

INTELLIGENT CONTENT SEQUENCING THROUGH PREFERENCES AND FEEDBACK OF SPECIAL NEED LEARNER

A Thesis submitted to Gujarat Technological University

for the Award of

Doctor of Philosophy

in

Computer Science

By

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under Supervision of

Dr. Devarshi Mehta



**GUJARAT TECHNOLOGICAL UNIVERSITY
AHMEDABAD**

February – 2019

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ABSTRACT Learning through technology possesses two main components: First, digital learning objects for learning and second, the order in which the learning objects are taken for learning. The general tutoring systems provides the learning content and the order in which they are delivered in a fit for all strategy. In the current scenario, with students with different learning capacities this strategy does not work. Hence, there is a need whereby the students can learn at their own pace and in the order in which they understand best. For this to happen, personalization of learning content and sequence is needed. This research mainly focuses on the

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ABSTRACT

Learning through technology possesses two main components: First, digital learning objects for learning and second, the order in which the learning objects are taken for learning. The general tutoring systems provides the learning content and the order in which they are delivered in a fit for all strategy. In the current scenario, with students with different learning capacities this strategy does not work. Hence, there is a need whereby the students can learn at their own pace and in the order in which they understand best. For this to happen, personalization of learning content and sequence is needed. This research mainly focuses on the later part, which is sequencing of the learning content. Many sequencing algorithms have been developed that provide methods for dynamic content sequencing, ant colony optimization method being one of them. Ant colony optimization algorithm is an approach used for finding most appropriate and effective learning paths for learners. It is an efficient approach for self-organizing learning and assists in personalizing the learning requirements. Education is one of the primary needs of every individual. This is equally true for special children who are not part of the regular teaching curriculum due to the difficulties they face. The special children are broadly classified into two categories:

1. Physically challenged.
2. Mentally challenged.

This work focuses on how the need for education for mentally challenged children can be met. Learning through technology is a knowledge management concept where the learning resources have to be presented in a clear and comprehensive manner to the learners. This paper presents a new approach for recommending suitable learning paths for special needs learners by applying artificial intelligence technique, Ant colony optimization algorithm. The study is carried out for Attention Deficit and Hyperactive Disorder (ADHD) and children facing Learning Disability (LD).

The research proposes a meta-heuristic approach for sequencing of learning objects in creating personalized learning sequences using modified Ant Colony Optimization algorithm. Learning paths are recommended to the learners, using learner's preference and personal traits. As the learner takes up learning contents, depending on the learner's performance on the fly, new learning sequences are generated and provided to the learners.

In loving memory of my Mother

Acknowledgement

“Call to me and I will answer you, and will tell you great and hidden things which you have not known” – Jeremiah 33:3

In the first I would like thank God almighty, for giving me the promise of wisdom and helping me in all my difficult and impossible situations.

I would like to express my special appreciation and thanks to my Supervisor Professor Dr. Devarshi Mehta, she has been a tremendous mentor for me. I would like to thank her for encouraging my research and for allowing me to grow as a research scientist. Your advice on both research as well as on my career have been priceless. I would like to sincerely thank my Co-Supervisor Dr. Ratvinder Grewal for his constant motivation. My sincere heart filled gratitude to my Doctoral Progress Committee Members, Professor Dr. Priti Sajja and Dr. Prashant Pittalia for their innovative guidance and critical review on the work carried out. I would also like to thank all of them for constantly helping me in writing this thesis and giving brilliant comments and suggestions.

My special thanks to Dr. Ronak Pandit, psychologist and mentor and to all the teachers and mentors of “Arpan” – school for special education, school for allowing me to interact with the children and guiding me to handle special children. It was due to your support and guidance that I could carry out this research. I extend my gratitude to the children at Arpan who had been a factor of constant motivation.

A special thanks to all my family members without their constant support this work would be impossible. I would also like to extend my sincere thanks to my elder sister Dr. Joycee Mekie who helped me channelize my research area. A special thanks to my children Chris and Carol who were always motivational during my journey. It is because of all of the sacrifices that they’ve made on my behalf and their prayers for me was what sustained me thus far. I would also like to thank my brother Mr. Elvin McLean, who supported my journey and made it possible for me to get through this task. I extend my deep sense of gratitude to my Late Mother, Mrs. Moneka for her constant inspiration which gave me the strength to reach the goal. This work has been dedicated to her for her unfailing love towards me.

I would also like to thank all of my colleagues and staff members who supported me throughout my journey of research and motivated me to reach my goal.

It would be really unfair on my part if I forget to thank my beloved husband Mr. Vatsal Roman who spent sleepless nights and was always my support in the tiring moments. I really thank him for giving me strength, motivation and constant encouragement to complete this endeavor of mine.

Jonita Vatsal Roman

List of Abbreviation

Abbreviation	Full Form
ADHD	Attention Deficit Hyperactive Disorder
LD	Learning Disability
ACO	Ant Colony Algorithm
ITS	Intelligent Tutoring System
CAT	Computer Aided Technology
LT	Learning Technology
CAD	Computer Aided Design
SNL	Special Need Learner

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CHAPTER – 1

Introduction

1.1 Introduction

This is the era of Information Technology (IT), where much is talked about computer technology and what computers can do to help mankind. Education is one such promising field where computer technology has done wonders. It is a well-known fact that today's education system has integrated the use of computer technology in catering knowledge to the students. This includes the use of virtual class, assignment submission through Internet, flipped classroom teaching method, various multi-media devices being used and many more. This, along with the traditional method of teaching-learning mechanism enhances the learning ability of the learners. This is equally true for learners having learning difficulties [1, 2, 3, 4]. This thesis discusses how learning technologies [5, 6, 16, 18, 21] such as Computer Aided Technology (CAT), Computer Aided Design (CAD), Computer Assisted Interface (CAI), and similar to these can be of aid to special need learners.

1.2 Scenario

Learning technologies have come up with solutions for adaptive learning [15, 16, 22, 26]. Adaptive learning mainly has the following components:

- 1) Creation of learning objects
- 2) Storage of learning objects in the form of repository
- 3) Creation of repository for learners
- 4) Rules for usage of learning objects
- 5) Rules for Sequencing of the learning components

In normal scenario, where so much of learning content is available, it is difficult for the learner to identify which learning content to pick up for learning. Also the learning content that has to be provided for effective learning should be in accordance with the background knowledge the learner holds, the goals set for the learner, motivation level and many such [25, 34, 35]. With so many learning resources available, it is very important that appropriate content should be made available to the learners when it comes to learning through technology. Every individual has a unique learning requirement; hence, personalized learning will help the learners in learning. A very natural question arises, “Can this type of education mechanism be catered to special children – children with disabilities?” To answer this question it is very important to first of all identify what type of disabilities are talked about and what kind of disabilities are being considered. Disabilities are broadly categorised as:

- 1) Physical disability and
- 2) Mental disability

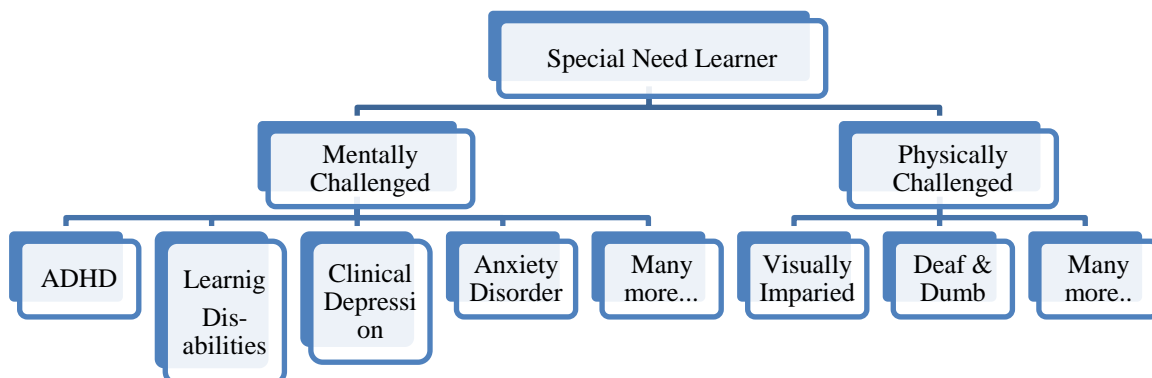


Figure 1.1: Broad classification of Special Need Learner

The figure 1.1 shows a broad classification of physical and mental difficulties faced by the special need learner. The physical difficulties are further classified as visually impaired, children having difficulty in auditory senses, difficulty in speech and many such. Mental difficulties are of different forms. Attention deficit hyperactive disorder (ADHD), learning disability (LD), Clinical depression, Bipolar disorder, Autism and many such belong to the category of mental disabilities.

In both the above cases, it is possible to meet the educational needs of the individual, but the approach is very much different. The need of a physically challenged child is very much

different from that of a mentally challenged child. A physically challenged child needs more of a physical assistance as compared to a mentally affected child. It is also possible that a child passing through mental difficulty may also have some physical difficulties as well. With so many complexities faced by the child, a need arises to find out solutions that can assist the child in taking the daily lessons with ease of understanding [5, 6, 7]. In doing so it is required to pose a question, can computer technology be of some aid to these children? This thesis discusses about how computer technology can help children facing mental difficulties for handling their regular learning requirements.

Mental disabilities have a wide spectrum, ranging from difficulties such as Autism spectrum disorders, Learning disability, Attention Deficit Hyperactive disorder, Bipolar disorder, Neurodevelopmental disorder, Intellectual disabilities and many such[1]. Apart from the types, these disorders come with various intensity levels. Some children suffer badly from these disorders while others are less affected. Each child has a unique combination of the type of disorder and the level of intensity. Also different children have different faculties to be addressed. Some have problems with their behaviour, some with their intellectual capability, some with cognitive, some face issues with remembering things and so on. It totally depends on the type of difficulty the child is facing. It has been researched that if individual attention is given to these children then these children can live up with their difficulties and can live a life with social acceptance.

The focus of the thesis is mainly on two categories of mental difficulties that a child faces: Attention Deficit and Hyperactive disorder (ADHD) and Learning Disability (LD). In the first place it is very important to understand the characteristics of ADHD and LD children and the type of difficulties they face. Looking to their difficulties and the need to solve their difficulties, a model is proposed that can help them overcome their difficulties.

According to National Institute of Mental Health [<https://www.nimh.nih.gov/index.shtml>] and American Psychiatric Association [<https://www.psychiatry.org>], ADHD is defined as: A mental disorder of the Neurodevelopmental type. It is characterized by problems like difficulty in paying attention, excessive activity, or difficulty controlling behaviour which is not appropriate for a person's age. This persistent pattern of inattention and/or hyperactivity-impulsivity interferes in the functional development of the child. Children suffering from ADHD generally have the following characteristics: they lack attention, are highly impulsive,

are over active, lack persistence, are socially clumsy, emotionally get over aroused quickly, are hypersensitive, have dramatic mood swings, lack in co-ordination, are disorganised, poor at time management, may have some specific learning difficulty (such as struggling with mathematics or language or any other such learning), contain very low self-esteem, are motivationally weak and are very stubborn. Depending on the number and intensity of disorder from the above characteristics and the severity in which they are, a child may be rated as mild, moderate or severe on the ADHD scale.

Learning disabilities arise from Neurological differences in brain structure and function and affect a person's ability to receive, store, process, retrieve or communicate information [<https://www.nimh.nih.gov/index.shtml>]. There are many categories of learning disabilities.

Three main types of learning disabilities are:

- 1) Dyscalculia (learning disability in math),
- 2) Dyslexia (learning disability in reading) and
- 3) Dysgraphia (learning disability in writing).

Along with the above disabilities, the areas of information processing that are commonly associated with LD are:

- 1) Auditory processing deficit (weakness in the ability to understand and use auditory information),
- 2) Visual processing deficit (weakness in the ability to understand and use visual information),
- 3) Non-verbal learning disability (have unique learning and behavioural profiles)

While the specific nature of these brain-based disorders is still not well understood, considerable progress has been made in mapping some of the characteristic difficulties of LD to specific brain regions and structures [1, <https://www.nimh.nih.gov/index.shtml>].

The most common types of specific learning disabilities are those that impact the areas of reading, math and written expression. They may co-occur with other disorders of attention, language and behaviour, but are distinct in how they impact learning. A child who has been diagnosed for learning disability generally has a short attention span, poor memory, difficulty in following instructions, are unable to discriminate among letters, numerals, sounds, colours, images etc., have poor reading and/or writing skills, poor coordination among the fine motors, lack in eye-hand coordination, face difficulty in sequencing various events/activities

and many such.

With this situation of the special children, teaching – learning process becomes very difficult. The difficulty is equally faced by the teachers/mentors/counsellors as it is with the children since they are in direct contact with the children for the teaching-learning process. A traditional method hence will not be enough to quench the educational thirst of these children. In order to enhance the teaching – learning process, along with the traditional method, technology based learning will give a good push to these children [23, 25]. The teaching-learning process could be further enhanced using computer technology in the form of an Intelligent Tutoring System (ITS). An ITS can definitely help these children to cope up with their learning requirements. The main components that ITS supports [35, 39, 40] are:

- 1) Creation of Digital Learning components also known as learning content
- 2) Sequencing of the learning components

This thesis mainly focuses on the sequencing of learning components for specially-abled children.

Learners learn at different pace, even when taught in the same learning environment. In a normal learning environment, the learners are provided with similar kind of learning objects. The sequence of these objects is also fixed. In this scenario individualized learning does not take place. Thus, the need of personalized learning arises [57, 62, 66]. As discussed earlier, when it comes to special children, their learning requirements are very different. Thus, a static sequence of learning objects will not help them to achieve their goals of learning. A need for personalised and dynamic sequence of learning objects is required that will provide individualized learning for these special abled children. The focus is thus on the following points that will assist the children to learn:

- 1) Provide repetition in learning of similar concept through different types of learning content for better understanding and learning purpose.
- 2) Variety of learning content to be provided for better understanding and learning of concepts.
- 3) Providing practice contents to reinforce learning.
- 4) Conducting periodic assessment to authenticate learning is done.
- 5) Understanding feedback of what is learnt by the learners

The above points will enhance the traditional teaching-learning method when complemented with computer technology.

1.3 Objectives of Research

Looking to the personalized learning requirements of the specially-abled children, the main research objective identified is to provide personalized learning to these children. Since this personalization is difficult to achieve in the regular class room mode or the traditional method of the teaching-learning process, learning through technology can help these children learn.

The following objectives have been identified:

- 1) Understanding and satiating the individual learning need of the special children using learning technologies.
- 2) Studying the role of Learning Technologies such as Computer Assisted Technologies, Computer Assisted Programs and Learning Object Models for preparing learning models for special children.
- 3) Analyzing the requirements of counselors, parents, teachers and experts who deal with special children.
- 4) Preparing customized content sequencing of the learning objects to meet the individual requirements of the special learners.
- 5) Generating learning paths on the fly using solutions that solve content sequencing problem using nature inspired algorithms such as Ant colony optimization algorithm.

1.4 Justification

Learning through adaptive tutoring model, provide an effective method for finding optimal learning paths based on self-organization. An improved model of adaptive tutoring system using Ant Colony Optimization (ACO) algorithm has been proposed in this work. The learning object is personalized based on the learning and the feedback provided by the specially-abled child. The ACO generates the adaptive optimal learning path where the objective is to make the learning effective as compared to speedy learning.

1.5 Application and benefits of the system

The proposed model is applicable not only to the specially-abled children, but fine tuning of the model can be of help to any adaptive learning system. Specially-abled children face difficulties other than the regular curriculum learning such as:

- 1) Social behaviours
- 2) Being hyperactive and impulsive
- 3) Are forgetful
- 4) Find difficulty in tackling new and unknown situations and many others

With the help of this model, special children can be made to learn various social skills needed for daily routine. The model will also help the parents and teachers of these children to regulate their daily needs.

1.6 Users and beneficiaries

The main beneficiary of the proposed system is the specially-abled children. The model is equally of use for:

- 1) Parents of the children
- 2) Teachers
- 3) Mentors
- 4) Counsellors
- 5) Psychologists
- 6) Domain experts
- 7) Psychiatrists

1.7 Research Contribution

The main idea of working in this area is to quench the learning thirst of the special category of learners. Although teachers, mentors, experts, psychologists, psychiatrists and other helpers are working in the direction for providing good learning to these children, still a need of personalized learning has been identified. This personalization of learning can be made possible by generating individual learning paths. Learners are given many content of the similar types for learning purposes. These contents are prepared by the experts and are initially tagged by the experts. As the system is being used, different content gain different

level of popularity. A fuzzy logic inference has been applied for tagging of the content for its difficulty levels. This tagging would help in mapping of content with the learner.

Many sequencing algorithms are available to solve this issue. By studying these algorithms, it has been observed that Ant Colony Optimization (ACO) algorithm suits as per the requirement of the learners. The ACO is well known as a meta-heuristic search algorithm, which aids in finding shortest paths for the problem in question. Fine tuning of the parameters will help to generate personalized learning paths that will provide efficient learning for the specially-abled children. The ACO has been modified for efficient learning rather than for fast learning. Apart from this, fuzzy logic inference has been applied for tagging of the content. This tagging would help in the mapping of the content with the learner.

1.8 Thesis organization

The rest of the thesis is organized as follows:

Chapter 2: This chapter provides a detailed background study required for the research. It is carried out in two phases. A detailed study on the need of learning technologies for special needs children is carried out in the first phase of the review. Various assistive technologies and other tools available for these children are also discussed. The need for personalization in the teaching-learning process for special children is shown in this chapter. In the second phase a detailed and systematic review on the need and how the sequencing of learning objects in Intelligent Tutoring Systems (ITS) is done has been discussed. It provides the details about various sequencing algorithms. It also discusses about the advantages of using Ant Colony Optimization (ACO) algorithms in the present research.

Chapter 3: The proposed model related to the whole system is explained in this chapter. The system architecture along with the various modules, repositories and interactions is mentioned here. A detailed design along with the algorithm to be used for the research has been explained. The fuzzy logic inference system used for the tagging of the content level is also discussed in this chapter. It also discusses the proposed model prepared for specially-abled children. The chapter briefs about the general Ant Colony Optimization (ACO)

algorithm and then it elaborates on the modified algorithm developed for the proposed model. The sequencing of the learning objects on the basis of the proposed model is also discussed. Various parameters on which the proposed model depends are also discussed.

Chapter 4: The experimental setup for the research is explained in this chapter. The system is accessed by the beneficiaries of the system through user interfaces. These interfaces are elaborated and explained here. This chapter also explains the various phases of the system. The input to the system through the interfaces, the storage of data in terms of repository, the rules for sequencing and all the activities related to the proposed system are discussed in this chapter. The bifurcation of the interfaces activity wise and user wise is also explained in detail. The rules for tagging of the content for its difficulty levels are discussed in this chapter. The parameters that are used for sequencing are suggested in this chapter. The usage of rules for tagging of the content for their levels has also been discussed here.

Chapter 5: The output in the form of results of the various modules of the proposed system as per the objective of the system is discussed in this chapter. The data related to the student difficulty and intensity is shown here. Result in terms of learning and practice module taken by the learners is shown in this chapter. The results of assessment taken, the comparison with the standard value and the average result of the student have been recorded. The path recommended by the system and the actual path taken by the learner has also been shown here. Thus this chapter discusses the overall output of the system.

Chapter 6: Any research has a scope for improvement. So it is with this work. This chapter gives concluding remarks on the work done and gives the future scope of enhancement. The chapter also discusses the various applications and benefits of the system. It explains the limitations and provides the future scope of the research.

CHAPTER – 2

Literature Review

2.1 Introduction

In the recent years, learning through technologies has become an inseparable part of the teaching learning process. Learning through technology enhances the way children learn. Learning technologies help both physically as well as mentally challenged children [1, 6, 9, 26] in their regular teaching – learning process. Study also reveals learning through technology not only benefits regular school goes but also helps specially-abled children for meeting their learning requirements [15]. Various assistive tools [16, 17, 23] are devised in order to help the special needs children to fulfill their learning requirements [5, 6, 8, 10]. Assistive technologies come up in variety such as Computer Aided Technology (CAT), Computer Aided Design (CAD), and many such [21, 22, 34, 35, 36].

Various nature inspired algorithms are available that are used in solving different types of optimization problems. Particle Swarm Optimization, Bee algorithms, Genetic algorithms, Ant colony algorithms are few algorithms that are generally used in solving non-deterministic polynomial time hard (NP-Hard) problems. Since providing dynamic learning content sequencing belongs to the NP-hard problem category, nature based algorithms can be used to solve this problem.

2.2 Learning Technologies for Special Need Learner

Use of various Learning Technologies has had a dramatic impact on the teaching learning processes of the learners. This is not restricted to the so called normal learners, but it also caters to the special needs learners, even those having difficulties with their mental faculty [14, 16]. Many eLearning tools are being devised using various educational theories, so as to help these learners cope with their special educational needs [8, 14, 20, 21]. The objective in doing so is to be of some aid to these learners where their learning difficulties can be addressed. Learning technology in the form of Assistive technologies help special needs learners to take up online courses [16]. Generation of any assistive technology mainly addresses to two areas:

- 1) Content of Learning in the form of learning objects
- 2) Sequencing of these learning objects to get the best learning sequences.

The following research papers were studied to understand the importance of learning technologies in imparting education to special children.

- "Multimedia interfaces for users with high functioning autism: An empirical investigation." – Grynszpan, Ouriel, Jean-Claude Martin, and Jacqueline Nadel. *International Journal of Human-Computer Studies* 66.8 (2008): 628-639.

During their study the authors found that, Computer Aided Technological programs can turn out to be beneficial for Autistic children, but they encountered that there was a severe problem with the children in attention part. The children showed unstable attention patterns. Each child has a unique area to be focused on, thus an individualized program was required for these children as compared to a general program.

- "The identification, implementation, and evaluation of critical user interface design features of computer-assisted instruction programs in mathematics for students with learning disabilities." – Seo, You-Jin, and Honguk Woo. *Computers & Education* 55.1 (2010): 363-377.

In their study, You et al [12] designed and developed a computer assisted instruction

program, 'Math Explorer', for students with learning disability. Mathematics being a crucial subject in the main stream education is difficult for children to understand. It is observed that children suffering from learning disabilities struggles in their math concepts. In order to address this problem, You et al designed the "Math Explorer" The main focus of the study was the design features that would assist the learners in better learning and understanding of a given basic mathematical word problem for addition and subtraction. The results of the study indicated that given a critically designed user interface feature facilitate the special need learners to mathematical learning. The authors also agree upon that more critical analysis needs to carried out in order to facilitate the children in a better way.

- "Effects of computer-based practice on the acquisition and maintenance of basic academic skills for children with moderate to intensive educational needs." – Everhart, Julie M., Sheila R. Alber-Morgan, and JuHee Park, *Education and Training in Autism and Developmental Disabilities* 46.4 (2011): 556.

