it is essential for people with visual impairments who cannot fully rely on pointing devices such as a mouse ; the preservation of the basic accessibility features provided by operating systems is requested, including the maintenance of a number of features which are fundamental for low vision users such as the possibility of enlarging characters, reversing the color scheme, setting color brightness and contrast, increasing the contrast between text and background.

2.4.2. ICT Enabled and Assistive Devices for Persons with Hearing Impairment

Ali et al. (2013) in their study "Interactive Employment Model to Assimilate the Deaf persons in workplace by using ICT" aimed to induct the deaf persons in workplace by the use of Information and communication technology. This research work emphasis on the special need and training required for the deaf individuals and to make and train them how to move in workplace with different social and technical barrier. In recent era, technology play important role in each and every part of life. Using the facility of Information and Communication Technology deaf can be easily assimilated in workplace.

Valentine & Skelton (2008) in their study "Changing spaces: the role of the internet in shaping Deaf geographies; explored how Deaf people are using the internet to communicate with each other and, in doing so, to reflect upon how the internet is contributing to the re-specialization and scaling-up of this community while also having other unanticipated effects on Deaf people's mobility and the space of the Deaf club. The study draws on a research project involving both a scoping survey and qualitative interviews. The first stage involved a national survey of D/deaf and hard-of-hearing people which explored their access to, and use of, the internet, and collected data about the informants' Self-identifications and

preferred modes of communication. In order to reach this diverse population the survey was made available on-line through the research project's website. Information about the survey and how to access it was posted on 20 D/deaf-related websites and this information, as well as hard copies of the survey for non-internet users, were distributed to 174 Deaf clubs/organizations in the UK. The finding showed that ICT may in the longer term open up divisions within deaf worlds between those who have the skills and or other resources to use new technologies, and those who do not. If the internet is to fulfill its potential to bring Deaf and hearing people closer together there needs to be an integrated and comprehensive national response to the technology that genuinely incorporates the needs or preferences of sign language users into universal and affordable service. This would necessitate hearing people acknowledging the information and communication needs of deaf people not only on-line but also offline. Only then might ICT truly change the Deaf community's place in the world.

2.4.3. ICT Enabled and Assistive Devices for Persons with Locomotor Impairment

Lidstrom et al. (2012) studied the use of ICT in school: a comparison between students with and without physical disabilities. The aim of the study was to determine the information and communication technologies use in school activities of two groups of students with physical disabilities, comprised of those who did and those who did not use a computer based assistive technology device (ATD) and to make a comparison with students from the general population.

The method adopted for the study, was a cross-sectional survey about computer-based activities in school among students with physical disabilities (n = 287); including those who used (n =127) and those who did not use (n = 160) a computer-based ATD in school (mean age 13 years 6 months). Group comparisons were made with students from the general population (n = 940).

The results showed that the most frequent computer users were students with physical disabilities, who used a computer-based ATD daily. However, when considered as a group, students with physical disabilities used the computer for less varied educational activities than the reference group. The researcher concludes that, regardless of whether they use a computer-based ATD or not, students with a physical disability have restricted participation in some computer-based educational activities in comparison to students from the general

population. An individual plan could be beneficial for each student to: focus on the aim of the computer use; examine the students' needs in terms of computer-based ATDs and their inclusion in education; and ensure that the students' digital skills are fully utilized.

Anderberg & Jonsson (2005) in their study examined the use of the Internet as experienced by people with significant mobility or physical impairments who are accustomed to using computers. A total of 22 people were interviewed, eight women and 14 men, ranging in age from 25 to 60. Pseudonyms have been used to ensure anonymity. All of the informants have mobility impairments and all are experienced in using computers and the Internet in their everyday work and for personal purposes. Nineteen of them require personal assistance (PA) from seven to 24 hours a day. Participants were invited to take part in a face-to-face interview or an online interview conducted via MSN (Microsoft Network) Messenger. Fifteen of the informants chose a face-to-face interview and the remaining seven the MSN Messenger option. In the latter group, four of the informants had spoken language impairments as well, and three preferred Messenger because of geographical distance. It was found that the lives of people who are already there, taking full advantage of the online independence, learning and communications opportunities, an overall picture emerges of how computers and the Internet can have an even greater impact on the lives of people with mobility or physical impairments than many of the initial predictions foresaw.

Bowker & Tuffin (2002) focused on **"**Disability discourses for online identities". The study offers an analysis of talk situated in a cultural world which disabled people access when they participate in online conversations. Participants were recruited from various disability organizations in New Zealand and were invited to take part in an online interview. Fifteen participants with physical and sensory impairments, ranging in age from 30 to 59 years, were interviewed. Physical impairments incorporated ataxia, cerebral palsy, brain injury, post-polio syndrome and terminal illness, while sensory impairments included blindness and visual impairment. Participants were engaged in the following occupations: lecturer, researcher, legal advisor, chief executive officer, company director, consultant, librarian, student, receptionist, counselor, copy-typist, apprentice carpenter, pastor and an early childhood carer. The finding of the study highlighted how disabled people valued (albeit temporarily) leaving impairment out of the dynamics of social interaction. This was a choice they made very willingly. Moreover, the ability to engage in interaction without impairment

was conceptualized in very positive terms. Contrasts between on- and offline contexts showed that disabled people were not afforded access to a non-disabled subjectivity in face-to-face settings. Engaging in an identity removed from impairment outside of face-to-face encounters was therefore justified.

2.5. ASSESSMENT OF UTILIZATION OF ICT ENABLED AND ASSISTIVE DEVICES FOR DIFFERENTLY ABLED

2.5.1. Access to Technology

Stendal (2012) examined how do people with disability use and experience virtual worlds and ICT: A literature review and highlighted that one of the challenges for people with disability is access to technology, which is found in the cross-section between VWs (Virtual Words) and ICT. A digital divide is present in some countries, and affects people with disability. Access to technology is proving to be of value for people with disability, but lack of access may mean this group is not being able to take advantage of the values technology offer. Ways to ensure access and availability of technology for people with disability warrants research. The statistics on world internet use show only 30.2% of the world population uses the internet. Only 54 % of Americans living with a disability use the internet and only 41% of the same group has broadband at home. Such figures indicate there is still a way to go in this area.

2.5.2. Technology and its Significance for Differently Abled

Hersh (2014) in his study, evaluating ICT based learning technologies for disabled people and discussed the need for an evaluation framework specifically for (ICT-based) learning technologies for disabled learners and demonstrates the limitations of existing approaches based on the evaluation of assistive technology or learning technologies for non-disabled learners. Thus, quality of life approaches may evaluate how useful blind and dyslexic people or a particular blind or dyslexic person finds having a screen reader rather than what they think of a particular screen reader. The importance of learning (and any other applications they are using the technology for) to the particular disabled individual will also make a significant contribution to quality of life based evaluations. While there are general principles that hold for all types of evaluation, this is not the case for the details of evaluation. Thus, different approaches are required for, for instance, a manual wheelchair or

long-handled gardening tool and a screen-reader accessible foreign language dictionary or online vocational training tests designed for unemployed physically disabled adults.

Singh (2013). ICT provides a basket of rapidly evolving technologies like desktop, notebook, handheld computers, LAN, Bluetooth, Internet and of late cloud computing. Other applications are streaming videos, CDs, DVDs, word processors, spreadsheets, e-mail, videoconferencing, etc. Development of wireless technologies like Bluetooth using infrared links make it possible for a disabled user to learn and communicate with the external world. All these tools support the PWDs resulting in learning and capacity building. Moreover, it has a vital role in communicating with peers, promoting concerted and social learning environment.

Fichten et al. (2012) explored ICT related needs of students with different disabilities are being met on campus at institutions of higher education, at home and in e-learning contexts. They also explored the disciplines and programs pursued by students with different disabilities and the specialized ICTs they use. A total of 1,354 Canadian university and junior/community college students with various disabilities were taken. It was found that Post-secondary students often have several disabilities which may affect how easily they can use ICTs. Students' disabilities also influenced the specialized ICTs they use and how well their ICT-related needs are being met. The result of study clearly indicated that, overall, student's ICT-related needs are generally well met, the results also show that these are better met on campus than at home, and at colleges than at universities. This is not related to institution size or to students' disciplines.

Liu et al. (2007) in their study, ICT and Special Educational Needs: Using Meta-synthesis for Bridging the Multifaceted Divide, elicit some critical views on how the applications of information communication technology (ICT) can be approached for people with special educational needs (SEN). The findings of this study is based on a number of concrete case studies and it clearly confirms that, despite of the huge research and developmental effort having been made for advancing ICT applications in education, ICT as a whole is surprisingly lacking a systematic discourse with educational domains, even much less concerning those who have learning difficulties. Whilst well known technical tools such as word-processors, screen-reading software and problem-solving software packages still provide useful "snapshots" of ICT applications from particular points in time and they

argued that these pictures now require updating. They suggested enabling the ICT development crossing multi-disciplinary boundaries; a meta-synthesis approach is innovated. The approach consists of four inter-operated components through ICT, i.e., assistive, sensory, communicative and interactive component.

2.5.3. Extent of Usage of ICT Enabled Devices by Differently Abled

Martinez (2011) in his study disability and the use of ICT in education: do students with special needs recognize the support given by teachers when using technology, analyzed the availability of the necessary resources to these students, checked the usage of the available technology and examined up to what point the students recognize the support of the teachers using information and communication technologies (ICTs) to help them succeed in their studies. In the present study 37 students with special needs participated coming from a secondary school in Alicante (n=18) and from the University of Alicante (n=19). Self-made- questionnaire was prepared to investigate the use, experience and recognition of the support given by the teachers using ICT with these students. The study is based on a quasi-experimental basis as had control of the type of participants. Also, the study was not done at random as the students belonged to a specific context and were grouped according to the type of educational course. Data were analyzed using frequencies, percentages and descriptions of the study in each of the variables (mean and typical deviations). Descriptive analysis was performed on these frequencies and valid percentages. Researcher also carried out different multivariate analysis of co-variance (MANCOVA) according to the independent variables of the educational course (secondary school or University) matching this to the type of special needs (physical, psychological, visual or auditory) with the gender used as a co-variant to control its effect. The results indicated that these students felt ready to use the technology resources in their studies. However, they did not receive support by the teachers and they noticed differences in approach, depending on the stage of the educational course and the type of disability.

Vicente & Lopez (2010) conducted a study on "A Multidimensional Analysis of the Disability Digital Divide: Some Evidence for Internet use to Examine the Internet Digital Divide Between People With and Without Disabilities from A Multidimensional Approach". They found that lower level of use among those with disabilities is largely explained by the fact that for many of them Internet use is beyond their means. As the study indicate that

disabled community is generally poorer than the general population but even among individuals with the same income level, many people with disabilities are still less likely to use the Internet because they have to incur the extra costs of the adaptive technology for accessing the Internet. In the present study, the researcher used data come from the publicly available data set of the project e user (2005), funded by the European Commission's Information Society Technology (IST) program. Our analysis is a secondary analysis of this data set. Therefore, the process of making the Internet accessible has taken a great deal of time, and it is clearly unfinished work. Although accessibility has been on the European agenda since 2000, the EU has failed to make laws that ensure accessibility.

Jagannathan et al. (2008) in their study "ICT for Physically Challenged Persons had analyzed how ICT can meet requirements of education and employment of physically challenged people".

People with visual disabilities in this study are individuals who are blind, have low vision, or have color blindness. They found that People who are blind need text equivalents for the images used on the Web page, because neither they nor the assistive screen reader technology can obtain information from an image. A person who has a visual disability will not find the mouse useful because it requires hand and eye coordination. People with color blindness or those with low vision need good contrasting colors to be used in design or an alternate attribute of information being presented. As far as mobility impaired people are concerned they have physical impairments that substantially limit movement and fine motor controls, such as lifting, walking, and typing. Mobility impaired individuals experience difficulties in using the computer's input devices and in handling storage media. Such people need devices for mobility, control and manipulation and alternate input devices on Computers. The study also focused on people who are deaf or hard of hearing and they require visual representations of auditory information that a Website can provides. Solutions for these disabilities include closed captioning, blinking error messages, and transcripts of the spoken audio. The primary concern is to ensure that audio output information is provided in a redundant equivalent visual form.

Dobransky & Hargittai (2006) conducted a study on the disability divide in internet access and use with certain objectives as to identify the extent to which people with disabilities are embracing use of the Internet; how their use of the Internet compares with the Internet uses

of the rest of the population; how having a disability relates to and interacts with other social statuses (e.g. socioeconomic status, age, gender) with regard to Internet use; and what explains these trends. They used data from the Computer and Internet Use Supplement (CIUS) of the Current Population Survey (CPS) administered in October 2003 by the US Bureau of Labor Statistics and the Bureau of the Census (NTIA, 2004). This data set is particularly well suited to answer the questions of interest presented in this paper. First, the data set is administered on a large number of respondents randomly sampled from the American population. Second, the survey collected detailed information about people's computer and Internet uses. Third, the survey asked respondents to identify whether they have any one of five long-lasting physical disabilities. The finding of the study demonstrated that there is, indeed, a disability divide that needs to be taken into consideration when discussing digital inequality. Whether it is in terms of access to or use of computers and the Internet, many people with disabilities lag behind those without such impairments. However, the relationship of disability status with ICT uses is not universal regardless of type of impairment, highlighting the importance of more nuanced measures and a focus on the specifics of people's conditions. The outcome of the study clearly revealed that people with disabilities are less likely to live in households with computers, are less likely to use computers and are less likely to be online. However, once socioeconomic background is controlled for, it is found that people with hearing disabilities and those who have limited walking ability are not less likely to be Internet users. This research enables a deeper understanding of both the use of the Internet by people with disabilities and the spread of new IT more generally. Future scope for data collection efforts should try to disaggregate categories and studies should be mindful of the divergent situations faced by people living with different disabilities.

2.6. BARRIERS IN THE USAGE OF ICT AND ASSISTIVE DEVICES FACED BY DIFFERENTLY ABLED

Ashraf & Raza (2013) conducted the study on **"**Heuristic Evaluation of Social Websites: For Blind People". The study aims to identify different usability problems of social websites from the perspective of blind people. The survey was conducted in different universities of Pakistan. Comparative analysis of YouTube and Facebook applications for blind people has been presented in the paper. The participants were free to use websites for one hour; to make

them more familiar with the usability issues. Two questionnaires were prepared against each website. Soft copies of two questionnaires were provided to each visually challenged people. The finding of the study highlights the usability issues of two commonly used websites. It has been clearly found that heuristics are the key attribute of software applications and also a good parameter for measuring usability. This paper addresses the social networks usability problems and their evaluation by choosing Jakob Nielsen's ten Heuristics. There is an analysis to improve usability of social websites, by evaluation, comparison and questionnaire results.

Internetsociety.org (2012). Persons with disabilities face as many different barriers as there are types and degrees of disability. For example, people with a visual impairment who use screen-reading software may be confronted by websites that have confusing navigation, or that lack descriptions of images; while people with a hearing impairment may be unable to participate in online conferencing because it lacks captioning. Through removing barriers, persons with disabilities will be better able to use and contribute to the richness of the Internet by participating independently in the communities of their choice. While making websites accessible is vital, solutions for accessibility are needed to deliver any product or service over the Internet and to accept content or services created by persons with disabilities regardless of the equipment or medium of input. This includes websites, databases, browsers, multimedia applications, mobile phones, computers and their auxiliary equipment. Changing peoples' attitudes to disability is fundamental to achieving greater accessibility. The traditional view of disability is through the medical model that is, attempting to "fix" or rehabilitate a person to society's norms. The social model of disability aims to dismantle barriers so that a person with a disability can fully participate in the community. This more contemporary model emphasizes a person's abilities rather than disabilities and encourages a person's independence and capacity by decreasing environmental barriers.

Mishra et al. (2012) conducted a study on **"**ICT as a Tool for Teaching and Learning in Respect of Learner with Disability" and found that due to different kind of limitations, disabled people may not be able to use ICT applications and devices with ease, as it may be used by others. Some of the difficulties which are generally faced by different types of a disabled are:

- A physical impaired user may have difficulties in using input devices.
- A visual impaired user may have difficulties in seeing display devices.
- A hearing impaired user may have difficulties in hearing audio information.
- A person with learning or cognitive disability may have problem in understanding system operations.

To solve above mentioned problems assistive technologies are used. Some of the assistive technologies such as touch screen interface can be beneficial to those who have difficulty in using input devices such as a mouse or keyboard. When it is used in combination with software such as on-screen keyboards, or other assistive technology, they make computing facility more accessible to people who are having difficulty in using computers. ICT usually improves the efficiency and effectiveness of a common individual learner, but for a disabled learner it represents more than this. ICT for them is a sort of extension of their physical body part and provides an opportunity to communicate, gain access to education services and become gainfully employed.

Fuglerud (2011) in his research a study on the barriers to and benefits of use of ICT for people with visual impairment, conducted a focus group interview and a field study, which includes 28 visually impaired PC users in Norway. The main goal of the study was to identify benefits of, and barriers to, use of ICT for the visually impaired, and to propose measures to remove barriers.

The researcher utilized a broad and exploratory approach in which several qualitative methods were combined; namely a focus group interview and a field study with 28 visually impaired PC users. This approach would give the possibility to go in-depth on the experiences and individual challenges of the participants' everyday life, and also the possibility to bring to light issues and topics that were not known in advance. The use of Internet services, mobile phones, kiosks, ticket machines, ATMs, and queuing management systems, were studied. The analysis revealed that several commonly used ICT services, such as online banking, electronic forms, and learning material have major accessibility problems. The first barrier is often mechanisms for registration and authentication.

D'Aubin (2007) in their study, "Working for Barrier Removal in the ICT area: Creating a more accessible and inclusive Canada" with the objective to access the information and

Communications Technologies (ICT) used by the Council of Canadians with Disabilities (CCD).

The Council of Canadians with Disabilities sees regulation in ICT, reflecting existing human rights commitments, as the most effective way forward in ensuring access and inclusion in information technologies. The researcher stated that people with disabilities are not able to use the most significant vehicles of change in our society, and creates for them exclusion and segregation instead of participation as full citizens.

Brodin & Lindstrand (2003) in their study, "What about ICT in Special Education; special educators evaluate Information and Communication Technology as a learning tool" focused on special educators working with children with disabilities and in need of special support and their relation to information and communication technology (ICT). The study is intended to evaluate National State Programme and to train special educators in the field of ICT. The training programme focused on difficulties in reading and writing, although most of the teachers desired a more general knowledge about children with disabilities. The study was carried out partly through a questionnaire and partly through interviews with special educators and head teachers. A total of 1,350 questionnaires were distributed to 21 counties in Sweden. As the study aims to evaluate ITiS in-service training for special educators, who work as consultants with teachers working with pupils who have disabilities and children in need of special support, the author obtained a deepened comprehension of educators' understanding of ICT and they carried out randomly selected interviews with 20 special educators and 10 head teachers geographically spread over the country. The result of the study clearly showed that majority of the participants in this study believes that ICT is a useful tool to compensate for functional obstacles or certain learning difficulties. It was also found that there is a great need of education in the ICT field and that the lack of time and financial resources affect the work in the school. It was also appeared that the knowledge within this area of special education is mainly based on how these practitioners understand their own work. New thinking and innovations in the area are judged, accepted or rejected on the same basis. The head teachers lacked knowledge about the training and were not engaged in this special effort, although they are responsible for the development of the school.