In a study carried out by Everhart et al [13], two children with disabilities were studied. These children had moderate to intensive disabilities and were investigated for their basic academic skills. The special education teacher created individualized computer games corresponding to their individual needs. The computer games were created in such a way that children could practice independently. These games checked the basics such as letter-sound, number identification and word identification and provided discrete learning trials with quick feedback for every answer. The program helped the children in successful acquisition of the basic skills. The results demonstrated regular computer practice enabled not only independence in work, but also increased the attention span of the moderate to intensive disabled children, as mentioned in the experimentation.

- "Identifying emerging trends for implementing learning technology in special education: A state-of-the-art review of selected articles published in 2008–2012." – Liu, Gi-Zen, No-Wei Wu, and Yi-Wen Chen published in *Research in developmental disabilities* 34.10 (2013): 3618-3628.

A thorough study was carried out by the authors for the understanding of the

implementation of learning technologies in special education. They studied 86 research papers to understand the need of LT for special children. During their study they mainly found the effectiveness of usage of learning technologies for special education students (75%), how educational activities were designed (14%) and the responses of the students and teachers towards learning technologies (11%). They also studied the distribution of the usage of learning technologies and observed that learning technology usage in terms of assistive technologies was 71%, specific software usage was 18% and mobile learning and (11%). The study also revealed that as compared to physically challenged learners, learning technologies are more used for mentally challenged learners.

- "Use of computer-assisted technologies (CAT) to enhance social, communicative, and language development in children with autism spectrum disorders." - Ploog, Bertram O., et al., published in *Journal of autism and developmental disorders* 43.2 (2013): 301-322.

In their study for Autistic Spectrum Disorder children, the authors considered remediation of deficits in language skills, reading, social skills including verbal and non-verbal and daily life skill as the four basic categories for learning. During their study they observed that Computer Assisted Technology (CAT) enhanced the social, communicative and language related aspects of Autistic children. They also observed that properly designed CAT programs are advantageous to ASD children. They also found a few limitations:

- (i) ASD children have abnormal attention patterns; hence if any complex concept has to be made understood proper care has to be taken for content preparation.
 - (ii) Poorly designed CAT programs may isolate the children from being social.
 - (iii) There are very limited acts of behaviors and ways for ASD children respond to various stimuli. Majority of CAT programs lacks in generalization of treatment effects which become a problem for ASD children.
- "Do programs designed to train working memory, other executive functions, and attention benefit children with ADHD? A meta-analytic review of cognitive,

academic, and behavioural outcomes", Rapport, Mark D., et al. *Clinical psychology review* 33.8 (2013): 1237-1252.

Children with Attention Deficit Hyperactive Disorder (ADHD) are characterized frequently as possessing underdeveloped executive functions and problems with attention abilities. In their research the authors studied that computer-based cognitive training can remediate these impairments and provide significant and lasting improvement in their attention, impulse control, social functioning, academic performance, and complex reasoning skills. The review evaluated the benefits of a facilitative intervention training (FIT) program which improved the cognitive and behavioural functioning of ADHD children. These programs were developed based on the dual suppositions that (i) Executive Functions (EFs) and/or attention seeking processes integral to successful EF operation are significantly underdeveloped or impaired in children with ADHD; and (ii) that the maturation and/or efficiency of neural circuitry underlying targeted executive functions can be accelerated by means of protracted training, practice and feedback. The review shows positive effect of FITs for ADHD children with a variation in the level of executive functioning. It also opens up the possibility that cognitive training techniques of the type FITs designed to improve empirically documented executive function deficits benefit children with ADHD.

- Nakamura, Camila Gernhardt. "HOW WEARABLE COMPUTING CAN HELP YOUNG CHILDREN WITH ADHD TO LEARN." (2015).

Wearable computing adoption can make learning more exciting; make things more obvious and easier for children with ADHD. As reviewed by the researchers, this kind of learning with the cooperation of the student and teacher would make learning more creative and knowledge filled. Self directed knowledge will help the children to have more information about what they really want to do in future, which really is very important for children with ADHD. Various wearable computing such as ICALM, EMOTIV, XOX wristband monitor the emotional and physiological processes of the ADHD children. Usages of these devices help the parents and teachers monitor the level and take appropriate actions whenever required. Creation of learning dashboards also helps the children in learning which makes learning fun-filled and meaningful.

The main concern in creation of learning dashboards is the design which should be user centric and more of self driven learning which creates passion among the children for gaining knowledge. In all this computing assistance, one indispensable part is the continuous monitoring of the teachers for making comfortable learning possible for the children.

- Sonne, Tobias, et al. "A Follow-up study of a successful assistive technology for children with ADHD and their families." *Proceedings of the The 15th International Conference on Interaction Design and Children*. ACM, 2016.

Assistive Technology in the form of MOBERO mobile system was designed and given for use to parents of children with ADHD. The parents and the children agreed upon its usage and monitored the changes in the behaviour of the children using the system. Through interview and questionnaire the feedback regarding the system was taken. The feedback was a mixed one; many parents did find it very helpful and were able to regularize the schedule of their children while some parents still found it difficult to manage with the children. The researchers find the need to explore more potential technologies that would help the families of these children in regularizing the daily routine.

- Heiman, Tali, et al. "Access and perceived ICT usability among students with disabilities attending higher education institutions." *Education and Information Technologies* (2017): 1-14.

In their findings, Heiman et al, found that an increasing number of students with disabilities were taking up higher education. In order to cope up with the academic skills these students preferred information and communication technologies (ICT) as a medium for study. ICTs can provide a platform for independent, easy access and adaptive ways for learning. This becomes a key point for preference of ICT by students with learning disabilities. In their research Heiman et al examined the perception for ICT among students and professors of post secondary educational institutions in Canada and Israel. They concluded that in comparison to Canada, Israeli students and professors had a higher usage and greater accessibility of use of ICT. The study's findings and its implications are likely to be important for

promoting access to ICT for students with and without disabilities. The study did not incorporate the student academic characteristics such as grades, area of study, facilities etc; which are planned to be covered as future scope. These parameters which are important would also be considered in future for usage of ICT in learning environments.

- Baglama, Basak, Yucesoy, and MukaddesSakalliDemirok. "USE OF COMPUTERS IN SPECIAL EDUCATION: BENEFITS AND OUTCOMES." *Near East University Online Journal of Education* 1.1 (2018): 54-62.

In the study carried by Baglama et al, found that the use of computers for technological tool in special education; enhances teaching concepts and skills and increases permanence and generalization of learned concepts and skills. The study was carried out by examining the articles published in Scopus database. These articles were examined on the basis of their study, the authors concluded that computers as a technological tool provides many opportunities for individuals with special needs in terms of many dimensions in order to improve life standards in the society, participate into social life and maintain various skills for learning a profession or living independently in the society. Computer-supported education programs were frequently used in teaching many academic skills such as mathematics, reading-writing, communication skills, other life skills including self-care skills and daily living skills. In addition to teaching these skills, computers help individuals with special needs to learn and transfer new knowledge and skills to other situations. The study ends with a positive note on usage of computers for learning of special needs children.

2.3 Observations of work done on Learning Technologies

Effective teaching – learning can be catered to children with special needs. Learning challenges can be met through audio-visual representation, usage of computers, using assistive tools and many such. Learning done in this manner makes learning simple, easy

and has a lasting effect. Although computer assisted technologies for learning technology are more effective in special education, individualized programs that are adaptive in nature needs to be created. The design of interactive and self-regulated learning environment will promote and motivate special needs children for learning. Intervention of instructor if needed should be incorporated with the program for better understanding of learning.

From the above observations a need arises to understand adaptive technologies that can be given to the special needs children for learning. In developing adaptive technology, main components to be taken care of are:

- 1) Construction of content to be given for learning purpose and
- 2) Sequencing of the learning content to be learnt

The thesis focuses on sequencing of learning content to be provided to the special needs children. This content sequence needs to be individualized and adaptive in nature in order to fulfill the individual need of the child. The next section discusses a brief review on the various heuristic methods used in content sequencing.

2.4 Heuristic methods used in content sequencing

Soft computing methods are found to be especially good in solving non-deterministic polynomial time-hard (NP-hard) problems [47, 48, 49]. According to [45, 48, 52, 60], content sequencing methods are majorly categorized into two distinct categories:

- 1) Content sequencing for social groups: Methods that work on the recommendation from the experiences of similar learners through group formation.
- 2) Content sequencing for Individuals: Methods that focus on the individual learner experience.

Among the various algorithms used for solving individual content sequencing problem such as Neural Networks, Genetic Algorithms and other Particle Swarm Optimization algorithms, Ant Colony Optimization algorithms are more suitable and recommended for individualized content sequencing [44, 46, 62, 63, 64].

A simplified Ant Colony Optimization (ACO) algorithm was developed by [44], that kept the records of the paths selected by the learners who had successfully completed the course, as determined by a post course 5- question multiple choice quiz. A transition matrix that recorded the number of learner transitions between individual pairs of nodes

on such paths was maintained. The full path was then recommended to the next learner using the roulette wheel mechanism.

In a graph based ACO approach by [46], nodes were represented learning units and arcs were represented as performance. A sequencing graph was constructed and used to record the frequencies and the performances in terms of “successful” or “failure” of the learners through various paths taken by the learners. The information was presented to the target learner every time he/she would finish a learning unit (a “node” in their context), so that he/she could choose the next unit by referring to how all other peers performed (i.e. the numbers of successful and failed peers) in the same situation.

A set of course sequencing algorithms that combined both prescriptive navigation rules and inductive mechanism was proposed by [64] which they called the Dynamic Learning Path Advisor (DYLPA). They used the Style-based Ant colony system (SACS), where the learning styles of the alumni was captured and maintained for providing the new learners with the same style. They categorized the alumni into four learning styles named as: Visual, Aural/Auditory, Read/Write and Kinesthetic. For recommending the next node, the pheromones deposited by the alumni in terms of the number of times the path was traversed, who belonged to the same category as the target learner were favoured during computations. The model provided an adaptive learning path using meta-heuristics. Due to its robustness and adaption to the ever changing learning environment, this algorithm proved to be one of the best choices.

In their work [51], proposed a new dimension to detect learning styles using a multi-agent system. It involved people socially attached with the learner such as friends, parents and teachers. They used a combination of ACO and fuzzy logic as tools to detect learning styles.

An Adaptive Content Sequencing in eLearning (ACSeL), was proposed by [62, 63] for providing learning content to online learners. Using ant-based algorithm, it evaluated the level of a learner and recommended appropriate contents to the learner for learning purpose. The behaviours of past learners were captured and utilized to recommend content to prospective learners.

2.5 Ant Colony Optimization (ACO)

Out of the many nature inspired methods available for solving the content sequencing problem, Ant Colony Optimization (ACO) algorithm is most popular algorithm [41, 46, 62, 63]. Ants are able to construct network paths so as to link their nests to the food sources. These networks lead to the formation of minimum spanning trees which are the shortest paths from the nest to the food [41]. During this search, the ants explore various paths so as to reach the food. Several ants start from the nest to reach the destination. Once the food is obtained they carry the food and go back to their nests. While this journey, the ants drop a special kind of chemical known as pheromone. This pheromone becomes an indicator for other ants to follow the path for food availability. Since many paths are available for food search, those paths have a high probability of being chosen that have a good density of the pheromone drops. These paths that have the pheromone drops are heuristically chosen by other ants making that path to be the most used path and becomes recommended path for the other ants. The path that has more concentration of pheromone deposition is generally the shortest path as it would be the path that was travelled with more frequency and in less amount of time.

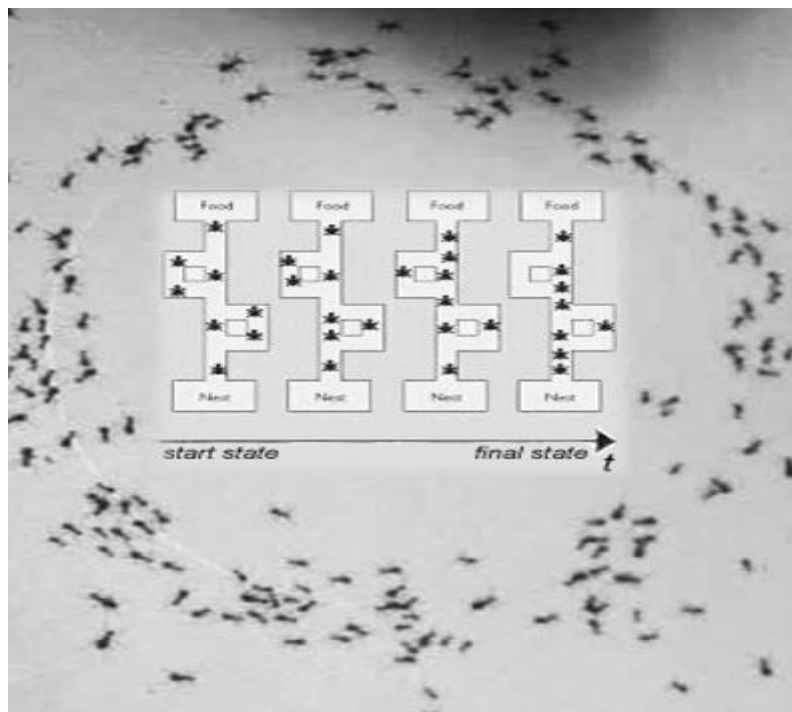


Figure 2.1: Ants travelling various paths from nest to food source

(Ref: https://upload.wikimedia.org/wikipedia/commons/9/95/Artificial_ants.jpg)

Ant Colony Optimization is a nature based optimization algorithm [41] which is inspired by ants that travel in search for food from nest to the food source. This concept of ant searching for food and finding a shortest path while their search; is extended to generation of learning paths for learners [41]. A graph based ACO algorithm takes nodes as contents to be learnt where as the weights on the arcs decide the next path to be taken by the learner. The choice of the path depends on the pheromone value suggested by the model applied.

The general Ant Colony Optimization procedure is mentioned below:

```

Procedure ACO Algorithm
  Set parameters, initialize pheromone trials
  While (conditions are not met) do
    Solution construction
    Location search
    Pheromone update
  End
End ACO Algorithm

```

The next section discusses the literature review carried out for algorithms and methods used in dynamic content sequencing.

2.6 Literature Review on Ant Colony Optimization Algorithm for Sequencing Problem

A few research papers on dynamic sequencing for learning content were studied. A brief of each is discussed below:

- “Forming Heterogeneous Groups for Intelligent Collaborative Learning Systems with Ant Colony Optimization” – Sabine Graf and Rahel Bekele: published in *International Conference on Intelligent Tutoring Systems*. Springer, Berlin, Heidelberg, 2006.

In the research work carried out by Graf et al., heterogeneous learning groups were formed to improve learners’ academic performance. A mathematical model was proposed to formulate heterogeneous groups on the basis of the personality traits and

performance of the students. In order to maximize the heterogeneity of the groups so formed, a tool using Ant Colony Optimization algorithm was implemented. In order to implement the mathematical model for group formation: student score, heterogeneity of students, goodness of heterogeneity of students and formation of heterogeneous groups were considered. The student score was measured on the basis of group work attitude, interest for the subject, achievement motivation, self-confidence, shyness, level of performance in the subject and fluency in the language of instruction. Heterogeneity of students was measured considering the Euclidean distance (ED) method; where ED was defined as the distance between the vectors representing two students' details. The heterogeneous groups were formed on the basis of the student scores as a combination of low, average and high score. It was also studied that when students with different levels are grouped together they perform relatively well. This concept was used in formation of groups with heterogeneity. The goodness of heterogeneity was measured using the average of maximum and minimum student score in the group. In formation of heterogeneous groups it was observed that instead of having a random value for group heterogeneity, it was better to apply the average, coefficient of variance and the Euclidean distance method. Ant Colony System was used in formation of groups for the collaborative learning systems. Here, the group forming problem was solved using the Graph representation similar to solving of the Travelling Salesman Problem. Students were grouped into ' m ' different groups each with a size of 4-5 students according to the parameters discussed previously. The pheromone Update rules were decided by the performance of the students.

Experimentation showed that the algorithm delivered stable solutions which were close to the optimum for different dataset of about 100 students, which when extended to 512 students also gave optimum results showing scalability of the algorithm.

- “Adaptable Learning Pathway Generation with Ant Colony Optimization” – Wong, Lung-Hsiang, and Chee-Kit Looi, published in *Journal of Educational Technology & Society*, 12.3 (2009).

Dynamic Learning Path Advisor (DYLPA) is a course sequencing model that used a

combination of prescriptive navigation rules and inductive mechanism for recommending learning paths to the learners of a course. Apart from the recommendation done, the model also allowed the learner to make a choice of its own for learning purpose. The DYLPAs process used the Ant Colony Optimization algorithm in recommending the paths for the learner. According to system, a learning path is recommended to a new target learner at the early stage of a new course. The course administrator specifies a DYLPAs training size of ' n ' and a DYLPAs training threshold value as ' t '. DYLPAs recommends learning paths on the basis of prescriptive rules, even without substantial amount of learner history, but does not force the learner to take that path. Past learners' paths and performances were measured and stored. The past learners were called the "Alumni". On the basis of the performance of the alumni, similarity levels between the individual alumni and the target learner was obtained. After the similarity was calculated, the course network was traversed. The more often a path was taken by the learner, the probability of its consideration for other learners increased. Although, inductive course planning had been used in the field of learning technology, DYLPAs is considered to be novel as it combined prescriptive and inductive planning technique. As a limitation to the above model, the computation of pheromone needs to be improved. Also there is scope of improvement in the computation of the degree of similarity and the choice of learner attributes as they are relatively ad-hoc and needs revision.

- "Building Intelligent Tutoring Systems Immersed in Repositories of e-Learning Content." – Marciniak, Jacek, *Procedia Computer Science* 35 (2014): 541-550.
Creation of Intelligent Tutoring Systems which are active in dynamically growing repositories of e-learning contents are discussed in this research. The components of the intelligent tutoring system in expanding e-learning content repository were: Content structure in repository, Resource indexing with wordnet based ontologies, Domain model and the Pedagogy model. The content was described using the Universal Curricular Taxonomy System (UCTS). The UCTS contained the learning unit, the learning module and the curriculum. Each learning unit is the smallest content structure that is cohesive in terms of subject matter at the same time making it

possible to achieve defined didactic goals. The Learning Module (LM) contained a component of exam type to verify knowledge gained in the module and to modify the learner data. Curriculum was taken as a complete training program that exhaustively discussed a given topic composed of one or more learning modules. Further in the model, the Curriculum may contain an element of the exam type serving as final exam. The model assumed that Learning Unit was made up of smaller components that may exhaustively have a single topic or some defined competences. The components of the learning unit were the learning object, exercise, self assessment, exam and references. A learning object is a section of material which introduces new

contents organized as 'knowledge capsules'. The exercise is a component designed only for self verification of knowledge, the results were not sent to either learning management system (LMS) or to the teacher. Self assessment is a special type of exercise that enabled the students to verify their progress in a given section of contents. Questions in this component had a cross-sectional character. Exam was a component that verified students' progress in a defined section of the material; the results were sent to the LMS and were also made available to the tutor. References were a list of literature that was used for discussion on issues related to learning. Resource indexing was done using wordnet based ontologies: Here help of wordnet based ontologies was taken so as to see that resource was properly indexed. The tagging further helped in proper resource indexing. The domain model comprised of a set of domain ontologies, wordnet based ontology and index of the tags. This model consisted of the pedagogical strategies, patterns and various intelligent tutoring system agents.

The system worked on the content collected in a repository that may be supplemented with e-learning content repository model Sharable Content Object Reference Model (SCORM). The authors have used SCROM – CAM (Content Aggregation Model) content organization where information related to content hierarchy, metadata and sequencing behaviour model are stored. The presented architecture, based on SCROM-CAM enabled the didacticians to simply and conveniently create didactic content that adapted to learners' needs at the same time shifting responsibility for creation of pedagogical patterns to content authoring professionals who create a

library of ready-made solution for the former. More agents need to be developed in order to refer to the students' information.

- "Ant Colony Optimization for Competency Based Learning Objects Sequencing in e-Learning." – Dharshini, A. Priya, S. Chandrakumarmangalam, and G. Arthi, *Applied Mathematics and Computation* 263 (2015): 332-341.

A novel approach for obtaining better learning paths for different learners groups was formulated by Dharshini et al. The problem was stated as a constraint satisfaction problem in which meta-data and competencies were used to formulate the learning object (LO) sequences. A dynamic learning path using Ant Colony Optimization was used. The conceptual data model for LO sequencing had various components. Competencies were considered as multi-dimensional value which in turn comprised of knowledge, skills and other psychological factors to understand the complex behavioural responses of the learner. Automatic sequencing of learning object was modelled using the components like competency, meta-data and learning objects sequences. Mathematical formulation was done using the constraint represented in the form of a finite set of variables. A mathematical function was devised to correspond to the domain with a set of constraints for the given problem. Valid assignment of the variables to satisfy the constraint was done using various permutations.

A graph based approach was used where the nodes were the pedagogical items such as lessons, quizzes, assignments etc and the weight on the arcs were the probabilities to suggest subsequent nodes to students. The stigmergic information representing the interaction between the students and the pedagogic material is stored in the environment that helps in finding the appropriate paths for the students in learning. The major advantages of the approach were the model supported the e-learning activities in terms of less processing time and minimal sequencing cost. Proper formulation of the constraint set is very important for the effectiveness of the model.

- "Improved Modeling of Intelligent Tutoring Systems Using Ant Colony Optimization." – Rastegarmoghadam, Mahin, and KoorushZiarati, *Education and Information Technologies* 22.3 (2017): 1067-1087.

To provide an effective method for finding optimal learning paths on the basis of self-

organization, in adaptive e-learning systems, Ant Colony Algorithm was used by Rastegarmoghadam et al. In their work, improved modeling of adaptive e-learning system for formulating adaptive optimal learning path is developed. The authors have used Style based Ant Colony System (SACS) algorithm where personalized parameters, change in the main factors for heuristic information value and pheromone update and optimized algorithm parameters to conform to the actual pedagogical process were added. A graph structure for a course sequence with content was proposed. Content adaptations using the VARK (Visual, Aural/Auditory, Read/Write, Kinesthetic) learning styles was done. The proposed model performed the following tasks for the construction of optimal learning paths and updating the pheromone:

- 1) Construction of learning paths: Initially the learners (ants) are given random learning objects. The selection of the next learning object takes place on the basis of probability that is assigned according to the randomized comparative law.
- 2) Maintaining Heuristics information: The formula for heuristic information is taken from the SACS algorithm. The heuristics value is inversely proportional to the time and is derived from the forgetting curve that represents the decline in the learning curve of the learner. This part of the model maintains the recall information of the student for traversing the learning path.
- 3) Local search: During the construction of learning paths of the learners, an improvement in the process of local search takes place. Those learners whose mean score along the path is in the pass mode and the total time spent for studying learning objects has not passed a certain limit are considered to be best learners and their learning experience is considered for path construction during the next iterations.
- 4) Updation of pheromone trails: The amount of pheromone increase for each learner is dependent of the following three main parameters:
 - a. The time duration between the i^{th} node to the j^{th} node (the forgetting parameter)
 - b. The time an ant spends studying a course concept and doing exercises
 - c. The score that an ant obtains from doing the exercises related to the course concept.

The authors in this research applied ACO based solution which personalizes the course content based on the VARK learning style and the Myers-Briggs Type Indicator method for problem solving. The algorithm decided the next learning object when the learner had crossed the previous learning object with a high success rate. The actual implementation using a practical experiment in a learning environment is still a challenge which needs to be addressed.

- "Learning Path Recommendation Based On Modified Variable Length Genetic Algorithm." Dwivedi, Pragya, Vibhor Kant, and Kamal K. Bharadwaj. *Education and Information Technologies* 23.2 (2018): 819-836.

In their work, Dwivedi et al have attempted to develop e-learning systems with personalized learning mechanisms for assisting learners for better efficiency using Variable Length Genetic algorithm. Curriculum sequencing is considered as an important concern for developing more efficient personalized e-learning systems. A more effective personalized e-learning recommender system should recommend a sequence of learning materials called learning path, in an appropriate order with a starting and ending point, rather than a sequence of unordered learning materials. Further the recommended sequence should also match the learner preferences for enhancing their learning capabilities. Moreover, the length of recommended sequence cannot be fixed for each learner because these learners differ from one another in their preferences such as knowledge levels, learning styles, emotions, etc. In this paper, we present an effective learning path recommendation system (LPRS) for e-learners through a variable length genetic algorithm (VLGA) by considering learners' learning styles and knowledge levels. Experimental results are presented to demonstrate the effectiveness of the proposed LPRS in e-learning environment.

2.7 Observations on Ant Colony Optimization Algorithm for Content Sequencing

In order to have adaptive learning creation of content repository and sequencing of content created are very crucial steps. The creation of content is generally done by the domain experts. Sequencing of content is to be done on the basis of the learning

requirements of the learner. Dynamic content sequencing is an NP-hard problem which can be solved using nature inspired algorithms. A graph based ACO is thus a good choice for dynamic content sequencing. The generation of content paths are based on the general parameters such as student basic knowledge, performance, positive change in the learning curve and other such factors.

2.8 Conclusion

Learning Technologies, assistive technologies and many such assist the special children learn in effective manner. Individual learning tools for special needs learners have been developed to fulfil the learning requirements but none of them offer personalization of learning. Learning using technology requires learning objects to be catered to the learners as per their requirement and their pace of learning, this sequencing is done majorly for normal children, similar can be developed for special children also. Generating learning paths on the fly is combinatorial NP Hard problem which needs to be solved using artificial intelligence algorithms. Ant Colony Optimization algorithms work best for generating learning sequences dynamically to satiate the learning requirements of the children. The same can be extended to generate learning sequences for special needs children.

From the survey carried in the various sections of the chapter, it is very clear that special needs children need learning technologies to assist them in their routine teaching-learning processes. Although many separate tools and assistive techniques have been developed to help the special needs children no technology is found that satiates the overall learning needs of the special children. The thesis proposes a model that will meet the learning requirements of the special needs children through learning technologies. The next chapter gives the detailed design of the proposed system. It explains the need for ant colony optimization algorithm in content sequence generation. It also explains the modification needed to be made in the parameters in order to have effective learning of the special needs children.

CHAPTER – 3

Architecture of Content Sequence Generator System

3.1 Introduction

Learning requirements of Special Needs Learners (SNL) are different from that of normal children. These children are generally taught by the teachers, mentors and psychologists using the traditional teaching – learning methods. The traditional teaching – learning method includes chalk-and-talk method, flash card method, play therapy and the like. With the much use of computers in general education, teachers have been motivated to use computer as technology to help the children learn better. In general scenario, children go through similar kind of disorders are put in the same class. Experts design the curriculum as per this similarity. Thus a fit for all kind of strategy is used while designing the course curriculum. This is done so that the children could be managed and taught properly. Even though students having same difficulty are put in the same class, their learning ability is quite different. Every individual is different and has a different learning requirement. Thus the fit for all strategy does not work well here.

This gives rise to the need for personalized learning to be provided to the special needs children. A Content Sequence Generator (CGS) system is designed and developed to meet this individualized learning requirements of SNL (student/child will be synonymously used in the later part of the chapter). The sequence in which the content is to be provided to the SNL has to be decided dynamically. Dynamic content sequencing is an NP-Hard problem, which can be solved using soft computing algorithms. In this thesis, the dynamic content sequencing is done using Ant Colony Optimization (ACO) algorithm. The next few sections discuss the overall system architecture and the generalized approach used in dynamic content sequence generation.

3.2 System Architecture

The overall system architecture is given in figure 3.1. There are various modules that interact with each other to have a smooth functioning of the system. The two main components are the content repository and the Special Need Learner module.

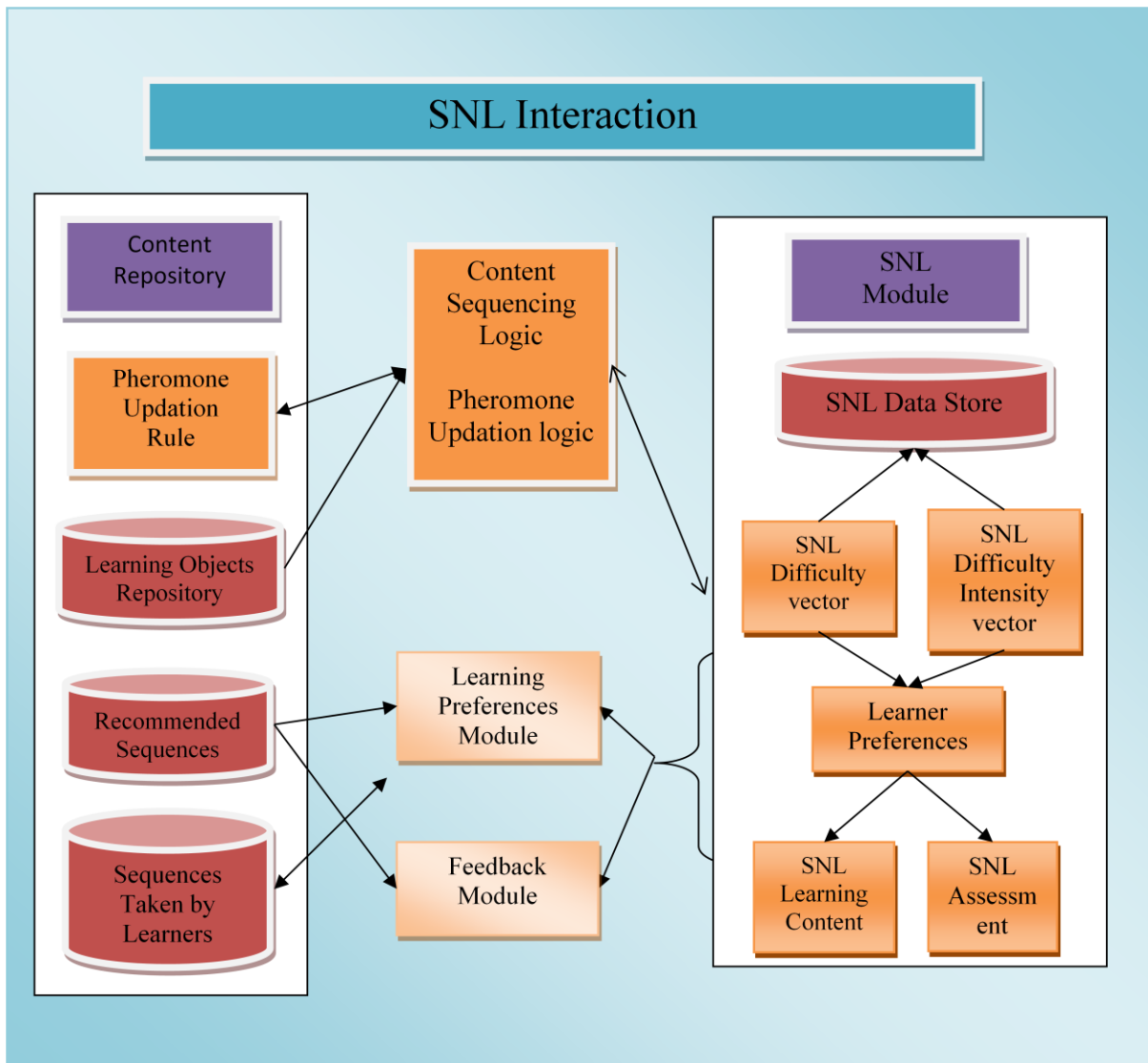


Figure 3.1: Components of Learning Sequence Generator model

The content repository contains the learning module, practice module, assessment module and the feedback module. Apart from this, recommended content sequences, rules for sequence formation and sequences taken by the SNL are stored here. The SNL module stores the information related to the student taking up learning process. This module also has the

data regarding the difficulty faced by the learner, the learner’s preferences and other SNL information such as the log of activities carried out by the student. Each module of the architecture is explained as given below:

3.2.1 Content Module

The learning content follows the hierarchy given below:

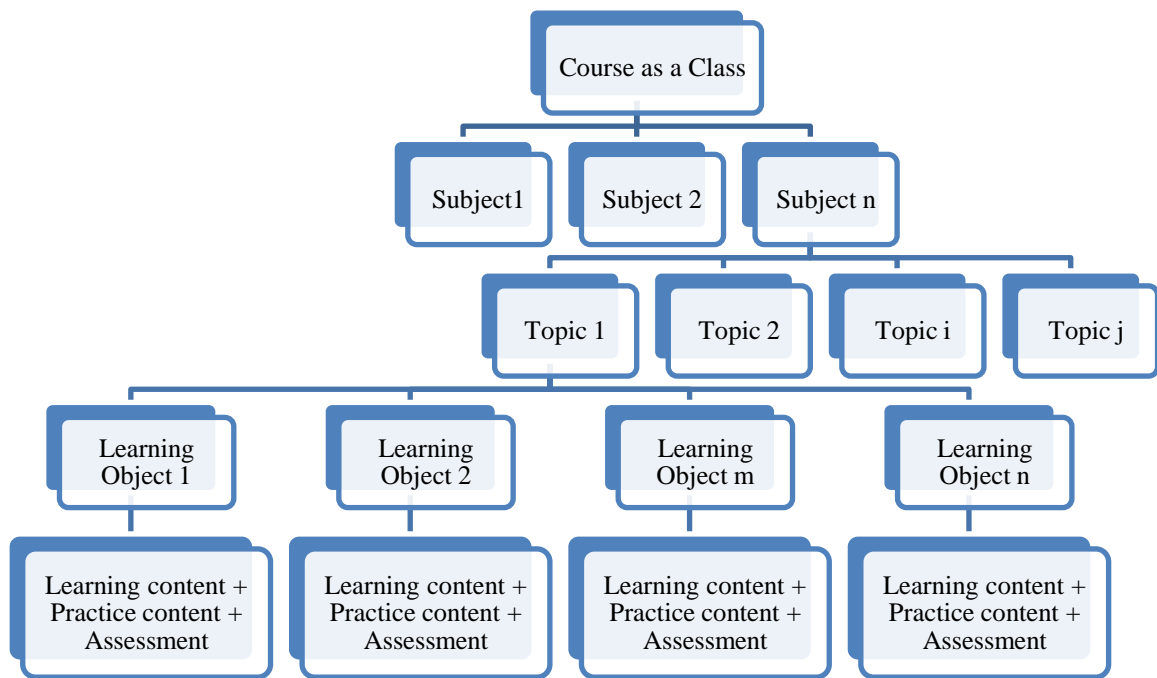


Figure 3.2: Hierarchy showing course to learning content maintained as a part of content module

The learning content that is provided to the learners is class based. Each course is considered to be a class. In the case of specially-abled learners, the class to which the learner belongs does not depend on the physical age of the learner, but is highly dependent on the mental age of the child. Each class further has various subjects to be learnt. Each subject further has various topics. These topics are at the lowest level in the hierarchy. For every topic, contents are provided in a variety to the learner for learning purpose. A learning object is a combination of learning content, practice content and assessment content. A pool of learning objects is made available to the students. On the basis of the content taken for learning, practice and the value of assessment decides whether the learning object is to be placed in the sequencing list or not. Every content of the topic is tagged as one of the values given in the set $ContentLevel = \{“Very Tough”, “Tough”, “Moderate”, “Easy”, “Very Easy”\}$ along

with the content priority; any value in the range of 1 to 5. The content priority is decided by the expert on the basis of the topic to be learnt. The general trend in a subject related to a course is, initially the topics are fundamental based and start with easy level. As the subject progresses, the topics in a subject grow from moderate to hard to very hard concepts. Each concept has many learning objects attached. The tagging of the “ContentLevel” is done dynamically as the learner takes up learning. The content has various parameters attached through which dynamic tagging is done. The detailing of this module along with the user interface for interaction with the content module is elaborated in the next chapter.

3.2.2 Special Need Learner Module

It has already been discussed previously that specially-abled children are broadly classified as physically abled and mentally abled children. The details regarding their classification have already been discussed in Chapter 1. Among the various mental faculty difficulties, the thesis concentrates on two main difficulties faced by the learners. They are:

- 1) Attention Deficit Hyperactive Disorder (ADHD) and
- 2) Learning Disability (LD)

Apart from the difficulty faced by the children, every difficulty has its own intensity. This intensity value ranges from “Border Line” to “Extreme”. The hierarchy given in the figure 3.3 shows this intensity classification that would be considered in allocation of content for learning.

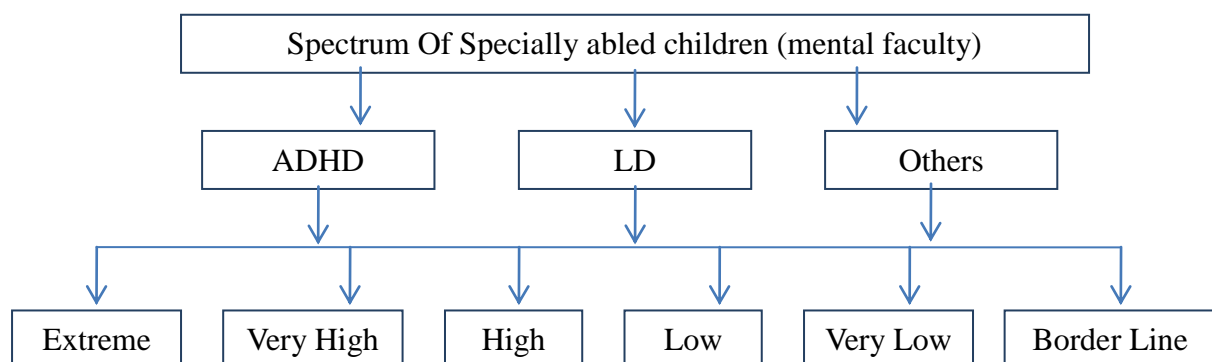


Figure 3.3: Classification of specially-abled children according to their difficulty and intensity

Once the type of difficulty is known and the intensity is obtained, the learner’s difficulty scale can be identified and accordingly the learning content can be provided by applying

sequencing rules.

In the learner module, before the child gets registered with the system, the difficulty type and the difficulty intensity are known values. These values are decided by the psychologist through various experiments carried out before the child's difficulty is announced. This process is an independent one and is not a part of the current system but acts as an input to the system and helps in the sequence generation process.

Each Special Needs Learner (SNL) has a profile that consists of the various details related to the SNL. This profile is maintained for mapping purpose of the content with the SNL.

The details of the SNL are maintained in two phases:

Phase – I: Basic data related to Special Needs Learner (SNL)

During this phase; the basic details related to the special needs learner is stored and used for further processing. Following data stored are as follows:

- 1) Learner's Difficulty: Here the difficulty faced by the learner is stored. As mentioned earlier, Attention deficit hyperactive disorder (ADHD), Learning Disability (LD) and a combination of the two are considered. It is also possible that a child suffering from ADHD or LD may also suffer from other difficulty.
- 2) Difficulty Intensity: The learner's disability intensity is maintained. This is a spectrum of various qualitative values ranging from "Border Line" to "Extreme". Categories of the difficulty intensity are as follows: {Border Line, Low, Moderate, High, Extreme}
- 3) Other Personal Information: Here the personal details of the learner are maintained. Details such as mental age, physical age, gender and other such basic details are fetched here.

Phase – II: Maintaining Activity Log of the Special Needs Learner

This value is maintained by the system when the SNL interacts with the system. A log of various activities carried out by the SNL is maintained so as to provide a personalized learning environment. The log maintains the following data:

- 1) Recommended Learning Paths: stores the contents that are recommended to the SNL by the system.
- 2) Count of Learning Activity done: here the count of actual learning object is considered. The count is recorded by the approval of the expert or the mentor. The

count becomes valid only when enough time is spent after the learning content and the student has actually attempted to learn the concept. Mere opening of the content is not considered as a learning count.

- 3) Count of Practice Taken: the practice object is given to the student after the learning object is done. The practice object has similar attributes as that of the learning object but is used for reinforcing the concepts of the learner. More practice content is given to learners who have been reported with weak concentration or less attention span.
- 4) Attention Span: This factor is stored in terms of the time taken by the SNL for completion of a particular task.
- 5) Interest in Activity: This factor stores whether the SNL is interested in a particular activity or not. A value in terms of yes/no is considered for processing purpose. In order to find out the interest value, a threshold time is considered, if the time value is within the specified range we get the answer yes else a no is stored.
- 6) Completion of Task: This is Boolean value and a comparison with a standard value fetches a yes/no value for the SNL.
- 7) Concentration During the activity: This value is taken as the number of times the SNL has taken up a particular activity and in what time s/he has completed it. Since SNLs generally struggle with concentration, various turns are provided for a particular learning object to be learnt.
- 8) Assessment Results: The assessment results are maintained content wise separately and are tabulated for further processing.
- 9) Actual Path Taken: stores the actual path taken by the SNL during a learning scenario.
- 10) Learning Path Information: Information regarding every concept learnt by the SNL is stored here.

3.2.3 Mapping between Special Need Learner and Course Content

The type of difficulty and its intensity are obtained from the learner module. The record of the difficulty faced by the child and the intensity of the difficulty are known at the time the child gets registered. The relationship between the learner type, its intensity and the content type that is provided for learning purpose is depicted in the figure 3.4.

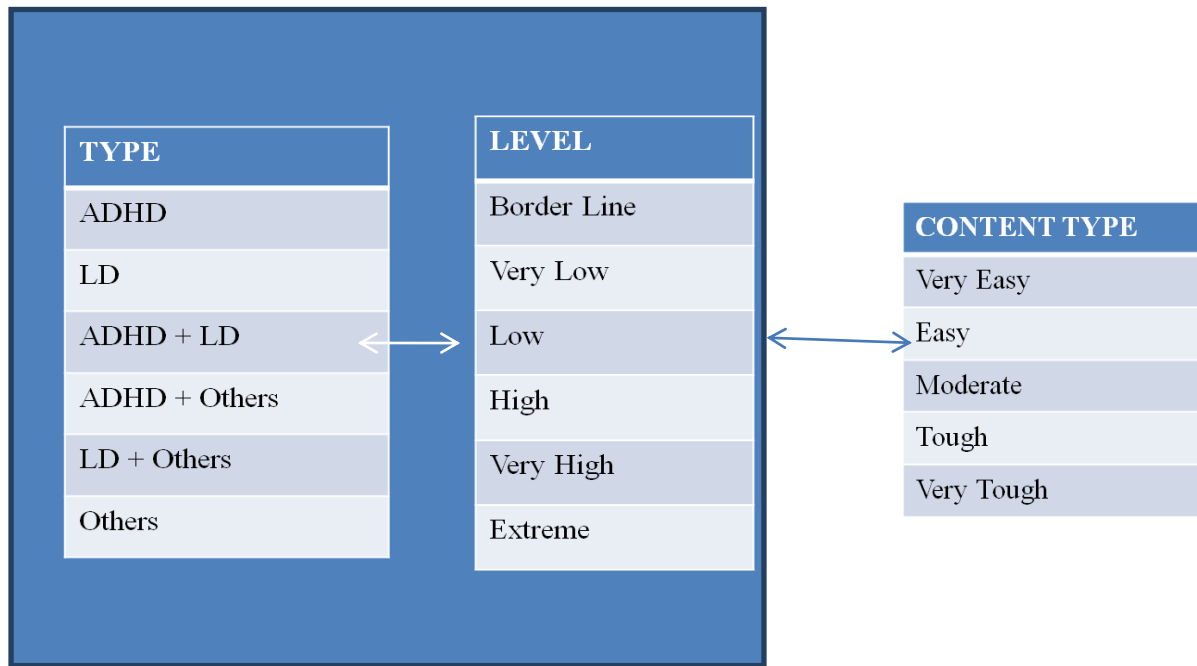


Figure 3.4: Special Need Learner – Content Type mapping

A rule based model is used to prompt content to the special children on the basis of the difficulty faced and intensity of the difficulty faced. According to the study carried out, it has been observed that children with Attention Deficit Hyperactive Disorder (ADHD) with various levels of intensity have good cognitive skills as compared to that with children with Learning Disability (LD). Not only this; but ADHD children even outgrow their normal peers at times showing excellent learning skills. Thus it is very necessary to provide appropriate learning contents to these categories of children. The model decides the content level of being in the range of “Very Low” to “Very Tough” on the basis of the tagging done by the experts and the frequency of the content used by the learners. Thus, the learner – content mapping is very crucial in generating the sequences for special needs children.

A pool of content is maintained in the content repository. The content has various parameters attached with itself. The parameters of the content are given as follows:

- 1) Class of the content: this stores for which class the content is prepared
- 2) Subject specification: this stores the subject on which the content is prepared
- 3) Priority: the priority of the content is decided by the domain expert or pedagogy expert. Generally, it has been observed, in normal curriculum the topics at the beginning of the subject are pre-requisite for the later topics. Thus, the priority is

given from the fundamental topic to the advanced topics in a given subject. Depending on the number of topics and their relationship, the priority ranges from high to low. This is done since fundamental topics are of more importance and are mandatory to be covered as compared to the advanced ones. Internally it may also happen few topics may be taken in parallel and hence their priority may be same.

- 4) Content level: A dynamic value from the range of “Very Low” to “Very Tough” is assigned to each content. The level of the content is decided using a fuzzy inference system. It is difficult to tag the content as “Very Easy” or “Very Tough” as a content that is easy for one child may be tough for the other. A fuzzy implication function using the product operator is considered to represent the fuzzy set.

The process of content level selection is done using fuzzy logic, which is depicted in the figure 3.5.