Dickinson et al. (2002) tried to develop a highly configurable word processing environment by using what they called a pragmatic, obstacle-by-obstacle approach to alleviating some of the visual problems encountered by dyslexic computer users. They counted eleven visual difficulties associated with dyslexia such as short memory, pattern glare, motor control, spell checking, visual memory, word recognition, poor comprehension, and letter reversals. Their paper described the current version of the software and the development methodology, as well as the results of a pilot study which indicated that visual environment individually configured using the See Word software improved reading accuracy as well as subjectively rated reading comfort.

They altered several features of the visual environment of the software including spacing, font, synthesized speech, and character typeface among others.

Abbott and Cribb (2001) in their study aimed to establish the extent of internet use among special schools and PRUs in England and Wales. One of the objectives of the project was to find out the factors which might have hindered or encouraged the use of the web in these institutions, especially with regard to the creation of homepages or sites for the school or unit. The first aim of the survey was to establish the rate of internet access among these institutions before the arrival of the standard fund equipment. It was suggested that well over 90 per cent of secondary schools and possibly 50 per cent of primary schools had at least one Internet-connected computer by late 1997. In special schools and PRUs, the survey returns showed that only 25 per cent of institutions had an internet connection at the time. A total of 2.4 per cent only had access through a staff member's individual accounts. Only 3 per cent of the institutions returning the survey had created an institution web site. Where schools did not have internet access, their reasons varied but were usually related to cost (45 per cent), lack of equipment (60 per cent). Very few (6 per cent) saw no advantage at all in internet access and 5 per cent reported that staff attitude was obstructive to development in this area. The survey indicated related neglect in the area of development of ICT in special education in the past that appears to be continuing, at least in some parts of the country, despite significant new funding from government and local authorities. Besides the survey, four institutions were selected as case studies for interview. Interviews indicated the possibility of using ICT to bolster identity, reduce isolation, and bring the special skills to these schools and units to the mainstream community, an activity which would be of mutual

benefit. The case studies also illustrated many obstacles, technical as well as ideological, which may prevent positive developments.

2.7. CUSTOMIZATION OF ICT AND ASSISTIVE DEVICES FOR DIFFERENTLY ABLED

2.7.1. Accessibility

Internetsociety.org (2012). For persons with disabilities, accessibility means being able to use a product or service as effectively as a person without a disability. This means using inclusive design principles to make products and services usable by a wider section of the population. In some cases, this is not possible, and assistive technologies may be called upon to fill the gap. If so, mainstream technologies should enable the software or hardware connection of the assistive device seamlessly, in terms of both interoperability and data portability.

2.7.2. Technology

The term technology indicates not just physical objects – devices or equipment; more generally it refers to products, organizational set-ups or 'ways of doing things' that encapsulate a number of technical principles and components. The adjective assistive is applied to a technology when used to compensate for functional limitations, to facilitate independent living, to enable the elderly and people with disabilities to realize their potential to the full. The abbreviation AT will be used in the Module, therefore, must be read as assistive technology products or services **(UNESCO, 2006).**

2.7.3. Assistive Technology

Assistive technology is defined in this report as any equipment or system that assists people who have difficulties, due to age or disability, in carrying out everyday activities. **The Foundation for Assistive Technology (FAST)** uses a similar definition: "a product or service that enables independence for older or disabled people" **(FAST, 2001).**

Assistive technology is coming to be the preferred term for all such devices rather than "disability equipment" or "technical aids". It covers simple items such as walking sticks, bath seats and grab rails, as well as electro-mechanical equipment (e.g. powered wheelchairs), electronic aids (e.g. digital hearing aids and environmental controls), or equipment used by carers such as lifting aids**(Curry et al., 2002).**

In education, the technology supporting and helping students with disabilities increasingly implies computer-related applications. Information and communication technologies have expanded the Assistive Technology field to new dimensions, opening new doors, broadening horizons and enabling autonomy for many individuals with special needs. Over the last few years, the computer has turned into a valuable resource for teaching students with an ample range of learning difficulties. Rapidly grown processing power has let manufacturers provide sophisticated hardware and software to get the access and meet the learning needs. The Assistive Technology applied in education enable students with disabilities to exploit their cognitive potential, to interact with others, and to control certain aspects of their environment. Assistive Technology gives the opportunities to access the curriculum at the adequate level, providing facilities as well as incentives for learning. Using the right Assistive Technology device, suitable software, and appropriate educational methodology, children who can't hold a pencil can nevertheless draw and write, for example. Similarly, children unable to speak can use the computer as a communication tool **(UNESCO, 2006).**

2.7.4. Assistive Technology as an Instrument of Differently Abled

Alkahtani (2013) conducted a study on "Teacher's Knowledge and Use of Assistive Technology for Students with Special Educational Needs" to gather information about assistive technology knowledge and skills among teachers. He adopted mainly a quantitative approach supplemented with qualitative interviews in the study. Data were primarily collected through questionnaire survey. A two part self reporting questionnaire was distributed utilizing web-based technology via online survey website (Surveymonkey.com). A total of 127 participants responded to the online survey. Participants were from different geographical region. Quantitative data gathered from the questionnaire were analyzed using a computer statistical software program, Statistical Package for the Social Sciences (SPSS). Results indicated that the vast majority of responding teachers 93.7% (*n*=119) do not use or request assistive technology evaluation for their student. Nearly 94% (*n*=119) of the participants had not considered assistive technology when planning student's IEP. Ninety-one and three-tenths percent (*n*=116) of the participants reported that assistive technology was not available to be used in their schools. Thus, results suggested that teachers do not have adequate level of knowledge and skills of using assistive technology. Teachers, then, should have pre-service and in-service training to increase their overall knowledge of

implementing assistive technology and using universal design for learning for students with disabilities.

Lucky and Achebe (2013) described the assistive technology for persons with visual impairment include:

- **Screen reader:** Software program that works in conjunction with a speech synthesizer to provide verbalization of everything on the screen including menus, text and punctuation. It gives persons with visual impairment direct access to the world of print. It also creates independence in reading to the visually impaired. It helps a blind person to read freely at his/her own pace without assistance.
- **Braille translation software:** Translate text and formatting into appropriate Braille characters and formatting.
- **Braille writing equipment:** Used for creation of paper Braille materials; it can be manual or electron devices.
- **Closed circuit television:** Magnify a printed page through the use of a special television camera with a zoom lens and displays the image on a monitor.
- **Braille embosser:** A Braille printer that embosser's computer-generated text as Braille on paper.
- **Scanners:** Device that convert an image from a printed page to a computer file. Optical Character Recognition (OCR) software makes the resulting complete file capable of being edited. With the help of ICT, the visually impaired have been rendered special attention to fully participate in the world by providing them with best possible support necessary to bridge gaps between accessibility and literacy. More importantly, careers in science are now within the reach of the visually impaired and some of them have become successful in many scientific fields, including engineering, physics and chemistry.

Sugano et al. (2013) in their study 'Speech Training System for Hearing Impaired Children uses voice recognition software' described speech training system called Speech Trainer using personal computer. The system gives the characteristics of trainer's voice on CRT display and has some functions such as vowel training using fundamental frequency, articulation training using vocal tract shape and so on. Speech training system has many functions as vowel training, consonant training, spoken word training, pitch accent of speech

signal, stress accent of speech signal, intonation training, three dimensional displays of spectra, a kind of game using the fundamental frequency and music training. In the last researcher suggested such a system must have the function by which children can see the training result.

Singh, (2013) in his study "Exploiting ICT for Empowering People with Disabilities (PWDs)" mentioned some Assistive Technology Software used with Internet on computers and mobile phones offer incredible scope to bridge the digital divide, especially for PWDs living in secluded and rural areas. These assistive technologies are given below:

- **Window-Eyes:** powerful screen reader tool that gives total control over what one hears; also provides enhanced Braille support.
- **JAWS:** accessibility solution for visually impaired; reads information on computer screen using synthesized speech. It has a refreshable Braille display. It can be customized as per individual needs and preferences.
- **TOBII Eye Tracking System:** specialized eye tracking and eye control technology that makes it possible for computer to know exactly where users are looking.
- **I Communicator:** assistive tool for people with hearing impairments that assists in dependent communication for persons who are deaf or hard-of hearing; translates contents in real-time.
- **Head- Mouse Extreme:** this replaces the standard computer mouse for people who cannot use or have limited use of their hands when controlling a computer or augmentative communication devices. It is extremely useful for physically challenged suffering with arthritis or spinal cord injury.
- **Text Help System:** provides literacy software solutions that assist those with literacy difficulties, learning disabilities such as dyslexia or mild visual impairments.

Mathur (2011) explored ICT services for disabled Students: Indian Context. He pointed out some ICT tools are given below:

- **Computer Access Aids:** Hardware and software products that enable persons with disabilities to access, interact with, and use computers at home, work or school. It includes modified or alternate keyboards, switches activated by pressure, touch screens, special software, voice to text software, etc. Common sub-categories are:

- **Alternative Input Devices:** Includes alternative and adaptive keyboards, expanded keyboards, key guards, alternative and ergonomic mouse/pointing systems, head-operated pointing devices, Eye glaze pointing devices, mouth/tongue pointing devices, Morse code input devices, brain-actuated pointing devices, switches, touch screens, voice input systems, speech-to-text software, voice recognition/voice command software, dictation software, on-screen keyboards, cursor enlargement software, ergonomic computer-based equipment, etc.
- **Alternative Output Devices:** Computer-based output devices that generally enable Blind and Vision impaired persons to use or interact with a computer. This includes Braille display/output devices, Braille embosser/printers, screen reading software, screen magnification/enlargement software, large print monitor, etc.
- **Accessible Software:** Includes software applications adapted for children and adults with disabilities, operating system accessibility options, accessible web browsers, etc.

Burton et al. (2008) explored computer related assistive technology among persons with disabilities. The specific focus of this exploratory study was to assess the experiences, opinions and satisfaction levels of 24 individuals with disabilities using of computer-related ATD (Assistive Technology Device); to investigate their awareness of health risk factors related to computer usage; and to examine the psychosocial impact of computer-related ATD on users. Data were collected via telephone interviews with 24 individuals with physical disabilities who had experience using one or more ATD. The Quebec User Evaluation with Assistive Technology (QUEST) instrument was used to evaluate users' satisfaction with ATDs in a number of dimensions, including their physical attributes. It was found that training appeared to be an important component for ATD users, many of whom preferred a setting to try out devices rather than group or individual training. Respondents with visual impairments revealed a higher level of adaptability versus those without visual impairments (p=.001). Additional research is needed in developing specific survey items focused on users of computer-related ATDs and the evaluation of the psychosocial impact of ATDs on computer users.

2.7.5. Smart Cane for Visually Impaired

Sheth et al., (2014) have developed a "Smart White Cane – An Elegant and Economic Walking Aid" for visually impaired people. The main purpose of this research was to provide a simple, affordable yet an efficient solution for the visually impaired. The idea behind the design of the stick was to keep it structurally similar i.e. thin, lightweight and easy to handle, yet give an active feedback to the user regarding hazards in his walking path. The smart white cane uses the ultrasonic sensors arranged in such a way that it detects pits, potholes, downfalls, a staircase (up and down), low lying and knee level obstacles and even those above the waist. The author conclude that this device is a practically feasible product and convenient to carry around like any other walking stick. This could also be considered a crude way of giving the blind a sense of vision. This also reduces the dependency on other family members, friends and guidance dogs while walking around. It can serve as a benchmark in aid for the blind like crutches are for the paraplegic.

Saksham Trust (2012). Smart cane device is an electronic travel aid which fits as handle of the white cane. As white cane can only detect obstacles up to knee height, Smart cane compliments its functionality by detecting obstacles from knee to head height. It detects obstacles using sonic waves and the presence of obstacles is conveyed through intuitive vibratory patterns. It is powered using rechargeable Li–ion battery like cell phone and can be used in both indoor and outdoor navigation modes. It has been designed to accommodate varying types of user grips which are commonly used by visually challenged. Smart cane users have found that it is an extremely useful device in detecting different types of obstacles such as tree branches, side of a truck, hanging cloth strings, protruding equipment from walls of an office corridor such as air conditioners, railings, construction equipment and accessories. In other words it helps users to navigate independently without sighted assistance even in unstructured environments. Many users found it extremely useful in avoiding awkward collisions, way finding in narrow pathways and even to detect movements of human beings and animals.

Nassih et al., (2012) have developed "Obstacles Recognition System for the Blind People Using RFID (Radio frequency Identification)". This device is in the form of a tactile interface which has a system made of a wearable computer and two Finger- Braille interfaces linked via wireless communication using two Linux-based wristwatch computers

that communicate via a Bluetooth communication. On the other hand, the positioning system is based on RFID tags distributed on the ground. The Braille handle on the cane will allow the blind person to read - by touching - the information that was retrieved from the tag reader and to display it in the form of braille lines that the person will be able to touch and read. The cane used in this system is the one currently available in its specific market and that is commonly used by the visually impaired people. It has an RFID tag reader on the cane and a braille interface so the blind person can use it. However, the addition proposed consists on the incorporation of a mechanical battery that will enable the cane to always have a full battery which will avoid its users to run out of battery while using it. The proposed system would be powered by a battery that needs to be changed frequently. The innovation added to the current system consists on coming up with a technique that will prevent the user from recharging the battery every time and worrying about its lifetime while using it. The idea is to make to battery an autonomous component of the cane. The additional feature that had to be implemented concerns the battery. The cane and its wiring are complicated, and changing the battery can be difficult; especially if it dies at a critical moment. The proposed solution consists on installing an alternative method that will enable everyone to use the cane without worrying about its battery life. The added value to the smart cane relates to the installation of the same mechanical system that is deployed on wind-up watches. There would be an oscillating weight that will move at the slightest motion of wrist, and this motion will be amplified and transferred to the rotor. This same rotor charges the oscillating weight by magnetism effect which is caused by a rotor and then converted by a small generator to electricity that will be stored in a capacitor. Then, a smart chip regulates the quantity of energy that should be released in the circuitry to make the watch work. The developed prototype is user-friendly and cost efficient, though its difficulty in implementation; it is seen as an outstanding improvement in the field of blind recognition systems, thanks to its durability, user-friendliness, and cost benefit. In addition to that, the use of Braille in the cane's grid is considered as an assistive Technology and Universal Design for learning.

Balakrishnan & Rao, (2011) have developed smart cane for visually impaired and stated that it is an innovative device that can be mounted onto a traditional white cane. The device uses ultrasonic sensors to detect obstacles at up to three meters. The range of the detected

obstacles is conveyed to the user using vibratory signals with differentiated characteristics. It is designed as a user-detachable unit and is powered by a rechargeable lithium-ion battery, such as those commonly found in mobile phones and digital cameras.

Wahab et al., (2011) in their study "Smart Cane: Assistive Cane for Visually Impaired People" aimed to produce a prototype that can detect objects or obstacles in front of users and feeds warning back, in the forms of voice messages and vibration, to users. They stated that invention of smart cane resembles Guide Cane where this invention has a number of ultrasonic sensors and servo motors. This invention is designed with the aim at helping the blind in navigating. Ultrasonic sensors need to detect and avoid obstacles or objects located in front of the user. Meanwhile the fuzzy controller is required to determine the instructions that will be executed for example to turn right, left or stop. Like Guide Cane, this invention also has a control button on the handle, and the button has four different directions. This invention has the same weaknesses as the Guide Cane where there will be a problem to save space or to place the smart cane. Besides that, cost is also a weakness in this project as it uses ultrasonic sensors and a number of servo motors. If the cost is too high, users are not able to afford for it because the average income of the visually-impaired people is relatively small.

Singh et al. (2010) have conducted a study on "'Smart Cane for the Visually Impaired: Design and Controlled Field Testing of an Affordable Obstacle Detection System". In this study researcher developed an Electronic Travel Aid for visually impaired persons to enhance obstacle detection. They developed a navigation aid called smart cane that detects hazardous raised obstacles and increases detection range to 3m, thereby improving safety for the blind user. The developed Smart Cane employs directional ultrasound based ranging to detect obstacles in front or above knee-height within a range of 3m. Distance information is conveyed through patterns of vibration that vary incrementally with changing obstacle distance; hence the Smart cane can also be used by deaf-blind individuals. The device operates in two user-selectable modes: (i) Short Range Mode (<1m): Useful while navigating within a room and (ii) Long Range Mode (<3m): Used outdoors e.g. roads, parks etc. Detection and warning of fast-approaching obstacles, like vehicles, within 3m allowing time for a reflex action instead of being hit unwarned. The system is powered by rechargeable Li-ion battery which can be charged like a cell phone. This eliminates the

inconvenience of opening the battery pack to replace batteries and dependence on others to procure batteries from a store. Once fully charged, the batteries last at least 4 days of device usage after which a recharge is indicated through a beep pattern. Formal quantitative controlled trials with 28 users on 4 challenging obstacle courses possessing commonly encountered obstacles demonstrate (a) a 57.2 ± 4.1% increase in obstacle awareness, (b) a 91.6 ± 4.1% reduction in collision-risk and (c) a 2.61 fold increase in the average of obstacle detection distances with the Smart Cane over the traditional cane. The system reduces dependence on sighted assistance, improves independent mobility and paves the way for affordable electronic travel aids for the visually challenged particularly in developing countries.

MacNamara & Lacey (2000) in their study "A Smart Walker for the Frail Visually Impaired" tried to describe the design of a smart mobility aid for frail, visually impaired people. The device is based on the concept of a walker or rollator. They stated that frail visually impaired have extreme difficulty using conventional mobility aids such as guide dogs or long canes. The purpose of this study was to design an aid that would increase the independent mobility of people with both a visual impairment and mobility impairment. The mechanical design of the device is very similar to that of a conventional walker with a few important distinctions. The two castor wheels at the front of the walker have been replaced by two wheels with zero offset and are controlled independently by two separate motors. The motors are solely for adjusting the steering angle of the device, they do not in any way propel the device. The device has two modes of operation – manual and assistive. In manual mode, the user has complete control of the steering. The device will issue the user with voice messages giving the user information regarding the state of the environment but will not assume control of the device from the user. In assistive mode, the device controls the steering and will servo around obstacles while attempting to maintain the user's goal direction. Again, voice messages are given to the user with information pertaining to the immediate environment, If there exists a number of possible directions to take, the user can signal the direction in which he intends to travel (left, right, straight-ahead) by turning the handlebar in the appropriate direction. A ring of sonars was maintained on the walker for sensor redundancy. A user interface was developed which was both simple and intuitive to use. It allowed the users to maneuver out of difficult situations in manual mode and was

very robust to error in assistive mode where the user would use the interface to indicate intended direction. The PAM-AID (Personal Adaptive Mobility Aid) was evaluated on-site on twelve people (all female), all registered as visually impaired. The average age of the test participants was 79 years. They were all resident in a home for visually impaired persons. They suffered from a variety of other physical problems - 5 had painful arthritis, particularly of the knees, hips, ankles and hands, **3** were very frail and 2 had balance problems. After testing the device, the users were questioned on its performance. The results are summarized in the table below. The results were compiled using a ***5*** point likert scale.