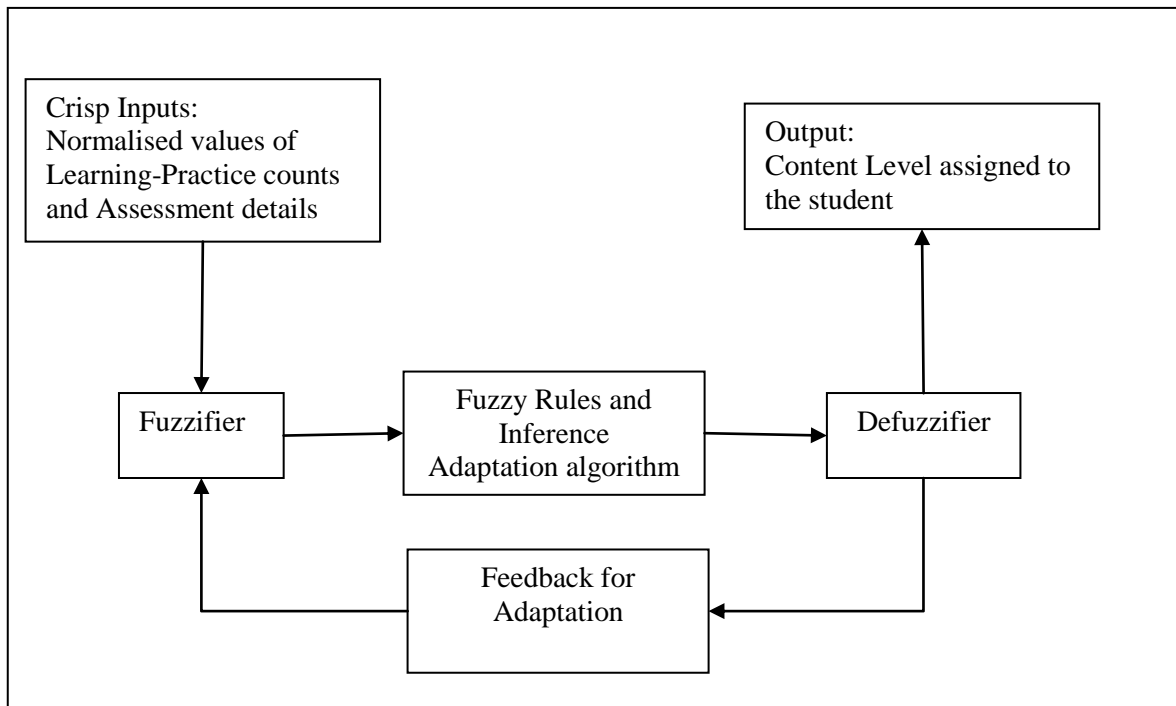


Figure 3.5: Fuzzy inference system showing the use of fuzzy rule for content level suggestion

3.2.4 Content Sequence Generation Concepts

This module of the system is the most important and crucial in content sequence generation. Ant colony optimization algorithm is taken as the base for generating of sequences. In a graph-based ACO approach, the nodes are considered to be the topics to be learnt by the

students in a particular subject for a particular course. The nodes (topics) to be traversed are either parallel or can be traversed in a particular sequence. In a regular teaching-learning process, this sequence of learning objects is decided by the teacher/domain expert/psychologist/psychiatrist or a mentor (all terms interchangeably used as experts). Looking to the preferences and the background these children, no, one kind of sequence will work for all. Thus, the experts, through system will recommend individual sequences to be taken by the learner for learning purpose, but the choice of learning of the topic remains with the student. Once the student makes a choice for a topic to be learnt, the next node is available only when the student achieves a minimum of threshold value for the traversal.

In the general ACO, ants drop pheromone (a chemical agent for path indicator) which helps other ants to traverse the same path for finding the food easily and possibly the shortest path. In the similar manner, weights are assigned dynamically to the edges so as to get an efficient learning path for the learners. Here, the values for traversing are maintained in terms of the following parameters:

- 1) Learner preferences
- 2) Log of activities performed by the learner
- 3) Assessment results of the learner and
- 4) Recommendations made for the learner.

The meta-heuristics method for selecting the next node in the graph based search helps in generating the solution for efficient learning of specially-abled children. The architecture as mentioned in the figure 3.1 shows the interactions of learner with other modules. It also shows the content repository, the set of rules governing the sequencing, data stores that store the learner activity and maintains the log and other details stored for further processing.

A learning object sequence is a collection of inter-related concepts/topics that are arranged in a particular order. The order here is mentioned in the form of a graph arrangement. In this graph structure, topics are represented as nodes and the rules for transition are the edge values. These edge values decide the next topic to be taken in the learning sequence. Each special needs learner (SNL) passes through the nodes and iteratively constructs sets of feasible solution. Every child thus, constructs his/her own solution for learning purpose. Each SNL makes a choice to traverse an edge (i, j) constructed between node i and node j by

applying state transition rule. The decision of SNL_k moving from node i to node j is evaluated as the probability $P_k(i,j)$.

This probability depends on the following factors:

- 1) Number of times a content taken for learning
- 2) Number of times a content taken for practice
- 3) Assessment results
- 4) Concentration during the learning process
- 5) Attention span during the learning process
- 6) Time taken to learn the given concept
- 7) Whether the SNL has taken the recommended path or path of his/her own choice
- 8) Successful completion of the concept taken by the SNL in terms of status.

The learning takes place in the form of learning scenarios. The learning scenarios are predefined sequences of concepts. The sequence of concepts is decided by the domain experts who decide and design the curriculum for SNLs. Thus, the learning scenarios should be designed as per the recommendations of these experts. Within the curriculum, as the learning progresses, the concept difficulty level increases. Every concept needs to be mapped with the level of difficulty apart from its position in the recommendation.

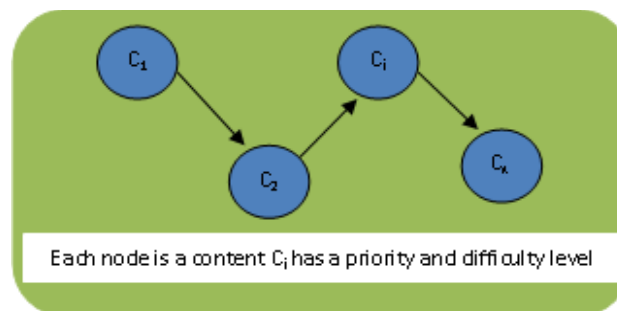


Figure 3.6: A sample sequence of concepts for a learning scenario

Learning scenarios are part of the content repository. The figure 3.6 shows a snapshot of a sample learning scenarios sequence. The learning scenarios consist of learning content, practice content and assessment content. The learning content and the practice content are given to the learners for learning purpose with a pre-defined count. The assessment content is part of assessment module where the assessments are carried out for the students. The

assessments that the student undergoes is mapped as per the learning-practice module the student has taken. Each student undergoes a minimum count of assessments with a threshold value of passing. This count of assessments is maintained so as to reinforce the learning taken by the student. A log is maintained for every student undergoing the learning, practice and assessment phase. The interrelation between the learning-practice content and assessment content is shown in the figure 3.7.

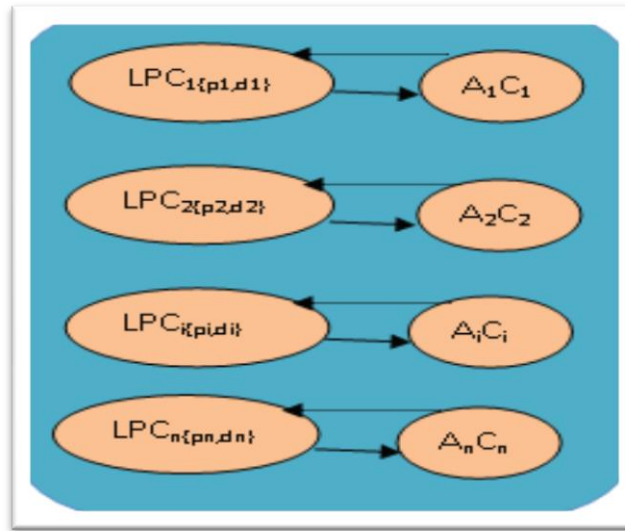


Figure 3.7: Internal structure of a learning content

Each learning scenario is represented as a set of learning concepts.

$$LC = \{LC_1, LC_2, \dots, LC_x\}.$$

Each concept is given a priority that is decided by the domain expert/counsellor. The priorities are denoted as $P = \{P_1, P_2, \dots, P_x\}$.

Furthermore, each concept is divided into various contents as

$$LC = \{LC_{11}, LC_{12}, LC_{13}, \dots, LC_{1k}, LC_{21}, LC_{22}, LC_{23}, \dots, LC_{2k}, LC_{x1}, LC_{x2}, LC_{x3}, \dots, LC_{xk}\}.$$

Further, each content is associated with a difficulty level as $D = \{D_1, D_2, D_3, D_4, D_5\}$ as {Very Easy, Easy, Moderate, Tough, Very Tough}. The content level changes dynamically on the basis of its popularity and use. This is maintained so that it can be mapped with the disability spectrum of the SNLs. For example, if a child is cognitively weak, then a content that is of very basic level could be given, whereas if the SNL is at par with cognitive then, an advanced level of content can be given. The concepts are given an initial sequencing as per the curriculum decided by the domain experts and counsellors. The contents residing in the

concept have two parts: learning-practice part and assessment part. The SNL, depending on the difficulty faced and the intensity of the difficulty faced and other parameters as discussed previously, a particular content is recommended as a part of its learning. The SNL can take either the recommended path or a path of his/her own choice for learning purpose. An assessment matrix is made available as a reference with values for comparison to move to the next node.

Thus, for the learning scenario following terms are:

$C = \{C_1, C_2, \dots, C_x\}$ where C is a set of learning scenario, the concepts placed in a sequence

$P = \{p_1, p_2, \dots, p_x\}$, where P is the priority attached with each concept

$LC = \{C_{11}, C_{12}, C_{13}, \dots, C_{1k}, C_{21}, C_{22}, C_{23}, \dots, C_{2k}, C_{x1}, C_{x2}, C_{x3}, \dots, C_{xk}\}$, where each C_{ij} are the contents provided within a concept for a given learning scenario.

$D = \{d_1, d_2, d_3, d_4, d_5\}$, where d_i is the difficulty level attached with each content. This is further mapped as content difficulty level as {"Very Easy", "Easy", "Moderate", "Tough", "Very Tough"}

$T = \{t_{11}, t_{12}, t_{13}, \dots, t_{1k}, t_{21}, t_{22}, t_{23}, \dots, t_{2k}, t_{x1}, t_{x2}, t_{x3}, \dots, t_{xk}\}$, where T is a set of threshold values for the SNL to move from one content to the other for a given learning scenario.

3.3 Fuzzy Inference System for Content Level Determination

A fuzzy inference system is used in order to tag the level of the content. Fuzziness is introduced to the content parameter since a content that is easy for one student may be found to be tough for other student. Thus the content level is decided on the basis of the tagging done by the domain expert and the type of the student taking up the learning content. The model considers the two dimensional membership function which takes the following values for the matrix generation:

- 1) Content level given by the domain and pedagogy expert and
- 2) Popularity and use of the content learning taken by the student with similar kind of difficulty.

The phases used in the fuzzy inference system are:

- 1) Fuzzification: Domain experts and pedagogy experts provide a value to the content in the range of [0, 1]. This value varies with the variation found with the type of difficulty. Along with this, the count of the learning content taken by the student with similar difficulty is considered. This count is then normalized to get a

value in the range of [0, 1]. These two values are together given to fuzzification interface which returns a value from the set defined as: {"Very Easy", "Easy", "Moderate", "Tough", "Very Tough"}

- 2) Decision making logic: Performs inference for fuzzy control actions. This value obtained from the fuzzification acts as one of the parameters in deciding the next content to be made available to the learner.
- 3) De-Fuzzification: The value obtained as the output from the decision making component decides the value for the content level

3.4 Ant Colony Optimization to Learning Scenarios

Ant Colony Optimization algorithm has the following two main components:

- 1) Heuristic Search:

The SNL starts with an initial learning content and moves further to add more contents to its learning path. The learning scenarios are perceived as nodes of a graph and the transition from one node_{*i*} to node_{*j*} is considered as the edge (*i, j*). The transition takes place only when the calculated value for the edge is greater than the prescribed value. The SNL starts learning the contents of the concepts one after the other as per recommendations suggested by the system. If the SNL is able to perform at par as per the recommended performance, the current node is added to the SNL's learning path and the SNL moves to the next node. Also the intensity of the recommendation for the current content increases and gets updated. In case, the performance is not as per expectation, the SNL is recommended content with lower difficulty value and the intensity of the recommended node decreases as per the rules of updation. These modified values affect the further recommendations in the system.

- 2) Pheromone Trail Intensity:

The pheromone intensity over an edge (*i, j*) gets updated on the basis of:

- (a) Number of times a content taken for learning
- (b) Number of times a content taken for practice
- (c) Assessment results
- (d) Preferred content type
- (e) Time taken to learn the given concept
- (f) Whether the SNL has taken the recommended path or path of his/her own choice
- (g) Successful completion of the concept taken by the SNL.

The whole process is explained in terms of an algorithm in the next section.

3.5 Proposed Algorithm

This section sketches the algorithm that evaluates the parameters to check out the performance of the SNL and eventually suggests the learning contents for the individualized learning of the SNLs.

Start

for each iteration iter = 1 to MAX

for student k = 1 to s

getStudentProfile (SNL_parameters)

for i=1 to N

if SNL selects the recommended path

repeat

select concept from the nodes list and recommend content as per SNL profile

SNL takes up learning process

SNL appears for assessment

calculate_Assessment_Result

compare with standard Assessment matrix

if assessed_val > std_val

provide next content

else assessed_val <= std_val

provide similar content with lower difficulty value

end //end of inner if-else

until appropriate content learnt

end //end of repeat until

begin updating the learning path details

if SNL_k takes the recommended path

if SNL_k is successful in learning

update the assessment_matrix as per the updating rule

else

no change in the matrix

end //end of inner if-else

```

        end // end of outer if-else
    end //end of inner begin
    else the SNL makes own choice of path //else part of outer most if
        SNL takes up learning process
        SNL appears for assessment
        calculate_Assessment_Result
        compare with standard Assessment matrix
        ifassessed_val>std_val
        provide next content
        elseassessed_val<= std_val
            provide similar content with lower difficulty value
        end //end of inner if-else
    end //end of outer most if-else
    check for the next SNL
end //end of inner for loop
end //end of outer for loop

```

3.6 Conclusion

Learning Technologies are of great help to special children. Dynamic and personalized content sequence generation greatly depends on the learner parameters that govern the individual aspects of the child. The difficulty faced and intensity of the difficulty faced by the child are very crucial factors that help in designed the content sequence. The main intension of this sequence generation is to help make the students at par with the regular curriculum. The proposed algorithm uses the ant colony meta-heuristic approach to prompt content sequences for the learner to cope up with the regular teaching – learning process.

A generic architecture on content sequencing is explained in this chapter. The system design explained in this chapter is a general purpose design. The same can be used in many applications such as:

- 1) In case of regular school goes; children who do not face difficulties in their daily routine but are comparatively slow learners can use this system.

- 2) The system can be used by children/students who face problem with some specific subject. The subject teacher can feed the system with content related to that specific subject and the student can benefit from the system.
- 3) The design of the system can be used in other domains as well.

The next chapter show the experiment carried out for special needs children. The results and discussions on the basis of experiment carried out are also shown.

CHAPTER 4

Experimental Setup for Content Sequence Generator System

4.1 Introduction

Every education system has its own pedagogical structure for learning purposes. In a general school education system, a course is defined by the experts of the corresponding domain. This course is further divided into various classes or standards. The standards grow from low to high as the learner progresses its learning. Each class or standard has various subjects to be learnt. These subjects are designed in such a manner that they are appropriate to the age of the learner. The subject further contains different lessons or chapters to be learnt. Each lesson or chapter further comprises of various topics. Following types of relationship among the chapters have been noticed.

- 1) First kind of relation that is observed among chapters is that of full dependence or total dependence. Under this type of relation in order to get the understanding of one chapter, a pre-requisite chapter needs to be learnt. For example, in English subject, in order to understand the concept of adjectives, it is important to know the concept of nouns. Similarly in Mathematics, in order to understand the concept of counting, knowledge of numbers is mandatory. These examples give the understanding of total or full dependencies between topics.
- 2) Another kind of relation among the chapters is that all the chapters are independent of each other and they can be taken individually by the learner. To exemplify, in language subject such as English when prose or poetry is considered for learning the chapter or the poem can be learnt individually and independently without the reference of other chapters or poems.

- 3) Yet another type of relation is that of partial dependency. Partial dependency can be seen among a few chapters of a subject. Say for example,

The above type of relationship is generally found in a regular school curriculum. A similar kind of structure is defined for specially-abled children. But in this case there is change in the way the course is designed. Domain experts such as psychologists, psychiatrists, counselors, mentors, teachers and other related persons come together to formulate and design the curriculum for the course to be taken by the children. The classes here are decided not on the physical age but on the basis of the mental age of the children. A few other parameters on which the course design depends are:

- 1) Difficulty faced by the children
- 2) Intensity of the difficulty faced by the children
- 3) Attention span of the children
- 4) Difficulty in following instructions
- 5) Difficulty faced in organizing tasks
- 6) Like/Dislike for a particular learning task

The pedagogical structure for specially-abled children is designed by domain experts. The content to be learnt and the way the content has to be provided to the learner for learning purpose are decided by the domain expert or the counselor or the mentor or the psychiatrist or the teacher. This is the normal traditional method through which the teaching-learning takes place.

The proposed model suggested by this thesis takes the input from the above experts and not only this, it also provides a system generated pedagogical sequence of learning content that will assist the learner to learn better. This not only benefits the learner but also the experts as they can give more inputs regarding better learning strategy for the children.

4.2 Tools and Technology Used

In order to have an interaction between the expert/mentor/teacher and the proposed system user interface and data storage or repository are designed. The user interface becomes a point of contact for input. Whatever input is given to the proposed system, is stored in the form of data storage or as a repository which can be later on retrieved by the teacher/mentor/expert

for smooth learning of the child. The front-end of the proposed system, the so called user interface and the back end are prepared using the GUI feature Tkinter and SQLite database of Python 3.6.3. The detailing regarding usage of Python is shown in this section.

"The fastest-growing use of Python is for data science, machine learning, and academic research" - says a StackOverflow analysis. These are actually the biggest trends in tech recently. As we can read, "Python became a common choice for that purpose". Following are the reasons:

- 1) Increased availability of data, more powerful computing, and the focus on analytics-driven decisions in business are the main parts of work (including academic and scientific research) for a growing number of people these days.
- 2) A variety of people use spreadsheet programs like Microsoft Excel or Google Sheets to work with huge amounts of data. These are powerful tools, but they have serious limitations, like problems with analyzing datasets above a certain size. Thus Python becomes an obvious choice as it is capable of handling a huge amount of data.
- 3) Python is easy to learn and fast to develop in. It requires less effort to write a program using Python than other languages like C++ or Java or any other language. People can do more with less code in a shorter period of time. Python saves a lot of time because it allows people to spend time doing actual research instead of having to constantly read through documentation before getting to the actual objective.
- 4) One of the major factors that makes Python is so popular is its versatility. One can use it not only for research, but also for web development, text processing, AI, machine learning, and more.
- 5) Python's versatility also means that there is a wide variety of libraries. This is done as Python had extremely stable libraries with great support. There are over 125,000 third-party Python libraries that make Python more useful for specific purposes, including research.
- 6) Libraries like NumPy, SciPy, Pandas, and matplotlib have been around for a long time, are extremely well maintained, optimized, production-ready and well documented.
- 7) Python is a dynamic language as it is interpreted; it is object-oriented, high-level programming language with dynamic semantics. It has high-level built-in data structures, combined with dynamic typing and dynamic binding. A user interface is

prepared that acts as an input to the system through which the expert or the teacher can interact. The proposed system works in the following phases for its smooth functioning.

4.3 Proposed Teaching-Learning Process for Specially-Abled Children:

A thorough study was carried out regarding the curriculum format and pedagogical structure for specially-abled children. Visits to local schools that handle children with various difficulties both physical and mental were carried out during the survey. Their names have not been mentioned for confidentiality purpose. After meeting the teachers, mentors, counselors and psychologists the course curriculum was discussed. As per the discussion, no generalized format or structure was found, but depending on the children and their difficulties, the experts design the course curriculum. In order, to help the experts in designing the curriculum, a hierarchy in course curriculum as a pedagogical structure was suggested. At the top most level the class resides. A class in the general academics consists of a group of various subjects. The subjects to be learnt by the child depend on its mental age and other parameters discussed earlier. Each subject further has various topics and sub-topics to be learnt. These topics and sub-topics may have total dependency, partial dependency and zero dependency among each other.

The hierarchical relationship given below shows the relationship between the course curriculum along with the subjects, topics and contents.

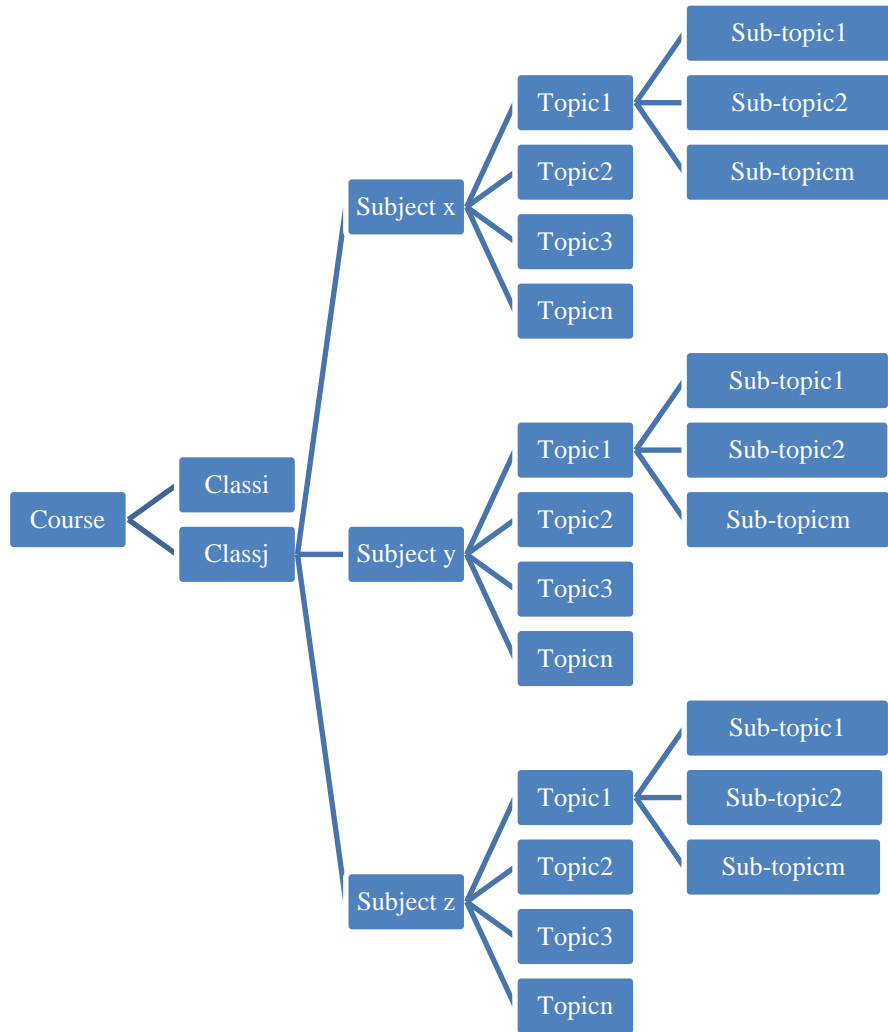


Figure 4.1(a) Hierarchical structure suggested for a generic course curriculum

Proposed Teaching-Learning process for Specially-Abled children

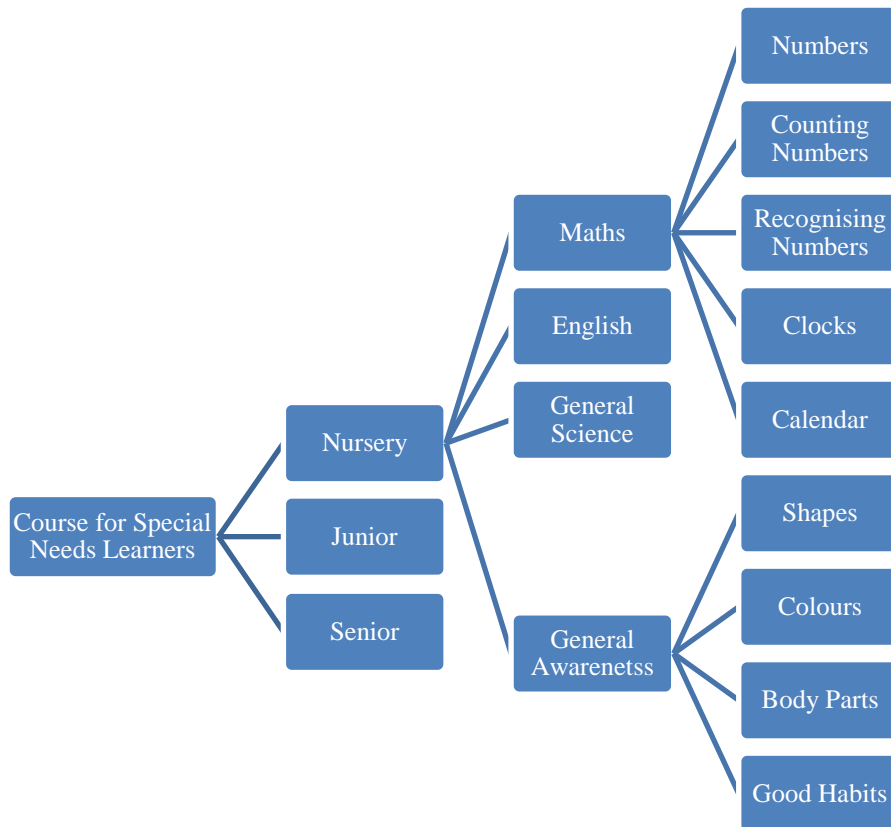


Figure 4.1(b) Example related to the hierarchical structure of course curriculum for special need learners

The hierarchical structure shows the relationship between the course elements. As shown in the figure 4.1(a) the course has many classes under it. Each class further teaches various subjects. Each subject is a collection of various topics and sub-topics. The proposed model goes one step further by providing different types of content for each topic and the corresponding sub-topic. This variety of contents that are provided to the children for learning purposes helps the teachers in making the children learn in a better way. The content to be provided to the children is prompted by the proposed system on the basis of the difficulty of the children and the intensity of the difficulty faced by the children.

An example is shown in figure 4.1(b) which depicts the actual hierarchy of course curriculum for special needs children. As a sample, data for “Nursery” class has been taken. Under this class various subjects like “Maths”, “English”, “General Science”, “General Awareness” and so on are offered. Under the subject of “Maths” various topics are taught to the children such as “Numbers”, “Recognition of Numbers”, “Number Counting”, “Clocks”, “Calendar” etc. are taken. Each topic further has contents provided that is used for learning purposes. The

main intension for creating more number of instances for the content is that a single type of content does not work for all the special children. One type of content may be suitable to one type of child and another type of content may be suitable to another type of child. Thus having more instances would help the child to learn in a personalized way.

4.4 System Interaction Module

The previous section discussed about the overall course curriculum in a general scenario and typically for special need children. A point of interaction with the system is mentioned in details in the following sections. The user interface becomes a point of contact for the expert so as to input the data and view the results through this interface.

4.4.1 Phase I: Creation of Content Repository

In this phase of experimentation, content repository is created that would be further used for mapping with the learning activity of the learner. The content repository can be prepared by following the hierarchy of the contents mentioned earlier. In order to maintain the hierarchy, a user interface is prepared that allows the interaction of the expert/teacher with the proposed system. Using the interface, class details, subject details, topic details and content details can be entered into the system.

To insert class and its details into the system a class master user interface is prepared. The following figure 4.2 helps the expert to enter class for a particular course.

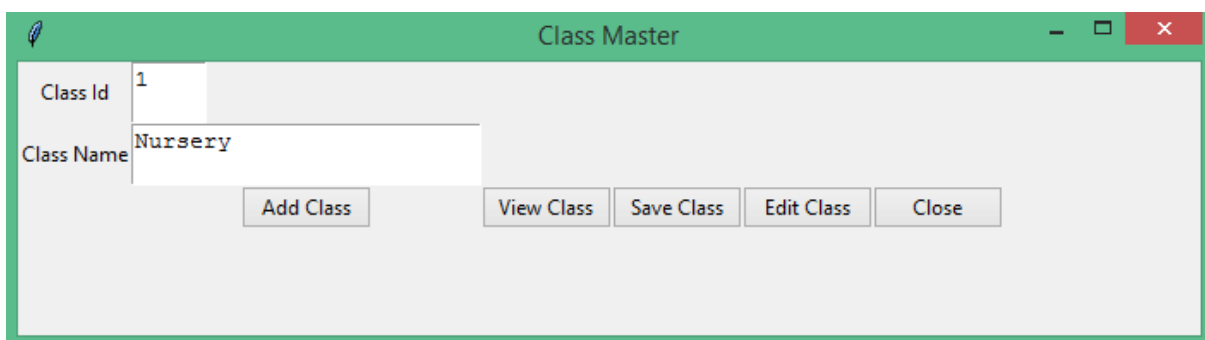


Figure 4.2: Snapshot showing the interaction with the system for class creation by the expert/teacher

Through this interface the expert can add a class, save the class details, view the details of classes added and can also update any class details. This class is the one that is decided by the

expert. Some sample data for Class Master are shown in the following table 4.1.

ClassId	ClassName
1	Nursery
2	Prep. Junior
3	Prep. Senior

Table 4.1: Table showing sample data for classes created by experts/teacher

In a similar manner, subject master user interface is provided to the expert to add the subjects per class. The values of the class are obtained from the “Class Master” that was previously created. The figure 4.3 shows the details of the “Subject Master”.

Figure 4.3: Snapshot of the interface for entering subject details into the system

This interface allows the expert/teacher to add subjects for a particular class and edit subject for a given class. Some sample data added to subject master by the expert/teacher are shown in the table 4.2.

Subject Id	SubjectName	ClassId	Class Name
1	Maths	1	Nursery
2	English	1	Nursery
3	General Knowledge	1	Nursery
4	Maths	2	Prep. Junior
5	English	2	Prep. Junior
6	General Knowledge	2	Prep. Junior
7	Maths	3	Prep. Senior
8	English	3	Prep. Senior
9	General Knowledge	3	Prep. Senior
10	General Science	1	Nursery
11	General Science	2	Prep. Junior
13	Hindi	1	Nursery
14	Hindi	2	Prep. Junior
15	Hindi	3	Prep. Senior
16	Gujarati	3	Prep. Senior
17	General Science	3	Prep. Senior
31	Gujarati	2	Prep. Junior

Table 4.2: Data related to subjects added to “Subject Master”

A user interface for adding topics, as shown in figure 4.4 for a particular subject is also provided. This user interface is used by the expert/mentor to add topics to the proposed system. The topics related to the class from the “Class Master” and subject from the “Subject Master” are provided in the interface for the ease of use.

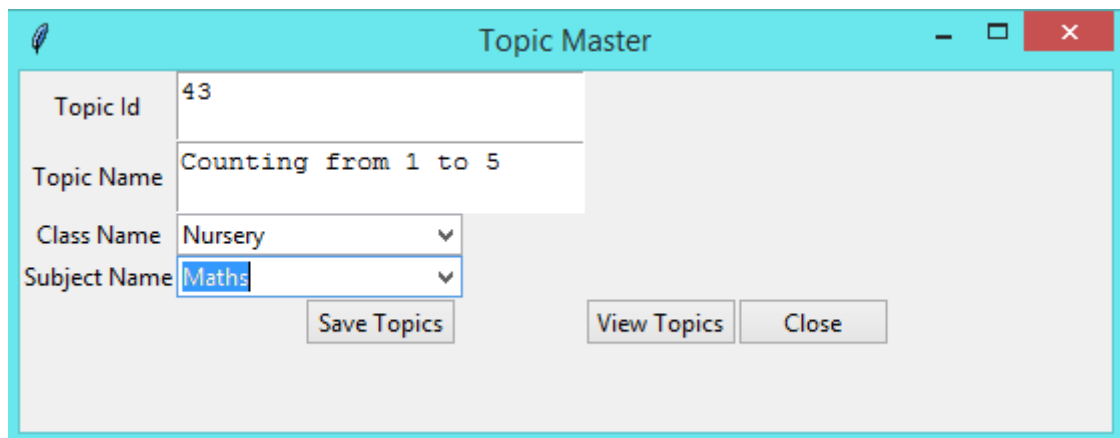


Figure 4.4: This figure shows how the topics can be entered to the system

The subject expert/teacher can add topics related to their subjects to the system through this user interface. The expert/teacher can view the topics that are added to the system and can also add new topics related to their subjects.

TopicId	TopicName	Class Id	Class Name	Subject Id	Subject Name
1	Numbers	1	Nursery	1	Maths
2	Number Recognition	2	Prep. Junior	1	Maths
3	Number Sequencing (1-5)	1	Nursery	1	Maths
4	Before-After-Between	1	Nursery	1	Maths
5	Comparator-Greater than	1	Nursery	1	Maths
6	Comparison-Less than	1	Nursery	1	Maths
7	Comparison-Equal to	2	Prep. Junior	1	Maths
8	Big-Small	2	Prep. Junior	1	Maths
9	Position Concept	2	Prep. Junior	1	Maths
10	Counting (1-5)	2	Prep. Junior	1	Maths
11	Counting (6-10)	2	Prep. Junior	1	Maths
12	Sequencing (6-10)	2	Prep. Junior	1	Maths
13	Recognition (6-10)	2	Prep. Junior	1	Maths
14	Missing numbers (6-10)	2	Prep. Junior	1	Maths
15	Counting (6-10)	2	Prep. Junior	1	Maths
16	Number Recognition	2	Prep. Junior	1	Maths
17	Missing Numbers	1	Nursery	1	Maths
21	Number Sequencing	2	Prep. Junior	1	Maths
22	Number Recognition	2	Prep. Junior	1	Maths
23	Missing Numbers	2	Prep. Junior	1	Maths
24	Number Sequencing	2	Prep. Junior	1	Maths
25	Number Comparison	2	Prep. Junior	1	Maths
26	Number Sorting Descending	2	Prep. Junior	1	Maths
27	Clocks	2	Prep. Junior	1	Maths
28	Calendar	2	Prep. Junior	1	Maths
30	Miscellaneous	2	Prep. Junior	1	Maths
33	Counting Numbers	3	Prep. Senior	1	Maths
34	Missing Numbers	3	Prep. Senior	1	Maths
35	Number Counting	3	Prep. Senior	1	Maths
36	Sorting Number Ascending	3	Prep. Senior	1	Maths
37	Number counting descending	3	Prep. Senior	1	Maths

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38	Clocks	3	Prep. Senior	1	Maths
39	Calendar	3	Prep. Senior	1	Maths
40	Misc	3	Prep. Senior	1	Maths
41	Number	1	Nursery	1	Maths
43	Counting from 1 to 5	1	Nursery	1	Maths
...
201	Alphabet Recogniton (A-E)	1	Nursery	2	English
202	Alphabet Object Mapping (A-E)	1	Nursery	2	English
203	Capital and Small (A-E, a-e)	1	Nursery	2	English
204	Alphabet Recognition (F-J)	1	Nursery	2	English
205	Alphabet Object Mapping (F-J)	1	Nursery	2	English
206	Capital and small (F-J, f-j)	1	Nursery	2	English
207	Alphabet recognition (K-O)	1	Nursery	2	English
208	Alhpabet Object Mapping (K-O)	1	Nursery	2	English
209	Capital and Small (K-O, k-o)	1	Nursery	2	English
210	Alphabet Recognition (P-T)	1	Nursery	2	English
211	Alphabet Object Mapping (P-T)	1	Nursery	2	English
231	Revision of capital and small letter A-Z, a-z	3	Prep. Senior	2	English
232	Recap of sight words	3	Prep. Senior	2	English
233	Phonic sounds and sight words - 1	3	Prep. Senior	2	English
234	Phonic sounds and sight words - 2	3	Prep. Senior	2	English
235	Phonic sounds and sight words - 3	3	Prep. Senior	2	English
236	Introduction to 3 letter words - 1	3	Prep. Senior	2	English
237	Introduction to 3 letter words - 2	3	Prep. Senior	2	English
238	Introduction to 3 letter words (using vowel a)	3	Prep. Senior	2	English
239	Introduction to 3 letter words (using vowel e)	3	Prep. Senior	2	English
240	Introduction to 3 letter words (using vowel i)	3	Prep. Senior	2	English
241	Introduction to 3 letter words (using vowel o)	3	Prep. Senior	2	English
242	Introduction to 3 letter words (using vowel u)	3	Prep. Senior	2	English
243	Simple sentences using "this"	3	Prep. Senior	2	English
244	Simple sentences using "that"	3	Prep. Senior	2	English
...
301	Good and Bad Habits	1	Nursery	3	General Knowledge
302	Good and Bad Manners	1	Nursery	3	General Knowledge
303	Body Parts	1	Nursery	3	General Knowledge
304	Self Awareness	1	Nursery	3	General Knowledge
305	Taking self care	1	Nursery	3	General Knowledge

306	Body Parts	2	Prep. Junior	3	General Knowledge
307	Self Awareness	2	Prep. Junior	3	General Knowledge
308	Good and Bad Habits	2	Prep. Junior	3	General Knowledge
309	Self awareness	2	Prep. Junior	3	General Knowledge
310	Body Parts(Major)	3	Prep. Senior	3	General Knowledge
311	Body Parts (Internal)	3	Prep. Senior	3	General Knowledge
312	Community Helpers	3	Prep. Senior	3	General Knowledge
401	Animals	1	Nursery	10	General Science
402	Birds	1	Nursery	10	General Science
403	Fruits	1	Nursery	10	General Science
404	Vegetables	1	Nursery	10	General Science
405	Plants and Flowers	1	Nursery	10	General Science
406	Daily Food	1	Nursery	10	General Science
407	Shapes	1	Nursery	10	General Science
408	Colours	1	Nursery	10	General Science
411	Wild animals	2	Prep. Junior	10	General Science
412	Domestic Animals	2	Prep. Junior	10	General Science
413	Fruits and Vegetables	2	Prep. Junior	10	General Science
414	Trees	2	Prep. Junior	10	General Science
415	Our Nature and their Products	2	Prep. Junior	10	General Science
416	Food (Milk Products)	2	Prep. Junior	10	General Science
417	Food (Vegetarian and Non-Vegetarian)	2	Prep. Junior	10	General Science
431	Body Care	3	Prep. Senior	10	General Science
432	Water Cycle	3	Prep. Senior	10	General Science
433	My Family	3	Prep. Senior	10	General Science
434	Animals and Birds	3	Prep. Senior	10	General Science
435	National symbols	3	Prep. Senior	10	General Science
436	Types of Houses	3	Prep. Senior	10	General Science
437	Days of week	3	Prep. Senior	10	General Science
438	Safety measures	3	Prep. Senior	10	General Science

Table 4.3: Sample data for topics added to “Topic Master”

The above table 4.3 shows a few records related to topics entered by the expert/teacher. Each class, as we have seen previously has various subjects to be taught, and under each subject, multiple topics lie. The contents related to these topics are stored in the content repository which will be later on mapped with the student’s difficulty and difficulty intensity.

The major contributor to Phase – 1 of the system is the content that needs to be provided for learning. This content is added to the repository by the expert/teacher who is responsible for making the children learn. The snapshot given in figure 4.4 shows the user interface for adding content to the repository through the “Content Master”.

Content ID	502
Content Name	Learning Numbers
Content Description	This content helps the child learn numbers
Content Type	Video
Class Name	Nursery
Subject Name	Maths
Topic Name	Numbers
Content Level	Moderate
Content Priority	2
Content Path	"C:\Program Files\ContentVideos\Nurse

Save Content Close

Figure 4.5: Snapshot showing the content along with various attributes to the proposed system

The user interface so developed shows the content that is added to the repository. Along with the content, various content attributes such as name, description, content type, content level, content priority and the path where is content is placed is also stored. The expert/teacher takes enough care that the content added to the repository is appropriate for the children. The user interface is designed in such a way that the validation related to proper hierarchy of the class, subject, topic and content are maintained. As it can be visualized from the figure 4.4, the class details can be obtained from the “Class Master”, the subject details can be obtained from the “Subject Master”, the topic details can be obtained from the “Topic Master”, the content priority is a pre-defined value by the experts. The content level value is fed to the system through the fuzzy inference system.

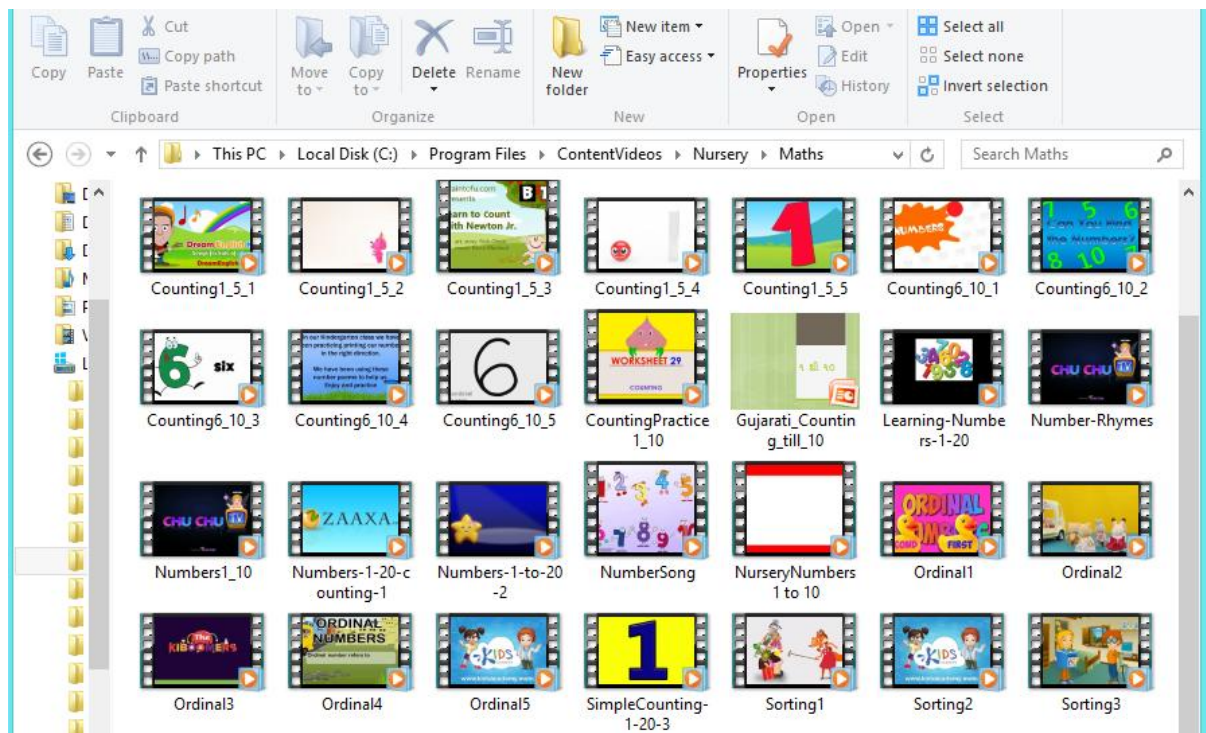


Figure 4.6: Content repository snapshot showing content for Maths subject for Nursery children

The above figure 4.6 shows a content storage snapshot for “Nursery” class with “Maths” as a subject and a few topics related to the subject. This repository area contains the content of the type video, which has been stored for further use by the children. The content master is one of the major record keeping components in the proposed system. It maintains the record related to the content itself, the type of content, the class, subject and topic to which the content belong, the level of the content as well as the priority of the content. This content is then given to the child for learning purpose on the basis of the rule defined by the student-content mapping module.