CHAPTER-3 METHODOLOGY

The present chapter deals with the methodology adopted by the researcher for the study. Detailed account of methodology in the present investigation has been distinctly covered in this chapter. A systematic methodology is an important step to any research because it directly influences the validity of the research findings. This chapter precisely describes the methodological tools and instruments adopted in conducting the research.

The materials and methodological steps incorporated to carry out the study on **"A Study on ICT Enabled Devices for Differently Abled: An Exploratory Research"** have been broadly classified under the following subheads:-

3.1. Research Design

3.2. Phase wise work plan

3.3. Inclusion and exclusion criteria

3.4. Locale of the study

3.5. Sample selection

3.6. Sampling Design/ Sampling Distribution

3.7. Market Survey

3.8. Institutional Survey

3.9. Pilot Study

3.10. Tool Development

3.11. Standardization of scale

- **3.11.1. Description of the scale**
- **3.11.2. Development of scale**
- **3.11.3. Validity: Item analysis**
- **3.11.4. Reliability**

3.12. Description of finalized scale

3.13. Assessment of use of ICT and assistive devices by differently abled

- **3.13.1. Data Collection**
- **3.13.2. Variables**
  - **3.13.2.1. Independent Variables**
  - **3.13.2.2. Dependent Variables**
- **3.13.3. Data Analysis**

3.14. Design of the prototype

3.15. Testing of the prototype

3.16. Conceptual framework of the study

3.17. Operational definitions of the terms of research

3.1 RESEARCH DESIGN

A research design is a plan, structure and strategy of investigation so conceived as to obtain answers to research questions or problem. The plan is the complete scheme or program of the research. It includes an outline of what the investigator would do from writing the hypothesis and their operational implications to the final analysis of the data.

Research design is defined as the detailed blue print which guides a research study towards its objectives. Research design is a logical task undertaken to ensure that the evidence collected to enable to answer the questions or to test theories as unambiguously as possible.

For the present study exploratory cum experimental research design was adopted to study the usage of ICT enabled and assistive devices by differently abled. In the current research, exploratory research design deals with usage and purpose of ICT and assistive devices and barriers faced by differently abled in using these devices. On the other hand, experimental research design is concerned with development and customization of identified device.

Exploratory Research is research conducted for a problem that has not been clearly defined. It often occurs before we know enough to make conceptual distinctions or to posit an explanatory relationship. Exploratory research develops concepts more clearly, established priorities, develops operational definitions and improve the final research design. Exploratory research helps determine the best research design, data-collection method and selection of subjects. It should draw definitive conclusions only with extreme caution. Given its fundamental nature, exploratory research often concludes that a perceived problem does not actually exist **(Shields, 2013).** Experimental Research has a control group, the subjects have been randomly assigned between the groups, and the researcher only tests one effect at a time. A very wide definition of experimental research, or a quasi experiment, is research where the scientist actively influences something to observe the consequences **(Blakstad , 2008).**

3.2. PHASE WISE WORK PLAN

The investigation was carried out in the following phases:

Phase I: Exploration of ICT and assistive devices through market survey-In the first phase; various markets in Uttar Pradesh were identified and explored to check the availability of ICT and assistive devices for differently abled.

Phase II: Exploration of ICT and assistive devices through institutional survey- In the second phase; educational institution for differently abled was identified and various ICT and assistive devices were explored for them.

Phase III: Pilot Study- In the third phase, a pilot study was conducted in one of the institutes for disabled, by selecting a sample of ten from each category of disability (visually impaired, hearing impaired and locomotor impaired) to make a total of thirty respondents.

Phase IV: Development of tool - In the fourth phase, a tool was developed to assess the extent of use, purpose of use and barriers in using ICT and assistive devices. The tool was developed based on literature review, market survey and pilot study.

Phase V: Standardization of the tool- In this phase, the developed tool was validated with the help of fifty experts in the related and allied fields. The reliability of the scale was also tested on thirty respondents from each category of disability.

Phase VI: Collection of Data- In this phase, data was collected (using self structured and standardized tool) from differently abled in the identified institution offering higher education courses.

Phase VII: Prototype Development- On the basis of results obtained from the survey conducted on visually impaired, a customized prototype was developed.

Phase VII: Testing of the Prototype-In this phase, the developed prototype will be tested on visually impaired.

3.3. INCLUSION OR EXCLUSION CRITERIA FOR SAMPLE SELECTION

For the present research, differently abled students were selected from the three categories of the disability (visual impairment, hearing impairment and locomotor impairment) whereas other categories were excluded from the research. Differently abled were selected from higher educational institutes only whereas students having less educational

qualification were excluded from the sample as the students of higher educational institutes are available in clusters and are suitable for the research.

3.4. LOCALE OF THE STUDY

Investigation was carried out purposively from Lucknow district as it is the capital city of Uttar Pradesh and one institution offering higher education for special students, is located in Lucknow. This institute caters to provide accessible and quality higher education to all challenged students. Higher education institute was purposively selected for data collection because differently abled students pursuing higher education courses are more influenced by information and communication technology as compared to differently abled students having different educational background. Hence it was very easy to assess influence of ICT and assistive devices among differently abled.

3.5. SAMPLE SELECTION

The respondents were selected based on their disability, who were categorized as: visually impaired, hearing impaired, and persons with locomotor impairment. Respondents were selected pursuing higher education courses. They were from various disciplines; BA, MA, B.Ed., M.Ed., MBA, MSW and Ph.D and hence the respondents belonged to various age groups; (18-23), (24-29), (30-35) and (36-41). From the category of visually challenged, fifty respondents, ninety respondents from locomotor impairment and from the hearing impairment, forty respondents to make a total of 180 respondents were included in the sample using random sampling technique.

3.6. SAMPLING DESIGN/ SAMPLING DISTRIBUTION

A sample distribution is a statement of the frequency with which the units of analysis or cases that together make up a sample are actually observed in the various classes or categories that make up a variable.

Figure 3.1 represents the sampling distribution of the respondents. Sample was selected from Lucknow district to carry out this research. Respondents were selected from higher educational institute, Dr. Shakuntala Misra National Rehabilitation University, Lucknow. Respondents were selected from sample catering to three kinds of impairment; visual impairment, hearing impairment and locomotor impairment. Respondents were selected using multistage random sampling technique. Fifty respondents were from visual impairment, forty from hearing impairment and ninety respondents from locomotor to make

a total of 180 respondents, based on the availability and willingness to respond/participate in the study.

3.7. MARKET SURVEY

A market survey was conducted to explore the various assistive and ICT devices for differently abled available in the market. To have an insight on different communication and assistive technologies, their cost and market demand, market survey was conducted. With the help of market survey, various ICT related devices have been identified which were found to be popularly used by differently abled for their academics and daily life activities.

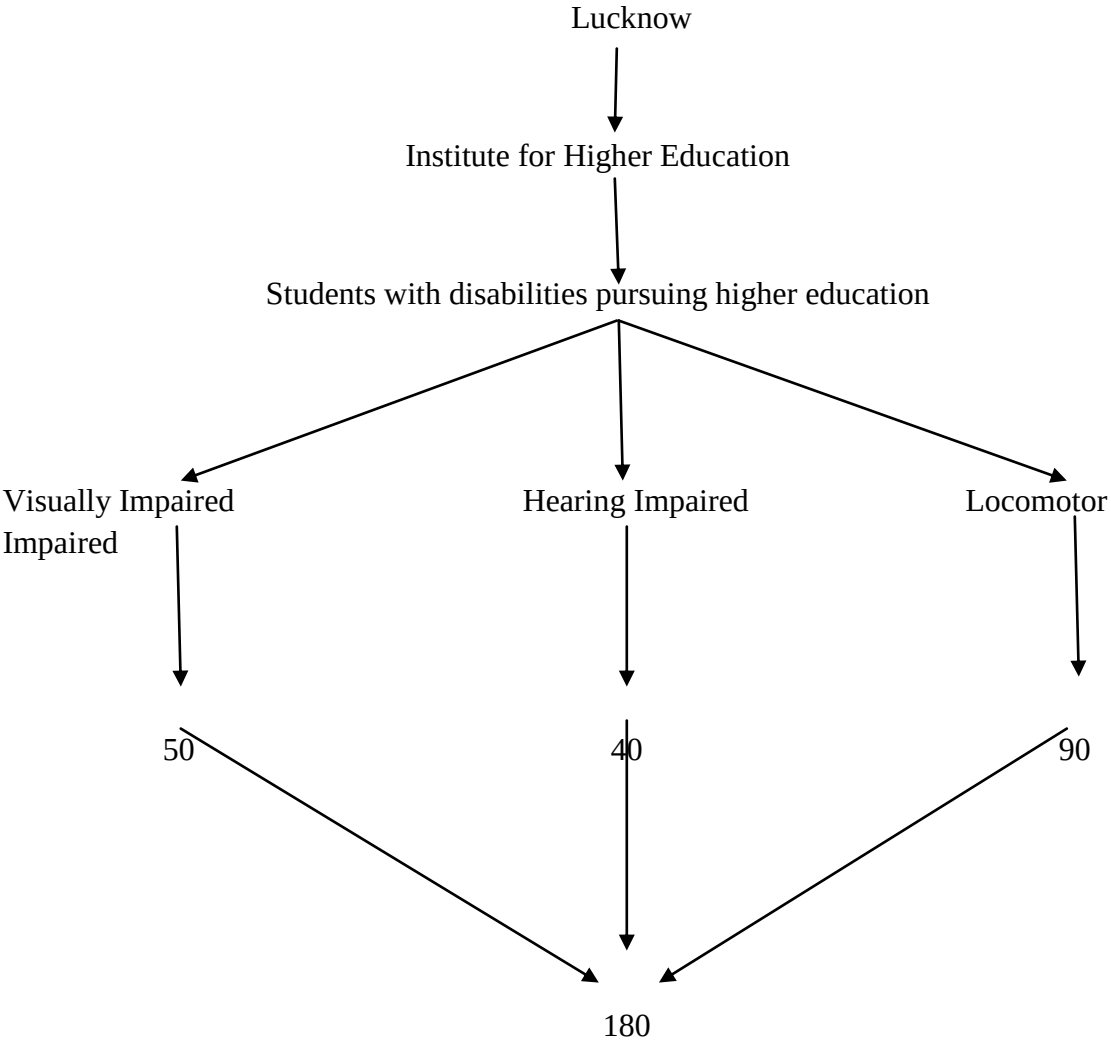


Fig. 3.1. Sampling Design

3.8. INSTITUTIONAL SURVEY

Educational institutes were surveyed to explore the available ICT and assistive devices in the laboratory. During institutional survey, information was collected from differently abled regarding available ICT and assistive device in the laboratory.

3.9. PILOT STUDY

A pilot study is a small scale replica of the main study. It provides better knowledge of the problem under study, and provides guidance on conceptualization, identification and operationalisation of concepts.

The pilot study was conducted, by selecting one of the institutes for disabled, by selecting a sample of ten from each category of disability (visually impaired, hearing impaired and locomotor disability) to make a total of thirty respondents. The sample taken for pilot study was not included in the main sample. An open ended questionnaire (unstructured questionnaire) was constructed and administered on thirty differently abled students.

3.10. TOOL DEVELOPMENT

On the basis of relevant literature, market survey, institutional survey and pilot study a structured questionnaire has been prepared to collect information from differently abled. The questionnaire consisted of three sections 'A', 'B' and 'C'. Section 'A' deals with assessment of utilization of ICT and assistive devices. Section 'B' deals with the purpose of using ICT and assistive devices and section 'C' deals with barriers faced by respondents in using these devices. Respondents had to answer the questions of section 'A' in Yes or No, section 'B' deals with multiple choice questions and section 'C' deals with open ended type question. Thus with the help of pilot study, market survey and literature review, a structured questionnaire was prepared for standardizing the same.

3.11. STANDARDIZATION OF SCALE

3.11.1. DESCRIPTION OF THE SCALE

The scale was developed to assess the utilization of ICT enabled and assistive devices for differently abled and identifying the barriers in the usage of ICT enabled and assistive devices and same was validated and checked for its reliability. The scale was also used in customizing one of the identified ICT enabled device for differently abled for enhancing their accessibility and improve their quality of life.

3.11.2. DEVELOPMENT OF SCALE

Preparation of Scale: The items of the scale were structured on the basis of market survey, literature review, pilot study and opinion of the experts. This scale was developed for the assessment and utilization of ICT and assistive devices for differently abled.

3.11.3. VALIDITY: ITEM ANALYSIS

The validity of the scale was measured through item analysis. A group of fifty experts were consulted in the related and allied fields to validate the questionnaire. The experts were asked to evaluate the instrument in terms of clarity of items, linguistic accuracy and appropriateness of the instrument to achieve the purpose of the study. The items for relevance with the help of experts using 3 point likert scale were evaluated. Each item was scored as 3, 2, 1 i.e. highly relevant, moderately relevant and irrelevant. The items of the scale have been critically examined by the experts. Correlation statistics were used to check the relevance of each item. Correlation statistics were used to test the relevance of each items using PAS software (version 20). Revisions and suggestions made by experts were taken into account. After validation of the instrument, some parameters were added and some were deleted for its relevance and appropriateness.

3.11.4. RELIABILITY

It is the degree to which the test measures consistently whatever it measures. Test-retest reliability method was used for testing the reliability of the scale. It measures the degree to which the scores are consistent over a period of time. A total of thirty respondents were consulted to collect the information from the three categories of disabilities as visually impaired, hearing impaired and locomotor impaired. Approximately 30-40 minutes were taken to fill up the questionnaire. Data from the hearing impaired students were collected with the help of an interpreter. The reliability of the scale has been calculated by test retest method.

3.12. DESCRIPTION OF FINALIZED SCALE

The scale was prepared to assess the knowledge of differently abled students regarding usage of ICT and assistive devices. The finalized scale consisted of 5 sections as A, B, C, D&E. Section ‘A’ consists of items to assess usage of various ICT and assistive devices. Respondents have to answer in Yes and No. Section ‘B’ consists of items to evaluate purpose of using various ICT and assistive devices. Respondents were asked to choose one

option as questions in this section were multiple choice questions. Section 'C' consisted of items to assess problems faced by differently abled in the usage of ICT and assistive devices. Section 'D' and 'E' dealt with the open ended questions as to what features they feel to be incorporated in any of the ICT and assistive devices and what other devices they feel to have to improve their quality of life. Thus the scale was developed, validated and finalized to collect information from differently abled regarding usage of ICT and assistive devices, purpose of using ICT and assistive devices and barriers in the usage of ICT and assistive devices.

3.13. ASSESSMENT OF USE OF ICT AND ASSISTIVE DEVICES BY DIFFERENTLY ABLED

Data will be collected from differently abled (visually impaired, hearing impaired and locomotor impaired) for the assessment of ICT and assistive devices by identifying appropriate dependent and independent variables. Appropriate statistical techniques will be used for data analysis.

3.13.1. DATA COLLECTION

With the help of self structured and validated scale data was collected from differently abled (visually impaired, hearing impaired and locomotor impaired). Interview method was used to collect the data from the selected respondents. The data from the hearing impaired was collected with the help of interpreter.

Fig.3.2. Collection of information from Visually Impaired

Fig. 3.3. Collection of information from locomotor impaired

Fig.3.4. Collection of information from hearing impaired with the help of sign language interpreter

3.13.2. VARIABLES

Variables are the characteristics of conducting research that are manipulated, controlled or observed by the research. The variables were selected according to the objectives of the study. A set of independent and dependent variables have been identified for the study.

3.13.2.1. INDEPENDENT VARIABLE

Independent variable is what is varied during the experiment; it is what the investigator thinks will affect the dependent variable. A variable that is selected or controlled by the researcher, to determine its relationship to the observed outcome of the research—also called explanatory, predictor, or manipulated variable. The nature of what is varied should be carefully described so that the attributes of the different interventions or experiences are clear. The independent variable is the factor that is measured, manipulated or selected by the researcher to determine its relationship with observed phenomenon. For the present study independent variables identified were as under -

- **Gender**
  - Male
  - Female
- **Age (in years)**
  - 18-23
  - 24-29
  - 30-35
  - 36-41
- **Family Background**
  - Rural
  - Urban
- **Educational Status**
  - BA
  - MA
  - B.Ed
  - M.Ed

- D.Ed
- MBA
- MSW
- Ph.D

- **Type of Disability**
  - Visual Impairment
  - Hearing Impairment
  - Locomotor Impairment

3.13.2.2. DEPENDENT VARIABLE

The variable being measured as an outcome also called outcome, response, criterion, or explained variable. The dependent variable is the factor that is measured to determine the effect of independent variables.

- Extent of use of ICT enabled devices
- Awareness regarding ICT enabled devices
- Barriers in using ICT devices

3.13.3. DATA ANALYSIS

Analysis means a critical examination of the assembled and grouped data for studying the characteristics of the object under study and determining the patterns of relationship among the variables related to it.

The data was coded, tabulated and analyzed using appropriate statistical techniques i.e. mean, SD, t-test, frequency and percentage was administered to analyse the data accordingly using PAS software.

3.14. DESIGN OF THE PROTOTYPE

From the analysis of results obtained, observation and based on the review of literature a set of criteria were developed to design the prototype. The survey has been conducted on differently abled students pursuing higher education courses. Prototype will be designed on the basis of problems identified in the usage of ICT and assistive devices during survey and

observation. Proposed improvement will be incorporated in the prototype to create barrier free environment for differently abled and improving their quality of life.

3.15. TESTING OF THE PROTOTYPE

The developed prototype will be tested on differently abled respondents in terms of their safety, comfort and improved quality of life by creating barrier free environment. Prototype will be tested using five point likert scale to assess various parameters of the developed prototype. Table no. 3.1 shows the scale used for testing the developed prototype. Scoring of the scale represents percentage of betterment in many parameters of the prototype. Zero indicates no improvement, one indicates 20 percent, two indicates 40 percent, three indicates 60 percent, four indicates 80 percent and five indicates 100 percent improvement in the developed prototype across the various parameters (Table 3.1).