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Content ID	Content Name	Content Description	Content Path
101	Learning Numbers	Children learn numbers	C:\Program Files\ContentVideos\Nursery\Maths\Learning-Numbers-1-20.mp4
102	Counting 1 to 10	Simple counting 1 to 10	C:\Program Files\ContentVideos\Nursery\Maths\NurseryNumbers1 to 10.mp4
103	Number 1 to 10	Number 1 to 10	C:\Program Files\ContentVideos\Nursery\Maths\NumberSong.mp4
104	Nursery Rhymes	Nursery Rhymes	C:\Program Files\ContentVideos\Nursery\Maths\SimpleCounting-1-20-3.mp4
105	Counting 1 to 20	Counting 1 to 20	C:\Program Files\ContentVideos\Nursery\Maths\SimpleCounting-1-20-3.mp4
106	counting 1 to 20 Part 2	Counting 1 to 20 Part 2	C:\Program Files\ContentVideos\Nursery\Maths\SimpleCounting-1-20-3.mp4
107	Counting 1 to 20	Counting 1 to 20 Part 3	C:\Program Files\ContentVideos\Nursery\Maths\SimpleCounting-1-20-3.mp4
...
201	Counting 1-5	Counting 1-5	C:\Program Files\ContentVideos\Nursery\Maths\Counting1_5_1.mp4
202	Counting 1 to 5	Counting 1 to 5	C:\Program Files\ContentVideos\Nursery\Maths\Counting1_5_2.mp4
203	Counting 1 to 5	Counting 1 to 5	C:\Program Files\ContentVideos\Nursery\Maths\Counting1_5_3.mp4
204	Counting from 1 to 5	Counting from 1 to 5	C:\Program Files\ContentVideos\Nursery\Maths\Counting1_5_4.mp4
205	Counting 1 to 5	Counting 1 to 5	Files\ContentVideos\Nursery\Maths\Counting1_5_5.mp4
206	Counting 6 to 10	Counting 6 to 10	C:\Program Files\ContentVideos\Nursery\Maths\Counting6_10_1.mp4
207	Counting from 6 to 10	Counting from 6 to 10	C:\Program Files\ContentVideos\Nursery\Maths\Counting6_10_2.mp4
208	Counting 6 to 10	Counting 6 to 10	C:\Program Files\ContentVideos\Nursery\Maths\Counting6_10_3.mp4
209	Counting 6 to 10	Counting 6 to 10	C:\Program Files\ContentVideos\Nursery\Maths\Counting6_10_4.mp4
210	Counting 6 to 10	Counting 6 to 10	C:\Program Files\ContentVideos\Nursery\Maths\Counting6_10_5.mp4
211	Ordinal numbers	Ordinal numbers	C:\Program Files\ContentVideos\Nursery\Maths\Ordinal1.mp4
212	Ordinal Numbers	Ordinal Numbers	C:\Program Files\ContentVideos\Nursery\Maths\Ordinal2.mp4
213	Ordinal Numbers	Ordinal Numbers	C:\Program Files\ContentVideos\Nursery\Maths\Ordinal3.mp4
215	Ordinal Numbers	Ordinal Numbers	C:\Program Files\ContentVideos\Nursery\Maths\Ordinal4.mp4
216	Big Small Concept	Big Small Concept	C:\Program Files\ContentVideos\Nursery\Maths\BigSmall1.mp4
217	Big and small concept	Big and small concept	C:\Program Files\ContentVideos\Nursery\Maths\BigSmall2.mp4
218	Big and small concepts	Big and small concepts	C:\Program Files\ContentVideos\Nursery\Maths\BigSmall3.mp4
219	Big and small concepts	Big and small concepts	C:\Program Files\ContentVideos\Nursery\Maths\BigSmall4.mp4
220	Big and small concepts	Big and small concepts	C:\Program Files\ContentVideos\Nursery\Maths\BigSmall5.mp4
221	Sorting concepts	Sorting concepts	C:\Program Files\ContentVideos\Nursery\Maths\Sorting1.mp4

222	Sorting concepts	Sorting concepts	C:\Program Files\ContentVideos\Nursery\Maths\Sorting2.mp4
224	Sorting concepts	Sorting concepts	C:\Program Files\ContentVideos\Nursery\Maths\Sorting4.mp4
225	Sorting Concepts	Sorting Concepts	C:\Program Files\ContentVideos\Nursery\Maths\Sorting4.mp4
...
501	Lets learn numbers	This content teaches numbers to the children	C:\Program Files\ContentVideos\Nursery\Maths\NurseryNumbers1 to 10.mp4
502	Learning Numbers	This content helps the child learn numbers	C:\Program Files\ContentVideos\Nursery\Maths\NurseryNumbers1 to 10.mp4

Table 4.4: Table shows partial data from the Content Master for “Maths” subject of “Nursery” class

Few data related to content are shown in the table 4.4. The attributes such as the Class Id, Subject Id, Topic Id, Content Level and other such details are not shown here for ease of view purpose. These data would be further used by the student module for learning and practice purpose.

4.4.2 Phase II: Creation of Student Repository

Along with the content that is to be provided to the children for learning purpose, student repository is also maintained. This phase in the system takes care related to the student attributes and student activity.

The expert/teacher does the registration process of the child to the proposed system. The snapshot in figure 4.7 shows the registration process for the student.

The screenshot shows a 'Student Registration' window with the following data and options:

Field	Value / Option
Student Id	1200
Student Name	Samarth
Age	10
Gender	<input checked="" type="radio"/> Male, <input type="radio"/> Female
Class Name	Nursery
Difficulty	<input type="radio"/> ADHD, <input checked="" type="radio"/> LD, <input type="radio"/> ADHD&LD, <input type="radio"/> ADHD & Others, <input type="radio"/> LD & Others, <input type="radio"/> Others
Intensity	<input type="radio"/> Border line, <input checked="" type="radio"/> Very low, <input type="radio"/> Low, <input type="radio"/> High, <input type="radio"/> Very High, <input type="radio"/> Tough
Status	<input checked="" type="radio"/> Active, <input type="radio"/> Deactive

Figure 4.7: Figure showing student registration to the proposed system

The expert/teacher uses the above interface to register the student in to the system. Various details regarding the child such as its name, gender, difficulty type, difficulty level and status are maintained through this interface. The data related to the class of the student is obtained from the “Class Master”, the difficulty and intensity parameters are obtained from the respective tables of “Difficulty Master” and “Intensity Master”. The status value is a Boolean value which shows whether the student is active with the system or not. This is maintained to keep a track of the record of the child. Many times it happens that due to social issues, children are not able to continue their education. This field maintains the track of the availability of the child with the system. Records in the table 4.5 shows the values of the children register with the system.

StudentId	Age	ClassName	Gender	Difficulty	Intensity	Status
831	11	Nursery	Male	ADHD and Others	Low	Active
932	11	Nursery	Female	LD and Others	Very High	Active
1001	5	Nursery	Male	ADHD	Very Low	Active
1119	9	Nursery	Male	LD	High	Active
1140	8	Nursery	Female	ADHD	Extreme	Active
1185	13	Nursery	Male	ADHD and Others	High	Active
1190	9	Nursery	Female	LD	Very High	Active
1200	10	Nursery	Male	LD	Very Low	Active
1399	15	Nursery	Male	LD	Extreme	Active
1456	15	Nursery	Male	LD	Low	Active
1460	8	Nursery	Male	ADHD and LD	Border line	Active
1463	8	Nursery	Male	LD and Others	High	Active
1529	8	Nursery	Female	Others	Very High	Active
1547	10	Nursery	Female	ADHD and Others	High	Active
1550	8	Nursery	Male	LD	Border line	Active
9988	12	Nursery	Male	ADHD	Low	Active

Table 4.5: Record of student registration done through the proposed system

The student record for “Nursery” class has been displayed in the above table 4.5. Although the record of student name is taken by the system; however the table does not disclose this for confidentiality purpose. Apart from the class, the difficulty details are also shown. The status of the student is maintained which indicates the student would be currently using the system. In case the student leaves or the student discontinues, its status is deactivated.

4.5 Content Sequence Generator System Modules

The student learning module is further divided as:

- 1) Learning – Practice module
- 2) Assessment module
- 3) Feedback module

4.5.1 Learning – Practice module

During the teaching-learning process of the child, is given the content for learning through the proposed system. The snap shot in the figure 4.8 below shows the student learning – practice module.

The screenshot shows a window titled "Student Learning module" with a toolbar containing a feather icon, a minus sign, a maximize button, and a close button. The main area contains a form with the following fields:

Student Id	1001
Student Name	Shaurya
Class Name	Nursery
Subject	Maths
Topic	Numbers
Student Difficulty	ADHD
Student Intensity	Very Low
Learning content	C:\Program Files\Cont

A "Get content" button is located at the bottom right of the form.

Figure 4.8: Figure showing the content taken for learning

Once, the student is registered with the proposed system, the mentor/teacher helps in the learning process. On selection of the student id, all the details regarding the student get filled up automatically. Along with this the system prompts the content that the child can take up for learning. As for example, in the above snap shot when the student difficulty is “ADHD” and the difficulty intensity is “Very Low” the content shown in the table 4.6 is prompted by the system. The data provided below is just an indicative list. More such data is available for the child to learn.

Node No.	Class	Content Path
1	Nursery	C:\Program Files\ContentVideos\Nursery\Maths\Learning-Numbers-1-20.mp4
2	Nursery	C:\Program Files\ContentVideos\Nursery\Maths\SimpleCounting-1-20-3.mp4
3	Nursery	C:\Program Files\ContentVideos\Nursery\Maths\Counting1_5_2.mp4
4	Nursery	C:\Program Files\ContentVideos\Nursery\Maths\Counting1_5_3.mp4
5	Nursery	C:\Program Files\ContentVideos\Nursery\Maths\SimpleCounting-1-20-3.mp4
6	Nursery	C:\Program Files\ContentVideos\Nursery\Maths\Counting6_10_2.mp4
7	Nursery	C:\Program Files\ContentVideos\Nursery\Maths\Counting6_10_3.mp4
8	Nursery	C:\Program Files\ContentVideos\Nursery\Maths\Ordinal3.mp4
9	Nursery	C:\Program Files\ContentVideos\Nursery\Maths\Ordinal4.mp4
10	Nursery	C:\Program Files\ContentVideos\Nursery\Maths\BigSmall2.mp4
11	Nursery	C:\Program Files\ContentVideos\Nursery\Maths\BigSmall3.mp4
12	Nursery	C:\Program Files\ContentVideos\Nursery\Maths\Sorting2.mp4
13	Nursery	C:\Program Files\ContentVideos\Nursery\Maths\Sorting3.mp4

Table 4.6: Content to be provided to children with difficulty = “ADHD” and intensity = “Very Low”

Table 4.6 shows a subset of content given to the learner for learning purpose for a particular subject; here “Maths”. As the list of content is prompted to the child for learning, the system records the activity of the learner in terms of activity log maintained by system.

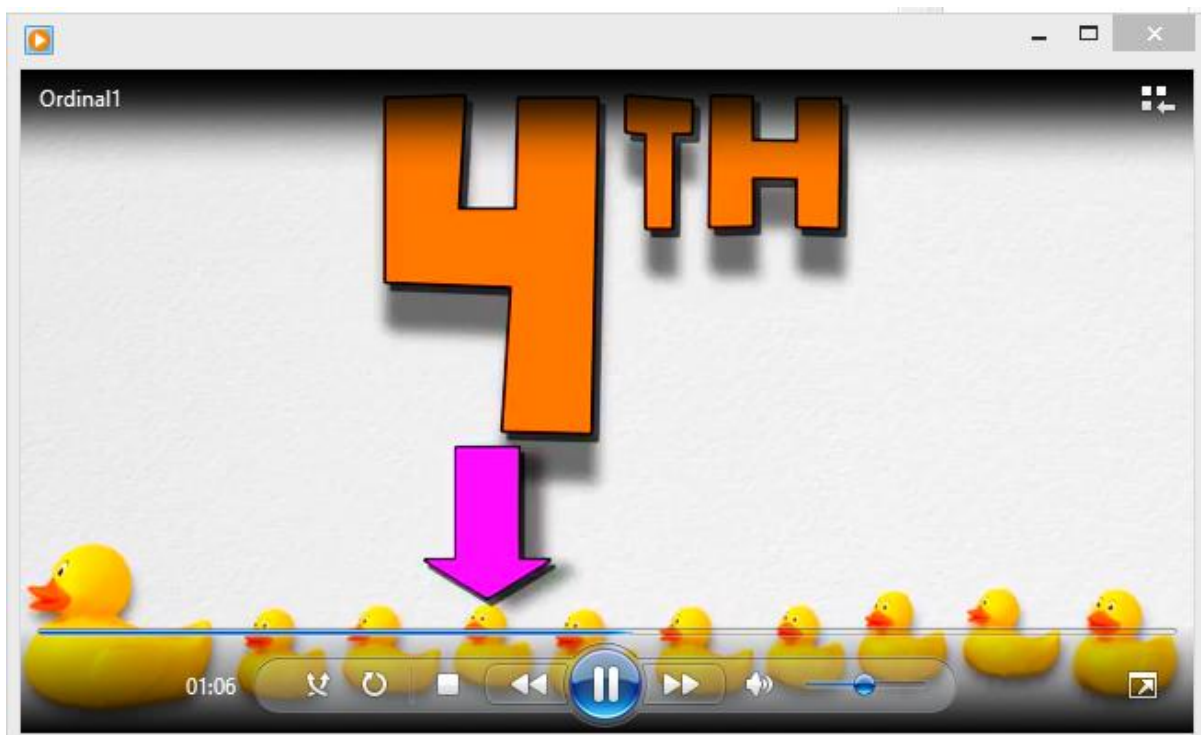


Figure 4.9: A sample content given to child with ADHD for learning purpose

A sequence of objects is recommended to the learners by the system. The child is free to take the recommended content in the sequence or a content of its own choice. The figure 4.8 shows one such content the child taking up one for the learning purpose. Here the topics provided to the child for learning are independent of each other and hence they can be randomly selected by the learner. In case of dependency of topics, only those content would be prompted which needs to be taken prior to the current topic. This can be understood in terms of the graph given below:

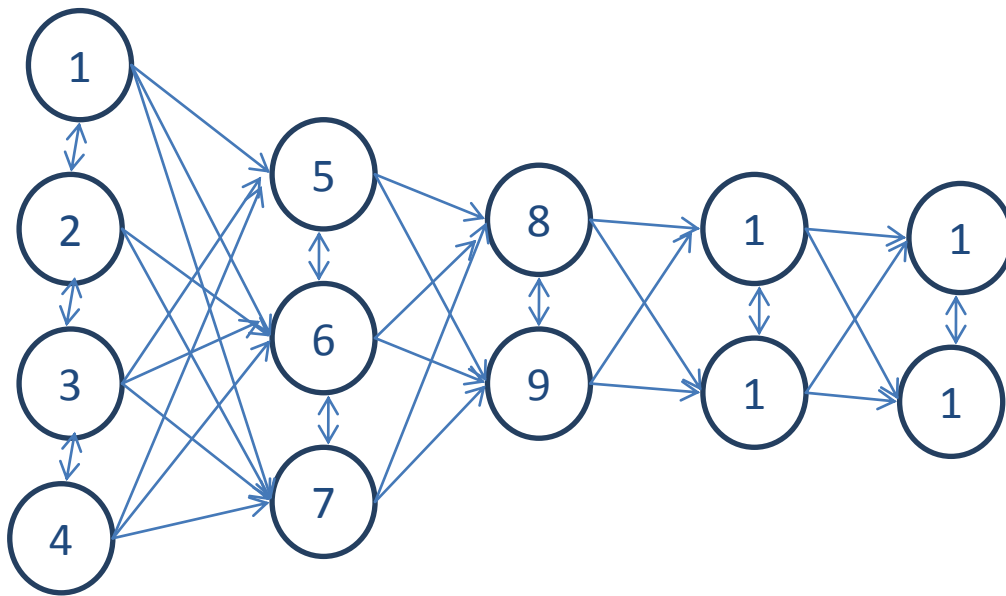


Figure 4.10: Sample Graph showing the topic dependencies and possible content sequences for 13 nodes

Topics are given to the learners either in a sequence or in parallel, which can be seen in the above graph. As a sample data for 13 topics, a few are taken as parallel topics i.e. independent topics while others are taken as dependent topics. The learner is free to take any topic in any sequence for learning purpose. Due to this liberty various sequences for contents are generated. Such kind of sample sequence is shown below:

Various Permutations formed for 13 node content																						
Permutation Set 1					Permutation Set 2					Permutation Set 3					Permutation Set 4							
1	5	8	10	12		2	5	8	10	12		3	5	8	10	12		4	5	8	10	12
1	5	8	10	13		2	5	8	10	13		3	5	8	10	13		4	5	8	10	13
1	5	8	11	12		2	5	8	11	12		3	5	8	11	12		4	5	8	11	12
1	5	8	11	13		2	5	8	11	13		3	5	8	11	13		4	5	8	11	13
1	5	9	10	12		2	5	9	10	12		3	5	9	10	12		4	5	9	10	12
1	5	9	10	13		2	5	9	10	13		3	5	9	10	13		4	5	9	10	13
1	5	9	11	12		2	5	9	11	12		3	5	9	11	12		4	5	9	11	12
1	5	9	11	13		2	5	9	11	13		3	5	9	11	13		4	5	9	11	13
1	6	8	10	12		2	6	8	10	12		3	6	8	10	12		4	6	8	10	12
1	6	8	10	13		2	6	8	10	13		3	6	8	10	13		4	6	8	10	13
1	6	8	11	12		2	6	8	11	12		3	6	8	11	12		4	6	8	11	12
1	6	8	11	13		2	6	8	11	13		3	6	8	11	13		4	6	8	11	13
1	6	9	10	12		2	6	9	10	12		3	6	9	10	12		4	6	9	10	12
1	6	9	10	13		2	6	9	10	13		3	6	9	10	13		4	6	9	10	13
1	6	9	11	12		2	6	9	11	12		3	6	9	11	12		4	6	9	11	12
1	6	9	11	13		2	6	9	11	13		3	6	9	11	13		4	6	9	11	13
1	7	8	10	12		2	7	8	10	12		3	7	8	10	12		4	7	8	10	12
1	7	8	10	13		2	7	8	10	13		3	7	8	10	13		4	7	8	10	13
1	7	8	11	12		2	7	8	11	12		3	7	8	11	12		4	7	8	11	12
1	7	8	11	13		2	7	8	11	13		3	7	8	11	13		4	7	8	11	13
1	7	9	10	12		2	7	9	10	12		3	7	9	10	12		4	7	9	10	12
1	7	9	10	13		2	7	9	10	13		3	7	9	10	13		4	7	9	10	13
1	7	9	11	12		2	7	9	11	12		3	7	9	11	12		4	7	9	11	12
1	7	9	11	13		2	7	9	11	13		3	7	9	11	13		4	7	9	11	13

Table 4.7: Permutation sets of sequences for 13 node contents as described in figure 4.10

The learner is free to take any path for learning purpose. During the learning being done, the learner is also free to switch over to other path. In the sequence provided to the learner through the proposed system for learning purpose, during the learning phase itself, assessment module is also incorporated as a part in the sequence. It is through this combination of the learning and assessment sequence that the child is allowed to use the next topic for learning. In the case where the child does not perform up to the prescribed marking level (the marking level as decided by the expert/teacher and is explained shortly), s/he needs to take up the learning again. The system provides the facility of changing the sequence that was earlier prompted, in case the child does not perform well. Also, if the expert/mentor finds the need to change the sequence of learning, the flexibility to change the learning sequence is

available. Apart from this, it is also possible to provide more learning content from the same bunch of topics in case the expert/mentor feels the need of it. Thus, it is possible that if the content related to topic 1 is provided, in the same line, topic 2 may also be given for more learning or practice purpose.

The mentor/expert decides the marking level the student should attain in order to continue and go to the next topic in the learning process. Following table shows the normalized marking level set by the expert for learning, practice and assessment purpose.

Difficulty Type	Normalized learning count	Normalized practice count	Assessment Result Threshold
ADHD	0.6	0.8	45-50%
LD	0.8	0.9	35-40%
ADHD and LD	0.6	0.8	40-50%
ADHD and Others	0.6	0.8	40-50%
LD and Others	0.8	0.8	35-40%
Others	0.7	0.8	35-50%

Table 4.8: Threshold values for learning content, practice content and assessment module as decided by the expert for topic related to “Numbers”

The table above shows the three main parts of learning done by the child. The learning content, practice content and the assessment threshold values are provided. These values vary as per the difficulty faced by the child. The numbers provided are the minimum values that need to be considered, more number of times learning and practice can be taken by the child.

4.5.2 Assessment module

Assessment carried out for the child has to be taken very carefully and with great correctness. Assessment is considered to be very vital factor in deciding whether the child has actually learnt or not. In case of children suffering from various difficulties in terms of disorders, this not only becomes crucial but also very difficult for the teacher as they have to dig out from the children what actually they have learnt and with proper understanding. Generally assessments are taken as in the following forms:

- (i) Oral and
- (ii) Written

But, in case of special children many a times physical discomfort is accompanied with mental difficulty. Thus they are not comfortable at reading or writing either. In such cases, the mentor/teacher assists the child while assessing them. Thus, assessment takes place in the presence of the teacher/mentor. The teacher/mentor gives questions where the children can give answers to the questions asked. In the traditional situation of assessment all the children get similar kind of questions for the test. In the proposed model as the learning is prompted to the child, similarly, the assessment questions according to the learning module are prompted to the child. The assessment sheet is given to the child either in the form of a question-answer sheet or in the form of visuals. Similar to traditional method of assessment, here also the teacher/mentor needs to be present with the child for assistance. The assistance is in terms of physical presence so that the child is comfortable using the system. At times the teacher/mentor also helps by reading the instructions to the child as what has to be done. This not only increases the confidence of the child but also helps him/her to perform well.

The system provides the teacher/mentor an entry point where they can post question – answer sheets as well as visuals which can be given to the children for assessment.

Question ID	356
Class Name	Nursery
Subject Name	Maths
Topic Name	Counting from 1 to 5
Question	Question related to counting
Question Image Path	E:\PhD\ContentArpan\ImagesForAssesement\Maths\CountAndMatch1.pdf
Option 1	E:\PhD\ContentArpan\ImagesForAssesement\Maths\CountAndMatch_A1.pdf
Option 2	E:\PhD\ContentArpan\ImagesForAssesement\Maths\CountAndMatch_A2.pdf
Option 3	E:\PhD\ContentArpan\ImagesForAssesement\Maths\CountAndMatch_A3.pdf
Option 4	E:\PhD\ContentArpan\ImagesForAssesement\Maths\CountAndMatch_A4.pdf
Correct Option	1
Content Type	Moderate

Figure 4.11: User interface snapshot related to assessment module

The figure 4.11 shows the storage of question–answer sheets for assessment purpose. The mentor/teacher uploads the assessment sheets along with the following attributes of the assessment to be carried out:

- 1) Class for which the assessment has to be done
- 2) Subject on which the assessment content has been prepared
- 3) Topic of assessment
- 4) Question description
- 5) Question content path; here the sheet or the visual is stored for later retrieval
- 6) Options for the question posted
- 7) Correct option provided for assessment
- 8) Level of the question content posted; the level can be any one of the following:
 - a. Very Easy
 - b. Easy
 - c. Moderate

- d. Tough
- e. Very Tough

A sample data set of questions asked by the teacher/mentor through system interaction. Due to the limitation of the student related to reading/writing the teacher/mentor helps the student by reading the question and options aloud and then marking the respective answers. This module has been created especially for the teacher and the mentors where they can have their own repository of questions and answers. The table 4.9 shows a sample of questions present in the repository along with the options and answers.

Question	Option 1	Option 2	Option 3	Option 4	Correct Option
What number is this "1"?	1	2	3	4	1
What number is this "2"?	1	2	3	4	2
What number is this "3"?	1	2	3	4	3
What comes before 3?	1	2	3	4	2
What comes before 4?	1	2	3	4	3
What comes after 5?	5	3	7	6	4
Arrange the number in proper order 4 and 2.	4, 2	2, 4	2	4	2
Arrange the following in proper order 4, 6:	4	6	4,6	6,4	3
Arrange the following in correct order 8, 7	8	7	7,8	8,7	3
What comes after 9?	7	9	10	8	3
What number comes before 1?	1	2	3	0	4
What comes before 2?	1	2	3	4	1
Arrange the following number in proper order: 5, 3	3	5	3,5	5,3	3
What comes before 10?	1	2	9	11	3
Arrange the following in proper sequence: 2,3	2,3	2,2	3,2	2	2
Arrange the given numbers in proper order: 1,5	1	5	5,1	1,5	4
Arrange the following numbers in proper order 1,4	1,4	1	4	4,1	1
Arrange the following numbers in proper order 1,3	1	3	3,1	1,3	4
Arrange the following numbers in proper order 1,3	1	1,3	3	3,1	2
Arrange the following in proper order: 2,5	2	5	2,5	5,2	3
Arrange the following numbers in proper order 2,1	1,2	1	2	2,1	1
Arrange the following numbers in proper order 2,5	2	5	5,2	2,5	4
Arrange the following numbers in proper order 3,1	3	1	1,3	3,1	3
Arrange the following numbers in proper order 1,4,2	1,2,4	2,1,4	4,2,1	4,1,2	1

Arrange the following numbers in proper order 1,3,4	1,4,3	1,3,4	3,1,4	3,1,4	2
Arrange the following numbers in proper order 1,2,5	1,5,2	2,1,5	2,5,1	1,2,5	4
Arrange the following numbers in proper order 2,4,3	2,4,3	2,3,4	4,3,2	3,2,4	2
Arrange the following numbers in proper order 1,4,3	1,4,3	3,1,4	1,3,4	4,1,3	3
Arrange the following numbers in proper order 2,4,5	2,5,4	5,2,4	4,2,5	2,4,5	4
Arrange the numbers in reverse order 3,4	3	4	4,3	3,4	3
Arrange the numbers in reverse order 3,5	3,5	5,3	5	3	2
Arrange the numbers in reverse order 1,5	5,1	1	5	1,5	1
Arrange the numbers in reverse order 1,3	1	3	3,1	1,3	3
Arrange the numbers in reverse order 3,4, 5	3,5,4	5,3,4	3,4,5	5,4,3	4
Arrange the numbers in reverse order 1,4,5	4,1,5	5,4,1	1,4,5	1,5,4	2
Arrange the numbers in reverse order 1,2,3	3,2,1	1,2,3	1,3,2	2,1,3	1
Arrange the numbers in reverse order 1,4,5,3	1,3,4,5	5,4,1,3	5,4,3,1	4,1,3,5	3
Arrange the numbers in reverse order 1,2,3,4	4,3,2,1	3,2,1,4	2,1,4,3	1,4,3,2	1
What lies between 3 and 5?	3	4	5	6	2
What lies between 1 and 3?	2	1	3	4	2
What lies between 2 and 4?	2	4	1	3	4
What comes after 3?	1	2	3	4	4
What comes before 3?	1	2	3	4	2
What lies between 3 and 6?	2,4	3,4	4,5	5,4	3
What lies between 1 and 4?	2,3	1,2	3,4	3,2	1
What numbers come before 3?	4	5	1,2	3	3

Table 4.9: Data related to assessment for a few topics

Another method of assessment is by showing various types of images that are stored in the repository. These images are given to the students for assessment purpose. The mentor/teacher does this assessment with various different question sets prompted by the system to ensure that the child is answering the question right with proper learning and understanding. Another factor that is important while assessing the children is the number of times the assessment that takes place. In case of special children, the mentor/teacher takes more than five-seven assessments for each topic to ensure proper learning done by the child.

Assessment done through visuals:

Another mode of assessment for the specially-abled children is through visuals. The children are shown short visuals related to the topics already learnt. At the end of the short visual questions are posed. The children need to answer these questions and the teacher/mentor

assesses the child on the basis of the answer given. As an example, the following snapshot is taken where number counting is shown and the child needs to say the number present in the visual. This type of assessment lies under the category of oral assessment.

The teacher/mentor enters the assessment related content such as audios, videos, power point slides and other such aids. Through this repository of the assessment content, the teacher/mentor is able to assess the students orally. The main intension to have oral assessment is that through oral assessment the teacher/mentor can be sure regarding the learning done by the child. This human intervention reinforces the learning done by the child and gives confidence to both the teacher/mentor and the student.

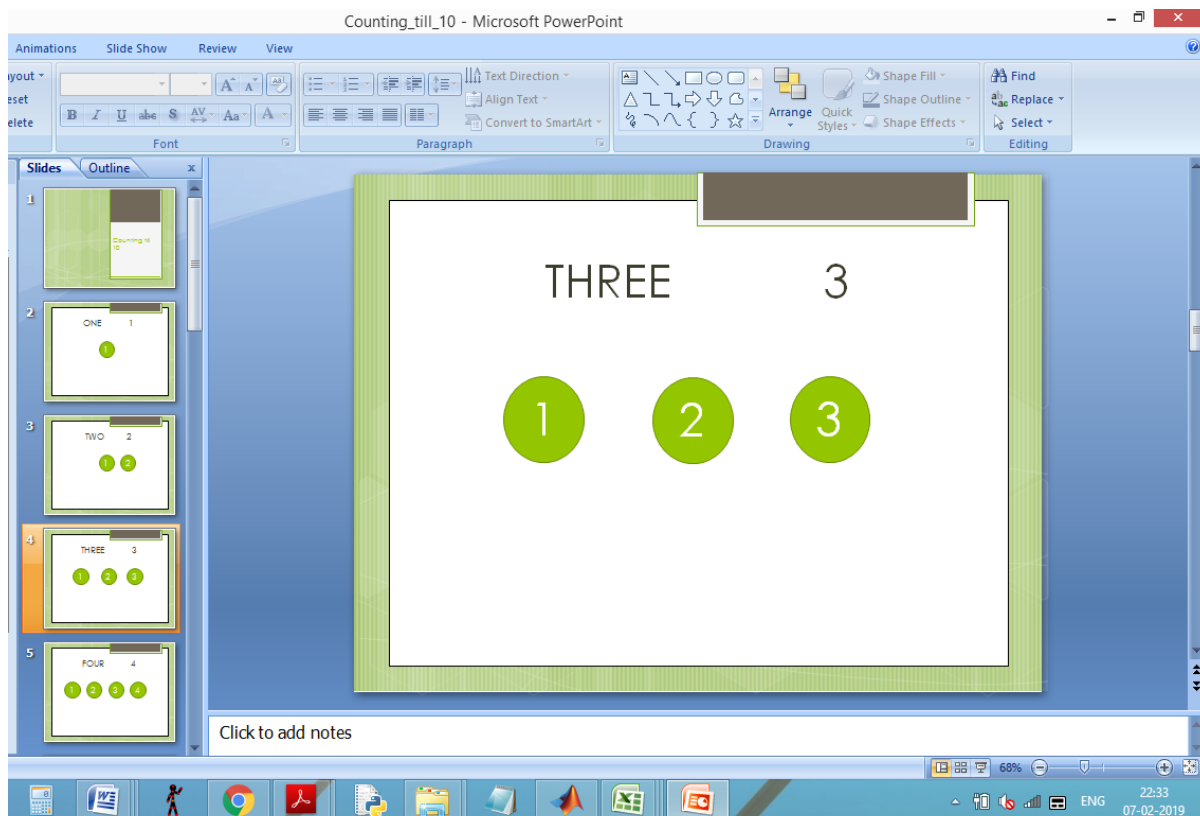


Figure 4.12: Oral assessment carried out using power point slide as a part of visual assessment

Figure 4.12 shows the oral assessment carried out for children through the teacher/mentor as a part of human intervention during learning.

The assessment record as maintained by the teacher/mentor during the assessment carried out for a particular topic. The assessment results of the children are maintained in the activity log of the child. The general scenario for assessment for special needs children is as follows:

The teacher/mentor generally assesses the students on the basis of their oral performances and other visual based performances. This is because many students are not able to write properly due to their mental and physical limitations. However, they are taught to use devices that help them in learning; for example operating a mouse or a keyboard. This is simpler for the children to use as it assists the learner in using the system.

The table 4.10 shows a snap shot of data regarding assessment carried out for the children for various topics.

Sr. No.	Student Id	Class	Subject	Assessment Result 1 (Out of 10)	Assessment Result 2 (Out of 10)	Assessment Result 3 (Out of 10)	Average Result
1	831	Nursery	Maths	4	7	7	6
2	932	Nursery	Maths	2	8	8	6
3	1001	Nursery	Maths	5	4	6	5
4	1119	Nursery	Maths	5	9	9	7.67
5	1140	Nursery	Maths	3	9	8	6.67
6	1185	Nursery	Maths	2	2	7	3.67
7	1190	Nursery	Maths	5	9	4	6
8	1200	Nursery	Maths	4	5	6	5
9	1399	Nursery	Maths	5	6	7	6
10	1456	Nursery	Maths	4	1	3	2.67
11	1460	Nursery	Maths	3	4	2	3
12	1463	Nursery	Maths	8	5	7	6.67
13	1529	Nursery	Maths	6	8	9	7.67
14	1547	Nursery	Maths	5	8	3	5.33
15	1550	Nursery	Maths	3	3	6	4

Table 4.10 : Assessment record of a few children taking assessment for the topic related to “Numbers”

As discussed for each topic, the student goes for a minimum of three assessments. The teacher ensures that the assessments carried out are given in different variety. In case the student is not able to perform up to the mark in all the three assessments additional assessments are carried out and best of three are retained. Their average is calculated as this will act as one of the parameters in selection of the next content in the sequence. This value is also important for the feedback module.

4.5.3 Feedback module

Just as the assessment module plays a key role in deciding the learning taken place by the child, so is the feedback module. The feedback maintains the overall record of the child topic wise in terms of learning taken and assessment done. On the basis of the child's difficulty, learning taken, practice done and assessment results automatic feedback gets generated and using this feedback the next level of learning is decided. If the feedback is up to the mark then next content is provided for learning, in case the feedback is not as per expectation, repetition in terms of practice takes place. The same topic with different type of content gets repeated for better learning purpose.

The process of selection for level of content is based on fuzzy inference logic. Here following inputs are considered:

- 1) Difficulty faced by the child
- 2) Intensity of difficulty faced
- 3) Learning-Practice taken by the student
- 4) Assessment result of the topic already learnt

On the basis of these two inputs; rules using fuzzy reasoning are formed that will provide the content for learning. This content will have the type and level as per the rules decided by the system.

The content repository has the content related to the learning module, practice module and the assessment module. The contents are prepared by the experts. The content prepared can be tagged as easy for one student where as it is tough for other student. This toughness of the content lies in a range of 0 to 1.

This toughness is classified as follows:

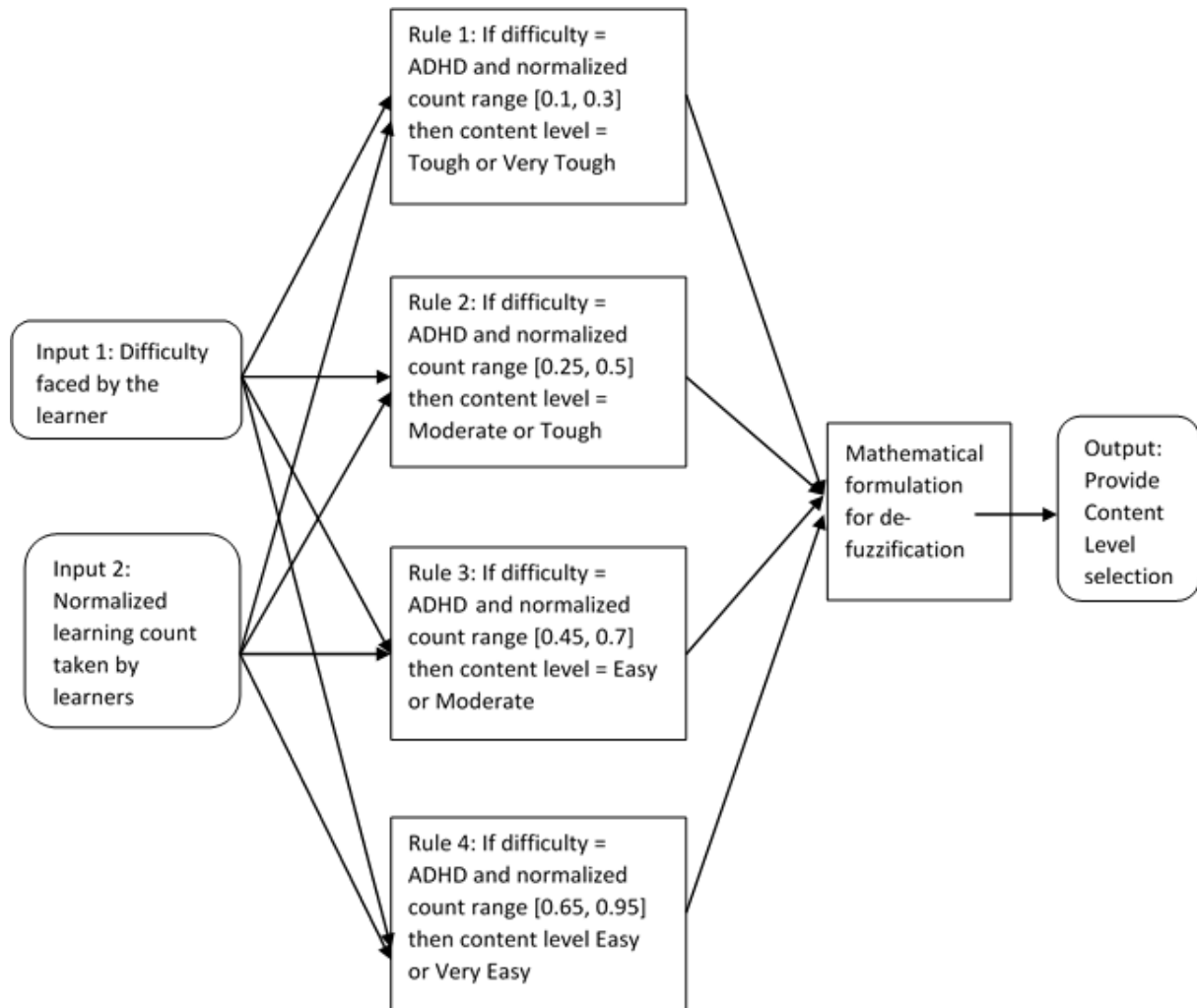


Figure 4.13 Rules for modification of content level on the basis of its usage

A rule based module decides the content level for updation. The feedback module works on the basis of the usage of the current content learnt by various students. The figure 4.13 gives a partial rule-base for the modification of the rules to be set for updation.

The feedback module is also responsible for updating the values of the edges whenever there is a change due to the learner value. This updation in value will help in the dynamicity of content selection by the learner. The content that is more used by other learner gains popularity and may become an important aspect for learning among the children.

4.6 Conclusion

This chapter gives the experimental details related to the work carried out through the usage of various interfaces. The user interfaces used by the teacher/mentor and students have been shown. Data supporting the user interface is also mentioned in the various sections of the chapter. The contents of the repository created for the students and the contents are mentioned in this chapter. The manipulation of the content for their levels is also discussed. The fuzzy logic applied for the dynamic change in the content level has been discussed. The modified ant colony algorithm has been used for the sequence generation is discussed. The recommended paths of content selection have also been shown. The next chapter discusses the results and inference of the system.

CHAPTER – 5

Results and Discussions

5.1 Introduction

The detailed system architecture has been already discussed in the previous chapter. The experimentation carried out for special children was also discussed. In this chapter the results and their inferences are being discussed. During the survey to various local schools teaching children with various difficulties; the data regarding the children was collected. The data was collected for study purpose and experiment was carried out at one of the local schools. The identity of the schools and the children of the schools are not being disclosed for various social reasons. However, the sample data and results obtained from the sample data are being shown and explained in the following sections.

In order to evaluate the design that is modeled in the thesis, experiment was conducted with special needs children of a local school in the presence of their teachers and mentors. The course structure and content as per the school curriculum was taken. Apart from the details maintained by the administration, the system took a handful of information required for the system to work. The details of the students were thus collected, maintained and used.

5.2 Inference of Data Collected Through the System

In the beginning of the system, the student data and content data are collected. The user interface for the same is given to the expert for entering the student data. After the student gets registered to the system, the data is stored in the student repository. The sample data of children with different types of disabilities is shown in the figure 5.1. Two main categories

for disabilities; Attention Deficit Hyperactive Disorder (ADHD) and Learning Disability (LD) have been considered. As mentioned in the previous chapters, it is highly likely that children may suffer from other additional difficulties also. Along with the difficulty, the combinations obtained from these disabilities have also been considered. Children other than these difficulties combinations have been categorized as “Other” disability.

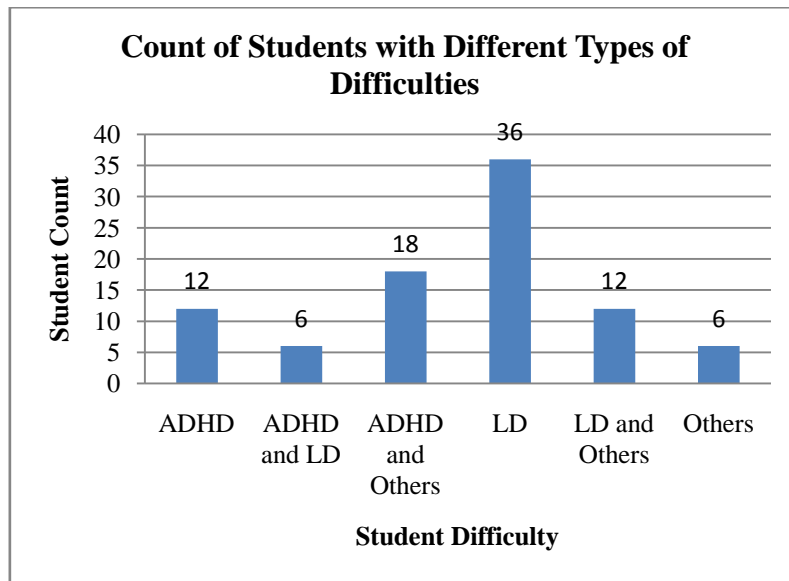


Figure 5.1: Graph showing the count of student along with various difficulties faced

Student Difficulty	Student Count
Attention Deficit Hyperactive Disorder	12
Attention Deficit Hyperactive Disorder and Learning Disability	6
Attention Deficit Hyperactive Disorder and Others	18
Learning Disability	36
Learning Disability and Others	12
Others	6

Table 5.1: Data of Student count with various Difficulties

Student data are one of the main data to be maintained and handled by the system. The importance of student difficulty data is due to this difficulty type, students get content to learn. Students who are having more problems in learning and understanding can be given simple contents to learn. Along with the student difficulty the intensity of the student difficulty is also maintained. This is given in figure 5.2. The difficulty and the intensity of the

difficulty both are one of the main inputs in channelizing the content for learning purpose.

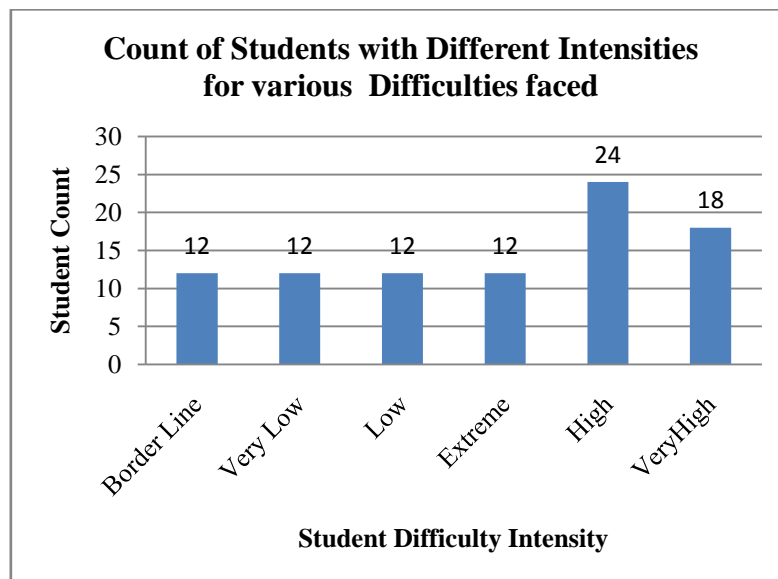


Figure 5.2: Graph showing the count of student having different types of intensity

Other important data to the system is the content. The content is stored in the content repository by the teacher/mentor. With every content placed in the repository an initial content level tag is attached by the teacher/mentor. This is the initial value given to the content. Later on as the students interact with the system for learning purpose and as they start learning the contents, there would be contents that are more used in learning as compared to others. This leads to popularity of the contents. This also helps in changing the content level on the fly. A content level wise distribution is shown in the figure 5.2. The data shown in the figure 5.2 is showing only partial data for “Nursery” class, “Maths” subject and a few topics.

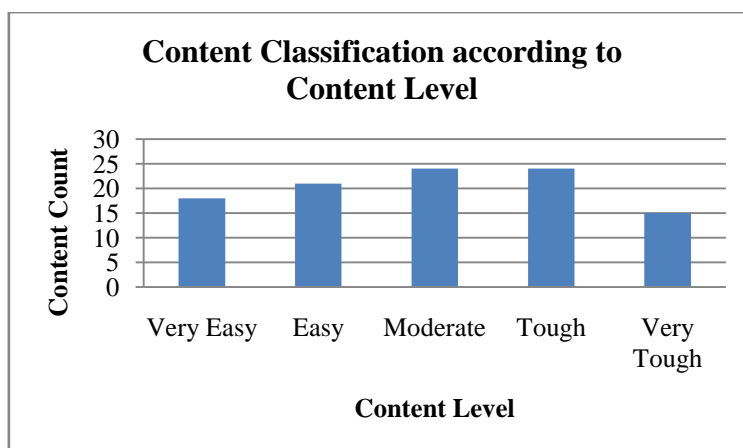


Figure 5.3: Graph showing the count of content along with the content level

The data for level wise content distribution is shown in the figure 5.2, and the table containing this data is shown in table 5.2.

Content Level	Content Count
Very Easy	18
Easy	21
Moderate	24
Tough	24
Very Tough	15

Table 5.2: Content count according to the content level

The general hierarchy in the course curriculum is course → class → subject → topic → contents. Every topic given for learning is supported with different types of contents. The need for different kind of content is to provide a wide variety for learning purpose. If a child is not able to learn with one kind of content, another type of content is made available for learning. The content is mentioned earlier is initially tagged by the expert. Thus an initial mapping of the content with the type of learner can be done. Figure 5.4 shows a snapshot of few content data made available to children with “Learning Disability” and having “Low” intensity.

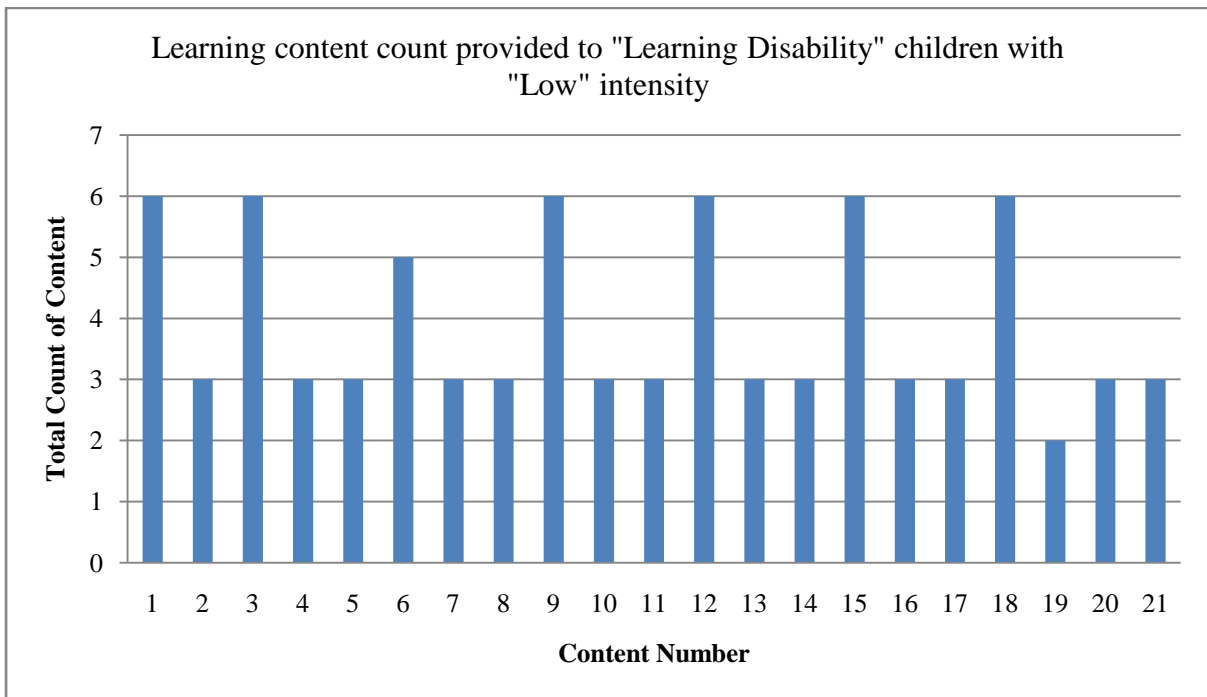


Figure 5.4 : Chart showing the count of learning-practice content provided to LD children

The graph in the figure 5.4 shows the count of the content given to “Learning Disability” children with “Low” intensity. The values on the x-axis show the content number and the values on the y-axis show the count of content made available to these children.