Table No. 3.1. Scale used for Testing the Prototype

S.No.	Scoring	Percentage of Betterment in the developed prototype
1.	0	0
2.	1	20
3.	2	40
4.	3	60
5.	4	80
6.	5	100

3.16. CONCEPTUAL FRAMEWORK OF THE STUDY

Fig. 3.5 indicates the conceptual model of the study. Conceptual model is a model, made of the composition of concepts, which are used to help people know, understand, or simulate a subject the model represents. Conceptual models are often abstractions of things in the real world whether physical or social. Rapid development of and widespread adoption of ICT has fundamentally changed every aspect of differently abled person's lives ICT devices play an important role to improve the socio economic status and quality of life of differently

abled persons. The conceptual model is concerned with ICT enabled devices used by respondents and it shows the impact of various ICT devices on respondent's quality of life. Accessibility to the devices improves quality of life while inaccessibility leads to impaired quality of life.

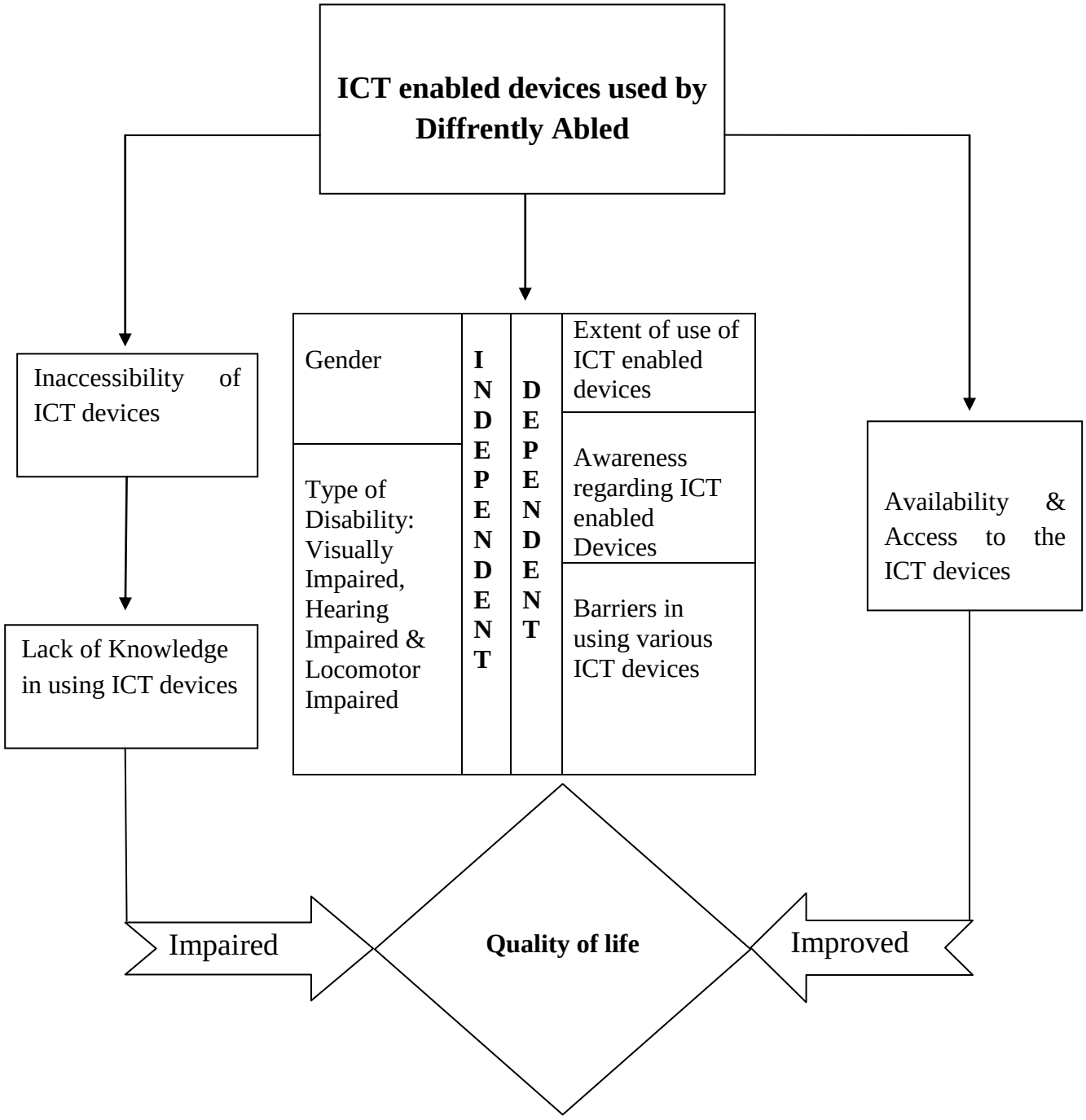


Fig. 3.5. Conceptual Model of the Study

3.17. OPERATIONAL DEFINITIONS OF THE TERMS OF THE RESEARCH

In the present research, the variables as mentioned under are considered and are defined operationally:–

Age: Computed years of age at the time of study were considered as the age of the respondents. Age of the respondents varies from 18 to 41 years. All respondents were pursuing higher education degree courses.

Gender: This refers to male and female respondents.

Educational Status: Educational status refers to various under graduate, post graduate and doctoral courses. This also refers to the level of systematic and formal education which the respondents achieved in a higher education institute. Educated persons are more prone to change and easily grasp the messages. They are likely to comprehend more and retain more knowledge as compared to an illiterate person.

Type of Disability: Respondents were selected from three categories of disability; visual impairment, hearing impairment & locomotor impairment.

Visual Impairment: Visual impairment is defined as a limitation of one or more functions of the eye or vision. The most common vision impairments affect: the sharpness or clarity of vision (visual acuity) the normal range of what people can see (visual fields).

Hearing Impairment: A hearing impairment is a hearing loss that prevents a person from totally receiving sounds through the ear. If the loss is mild, the person has difficulty hearing faint or distant speech. A person with this degree of hearing impairment may use a hearing aid to amplify sounds.

Locomotor Impairment: Locomotor impairment means disability of bones, joints muscles leading to substantial restriction of the movement of the limbs.

Family Background: This refers to respondent's background, whether they belong to rural or urban area.

Extent of use of ICT enabled and assistive devices: This refers to the quantum of use of ICT enabled devices by Differently Abled Persons pursuing higher education.

Awareness regarding ICT enabled and assistive devices: The awareness among Differently Abled Persons regarding ICT devices available in the market was to be explored and studied.

Barriers in using ICT and assistive devices: This refers to obstacles faced by Differently Abled Persons in using and handling various ICT enabled assistive devices.

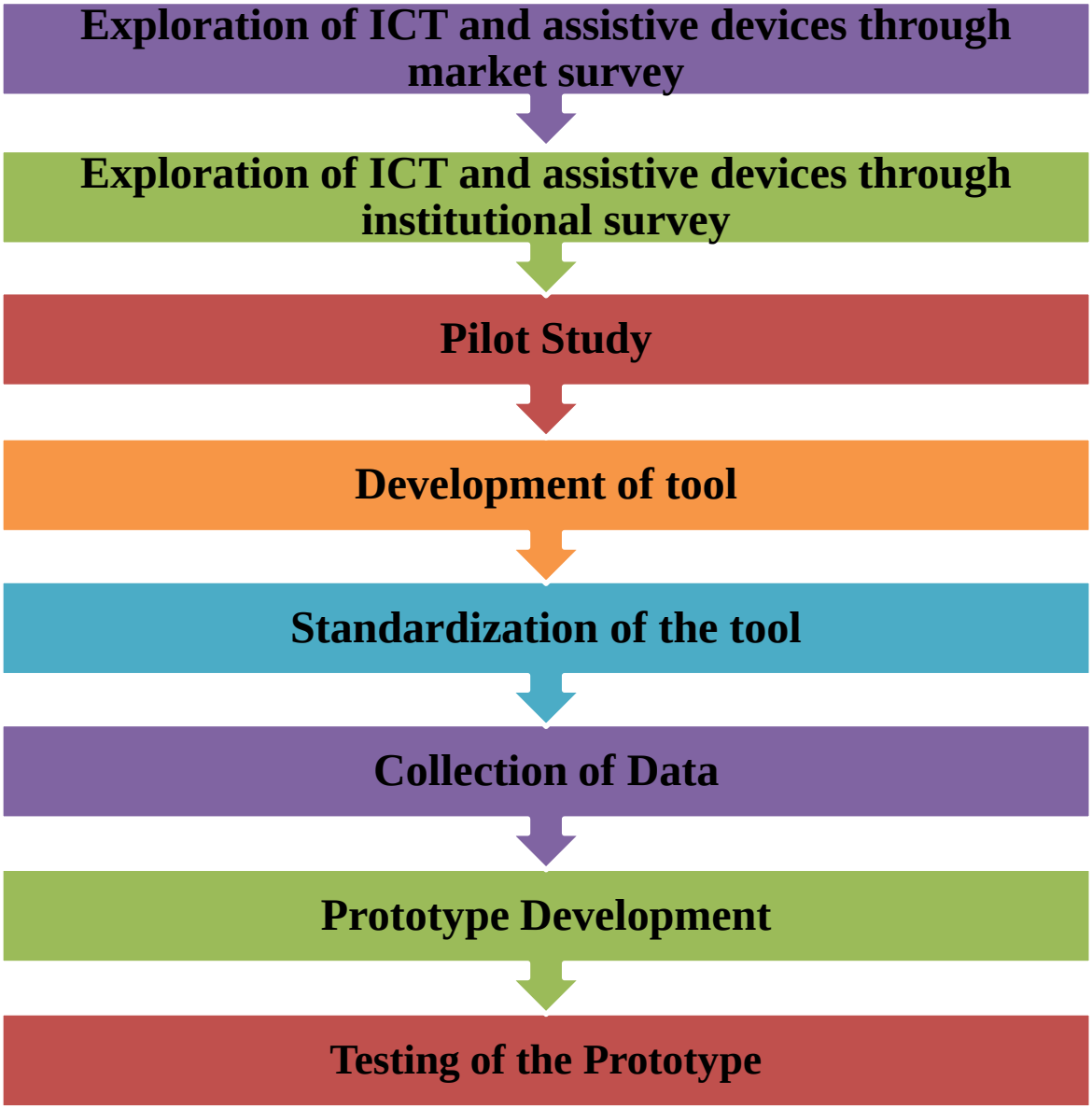


Fig. 3.6. Sequence of research work

CHAPTER-4 RESULTS AND DISCUSSION

This chapter deals with the analysis of the data and discussion of the findings. This chapter deals with the results incurred on different aspects of the study. The findings have been interpreted discussed in the light of the facts and previous findings.

4.1. Exploration of ICT and assistive devices through survey

4.1.1. Market Survey

4.1.2. Institutional Survey

4.2. Development and Standardization of the Scale for exploring the ICT and assistive devices

4.2.1. Validity of the scale

4.2.2. Testing the validity of the statements

4.3. Assessment of use of ICT and assistive devices by differently abled

4.3.1. Demographic profile of the respondents

4.3.2. Assessment of utilization of ICT and assistive devices for differently abled

4.3.3. Assessment of purpose of using ICT and assistive devices by differently abled

4.3.4. Barriers in the usage of ICT and assistive devices faced by differently abled.

4.4. Development and customization of the prototype

4.4.1. Identification of assistive device for enhancement of its design

4.4.2. Identified flaws and suggested modifications

4.4.3. Design of the prototype

4.4.4. Process diagram of developed prototype

4.4.5. Feature of the solar smart cane

4.4.6. Testing of the Prototype

4.4.7. Comparison of the developed solar smart cane with the cane used by the respondents

4.1. EXPLORATION OF ICT AND ASSISTIVE DEVICES THROUGH SURVEY

This section deals with exploration of ICT and assistive devices for differently abled (visually impaired, hearing impaired and locomotor impaired) through the survey of various markets and identified educational institute. Conducting a market survey and educational institute was very helpful in describing the present status regarding the availability of ICT and assistive devices.

4.1.1. MARKET SURVEY

A market survey was conducted to explore various ICT and assistive devices for differently abled (visually impaired, hearing impaired and locomotor impaired). As a part of market survey, various markets in Lucknow, Uttar Pradesh were surveyed to check the availability of various ICT and assistive devices. Assistive devices explored for visually impaired people were white cane, smart cane, mobile phones and laptop or computers with screen reader/ JAWS software, tactile devices, talking books and braille devices like Braille watch, Braille printer etc. Through the market survey, many devices were identified for hearing impaired people is hearing aids, laptop, computers, CDs with subtitles etc. Devices explored for locomotor impaired people were wheelchair, tricycle, crutches, walker, elbow sticks, assistive vehicles etc. Thus with the help of market survey, popular ICT and assistive devices were explored for differently abled people.

Table no. 4.1 presents identified devices, their price and brand name explored through market survey. ICT and assistive devices were explored for visually impaired, hearing impaired and locomotor impaired. Mobile phone is the ICT device used by visually impaired and locomotor impaired. Many brands of the mobile phones are available in the market like Moto E, Samsung, Micromax, Gionee etc. All the android phones have facility of talk back. They can use the feature of talk back and can get voice feedback. Thus it helps blind users in handling of android phones. Apart from android phones, multimedia phones are also

available in the market and it can be used with screen reader software and JAWS software. Laptop and computers are also ICT devices available in many brands as Dell, HP, Sony, Apple, Acer, Lenovo etc. and their prices varies as per the feature of the device.

Table-4.1: ICT and assistive devices explored through market survey for differently abled

S. No.	Item	Price	Brand Name
1.	Mobile phones	7000/-	Moto E, Samsung, Micromax, Toshiba
2.	Smart Cane	2500/-	NIVH (Dehradun)
3.	White Cane	400/-	NIVH (Dehradun)
4.	Laptop	32000/-	Dell
5.	Computers	15000/-	HP
6.	Pocket Braille slate	60/-	NIVH (Dehradun)
7.	German slate	140	NIVH (Dehradun)
8.	Signature guide	10/-	Saksham trust
9.	Braille Watch	1200/-	Titan
10.	Foldable Cane	200/-	NIVH (Dehradun)
11.	Abacus	50/-	NIVH (Dehradun)
12.	Taylors frame	110/-	NIVH (Dehradun)
13.	Hearing Aids	4499/-	Siemens
14.	CD Player	2931/- 6000/-	Philips, Sony
15.	Tricycle	8900/-	JSB W06
16.	Wheelchair	4655-12000	JSB W06
17.	Crutches	1470/-	Lamico
18.	Walker	1850 to 1959/-	Lamico
19.	Elbow Stick	300/-	Lamico
20.	Assistive Vans	11750/-	Honda

White cane and smart cane are the assistive devices which act as a guide tool for blind users. Smart cane provides vibration feedback to the users. These devices are manufactured by NIVH (National Institute for Visually Handicapped), Dehradun and Saksham trust, New Delhi. Other devices available in the market manufactured by NIVH and Saksham trust are pocket braille slate, German slate, foldable cane, Abacus, Taylors frame. Visually impaired people use CD player to listen the recorded materials in the CD. The brand of the CD player is Philips and Sony.

Hearing aids are used by partially deaf people. The explored brand of the hearing aid through market survey is Siemens and its range is 2937- 6000 rupees. Wheelchair and tricycle are available in the brand of JSW06. Crutches, walker, elbow sticks are manufactured by Lamico company and assistive vans are of Honda brand (Table no. 4.1).

4.1.2. INSTITUTIONAL SURVEY

After exploring various ICT and assistive devices through market survey, an educational institute offering higher education courses for differently abled students was surveyed to check the availability of ICT and assistive devices. The identified institution caters to academic orientation of the differently abled students. They have their own laboratory catering to the ICT education and needs of all categories of differently abled students. The institution is equipped in providing assistive devices for them. ICT and assistive devices for visually impaired students were mobile phones, laptop, computers with screen reader and JAWS software, white cane, long cane, folding cane, smart cane, tactile devices, talking books, German slate, Braille slate, traditional Braille slate, pocket Braille frame, Braille watch, brailler, smart brailler, Abacus, geometry kit, adapted playing cards and peg board. Students with hearing impairment are trained to learn sign language for effective communication and they use assistive devices like hearing aids, laptop, computers and CDs with subtitles. Students with locomotor disability use wheel chair, tricycle, crutches, walker, elbow sticks, assistive vans, mobile phones, laptop, computers etc.

Smart Cane

White Cane

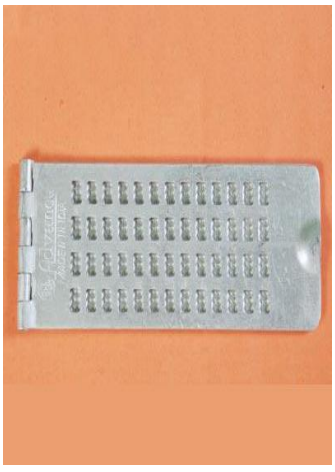
Foldable Cane

Signature Guide

Geometry Kit

ABACUS

Taylors Frame



Pocket Braille Slate

Fig: 4.1. Various devices available in the market

Table-4.2: ICT and assistive devices available in identified Institutions (for persons with Visual Impairment):

S. No.	Item	S. No.	Item
1.	Mobile phones	**16.**	Smart cane
2.	JAWS software	**17.**	White Cane
3.	Computers/ Laptops	**18.**	Abacus
4.	Screen readers	**19.**	Paperless Braille machine
5.	Radio	**20.**	Braille slate
6.	Tape recorders	**21.**	Tracing wheel/Geometry Kit
7.	Compressor	**22.**	Computer driven Braille printer
8.	Talking books/ DAISY books	**23.**	Braille translation software
9.	Talking computer terminal	**24.**	Braille kit
10.	Dictation devices and description	**25.**	German slate
11.	Text to speech software	**26.**	Braille watch
12.	Book scanner and software	**27.**	Tactile Devices
13.	Standalone reading machine	**28.**	Geometry kit
14.	Kurzweil reading machine	**29.**	Brailler/ smart Brailler
15.	Optacon	**30.**	Pocket braille frame

Table no. 4.2 shows the ICT and assistive devices available in the identified institution for visually impaired. Many of the ICT and assistive devices has been used by visually impaired for academic purpose and for daily activity purpose. ICT devices and ICT application devices like screen reader software, JAWS software, text to speech software, braille translation software, book scanner software, computer driven braille printer, talking computer terminal, kurzweil reading machine, brailler, smart brailler and compressor were available in the institution. Mobile phones, laptops, computers, radio, tape recorder, are the major source of ICT devices. The laboratory of the institution was well equipped with these devices. Assistive devices for academic purpose were abacus, braille slate, tracing wheel, braille kit, German slate, geometry kit, stand alone reading machine, dictation devices and description and pocket braille frame.

Table-4.3: ICT and assistive devices available in identified Institutions (for persons with Hearing Impairment and Locomotor Impairment):

S.No.	Devices for Hearing Impaired	S.No.	Devices for Locomotor Impaired
1.	Computers	**1.**	mobile phones
2.	Laptops	**2.**	computers/ Laptops
3.	Interactive video discs	**3.**	Radio/ tape recorders
4.	Voice carry over (VCO) telephones	**4.**	artificial limbs
5.	Closed captioning, TVs	**5.**	prosthetic devices
6.	Loop induction system	**6.**	Orthotic devices
7.	cochlear implants	**7.**	Wheelchair/ Tricycles
8.	Hearing aids	**8.**	vans or other assistive vehicles
9.	Speech trainer	**9.**	Walkers/ elbow sticks
10.	Group Hearing aid system	**10.**	Calipers

Table no.4.3 depicts the ICT and assistive devices used by hearing impaired people. Assistive devices for hearing impaired people were hearing aids, speech trainer, group hearing aid system, interactive video discs, loop induction system and cochlear implant whereas ICT devices were computer, laptop and voice carry over telephone explored in institutional survey.

Table no. 4.3 is also concerned with exploration of ICT and assistive devices for locomotor impaired in an identified institution. Assistive devices explored for locomotor impaired were wheelchair, assistive vans, walker, calipers, artificial limbs, tricycle, elbow stick, prosthetic devices and orthotic devices whereas ICT devices were mobile phones, laptop, computer, radio and tape recorder.

4.2. DEVELOPMENT AND STANDARDIZATION OF THE SCALE FOR EXPLORING ICT AND ASSISTIVE DEVICES

The purpose of developing and standardizing the scale is to assess the extent to which the ICT enabled and assistive devices are being used by differently abled, purpose of using ICT devices and what kind of barriers they are facing while using various ICT and assistive

devices. The main goal was to ensure that a scale may be developed which can be completed by the people with three kinds of impairment i.e. visual impairment, hearing impairment and locomotor impairment that would be able to evaluate how people are using various assistive and communication technologies to improve their quality of life and to make barrier free environment for them.

Developed tool consisted of five sections. First section of the scale consist a total of 52 items and these items will be used to collect information regarding usage of ICT and assistive devices among differently abled. Second section of scale consist a total of 29 items; will be used for assessment of purpose of using ICT and assistive devices among differently abled. Third, fourth and fifth section of the scale has open ended type questions that will assess barriers in the usage of ICT and assistive device, what features differently abled want to incorporate in any of the ICT and assistive device and what other devices they want to improve their quality of life. After developing the scale the validity and reliability of the scale will be assessed to standardize the same. With the help of developed tool (Appendix 1), the influence of ICT and assistive device on differently abled can be assessed. Moreover, the use of ICT and assistive device will enhance person's autonomy, self-esteem, self-confidence, and spirit of cooperation, particularly among those with special needs.

4.2.1. VALIDITY OF THE SCALE

ITEM ANALYSIS

The scale to assess needs of differently abled was constructed and same was validated through item analysis. The items for measuring various domains were identified and selected through relevant literature, market survey and pilot study. A group 30 experts were consulted in the related and allied fields to validate the questionnaire. The experts were asked to evaluate the instrument in terms of clarity of items, linguistic accuracy and appropriateness of the instrument to achieve the purpose of the study. In this phase the items for relevance with the help of experts using 3 point likert scale was evaluated. Each item was scored as 3,2,1 i.e. highly relevant, moderately relevant and irrelevant. Revisions and suggestions made by the experts were taken into account. After validation of the instrument,

some parameters were added and some were deleted for its relevance and appropriateness. Thus, the scale was developed and validated.

The developed scale consists five sections as; A, B, C, D and E. Section 'A' consists of uses of various ICT devices, Respondents have to answer in Yes, No and Sometimes. Section 'B' consists of purpose of using various ICT devices; respondents were asked to choose one option as questions in this section were multiple choice questions. Section 'C' consists of problems faced by the differently abled students in the usage of ICT devices. Section 'D' and 'E' deals with the open ended questions as what features they feel to be incorporated in any of the ICT devices and what other devices they feel to have to improve their quality of life. The opinion of the experts with respect to the relevancy of items confirmed that the scale has content and face validity. After that item analysis was done with the help of correlation.

4.2.2. TESTING THE VALIDITY OF THE STATEMENTS

The validity of various items across the entire domain was assessed through item analysis. The relevance of each item was checked using correlation statistics. The score obtained by each item was compared with degrees of correlation. If the 'r' value is +1 or -1, it shows perfectly valid statement, 'r' value is +0.9 , -0.9; it means very high valid statement, 'r' values lies between +0.75&-0.75 to +0.9&-0.9, it shows highly valid statement and if 'r' value lies between +0.25&-0.25 to +0.75&0.75. Thus all the statement found to be appropriate and relevant. Hence the instrument found to be valid for assessing ICT enabled and assistive devices used by differently abled.

Table no. 4.4 shows the result of validity of each statement regarding uses of ICT and assistive devices by persons with visual impairment. Correlation statistics has been used to check the validity of each statement. In the table no. 4.4, twelve items scored 'r' value in the range of 0.9 to 0.1; it shows very high valid statements. Eight items in the table shows highly valid statements as 'r' value is in the range of 0.75 to 0.9. Rest of the items is moderately valid statements. Thus it was found that all the items were valid to collect information regarding usage of ICT and assistive devices for visually impaired (Table no. 4.4).

Table-4.4: Usage of ICT and assistive devices by persons with Visual Impairment

S.No.	Items	R value
1.	Use of mobile phones	1
2.	Use of JAWS software	1
3.	Use of computers	1
4.	Use of laptops.	0.965
5.	Use of tactile devices	- 0.375
6.	Use of screen readers	0.750
7.	Use of radio	0.750
8.	Use of tape recorder	.075
9.	Use of smart cane	0.750
10.	Use of ABACUS	.871
11.	Use of Braille slate	.849
12.	Use of tracing wheel	-.375
13.	Use of Braille kit	.965
14.	Use of German slate	.963
15.	Use of compressor	.965
16.	Use of talking computer terminal	.367
17.	Use of kurzweil machine	.965
18.	Use of optacon	.375
19.	Use of computer driven Braille printer	.750
20.	Use of paperless Braille machine	1
21.	Use of talking book	.491
22.	Use of dictation devices	.750
23.	Use of standalone reading machine	.521
24.	Use of Braille translation software	-.491
25.	Use of text to speech software	1
26.	Use of book scanner	.736
27.	Use of Braille watch	1
28.	Use of white cane	1.00

Table-4.5: Usage of ICT and assistive devices by persons with Hearing Impairment

S.No.	Items	R value
1.	Use of hearing aids.	.404
2.	Use of speech trainer.	1
3.	Use of group system.	1
4.	Use of interactive video discs.	.937
5.	Use of loop induction system	-.761
6.	Use of computers/laptops	.404
7.	Use of videophones	.937
8.	Use of cap tel	.474
9.	Use of voice carry over telephones	.474
10.	Use of closed captioning	.529

Table no. 4.5 is concerned with the usage of ICT and assistive devices by persons with hearing impairment. Four statements in the table are very high valid statements. One item in the table shows highly valid statement and five items in the above table are moderately valid. On the whole, it can be interpreted that all of the items are valid for collecting information from hearing impaired.

The data presented in the table no. 4.6 are about usage of ICT and assistive devices by locomotor impaired respondents. All of the statements presented in the table scored 'r' value 1. So it is very clear from 'r' value of the table that all of the statements are perfectly valid statements to collect information from locomotor impaired respondents.

Data obtained in the table no. 4.7 shows the validity of the statements. Statements presented in the table no. 4.7 are related to purpose of using ICT and assistive devices by persons with visual impairment. A total of fifteen items are presented in the table 4.7 of which nine items are perfectly valid statements (r=1). Remaining items are moderately valid statements. Thus all the statements were valid to obtain information regarding purpose of using ICT and assistive devices by persons with visual impairment.

Table-4.6: Usage of ICT and assistive devices by persons with Locomotor Impairment

S.No.	Items	R value
1.	Use of wheelchair.	1
2.	Use of vans or other assistive vehicles.	1
3.	Use of walker.	1
4.	Use of caliper.	1
5.	Use of artificial limb	1
6.	Use of tricycle	1
7.	Use of elbow stick	1
8.	Use of prosthetic devices	1
9.	Use of orthotic devices	1
10.	Use of cochlear implant	1
11.	Use of mobile phone	1
12.	Use of computers/laptops	1
13.	Use of radio	1
14.	Use of tape recorder	1

The table no. 4.8 shows validity of the statements regarding purpose of using ICT and assistive devices by persons with hearing impairment. Correlation statistics has been used to check the validity of each statement. Six items in the table, scored 'r' value +1, so these items are perfectly valid and remaining items are valid. Thus it can be seen that all the statements presented in the table are valid to collect information.

It is evident from the table no. 4.9 that validity of the items were assessed through item analysis by using correlation statistics. A total of six items were assessed regarding purpose of using ICT and assistive devices by persons with locomotor impairment of which two items were perfectly valid, one item was highly valid and three items were moderately valid. Thus all the statements are valid for information collection.

Table-4.7: Purpose of Using ICT and assistive devices by persons with Visual Impairment

S. No.	Items	R value
1.	Purpose of using mobile phones	1
2.	Purpose of using computers	1
3.	Purpose of using laptops	1
4.	Purpose of using radio	.500
5.	Purpose of using screen readers	.500
6.	Purpose of using tape recorders	.500
7.	Purpose of using Braille translation software	.655
8.	Purpose of using Braille embosser	.655
9.	Purpose of using Braille E books	.655
10.	Purpose of using audio text books	1
11.	Purpose of using handheld magnifiers	1
12.	Purpose of using stand magnifiers	1
13.	Purpose of using spectacle magnifiers	1
14.	Purpose of using tactile materials	1
15.	Purpose of using optacon	1

Table-4.8: Purpose of Using ICT and assistive devices by persons with Hearing Impairment

S.No.	Items	R value
1.	Purpose of using closed captioning television	-.500
2.	Purpose of using real time captioning	1
3.	Purpose of using loop induction system	1
4.	Purpose of using video remote interpreting	.500
5.	Purpose of using computer	1
6.	Purpose of using laptop	1
7.	Purpose of using video phones	1.00
8.	Purpose of using cap tel	1.00

Table-4.9: Purpose of Using ICT and assistive devices by persons with Locomotor Impairment

S.No.	Items	R value
1.	Purpose of using wheelchair	1
2.	Purpose of using tricycle	1
3.	Purpose of using mobile phones	.309
4.	Purpose of using laptop	.271
5.	Purpose of using radio	.527
6.	Purpose of using television	.790

Thus the scale was developed, standardized and used to collect information regarding demographic profile of the respondents, usage of ICT and assistive device, purpose of using ICT and assistive devices, barriers in the usage of ICT and assistive devices and development and customization of the prototype.

4.3. ASSESSMENT OF USE OF ICT AND ASSISTIVE DEVICES BY DIFFERENTLY ABLED

This section deals with demographic profile of the respondents, assessment of utilization of ICT and assistive devices for differently abled, assessment of purpose of using ICT and assistive devices and barriers in the usage of ICT and assistive devices.

4.3.1. DEMOGRAPHIC PROFILE OF THE RESPONDENTS

The demographic profile of the respondents selected for the study, through adoption of proper sampling technique was conducted and assessed across various parameters viz., usage of ICT and assistive devices, barriers in using ICT and assistive devices, gender, age and family background. The table no. 4.10 depicts the demography of sampled respondents of all three categories of disability (visual impairment, hearing impairment and locomotor impairment).

Table-4.10: Demographic profile of the respondents

Variables	Disability			Total (N=180)
	Visually Impaired (N=50)	Hearing Impaired (N=40)	Locomotor Impaired (N=90)	
Gender				
Male	21(42)	28 (70)	40 (44.4)	89(52.13)
Female	29 (58)	12 (30)	50 (55.6)	91(47.86)
Total	50 (100)	40 (100)	90 (100)	180(100)
Age				
18-23	24 (48)	22 (55)	57 (63.3)	103(55.43)
24-29	19(38)	8 (22)	30 (33.3)	57(31.1)
30-35	7(14)	6 (15)	2 (2.2)	15(10.4)
36-41	0	4 (10)	1 (1.1)	5(3.7)
Total	50 (100)	40 (100)	90 (100)	180(100)
Educational Status				
BA	14 (28)	16(40)	21(23.3)	51(30.43)
MA	4(8)	4(10)	16(17.8)	24(11.93)
B. Ed	14 (28)	6(15)	10(11.1)	30(18.03)
MBA	0	0	6(6.7)	6(2.23)
M.Ed.	4(8)	4(10)	16(17.8)	24(11.93)
D. Ed	11 (22)	6 (15)	10(11.1)	27(16.03)
B.Com	1 (2)	4(10)	6(6.7)	11(6.23)
MSW	0	0	5(5.6)	5(1.86)
Ph. D	2(4)	0	0	2(0.66)
Total	50 (100)	40 (100)	90 (100)	180(10)
Family Background				
Rural	32(64)	14(35)	58(64.4)	104(54.46)
Urban	18(36)	26(65)	32(35.6)	76945.53)
Total	50 (100)	40 (100)	90 (100)	180(100)

The data presented in table no 4.10 portrays the demography of total (N=180) respondents with disability, wherein fifty respondents were from the category of visual impairment, forty respondents from hearing impairment and ninety respondents from the category of locomotor disability. The above table clearly shows that 58 percent female respondents and 42 percent male respondents were from the category of visual impairment. Seventy percent male respondents and thirty percent respondents were from hearing impairment. Among ninety locomotors, 55.6 percent respondents were female and 44.4 percent were male.

Respondents were from four categories of age group is 18-23, 24-29, 30-35, 36-41. It is evident from the table that 48 percent respondents were visually impaired, 55 percent respondents with hearing impairment and 63.3 percent respondents from locomotor impairment were from the age group of 18-23. From the age group of 24-29, 38 percent were from visual impairment, 22 percent from hearing impairment and 33.3 percent were with locomotor impairment, whereas from the age group of 30-35, 14 percent were having visual impairment, 15 percent from hearing impairment and only 2.2 percent were from locomotor impairment. Very few respondents belongs to age group of 36-41 of which 10 percent were hearing impaired, 1.1 percent were locomotor impaired. On the whole it can be interpreted that majority of the respondents belong to the age group of 18-23years.

The 4.10 table shows educational background of the respondents. From the category of visual impairment, 48 percent from BA, 8 percent from MA, 28 percent from B.Ed, 8 percent M.Ed, 22 percent from D.Ed., 2 percent from B.Com and 4 percent respondents were from Ph.d. From the category of hearing impairment 40 percent respondents were from BA and 15 percent respondents were from B.Ed and D.Ed. From the category of locomotor impairment 23.3 percent from BA, 17.8 percent from MA, 11.1 percent B. Ed, 6.7 percent from MBA, 17.8 percent M. Ed., 11.1 percent D. Ed, 6.7 percent B.Com and 5.6 percent respondents were selected from MSW. The above table also depicts family background of the respondents. It is evident that 64 percent respondents from visual impairment belong to rural area and 36 percent belongs to urban area. Among forty hearing impaired respondents, 65 percent were from urban area and 35 percent, were from rural area. From the category of locomotor impairment 64.4 percent, respondents were from rural area and 35.6 percent were from urban area.

4.3.2. ASSESSMENT OF UTILIZATION OF ICT AND ASSISTIVE DEVICES FOR DIFFERENTLY ABLED

In this section, uses of ICT and assistive devices among visually impaired, hearing impaired and locomotor impaired were assessed across the gender by comparing the mean value of male and female respondents.

Table-4.11: Use of ICT and Assistive Devices by persons with visual impairment across the gender

S.No.	Mean	Male		Female		't' value	'P' value
		Mean	SD	Mean	SD		
1.	Use of mobile phones	1.00	0.00	1.21	0.55	1.69**	0.00
2.	Use of JAWS software	1.57	0.67	1.97	0.56	2.23*	0.02
3.	Use of computers/ Laptops	1.67	0.79	1.90	0.82	0.99	0.87
4.	Use of radio	1.19	0.60	1.76	0.95	2.40**	0.00
5.	Use of tape recorders	1.29	0.64	1.79	0.86	2.27*	0.01
6.	Use of talking computer terminal	1.57	0.51	2.21	0.62	3.85	0.97
7.	Use of screen readers	1.57	0.67	1.52	0.83	0.24	0.26
8.	Use of text to speech software	2.00	0.77	2.14	0.74	0.63	0.86
9.	Use of book scanner and software	1.86	0.35	2.03	0.42	1.56	0.63
10.	Use of talking books/ DAISY books	1.10	0.43	1.97	0.91	4.06**	0.00
11.	Use of dictation devices and description	1.52	0.81	1.72	0.84	0.84	0.63
12.	Use of standalone reading machine	2.05	0.74	2.45	0.51	2.27	0.58
13.	Use of kurzweil reading machine	1.90	0.54	2.34	0.67	2.48*	0.01
14.	Use of optacon	2.00	0.32	2.00	0.00	0.00**	0.09
15.	Use of Braille translation software	2.24	0.62	2.41	0.50	1.10	0.73
16.	Use of computer driven Braille printer	2.14	0.65	2.17	0.60	0.16	0.77
17.	Use of tactile devices	1.29	0.64	1.21	0.56	0.46	0.39
18.	Use of smart cane	1.57	0.50	1.83	0.60	1.58	0.69
19.	Use of ABACUS	1.14	0.47	1.31	0.66	0.98	0.05
20.	Use of Braille Slate	1.43	0.74	1.79	0.94	1.47*	0.01
21.	Use of tracing wheel	1.67	0.65	1.97	0.86	1.32	0.15
22.	Use of Braille Kit	1.38	0.80	1.90	0.97	1.98**	0.00
23.	Use of German Slate	1.19	0.51	1.52	0.57	2.07*	0.01
24.	Use of paperless Braille machine	2.10	0.54	2.10	0.55	0.05*	0.82
25.	Use of Braille watch	1.62	0.74	2.45	0.68	4.08	0.65
26.	Use of white cane	1.14	0.35	1.34	0.48	1.61**	0.00
	Total use	43.19	4.93	51.00	8.07	3.92	0.17

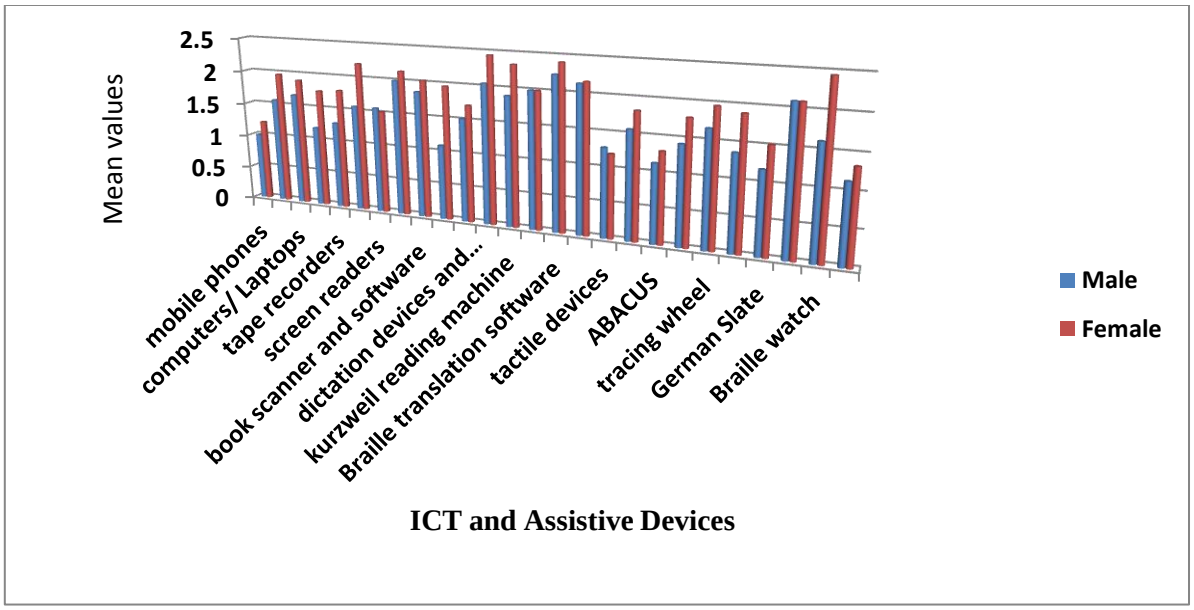


Fig.4.2. Usage of ICT and Assistive devices by Visually Impaired

Table no. 4.11 is concerned with the use of ICT related and assistive technologies used by persons with visual impairment. The table shows mean distribution of visually impaired respondents using ICT and assistive devices across the gender. 'T' statistics has been calculated to test the significant differences between male and female respondents. From the above table, mean and SD values of male and female respondents were compared and significant differences can also be interpreted from above data. The above table consists of many ICT devices and assistive devices such as mobile phones, JAWS software, computer/laptop, radio, television, screen reader, tape recorder, DAISY books, text to speech software, book scanner software, talking computer terminal, kurzweil reading machine, etc. Results obtained from table 4.2.1 shows highly significant differences between male and female respondents in the usage of mobile phones, radio and DAISY books. From the mean and SD values, it may also be interpreted that female respondents are more interested in using ICT devices than male respondents. Female respondents scored mean value as 1.21, 1.76 & 1.97 which more than male respondents mean and SD value 1.00, 1.19 & 1.10. Results obtained from the above table also show significant differences between male and female respondents as far as usage of JAWS software, tape recorder and kurzweil reading machine are concerned.