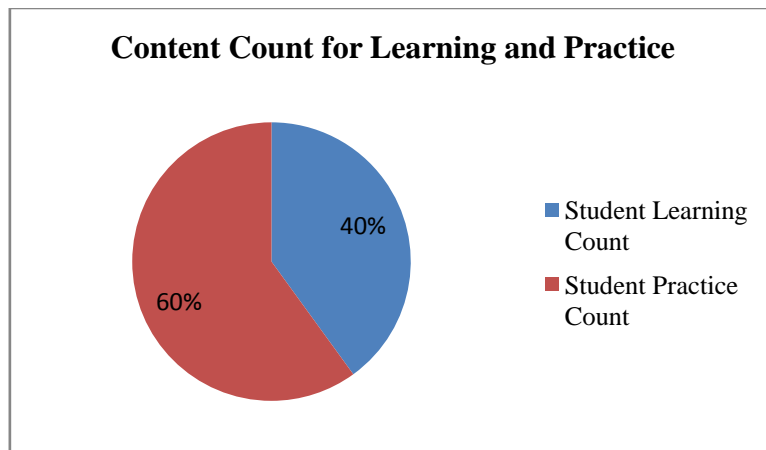


Figure 5.5 A Pie-chart showing distribution of content

The content made available for the children can be used as a learning content as well as practice content. The figure 5.5 shows a percentage wise distribution of a content given for learning and practice.

The learning object provided to the children for learning purpose is a bunch of learning – practice and assessment module. Along with every learning – practice content, assessment content is also provided. Once the learning and practice is done, the student undergoes the assessment process. The assessment process carried out for special children comes along with human intervention. The assessment for a particular topic is carried out for a minimum of three times (if the students is able to perform) or if required a few more times till the student has learnt.

As a sample assessment details on a particular topic is shown in the figure 5.5. A threshold value is maintained in the form of passing criteria for the assessment carried out. If the student is able to meet this threshold value the student can go to the next content otherwise the student needs to go for other assessment or needs to re-learn the concepts.

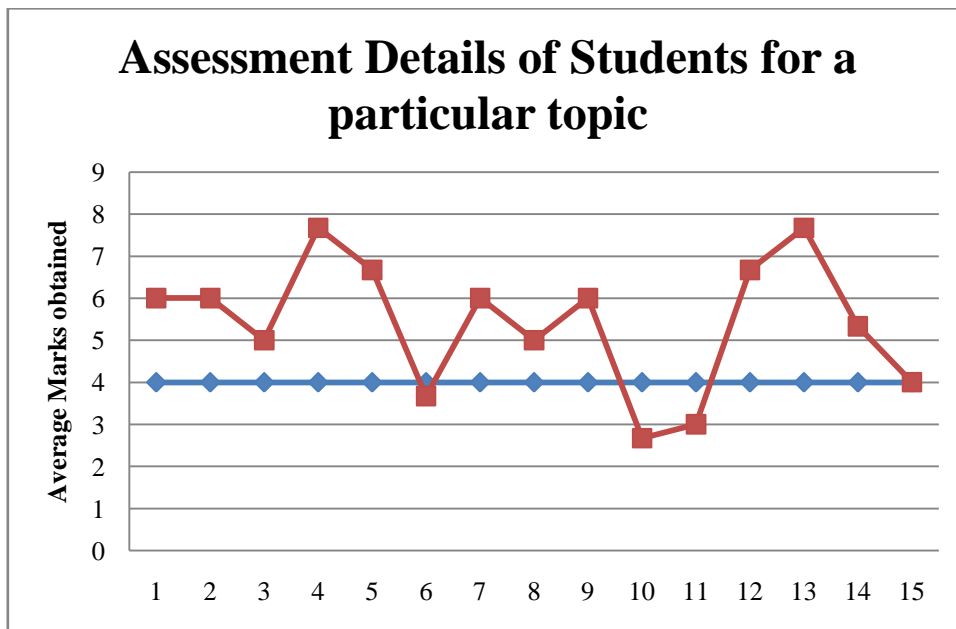


Figure 5.6 : Graph showing the comparison between the standard threshold and the average marks obtained

The figure 5.6 shows the assessment carried out for 15 students. An average marks from three best assessments was considered. A threshold of (04) was considered as passing criteria and in order to go to the next kind of content.

Sr. No.	Student Id	Class	Subject	Assessment Result 1 (Out of 10)	Assessment Result 2 (Out of 10)	Assessment Result 3 (Out of 10)	Average Result
1	831	Nursery	Maths	4	7	7	6
2	932	Nursery	Maths	2	8	8	6
3	1001	Nursery	Maths	5	4	6	5
4	1119	Nursery	Maths	5	9	9	7.67
5	1140	Nursery	Maths	3	9	8	6.67
6	1185	Nursery	Maths	2	2	7	3.67
7	1190	Nursery	Maths	5	9	4	6
8	1200	Nursery	Maths	4	5	6	5
9	1399	Nursery	Maths	5	6	7	6
10	1456	Nursery	Maths	4	1	3	2.67
11	1460	Nursery	Maths	3	4	2	3
12	1463	Nursery	Maths	8	5	7	6.67
13	1529	Nursery	Maths	6	8	9	7.67
14	1547	Nursery	Maths	5	8	3	5.33
15	1550	Nursery	Maths	3	3	6	4

Table 5.3: Table of assessment result (average of three best assessments considered)

5.3 Research Contributions

In this section review and analysis of the results of the experiment carried out is done. The objectives stated at the beginning of the thesis are addressed and solution is provided.

5.3.1 Research Contribution – 1

Here a group of students of class “Nursery” for the subject “Maths” with “ADHD” difficulty and “Extreme” intensity are considered and shown. Various contents are provided for learning and assessment. A snapshot of the content made available is shown in the table 5.5 where the content is made available where the content level has been dynamically assigned according to the difficulty and intensity of the child.

Content ID	Content Path
101	C:\Program Files\ContentVideos\Nursery\Maths\Learning-Numbers-1-20.mp4
102	C:\Program Files\ContentVideos\Nursery\Maths\NurseryNumbers1 to 10.mp4
103	C:\Program Files\ContentVideos\Nursery\Maths\NumberSong.mp4
104	C:\Program Files\ContentVideos\Nursery\Maths\SimpleCounting-1-20-3.mp4
105	C:\Program Files\ContentVideos\Nursery\Maths\SimpleCounting-1-20-3.mp4
106	C:\Program Files\ContentVideos\Nursery\Maths\SimpleCounting-1-20-3.mp4
107	C:\Program Files\ContentVideos\Nursery\Maths\SimpleCounting-1-20-3.mp4
201	C:\Program Files\ContentVideos\Nursery\Maths\Counting1_5_1.mp4
202	C:\Program Files\ContentVideos\Nursery\Maths\Counting1_5_2.mp4
203	C:\Program Files\ContentVideos\Nursery\Maths\Counting1_5_3.mp4
204	C:\Program Files\ContentVideos\Nursery\Maths\Counting1_5_4.mp4
205	C:\Program Files\ContentVideos\Nursery\Maths\Counting1_5_5.mp4
206	C:\Program Files\ContentVideos\Nursery\Maths\Counting6_10_1.mp4
207	C:\Program Files\ContentVideos\Nursery\Maths\Counting6_10_2.mp4
208	C:\Program Files\ContentVideos\Nursery\Maths\Counting6_10_3.mp4
209	C:\Program Files\ContentVideos\Nursery\Maths\Counting6_10_4.mp4
210	C:\Program Files\ContentVideos\Nursery\Maths\Counting6_10_5.mp4
211	C:\Program Files\ContentVideos\Nursery\Maths\Ordinal1.mp4
212	C:\Program Files\ContentVideos\Nursery\Maths\Ordinal2.mp4
213	C:\Program Files\ContentVideos\Nursery\Maths\Ordinal3.mp4
214	C:\Program Files\ContentVideos\Nursery\Maths\Ordinal4.mp4
215	C:\Program Files\ContentVideos\Nursery\Maths\Ordinal5.mp4
216	C:\Program Files\ContentVideos\Nursery\Maths\BigSmall1.mp4
217	C:\Program Files\ContentVideos\Nursery\Maths\BigSmall2.mp4
218	C:\Program Files\ContentVideos\Nursery\Maths\BigSmall3.mp4
219	C:\Program Files\ContentVideos\Nursery\Maths\BigSmall4.mp4
220	C:\Program Files\ContentVideos\Nursery\Maths\BigSmall5.mp4
221	C:\Program Files\ContentVideos\Nursery\Maths\Sorting1.mp4
222	C:\Program Files\ContentVideos\Nursery\Maths\Sorting2.mp4
223	C:\Program Files\ContentVideos\Nursery\Maths\Sorting3.mp4
224	C:\Program Files\ContentVideos\Nursery\Maths\Sorting4.mp4
225	C:\Program Files\ContentVideos\Nursery\Maths\Sorting5.mp4

Table 5.5: All possible content available for “ADHD” children with “Extreme” intensity of “Nursery” class with “Maths” subject

A pool of content is made available to the students for learning purpose. Out of the many contents available, in order to complete one cycle for learning purpose. The selection of the contents done by the students is given in the table 5.6.

Content Id	Content Path
102	C:\Program Files\ContentVideos\Nursery\Maths\NurseryNumbers1 to 10.mp4
103	C:\Program Files\ContentVideos\Nursery\Maths\NumberSong.mp4
104	C:\Program Files\ContentVideos\Nursery\Maths\SimpleCounting-1-20-3.mp4
201	C:\Program Files\ContentVideos\Nursery\Maths\Counting1_5_1.mp4
203	C:\Program Files\ContentVideos\Nursery\Maths\Counting1_5_3.mp4
204	C:\Program Files\ContentVideos\Nursery\Maths\Counting1_5_4.mp4
206	C:\Program Files\ContentVideos\Nursery\Maths\Counting6_10_1.mp4
207	C:\Program Files\ContentVideos\Nursery\Maths\Counting6_10_2.mp4
210	C:\Program Files\ContentVideos\Nursery\Maths\Counting6_10_5.mp4
214	C:\Program Files\ContentVideos\Nursery\Maths\Ordinal4.mp4
215	C:\Program Files\ContentVideos\Nursery\Maths\Ordinal5.mp4
216	C:\Program Files\ContentVideos\Nursery\Maths\BigSmall1.mp4
217	C:\Program Files\ContentVideos\Nursery\Maths\BigSmall2.mp4
223	C:\Program Files\ContentVideos\Nursery\Maths\Sorting3.mp4
224	C:\Program Files\ContentVideos\Nursery\Maths\Sorting4.mp4

Table 5.6: Content after the content level changed as per the requirement of the student

Thus, the objective of providing content from the pool that is used by specific category of learners gets fulfilled here.

5.3.2 Research Contribution – 2

The work done in the research considers a graph based approach for construction of solution sets for providing the content dynamically. In doing so, the probabilistic approach is used. The contents to be learnt are taken as nodes in the graph and the weights on the edges are the probabilities through which the solution gets generated. Initially all the paths are considered to be equal and hence equal probabilities are considered. As and when the contents are taken up for learning; the probability values change. As mentioned in the previous chapter on design of the system, the probability value depends on the many factors. All these factors have been considered in order to calculate the probability of the next content selection.

In the graph based content sequence generation the initial values of probabilities are given as 0.5 considering equal probabilities for each selection. Here it is assumed that two contents

with equal priorities are taken.

Initial Probability Values												
	101	102	104	201	202	206	207	212	213	216	217	221
101	0.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
102	0.5	0.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
104	0.5	0.5	0.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
201	0.5	0.5	0.5	0.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
202	0.5	0.5	0.5	0.5	0.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5
206	0.5	0.5	0.5	0.5	0.5	0.0	0.5	0.5	0.5	0.5	0.5	0.5
207	0.5	0.5	0.5	0.5	0.5	0.5	0.0	0.5	0.5	0.5	0.5	0.5
212	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.0	0.5	0.5	0.5	0.5
213	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.0	0.5	0.5	0.5
216	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.0	0.5	0.5
217	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.0	0.5
221	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.0

Table 5.7: Initial probability values for content selection

The table 5.8 shows a sample of content along with its id, priority and probability. These are initial values and will the probability values will change depending on the selection of the content and its popularity.

Content ID	Content Priority	Selection Probability
101	1	0.5
102	1	0.5
104	2	0.5
201	2	0.5
202	3	0.5
206	3	0.5
207	4	0.5
212	4	0.5
213	5	0.5
216	5	0.5
217	6	0.5
221	6	0.5

Table 5.8 Content with priorities and initial probability values

After the experiment carried out and on selection of contents by the students, the probabilities are updated. This updation depends on the following factors:

- 1) Learning output
- 2) Assessment result
- 3) Attention parameter (attention span, concentration etc)
- 4) Number of students who have already taken that content for learning purpose

	1	1	2	2	3	3	4	4	5	5	6	6
	101	102	104	201	202	206	207	212	213	216	217	221
101	0.0	0.6	0.5	0.77	0.67	0.37	0.6	0.5	0.6	0.27	0.3	0.67
102	0.6	0.0	0.23	0.33	0.45	0.67	0.47	0.63	0.5	0.3	0.6	0.67
104	0.5	0.23	0.0	0.5	0.4	0.66	0.34	0.45	0.63	0.7	0.44	0.5
201	0.77	0.33	0.5	0.0	0.23	0.33	0.45	0.65	0.8	0.66	0.44	0.5
202	0.67	0.45	0.4	0.23	0.0	0.23	0.34	0.65	0.67	0.56	0.44	0.46
206	0.37	0.67	0.66	0.33	0.23	0.0	0.23	0.67	0.44	0.54	0.67	0.55
207	0.6	0.47	0.34	0.45	0.34	0.23	0.0	0.5	0.44	0.23	0.8	0.45
212	0.5	0.63	0.45	0.65	0.65	0.67	0.5	0.0	0.3	0.45	0.56	0.64
213	0.6	0.5	0.63	0.8	0.67	0.44	0.44	0.3	0.0	0.55	0.65	0.44
216	0.27	0.3	0.7	0.66	0.56	0.54	0.23	0.45	0.55	0.0	0.23	0.67
217	0.3	0.6	0.44	0.44	0.44	0.67	0.8	0.56	0.65	0.23	0.0	0.54
221	0.67	0.67	0.5	0.5	0.46	0.55	0.45	0.64	0.44	0.67	0.54	0.0

Table 5.9: Updated probability values for content selection after path selection by students

The updated values in probability show the dynamicity in content selection and path generation.

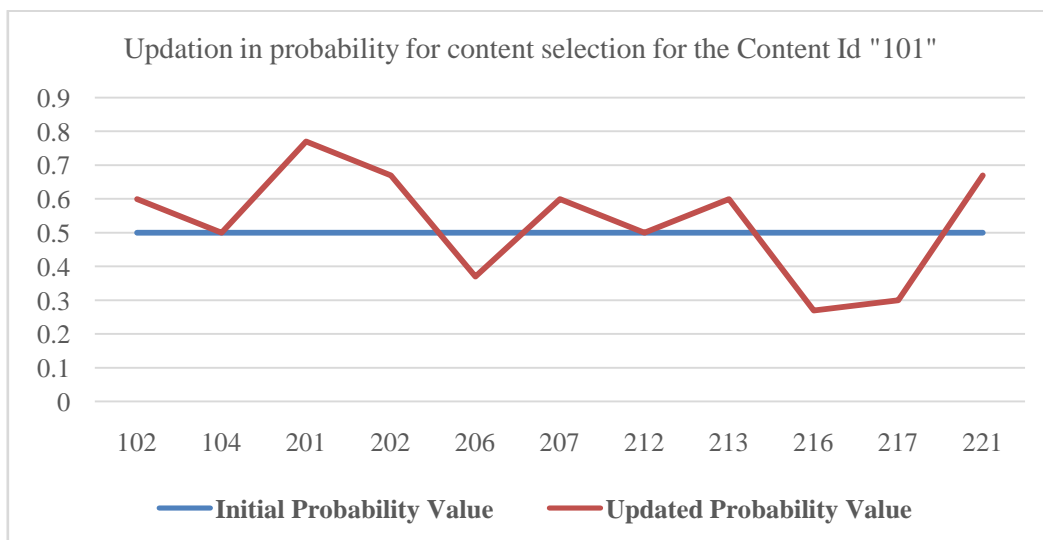


Figure 5.7: Graph showing the comparison of the initial probability value and updated probability value for the content id “101” with respect to other contents

The figure 5.7 shows the comparison of the initial probability value and the updated probability values for the content id “101” with respect to other content ids such as 102, 104, 201, 202, 206, 207, 212, 213, 216, 217 and 221. The graph shows that depending on the content selected by the learners the popularity of the content changes. The probability change also depends on the performance of the learners taking up the content for learning purpose.

5.4 Summary of Evaluation

As part of the experimental setup the students with different difficulties along with their intensities were considered. They were provided with a pool of contents from which a few recommended contents were provided. Also the children were given the liberty to make a choice of their own content for learning purposes. The system could give the contents to the learners on the fly. In summary, the system could help the special needs children in their academics apart from the traditional teaching – learning processes. The output of the model is shown in terms of the content path recommended to the learners. The learning practice module taken up by the learner, the assessment module taken by the learner is also discussed. The modification in the probabilities of the content taken up during the learning process has been successfully shown. The chapter thus shows that the model could help the learners in their learning process through the personalized sequencing of the contents.

CHAPTER – 6

Conclusion, Major Contributions and Future Scope

6.1 Conclusion

With the advancement of technology, specifically in the field of education, along with normal children more opportunities are available for specially-abled children for learning purposes. An adaptive learning environment can provide personalized learning support for learners with different disorders and varied intensity. One way to provide personalization in learning is by providing content sequenced as per the requirement of the child.

This thesis has the design and implementation for content sequence generation for special needs learner. The dynamic sequence generation algorithm designed in the system uses Ant Colony Optimization algorithm and provides personalized learning paths.

The content sequence generator uses various special child details; difficulty type and intensity being the major ones. Along with these, the usage of learning module, practice module and assessment module are recorded. The values are then used for suggesting next content on the fly for better personalization.

The content sequence generator model was evaluated by designing and developing different contents for “Maths” subject for children of class similar to “Nursery”. Children were given the contents using the system and at the same time the traditional teaching learning method was applied for learning purpose.

Observations show children when started learning through the content sequence generator could do comparatively better than the traditional method of teaching.

6.2 Major Contributions:

Contributions of this research are as follows:

- 1) The design and development of Ant Colony Optimization with modified parameters was used.
- 2) The algorithm incorporates learner's improvement in the process of a learning path selection.
- 3) In order to select the appropriate path for the choice of the next content, a mapping between the special need child's difficulty and intensity of difficulty and the content is maintained.
- 4) This value was updated as visit through the path was made more common.
- 5) Using Fuzziness in the content level of toughness and the way the difficulty of the child is handled, new paths are provided to the child for learning purposes.
- 6) The sequencing of content that was done dynamically was compared with the normal and regular teaching.
- 7) Model based learning made children learn efficiently
- 8) Model based assists the regular teaching learning process.

6.3 Limitations of the Proposed System

As every system has its own limitations so it is with this system. Few system limitations are discussed below:

- 1) The assessment module has been implemented with human intervention. There are pros and cons for this implementation.
- 2) The content that is given to the students for learning purpose has not been designed by the experts but by the teacher and mentors. Better content with proper aesthetics and colour code can be prepared. This will lead to better understanding for the children.

6.4 Scope for Future Work

As suggested in the thesis, the special needs children have difficulty in their academics. Few of the students are at par with the regular students, some being even far better than their regular peers. However, majority of them struggle with their academics. This thesis has suggested a model that would help in solving this problem of the special needs children.

According to psychologists and experts, along with academics, majority students face difficulty in carrying out the routine tasks. They find it hard to cope up with their regular work be it school work or any house hold chores. This model can help the children as well as parents to schedule the jobs that are needed to be carried out.

The assessment module needs improvement in terms of human intervention. Though the whole system cannot be given to the children for operation; some liberty needs to be given to the learners while assessing them. Better assessment pages with images and selection tools can be given.

Special needs children have difficulty in social behaviour and interaction with different people or peers. At times these children due to mood swings and other personal factors throw tantrums. The model can be of help to children by creating content that are of the type where the children could be taught how to behave among social groups. Thus the model can help the children to improve interaction with their peers and improvise on their social skills.

Although the model has been prepared for special needs learners, the same can be used for normal children who are slow learners. Content sequences suitable to the slow learner can be prepared and provided to them for learning. This would make learning for them fun filled and will create interest in the children for further learning.

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- 1) “A Survey on Effects of Computer Based technology for Special Needs Learners” - International Journal of Advanced Networking and Applications (Nov 2014)
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- 5) “Learning Needs for Special Needs Learners: A Graph based Adaptive Approach for Content Sequencing ” 2017 International Conference on Soft Computing and its Engineering Applications (IEEE icSoftComp2017) (Dec-2017)

The A.D.D. Child

Poem by Pat Ryan 1997

Have you ever seen the turmoil a single child can cause?

From sunrise until sunset, he can go without a pause.

He drives his parents crazy, his teachers up a tree,

But he can't really help this, 'cause he has A.D.D.

Some doctors and some friends of mine, some teachers too - so I'm told,

Who don't know what is ADD and think the child is bold!

They talk about his parents, and say that they're to blame

But they have other children, who just are not the same.

This child who is so loving, so trusting and so kind,

But people who don't understand - they say I must be blind.

And when I try explaining, they tell me to "get real".

Not thinking for one moment, just how this child must feel!

This child has constant turmoil going round inside his brain,

He looks at other children and knows he's not the same.

And it's up to us, as people, at school as well as home,

To make sure that this friendless child does not feel all alone.

The moral of this story, and I'm sure you'll all agree,

Is, remember but for the Grace of God, this could be you or me!