On the other hand, some assistive devices like ABACUS, Braille slate, Braille Kit, Jerman Slate and white cane, being used by persons with visual impairment, were also studied. Results indicate significant difference between male and female respondents because these items scored p value 0.05 and 0.01.Thus from the table it can be interpreted that female respondents are more active in using ICT devices. Results of a similar study conducted by **Nanda and Ramesh (2012)** emphasizes that ICT provides an effective mode of communication with professionals and they are well acquainted with the assistive technologies to some extent.

Table-4.12: Use of ICT and Assistive Devices by persons with hearing impairment across the gender

S. No	Items	Male		Female		't' value	'P' value
		Mean	SD	Mean	SD		
1.	Use of computers/ Laptops	1.14	0.52	1	0	0.93	0.35
2.	Use of closed captioning, TVs	1.21	0.56	1.17	0.38	0.26	0.79
3.	Use of interactive video discs	1.36	0.79	1.50	0.60	0.61	0.54
4.	Use of voice carry over (VCO) telephones.	2.14	0.52	2.25	0.45	0.61	0.54
5.	Use of loop induction system	1.93	0.60	2.17	0.60	1.15	0.25
6.	Use of Hearing Aids	1.29	0.46	1.33	0.49	0.29	0.77
7.	Use speech trainer	1.64	0.73	1.50	0.52	0.61	0.54
8.	Use Group Hearing aid System	1.93	0.72	2.00	0.85	0.27	0.78
9.	Use cochlear implant	1.79	0.41	1.83	0.38	0.33	0.73
	Total _ use	13.14	1.75	13.41	1.97	0.43	0.66

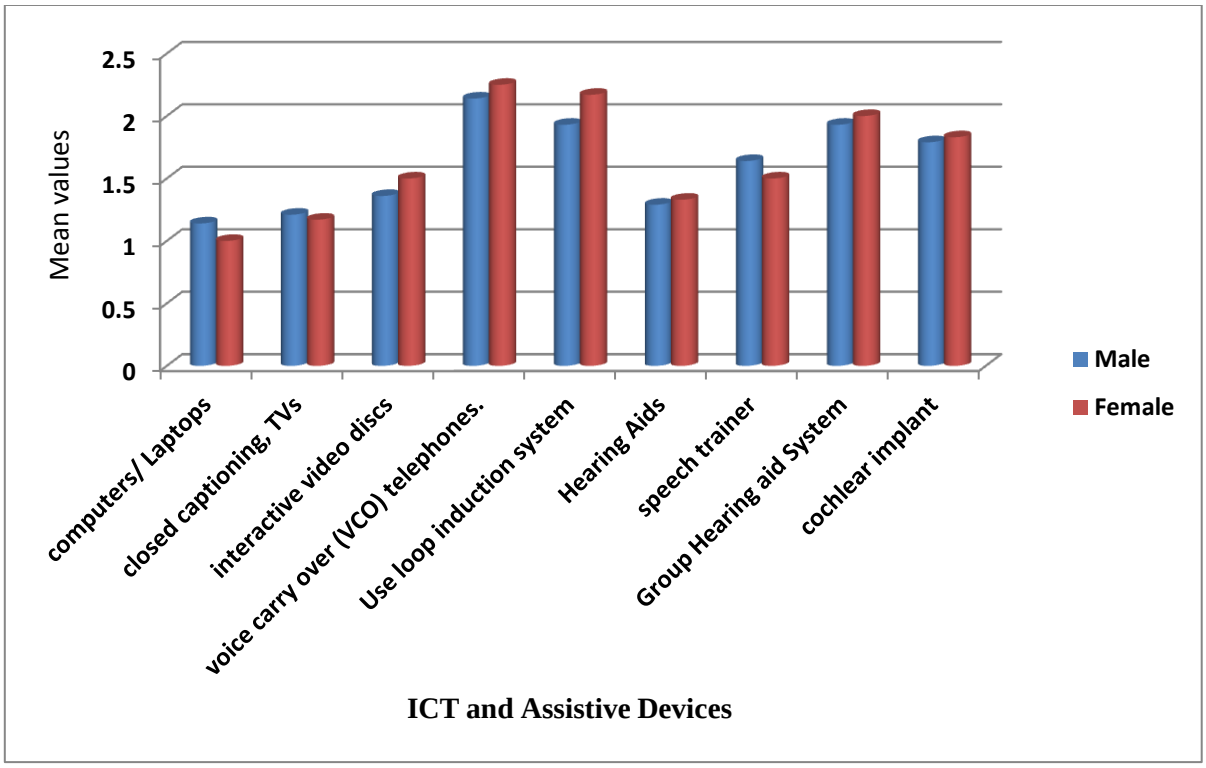


Fig.4.3. ICT and Assistive Devices used by Hearing Impaired

Table no. 4.12 depicts the uses of ICT and assistive devices used by hearing impaired across the gender. The content presented in the above table clearly shows that there exists no significant differences in the usage of ICT and assistive devices between male and female respondents. The mean score obtained by male and female respondents are almost similar. From the table, it could be seen that kind of devices used by hearing impaired such as hearing aids, speech trainer, group hearing system, interactive video discs, loop induction system, computers, laptop, voice carry over, closed captioning TV and cochlear implant. On the whole, it can be interpreted that male and female respondents are very active in using ICT and assistive devices.

In today's world, technology has been developed very fast and presents each action in digital form then it may be in images or audio format. In order to make their life more advanced, application is needed to be developed so people with hearing impairment can get opportunity to learn new thing and can get a chance to introduce to new technologies **(Patil, 2016).**

Table-4.13: Use of ICT and Assistive Devices by persons with locomotor impairment across the gender

S. No	Items	Male (40)		Female (50)		't' value	'P' value
		Mean	SD	Mean	SD		
1.	Use of mobile phones/Smart phones	1.4	.810	1.04	.283	2.93**	0.00
2.	Use of computers/ Laptops	1.65	.949	1.96	1.009	1.487	0.14
3.	Use of radio	1.8	.939	1.54	.838	1.386	0.16
4.	Use of tape recorders	1.8	.883	1.9	.886	0.533	0.59
5.	Use of wheelchair	1.78	.577	1.7	.614	0.591	0.55
6.	Use of vans or other assistive vehicles	2.25	.588	2.14	.535	0.927	0.35
7.	Use of walker	2.2	.464	2.02	.247	2.36*	0.02
8.	Use of Caliper	1.95	.504	1.88	.558	0.617	0.53
9.	artificial limb	1.63	.490	1.98	.141	4.87**	0.00
10.	Use of tricycle	1.95	.552	1.64	.563	2.618*	0.01
11.	Use of elbow stick	2.1	.545	2.08	.274	0.226	0.822
12.	Use of prosthetic devices	1.93	.267	1.94	.240	0.28	0.78
13.	Use of orthotic devices	1.93	.267	1.96	.198	0.714	0.477
	Total	24.5	2.70	23.78	2.36	1.06	0.28

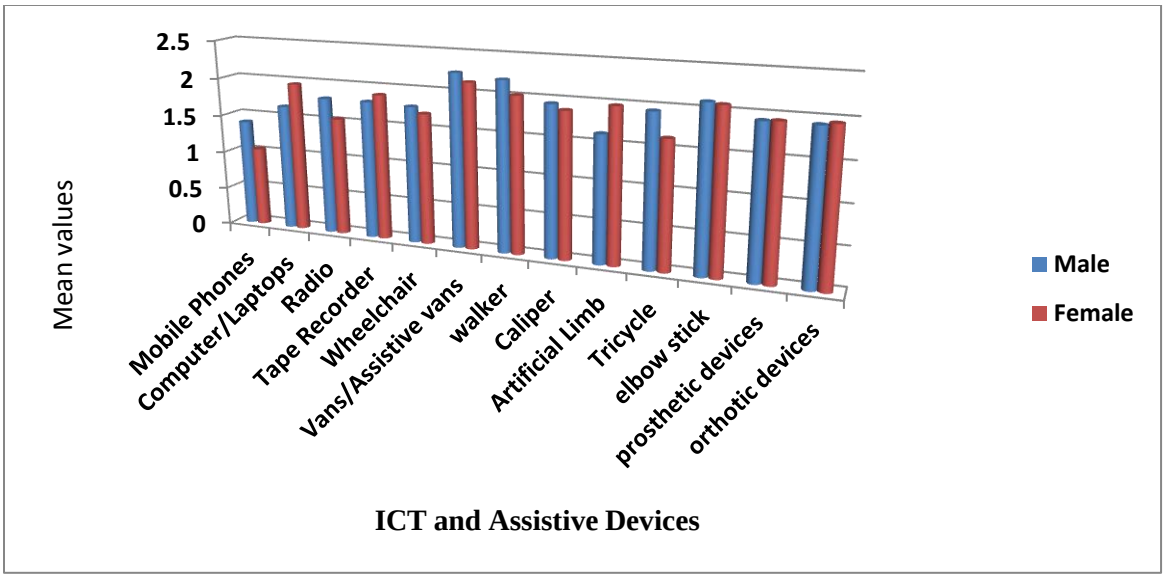


Fig.4.4. Usage of ICT and Assistive Devices by Locomotor Impaired

Table no. 4.13 portrays the uses of ICT and assistive devices by persons with locomotor disability. T test has been used to see the mean differences between male and female respondents. Statistically highly significant differences were found in the usage of mobile phones, smart phones and artificial limbs. Mean score obtained by female respondents (1.98) was found to be higher than male respondents (1.63) in using artificial limb. When comparing the mean score of male and female respondents in using mobile phones and smart phones, male respondents (1.4) achieved higher mean score than female respondents (1.04).

From the table no. 4.13, it can also be noted that there exist significant differences in the usage of walker and tricycle between male and female respondents. Respondents use walker and tricycle, as an assistive device for the purpose of mobility. Male respondents (2.2) & (1.95) obtained higher mean score than female respondents (2.02) & (1.64) in the usage of walker and tricycle respectively. It can be seen other ICT and assistive devices used by persons with locomotor disability are; elbow stick, assistive vans or vehicles, caliper, prosthetic devices, orthotic devices, radio, computers, laptops and tape recorder.

4.3.3. ASSESSMENT OF PURPOSE OF USING ICT AND ASSISTIVE DEVICES BY DIFFERENTLY ABLED

Purpose of using ICT and assistive devices by differently abled (visually impaired, hearing impaired and locomotor impaired) was assessed by using self developed and standardized

scale by the researcher. Purpose of using ICT and assistive devices was assessed and compared across the gender.

Table-4.14: Percentage distribution of differently abled respondents for purpose of using ICT and assistive devices:

S.No.	Purpose of using various ICT and assistive devices by Differently Abled	Visually Impaired (N=50)		Hearing Impaired (N=40)		Locomotor Impaired (N=90)	
		Male (N=21)	Female (N=29)	Male (N=28)	Female (N=12)	Male (N=40)	Female (N=50)
1.	**Academic**						
	Computer	8 (38.1)	14 (48.3)	22(78.6)	10(83.3)	13(32.5)	21(42)
	Laptop	8 (38.1)	4 (13.8)	4(14.3)	4(33.3)	21(52.5)	24(48)
	Screen Reader	10 (47.6)	10 (34.5)	0	0	0	0
	Tape recorder	8 (38.1)	9 (31)	0	0	0	0
	Braille translation Software	3 (14.3)	1 (3.4)	0	0	0	0
	Braille embosser	4 (19)	1 (3.4)	0	0	0	0
	Braille E Books	4 (19)	3 (10.3)	0	0	0	0
	Audio text books	10 (47.6)	6 (20.7)	0	0	0	0
	Real time captioning	0	0	22(78.57)	7 58.33)	0	0
2.	**Communication**						
	Mobile	4 (19)	11 (37.9)	0	0	29(72.5)	44(88)
	Laptop	0	1 (3.4)	6(21.4)	0	1(2.5)	7(14)
	Computer	4 (19.1)	4 (13.8)	2(7.1)	0	1(2.5)	7(14)
	Video remote interpreting	0	0	18(64.28)	6(50)	0	0
3.	**Entertainment**						
	Mobile	5 (23.8)	0	0	0	10(25)	6(12)
	Laptop	0	1 (3.4)	2(7.1)	0	16(40)	14(28)
	Computer	1 (4.8)	2 (6.9)	2(7.1)	2 (16.7)	5(12.5)	2(4)
	Radio	15 (71.4)	9 (31)	0	0	11(27.5)	18(36)
	closed captioning television	0	0	18 (64.28)	12(100)	0	0
	Television	0	0	0	0	10(25)	23(46)
4.	**News Programs**						
	Radio	15 (71.4)	9 (31)	0	0	7(17.5)	6(12)
	closed captioning television			8(28.6)	0	0	0
	Real time captioning	0	0	0	1(8.3)	0	0
	Television	0	0	0	0	6(15)	6(12)
5.	**Mobility Purpose**						
	Wheelchair	0	0	0	0	8(20)	13(26)
	Tricycle	0	0	0	0	6(15)	18(36)
	Walker	0	0	0	0	7 (17.5)	8 (16)
	Crutch	0	0	0	0	6(15)	6(15)
	Assistive Vans	0	0	0	0	3(7.5)	1(2)
	White Cane	18(85.71)	22(75.86)	0	0	0	0
	Smart Cane	3(14.28)	3(10.34)	0	0	0	0

Table no. 4.14 presents data on purpose of using ICT and assistive devices by differently abled across the gender. Devices used for academic purpose are computers, laptops, screen reader, tape recorder, Braille translation software, Braille embosser, Braille E books, audio text books and real time captioning. From the table, it is clear that computer and laptop is the common device used for academic purpose, communication and entertainment purpose used by respondents from the entire category.

Assistive technologies play very crucial role in equalizing opportunities for persons with locomotor disability in several aspects of life, as this technology enables them to overcome various limitations and obstacles faced in all types of environment **(Koulikourdi, 2008).**

It is evident from the table that 48.3% female respondents from the category of visual impairment use computer and 42% female respondents from locomotor impairment use commuter for academic purpose. Computer is an ICT device most commonly used for academic purpose among hearing impaired respondents (83.3% female and 78.6% male). It can also be noted from the table that 52.5% male respondents who were locomotor impaired use laptop for academic purpose.

The above table portrays that approximately 47% visually impaired respondents (male) use screen reader and audio text book, 38% male respondents (VI) use tape recorder and 19% respondents from the same category use braille embosser and braille E books for academic purpose.

From the above table, it can be interpreted that mobile phones, computers and laptops are important source of communication for visually impaired, hearing impaired and locomotor impaired. 88% female respondents and 72.5% male respondents form locomotors use mobile phones for communication while usage of mobile phones among visually impaired are comparatively lesser. 21.4% male respondents from hearing impairment use laptop for communication purpose.

Devices used for entertainment were mobile, laptop, computer, radio, television and closed captioning television. Mobile phones were used among visually impaired respondents (23.8% male) and locomotor impaired respondents (25% male). 40% male respondents and 28% female respondents from the locomotor impairment use computer for entertainment. 71.4% visually impaired respondents (male) use radio for entertainment. Cent percent female respondents from hearing impairment commonly used closed captioning television.

Radio is the most used ICT device for listening news among visually impaired and locomotor impaired. 71.4% male respondents and 30% female respondents from the category of visual impairment use radio for listening news while lesser number of respondents among locomotors use radio for listening news. 28.6% hearing impaired respondents use closed captioning television for watching news.

For mobility purpose, wheelchair, tricycle, crutches, walker, assistive vans are used by locomotors and white cane and smart cane are used by visually impaired. From the table it can be seen that 85.71% male respondents and 75.86 female respondents use white cane for mobility purpose. Tricycle and wheelchair was found to be mostly used by female (36% & 26%, respectively) for mobility purpose while near about 15% respondents use walker and crutches.

4.3.4. BARRIERS IN THE USAGE OF ICT AND ASSISTIVE DEVICES FACED BY DIFFERENTLY ABLED

In this section, barriers faced in using ICT and assistive devices by the respondents (visually impaired, hearing impaired and locomotor impaired) have been assessed across the gender.

Table-4.15: Percentage distribution of differently abled respondents for barriers in using ICT devices:

S.No.	Problems in the usage of ICT devices by differently abled	Visually Impaired (N=50)		Hearing Impaired(N=40)		Locomotor Impaired(N=90)	
		Male (N=21)	Female (N=29)	Male (N=28)	Female (N=12)	Male (N=40)	Female (N=50)
I	**Problems in the usage of mobile phones**						
1.	problem in the speech software	6(28.6)	10(34.5)	0	0	0	0
2.	low battery back up	5 (23.8)	8 (27.6)	0	0	6(15)	7(14)
3.	talk back is slow	2 (9.5)	4(13.8)	0	0	0	0
4.	screen reader quality is not good	2 (9.5)	1 (3.4)	0	0	0	0
5.	problem with JWAS software	3 (14.3)	2 (6.9)	0	0	0	0
6.	Problem in holding mobile phones	0	0	0	0	9(22)	9(18)
7.	Problem in pressing the keys	0	0	0	0	2(5)	6(12)
8.	Ill functioning of the keys	0	0	0	0	10(25)	1(2)

Contd.

II	**Problems in the usage of Laptops**						
1.	ill functioning of keys	6(28.6)	5 (17.2)	0	0	9(22.5)	17(34)
2.	low battery back up	2 (9.5)	1 (3.4)	0	0	2(5)	8(16)
3.	problem in the programming	7 (33.3)	6 (20.7)	0	0	0	0
4.	Problem in pressing the keys	0	0	0	0	9(22.5)	9(18)
III	**Problems in the usage of Computers**						
1.	problem in the programming	7 (33.3)	6 (20.7)	0	0	0	0
2.	ill functioning of keys	6(28.6)	5 (17.2)	0	0	9(22.5)	17(34)
3.	Problem in pressing the keys	0	0	0	0	20(50)	18(36)
V	**Problems in the usage of talking books**						
1.	accent/language problem	9 (42.9)	8(27.6)	0	0	0	0
2.	unavailability of language translation	4 (19)	4 (13.8)	0	0	0	0
VI	**Problems in the usage of JAWS software**						
1.	Slows down the PCs/computers	9 (42.9)	10 (34.5)	0	0	0	0
2.	Language/accent problem	4 (19)	2 (6.9)	0	0	0	0
3.	Improper instruction	4 (19)	1 (3.4)	0	0	0	0
VI	**Problems in the usage of dictation device and description**						
1.	Accent/language problem	11 (52.4)	15 (51.7)	0	0	0	0
2.	Unavailability of language translation	3 (14.3)	2 (6.9)	0	0	0	0
3.	Both	5 (23.8)	5 (17.2)	0	0	0	0
VI	**Problems in the usage of text to speech software**						
1.	Accent/language problem	9(42.89)	8 (27.58)	0	0	0	0
2.	Unavailability of language translation	2 (9.5)	8 (27.58)	0	0	0	0
VIII	**Problem in the usage of interactive video disc**						
1.	CD of class lecture not available with subtitle	0	0	12 (42.9)	4(33.3)	0	0
2.	CD of all movies not available with subtitles	0	0	8(28.6)	8 (66.7)	0	0

The table no. 4.15 portrays the percentage distribution of differently abled respondents in the usage of ICT devices. From the table, it can be interpreted that 34.5% female respondents face problem in speech software of mobile phones which is comparatively higher than male respondents (28.6%). Visually impaired respondents (27.6% female &23.8% male) and respondents with locomotor impairment (15% male & 14% female) reported that other major problem in the usage of mobile phone is low battery backup. Twenty two percent male respondents from locomotor impairment complained that they face problem in holding mobile phone. It can also be observed from the table that visually impaired face many problem in the usage of mobile phones as; slow talk back, screen reader quality is not good and problems with JAWS software.

It can be observed from the table that 42.9% male respondents and 34.5% female respondents face problem in using JAWS software. They complained that JAWS software slows down the computers, laptop and mobile phones. Problems in the usage of laptops and computers are almost similar as problem in the programming, ill functioning of keys and problem in pressing the keys. 33.3% visually impaired respondents (male) face more problems in programming in the usage of laptop and 50% respondents from locomotors complained about problem in pressing the keys of computers.

The above table portrays that 42.9% male respondents face accent/language problems in the usage of talking book. The above table also depicts data on the problems faced in the usage of text to speech software and dictation devices description. Majority of the respondents complained about accent/language problem in the usage of both of the devices.

It is clearly indicated in the table that 66.7% female respondents faced problems in the usage of interactive video disc and they complained that CDs of all the movies are not available with subtitles while only 28.6% male respondents faced the same problem. 42.9% male respondents and 33 % female respondents complained that CDs of class lecture are not available in subtitle form.

Table-4.16: Percentage distribution of differently abled respondents for barriers in using assistive devices:

S.No.	Problems in the usage of Assistive devices by differently abled	Visually Impaired (N=50)		Hearing Impaired (N=40)		Locomotor Impaired (N=90)	
		Male (N=21)	Female (N=29)	Male (N=28)	Female (N=12)	Male (N=40)	Female (N=50)
I	**Problems in the usage of smart cane**						
1.	unable to recognize the pit	5(23.8)	1 (3.4)	0	0	0	0
2.	low or absence of vibration	2 (9.5)	3 (10.3)	0	0	0	0
3.	unable to recognize obstacle at eye/head level	2 (9.5)	4 (13.8)	0	0	0	0
4.	unable to detect right or wrong side obstacle	1 (4.8)	5 (17.2)	0	0	0	0
5.	creates confusion in enclosures	1 (4.8)	3 (10.3)	0	0	0	0
II	**Problems in the usage of braille watch**						
1.	Heavy	11(52.4)	10(34.5)	0	0	0	0
2.	Not easy to repair	0	2 (6.9)	0	0	0	0
3.	Chances of breakage	2 (9.5)	8 (27.6)	0	0	0	0
III	**Problems in the usage of tactile devices**						
1.	Problem with map calibration	5 (23.8)	3 (10.3)	0	0	0	0
2.	Problem in coordination	6 (28.6)	5 (17.2)	0	0	0	0
3.	Both	5 (23.8)	12 (41.4)	0	0	0	0
IV	**Problem in the usage of Hearing Aids**						
1.	Creates more noise	0	0	0	0	12(24.9)	8(66.7)
2.	Heavy	0	0	0	0	8(28.6)	4(33.3)
V	**Problem in the speech trainer**						
1.	Problem in coping speech	0	0	22(78.6)	8(66.6)	0	0
VI	**Problems in the usage of callipers**						
1.	Pain in legs	0	0	0	0	10(25)	9(18)
2.	Feeling legs heavy	0	0	0	0	4(10)	5(10)
3.	Chances of falling down	0	0	0	0	9(22.5)	3(6)
VII	**Problem in the usage of wheelchair**						
1.	Pain in hands	0	0	0	0	5(12.5)	12(24)
2.	Not work properly	0	0	0	0	5(12.5)	6(12)
3.	Problems in up and down	0	0	0	0	3(7.5)	3(6)
4.	Less speed	0	0	0	0	1(2.5)	0
5.	Uncomfortable seat	0	0	0	0	4(10)	6(12)
VIII	**Problem in the usage of tricycle**						
1.	Pain in hands	0	0	0	0	5(12.5)	6(12)
2.	Heavy	0	0	0	0	1(2.5)	10(20)
3.	Difficulty in operating the tricycle	0	0	0	0	5(12.5)	11(22)
IX	**Problem in the usage of walker**						
	Heavy	0	0	0	0	8(20)	11(22)
	Not easy to handle	0	0	0	0	4(10)	2(4)

Table no. 4.16 is concerned with problems faced by differently abled in using assistive device. It can also be observed from the table that visually impaired face difficulty in using smart cane as this device is not very user friendly. 23.8% male respondents reported that this device is unable to recognize the pit. Other barriers faced by visually impaired are low or absence of vibration, unable to recognize obstacle at eye/head level, unable to differentiate between right side and wrong side obstacle and creates confusion in enclosures.

Braille watch is an assistive device for visually impaired. 52.4% respondents complained about heavy weight of Braille watch, while female respondents were 34.5%. Respondents with locomotor impairment use tricycle and wheelchair for mobility purpose. 24% female respondents reported that they feel pain in hand while operating wheelchair and 22% female respondents face difficulty in using tricycle. 25% female respondents complained that they feel pain in using calipers and 22% female respondents reported that walker is heavy so it is difficult to carry it.

Thus data from the table no. 4.15 and 4.16 revealed various problems in the usage of ICT and assistive devices of all the impairment. There are many types of disabilities, including physical disabilities, hearing-impaired, and visually-impaired. Assistive technology has been utilized in assisting them **(Mutalib et al., 2010).** However, developing an Assistive technology is expensive, making their selling price high. During survey, it was found that hearing impaired respondents face major problem with hearing aids as it creates more noise and it is heavy in weight. Locomotor impaired respondents use same ICT device as normal people use but they face major problem in the usage of tricycle and wheelchair (assistive device) because it creates pain in hands while operating these devices. From the result obtained during survey and observation, it was found that visually impaired face many problems in using ICT and assistive device. Mobile phone (ICT device) creates problem with speech software and smart cane was not user friendly for blind users. Thus on the basis of above interpretations, it was decided to identify the ICT and assistive device for the enhancement of its features that will be more compatible for differently abled.

4.4. IDENTIFICATION OF ASSISTIVE DEVICE FOR ENHANCEMENT OF ITS DESIGN

As per the World Health Organization (WHO), there are 285 million visually impaired people in the world, 39 million of which are blind and 246 million have a low vision. Now a

days, technology dominates and makes people's tasks easy in different domains. Yet, people who are visually impaired still struggle every day in performing actions that can be as simple as moving from one point to another without falling down, or knocking against obstacles. Research has been conducted on how to make white canes more technology-oriented to maximize their use and benefit. However, all technologies selected require power sources that can make the recharge of the canes difficult for the visually impaired, due to complications related to the wiring, for instance. This research suggests a system that will convert the mechanical energy created by the motion of the cane to electrical one, thereby making the charging of its battery a continuous process **(Noor et al., 2009).**

It has been found during survey that majority of the visually impaired respondents face difficulty in using smart cane. Independent mobility is prime factor which is lacking among visually impaired due to ill design of smart cane. This device has many limitations as it only provides vibration feedback, unable to detect the direction of the obstacle, not adjustable in height and it is only motor battery operated. During survey, it was observed that visually impaired were the most vulnerable group as they have lack of eyesight that affects their mobility. Thus, on the basis of information collected from visually impaired and observation, it was decided to improve the features of smart cane. The purpose of enhancing features of smart cane was to build a navigation system that will be able to guide a visually impaired person safely and with ease, in an indoor and outdoor environment. Thus keeping all the points into consideration, smart cane was identified for enhancement of its design and hence, it was decided to develop the customized prototype for visually impaired that can create barrier free environment for them. The developed prototype will be helpful in providing safe mobility among blind users and will enhance self autonomy.

4.5. DEVELOPMENT AND CUSTOMIZATION OF THE PROTOTYPE

Technology can help in reducing many barriers that people with disabilities face. These kinds of technologies are referred to as assistive technology **(Aziz, 2009).** Considering the design flaws in the existing smart cane, a solar smart cane for visually impaired was developed and the same was customized and tested. Many flaws have been identified during survey with the cane used by the respondents. Modifications or improvements in the design have been suggested to enhance the compatibility of solar smart cane. Process diagram of

the solar smart cane has been presented to show its functioning. Development of prototype also deals with description of used features, its functioning and testing of the prototype.

4.5.1. IDENTIFIED FLAWS AND SUGGESTED MODIFICATIONS

A survey has been conducted on visually impaired students pursuing higher education courses. A total of fifty visually impaired students were surveyed to know the difficulties they were facing with currently existing smart-cane in in-door and out-door environment. The blind Cane is one of the assisting tools for the visually-impaired and it is really important (**Mazo &Rodriguez, 1998).** One of the main problems of the visually-impaired is that most of these people have lost their physical integrity. Also, they do not have confidence in themselves **(Herman, 1999).** This statement has been proven by (**Bouvrie, 2007)** in which an experiment name "Project Prakash" has been carried out. It was intended at testing the visually-impaired to utilize their brain to identify set of objects. This can also be applied to different situation. When the visually-impaired walk into a new environment, they will find it difficult to memorize the locations of the object or obstacles. These examples demonstrate the difficulties of visually-impaired people **(According to Chang & Song, 2000).** So from the survey, it was clear that what devices they use, for what purpose they use and what kind of problems they are facing while using these currently existing devices. From the survey it was found that majority of the respondents face problem while using smart cane. Smart cane is an assistive device that guides visually impaired persons through voice feedback. It detects obstacles and provides feedback through vibration alert. It was reported by the respondents that smart cane is very limited in its ability as this is not very user friendly. This device is unable to differentiate right side and left side obstacle. This device creates confusion in enclosures, unable to recognize pit and obstacle at eye level. Thus in this work, design flaws were identified and improved model of smart cane was developed. From the result of the experiment and findings of the survey, many problems were identified with existing cane. Identified problems and suggested modifications are presented in table no. 4.17.

4.4.3. DESIGN OF PROTOTYPE

Usually blind people use smart cane for mobility purpose which is very limited in its ability. On the basis of survey conducted on visually impaired persons, it was decided to develop a

solar smart cane which will be better than existing smart cane. The developed prototype is user friendly, easy to handle and detects obstacle in three directions; left, right and front.

The identified flaw is at par with the modification suggested by **Singh et al., 2010**, who emphasized that there is a need for a knee-above obstacle detection and warning system with a user-friendly design, available at an affordable cost to users in low-income countries who presently have very limited access to electronic navigation aids.

Table-4.17: Identified problems and suggested modifications:

Smart Cane	Problems	Suggested Modifications
	Inability to differentiate the direction (left, right, front) of the obstacle.	Three IR (Infra-red) censors should be used that detect left, right front side obstacles.
	– It only provides vibration alert feedback. – No sound feedback	The system should have both features vibrator and sound.
	Inability to recognize the pit	Sensors to detect pits have to be incorporated in the model.
	– Inability to recognize knee above obstacle. – Inability to recognize obstacle at eye level. – Unable to recognize the branches the tree that sometimes leads to major injuries.	Sensors should be used to detect obstacles at knee level or above knee level has to be incorporated in the model.
	Cane is not with adjustable height	Cane used in smart cane should be adjustable as per person's height.
	It has low sense of vibration. Sometime in noisy area, people are unable to sense the vibration feedback.	Intensity of the vibration should be increased so that visually impaired can sense easily.
	It is only motor battery operated	Solar cell chargeable battery should be used to provide electrical energy for system functioning.

Figure 4.5, demonstrates that the ultrasonic sensor position at the front detects strong reflection of waves coming only from the front, meaning that there is an obstacle. The vibrator wrapped around the wrist band vibrate continuously and the recorded voice keep playing "Object is in front of the side" which means "Obstacle on the front" until the user moves away from the obstacle either walking towards left or towards right.

4.5.2. PROCESS DIAGRAM OF THE DEVELOPED PROTOTYPE

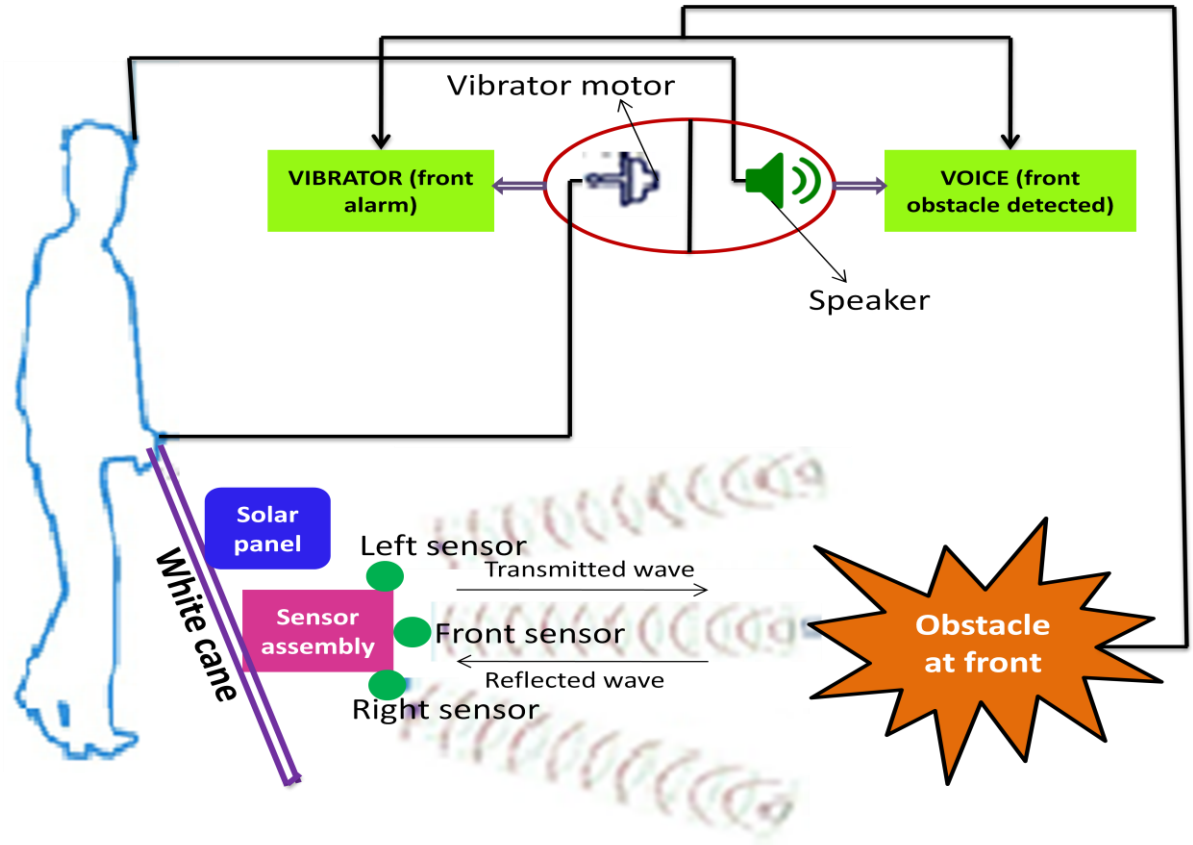


Fig. 4.5 Process diagram of the prototype

4.5.3. FEATURES OF THE SOLAR SMART CANE

A solar smart cane was developed for visually impaired with following features like grip and adjustable height of white cane according to person's height. This solar smart cane has other features for detection of obstacles using ultrasonic sensors. Implementation of vibration alert and voice feedback system using vibrator motor and chip-Corder were done respectively in this device. The system also has facility to detect obstacle in three different directions such

as front, left and right. The detection range for obstacle is 100 to 200 cm so that blind person can walk freely up to this distance. A microcontroller has been used to control the device.

Infrared sensors on the other hand, are highly recommended by researchers due to the concept of distance measurement for obstacle avoidance. They are inexpensive, light in weight, easy to use, it is widely available and requires limited learning curve. Using infrared sensors can be applied for constructing smart walking canes for visually impaired individuals. A smart cane can be produced by selecting an infrared sensor that enables obstacles detection within a range that is approximately equivalent to the length of the cane. Infrared beam is sent out as it does for distance measurement. Moreover, the sensors come in small packages compared to other devices mentioned above, use little power to operate, have a variety of output options and very low cost. Given the positive attributes of the infrared sensor, a simple and convenient way of making it accessible for the visually impaired or perhaps making it possible for users to develop or build with affordable materials is feasible **(Azigi & Hurst, 2009).**

Through voice recorder sound can be recorded in any language. If the obstacle is in front of the side voice recorder will play a sound like "The object is in front of the side" which means "Obstacle on the front" until the user moves away from the obstacle either walking towards left or towards right. Similarly if the sonar receives strong ultrasonic waves from the left or right, the system will provide vibration and voice feedback as "the object is in left side" and "The object is in right side". Finally a solar panel has been used to provide electrical energy to the system and make it portable. All electronic circuitry has been mounted on white cane.

4.5.4. TESTING OF THE PROTOTYPE

Developed prototype was tested on a total of thirty visually impaired respondents. For testing the prototype, a scale was developed and used to assess the betterment of developed solar smart cane in comparison to the cane used by the respondents. The developed prototype was tested on a total of thirty visually impaired respondents. Betterment of the solar smart cane was assessed in terms of grade of improvement as perceived by the users, presented in the table no. 4.19. The scale was developed including many parameters as light weight, mobility, safety, adjustable height, portability, obstacle detection, grip etc. Five

point likert scale has been used to compare the various parameters of developed solar smart than the cane used by respondents. The the scale was developed, to be administered on visually impaired respondents for their feedback regarding improvement in the developed solar smart cane.

Table-4.18: Features of the prototype

S. No.	Features of the prototype	Functions
1.	White Cane with adjustable height	To held the components of device as a mechanical support and to adjust the height of cane according to height of user.
2.	Grip	Grip is used for effective control/support over smart cane.
3.	Sensor assembly	It is used to detect obstacles. This consists of two main components transmitter and receiver. Transmitter generates infrared wave and the receiver senses infrared wave reflected from obstacle.
4.	Vibrator	It is used to produce vibration in smart cane when some obstacle is detected.
5.	Microcontroller	It is used to control the device functions.
6.	Speaker	It is an electro-mechanical component used to change electric current into sound. It is used in this smart cane to produce sound when obstacle is detected.
7.	Voice recorder	This device stores and reproduces voice signals in their natural forms. The voice signals for 'front', 'left' and 'right' obstacle detection is stored in this recorder.
8.	Solar Cell	It is a device which converts solar energy directly into electricity. In this smart cane, it is used to provide electrical energy to the system for functioning.

Fig. 4.6. Testing of the prototype

4.5.5. COMPARISON OF DEVELOPED SOLAR SMART CANE WITH THE EXISTING CANE (USED BY THE RESPONDENTS)

The table shows comparison of developed solar smart cane with the cane used by the respondents. The developed prototype has been tested on total thirty visually impaired respondents and their feedback was taken in terms of improvement of the device.

The data depicted in the table clearly indicate the grade improvement as perceived by the users. Grades use for assessment of improvement of cane is 0, 1, 2, 3, 4&5. Zero implies that developed cane is not better (0%) in any aspect than existing cane. 1 indicate 20% betterment, 2 indicates 40% betterment, 3 indicates 60% betterment, 4 indicates 80% betterment and 5 indicates 100% betterment in particular than the cane used by the respondents.

The table no. 4.19 is concerned with grade improvement of the developed solar smart cane in many aspects as weight of the cane, adjustable height of the cane, mobility, safety, portaility, user friendly, ease of use, better controllability, grip, detection of direction and obstackle, energy saving and overall design.

From the table no.4.19, it can be seen that approximately forty percent respondents reported that the developed prototype is 60% better in the aspect of mobility, controllabilty and light weight. Fifty percent respondents reported that the solar smart cane has 60% better portability than the existing cane.

Table-4.19: Comparison of developed solar smart cane with the cane used by the respondents

S.No.	Items	Grade of Improvement as perceived by the users					
		5	**4**	**3**	**2**	**1**	**0**
1.	**Light Weight**	0	11(36.7)	12(40)	5(16.7)	0	2(6.7)
2.	**Mobility**	4(13.3)	8(26.7)	12(40)	6(20)	0	0
3.	**Safety**	10(33.3)	8(26.7)	6(20)	6(20)	0	0
4.	**Adjustable height**	7(23.3)	4(13.3)	7(23.3)	6(20)	0	6(20)
5.	**Portability**	0	11(36.7)	15(50)	4(13.3)	0	0
6.	**Ease of use**	2(6.7)	8(26.7)	16(53.3)	4(13.3)	0	0
7.	**User friendly**	5(16.7)	9(30)	14(46.7)	2(6.7)	0	0
8.	**More features**	19(63.3)	11(36.7)	0	0	0	0
9.	**Controllability**	4(13.3)	0	12(40)	10(33.3)	2(6.7)	2(6.7)
10.	**Grip**	0	0	7(23.3)	7(23.3)	8(26.7)	8(26.7)
11.	**Comfort**	2(6.7)	6(20)	17(56.7)	4(13.3)	1(3.3)	0
12.	**Detection of direction**	21(70)	5(16.7)	4(13.3)	0	0	0
13.	**Detection of obstackle**	5(16.7)	13(43.3)	10(33.3)	2(6.7)	0	0
14.	**Design**	3(10)	4(13.3)	11(36.7)	6(20)	6(20)	0
15.	**Energy Saving**	18(60)	4(13.3)	6(20)	2(6.7)	0	0
16.	**Overall Design**	1(3.3)	10(33.3)	11(36.7)	6(20)	2(6.7)	0

Seventy percent respondents reported that the solar smart cane is 100% better in detecting the directon of the obstacle and 63.3% people felt that developed cane has more features. Sixty percent respondents reported that developed cane is 100% better in energy saving as

the solar cell has been used to provide electrical energy to the system where as more than fifty percent respondents reported that soalr smart cane is easy to handle and comfortable than existing smart cane. Thus with the help of developed scale, various parameters of developed solar smart cane has been compared in terms of grade of improvement or percentage of betterment, with the cane used by the respondents.

On the whole, it can be interpreted that the developed solar smart cane is more user friendly than the cane used by the respondents. The developed cane has better controllability and is more compatible for visually impaired respondents. The prototype is better in detecting the direction of the obstacle. The developed Solar Smart Cane; a mobility aid for visually impaired is very helpful in creating barrier free environment and improving their quality of life.

CHAPTER-5 SUMMARY AND CONCLUSION

ICT and assistive technologies play an important role in equalizing opportunities for differently abled in several aspects of life as this technology enables them to overcome various limitations and obstacles faced in all types of environments. Accessible technologies can have a remarkable effect on empowering persons with special needs accompanied with the ICT that provides great opportunity for connections to a range of people regardless of their location.

ICT offers great opportunities of social inclusion. Technological development can enable people with disabilities to improve their quality of life. They can accomplish tasks that would be impossible to do without the computer, such as: writing a letter, communicating, drawing a picture, etc. Moreover, the digitalization of many public services such as education (school, university), shopping, banking, library, or even sending a letter allows people with disabilities to live in much the same way as those who are not disabled. They can acquire an "independent life and achieve social integration. However, the prospective promised with the digital era often has not become the reality for most people with disabilities.

The word ***disability*** indicates human limitation of one kind or other, in performing various tasks performed by other human beings in general. It may be one or more of the kind of physical, mental or sensory, including visual and hearing. Generally people with disability automatically become underprivileged, because they may not have proper access to the resources, accessible otherwise. Persons with disabilities include those who have long-term physical, mental, intellectual or sensory impairments, which, in interaction with various barriers, may hinder their full and effective participation in society on an equal basis with others**.**

In present scenario, ICT has become a very important part of the educational delivery and management processes. ICT to a great extent, facilitates the acquisition and absorption of knowledge, and hence can provide extraordinary opportunities to developing countries for enhancing their educational systems particularly for the underprivileged constituency, and thereby for raising the level of quality of life of differently abled people. The new communications technologies promise to reduce the sense of isolation, and open access to knowledge in ways unthinkable, not long ago**.**

In the line of above, ICT and assistive devices can enable differently abled to improve their quality of life and to live in much the same way as those who are not disabled. They can accomplish tasks that would be impossible to do without ICT and assistive devices. However, the prospective promised with the ICT often has not the reality for most people with disabilities. They had been kept away from the mainstream society, denominating them as disabled. At present, the term disabled is no more prevalent; instead of it, words like differently abled or persons with disabilities are used. It is important to recognize that differently abled may have counterbalancing strengths in other areas too**.**

The present study entitled **"A Study on ICT enabled devices for Differently abled: An Exploratory Research"** focusing on exploring the usage of ICT and assistive devices by differently abled (Visually Impaired, Hearing Impaired and Locomotor Impaired) was conducted with following objectives:

1. To explore the ICT enabled and assistive devices available for differently abled through market and institutional survey.

2. To validate and standardize the schedule for assessing accessibility, purpose and barriers in using ICT and assistive devices.

3. To assess the utilization of ICT enabled and assistive devices for differently abled.

4. To assess the purpose of using various ICT enabled and assistive devices by differently abled.

5. To identify the barriers in the usage of ICT enabled and assistive devices by differently abled.

6. To develop and test the prototype of the identified device for the differently abled through customization.

Chapter wise Summary

The study has been completed in five chapters. The introduction has been presented in first chapter. Chapter two dealt with review of literature. Methodology has been presented in chapter third. Chapter four dealt with analysis of primary data. This is the last chapter of the thesis,

which provides summary and conclusion of the research. Below, summary has been presented chapter wise.

In Chapter 1, the introduction of the study, its objectives, research problems, sources of data have been outlined. This chapter begins with a short background of disability, concept of ICT, concept of disability, present status of disabled people, present scenario of ICT uses, specific problems and general problems. Objectives of the study are highlighted along with the sources of data, research questions method for achieving the answers of the problem.

Chapter 2 dealt with the major studies related to ICT enabled and assistive devices used by differently abled. This chapter also dealt with theoretical perspective of disability, purpose of using ICT and assistive devices, barriers in the usage ICT and assistive devices and customization of ICT and assistive devices for differently abled. The review of literature indicates the fact that there is an urgent need to explore the ICT enabled and assistive devices used by differently abled and study the user friendliness of the these devices. This study is an attempt to fill this gap between existing devices used by differently abled and devices with more features that can create barrier free environment and can improve their quality of life. The literature confirms that there is urgent need of development of more ICT and assistive devices and enhancement of features of the ICT and assistive devices used by differently abled.

Chapter 3 dealt with methodology of the Study, which provides a short introduction of the research design, sampling procedure, standardization of scale, tools and techniques, study area and sample procedure, data collection, data analysis, design of the prototype and testing of the prototype. It helps in preparing a framework for the further study. Conceptual Model of the research work operational definition of terms of research has been presented in this chapter. Identified dependent and independent variables have been discussed in this chapter.

Chapter 4 is concerned with detailed discussion of results and discussion. ICT and assistive devices explored through market and institutional survey has been presented in tabular form. Correlation statistics has been used to test validity of the scale. Utilization of ICT and assistive devices between male and female respondents were assessed using‘t’ test. Frequency distribution was used to calculate percentage of male and female respondents regarding purpose of using ICT and assistive devices. This chapter also deals with prototype development and customization of prototype. A customized prototype of ‘Solar Smart Cane’

was developed for visually impaired and it was tested on total of thirty visually impaired respondents. This device detects obstacles from three directions and provides vibration and sound feedback. The device will play sound feedback as 'obstacle is front of you', 'obstacle is on right side' and 'obstacle is in left side'. Thus, this device provides safe mobility and promotes self reliance among visually challenged.

5.1. MAJOR FINDINGS OF THE RESEARCH

5.1.1. Market and Institutional Survey

In the first phase, market survey was conducted to explore ICT and assistive devices for differently abled. Educational institution survey was conducted followed by market survey.

- Brand and cost of the ICT and assistive devices for visually impaired, hearing impaired and locomotor impaired respondents, were explored in the market survey.
- Laboratory of educational institution was surveyed to check the availability of various ICT and assistive devices available and used by various categories of differently abed.

5.1.2. Standardization of the Scale

Questionnaire was developed, standardization was done with the help of reliability and validity, which was assessed using test retest reliability method, and validity was also assessed using correlation statistics.

- The validity of various items across all the domains was conducted through item analysis. Correlation statistics was used to check the validity of each statement.
- Obtained 'r' value was compared with degrees of correlation. 'r' value in the range of +0.75 to -0.75 shows that statements are highly valid and 'r' value in the range of+0.9 to -0.9 shoes very highly valid statements. It is evident that a highly valid score for all the statements across domains was obtained.

5.1.3. Assessment of utilization of ICT and assistive devices by differently abled

- A significant difference was found in the usage of JAWS software, tape recorder, kurzwiel reading machine and braille slate between male and female respondents from the category of visual impairment.

- Statistically highly significant differences were observed in the usage of mobile phones, radio, talking books, optacon, braille kit, white cane between male and female respondents from visual impairment.
- Among hearing impaired most preferred ICT devices found were computer, laptop, voice carry over telephones and assistive devices were hearing aids, loop induction system, speech trainer and group hearing aid system among both male and female respondents.
- There was found to be highly significant differences in the usage of mobile phones, artificial limb and significant differences were observed in the usage of walker and tricycle between male and female respondents.

5.1.4. Assessment of purpose of using ICT and assistive devices by differently abled

- Among all the differently abled respondents (visually impaired, hearing impaired and locomotor impaired), common ICT devices used for academic purpose were computer and laptop.
- Mobile phone was found to be most used for communication purpose among visually impaired and locomotor impaired respondents.
- A difference was observed in the usage of screen reader between male and female respondents from visually impaired. Male respondents were more active in using screen reader than female respondents.
- Among hearing impaired, laptop and computer were the most preferred ICT device for communication purpose.
- Mobile phones, computer and laptop were found to be most used by visually impaired and locomotor impaired respondents for entertainment while hearing impaired respondents preferred closed captioning television is preferred.
- For mobility purpose, wheelchair, tricycle and walkers were the popular devices and among visually impaired, white cane and smart cane were used.

5.1.5. Barriers in the usage of ICT and assistive devices

- It was observed that visually impaired face problems in the usage of mobile phones. They face problem of low battery backup problems in speech software; it slows down the mobile phones while locomotor impaired respondents face problems in holding the mobile phones and pressing its keys.

- Problems identified in the usage of laptop and computers were ill functioning of keys, low battery backup and problem in the programming among visually impaired and locomotor impaired.
- A problem with talking book was observed among visually impaired as it creates accent/ language problem and unavailability of language translation.
- Problem was identified with JAWS software as it slows down the PC/computer and mobile phones among blind users.
- Smart cane was not found very user friendly as this device creates problem in recognizing the direction of the obstacle and it only provides vibration feedback. It was noticed that male respondents face more problems in using braille watch due to its heavy weight.
- Among hearing impaired respondents, it was observed that female respondents face more problems in using hearing aids than male respondents as hearing aids create more noise and heavy in weight.
- It was identified that respondents with locomotor impairment, face problem in using calipers; it creates pain in legs, feeling of heaviness in legs and chances of falling down.
- A difference was observed in the usage of wheelchair and walker; female respondents face more problem than male respondents among locomotor impaired respondents.

5.1.6. Development and Customization of prototype

- On the basis of survey conducted on differently abled various problems were identified in the usage of ICT and assistive device and hence from the observed problems it was decided to develop prototype for visually impaired.
- A customized prototype; 'Solar Smart Cane' was developed for visually impaired respondents. The developed cane is an obstacle detecting device for visually impaired.
- The developed prototype was tested on visually impaired respondents. Various parameters of developed cane were compared with the cane used by the respondents.

- It was found that developed cane is better in many aspects; mobility, controllability, obstacle detection, energy saving and have better portability than the cane used by the respondents.

5.2. CONCLUSION

The usage of ICT enabled devices for differently abled persons can be better assessed by analysing how each type of ICT and assistive devices contributes to the various dimensions involved in the social and economic upliftment of differently abled. Making ICT accessible, affordable, available, adaptable, acceptable and of appropriate quality requires efficient use of often limited resources. Use of Information and Communication Technologies (ICT) and assistive technology allow the removal of many of the obstacles faced by differently abled persons. With ICT, increasingly integrated into every aspect of the modern world, these pervasive technologies have become a positive force of transformation. ICT and assistive technologies are already providing access to key public services, with widespread implications for social progress and economic development aimed to eradicate poverty, promoting inclusive societies and sustainable development. Hence an urgent need was felt to explore ICT and assistive devices for differently abled and development of customized prototype for differently abled that will be more user friendly. Accessibility of ICT and assistive devices have the potential to provide differently abled persons exotic levels of access to education, employment, public services as well as the opportunity to participate in the economic, cultural and social life of their communities**.** Thus proved accessibility of ICT and assistive devices will be helpful in creating barrier free environment for differently abled and improving their quality of life.

5.3. IMPLICATIONS

The purpose of this study was to explore ICT enabled and assistive devices for differently abled persons (visually impaired, hearing impaired & loco-motor impaired) and to develop a customized prototype of solar smart cane for visually impaired. Implications of the study are given below:

- First major implication of this research is development and standardization of scale to assess ICT related needs of differently abled, suggested modifications in the existing ICT and assistive devices that can improve their quality of life and can

create barrier free environment for them. This scale is helpful in assessing the utilization of ICT enabled devices, purpose of using these devices and barriers faced in using these devices.

- Accordingly, second major practical contribution of this research is development of prototype; 'Solar Smart Cane' for visually impaired people. Solar smart cane is an obstacle detecting device. This device provides feedback through speech and vibration feedback. It detects the obstacle from the three directions right, left and front. Solar cell has been used in this system for providing electrical energy to the system.
- This research explored many problems with the devices used by differently abled. Hence, this research is very helpful in providing a roadmap for developing more user friendly and customized ICT and assistive devices for differently abled.

5.4. FUTURE DIRECTIONS OF THE RESEARCH

- The ICT enabled device, explored was quite specific as only three categories of disability were selected (visually impaired, hearing impaired and locomotor impaired). So a study may be conducted on the other categories of disability to assess their ICT related needs that can improve their quality of life.
- This study is only conducted on students pursuing higher education courses. So the transferability of study findings could be further strengthened by surveying differently abled people from rural and urban areas to gain the more comprehensive understanding of the issue raised by the respondents.
- This research suggests that for visually impaired people, such type of cane should be developed that can detect each and every items and can provide voice feedback to the respondents.
- This research provides future directions about calipers used by locomotor impaired. Calipers are very rigid and it creates pain in legs. Chances of falling down are more if little bit imbalance occurs. Hence, more customized calipers should be developed that remove observed barriers.

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