CHAPTER 4
METHODOLOGY

This chapter describes the methodology used in analyzing, designing and implementing ARITHHELP. Section 4.1 relates the method used to choose the domain knowledge in the system. Section 4.2 discusses the framework used for designing the system. Section 4.3 highlights the knowledge representation using rule-based reasoning and section 4.4 covers the selection of implementation tools.

4.1 SELECTION OF DOMAIN KNOWLEDGE

The domain knowledge is knowledge of an expert including declarative knowledge, procedural knowledge and operational skill. This knowledge is used as the source of information for teaching, helping and demonstrating expert performance. The observations are done to obtain the knowledge, which are really needed for help. These observations were primarily provided quantitative and qualitative bulk of data. Several students of different level of learning styles, gender and educational achievement were observed. The focus was on the way they solve problems when either using the manual references such as books, teachers and friends or by using help system provided over the Internet or compact disk. The observation also includes the efficiency and effectiveness of these two different methods of getting help. The time is set while the students start to get help from the manual or system in order to find the exact measurement of time used. The observation focused on the primary student because they have more exposure in using the computer rather than the secondary students. It is done by observing their accumulative work in working with a computer.

The results from the observation show that most of the students would like to obtain the help system for a reference and solve problems. Finding help is time consuming and this is especially so in the mathematics subjects. In addition, help manual may not be located immediately and also it takes time to split several pages or refers to the content in order to obtain the right solution. Also there might be only one or two copies of the manual to be used by many people.
4.2 THE CONTEXT USING IN ARITHELP

ARITHELP apply an initial framework of context for designing usable intelligent system. The context can be defined as something which consists of ideas, situations, events or information that relates to it and make it possible to understand in full [Patel, et-al, 1998]. The framework is concerned with producing a useful intelligent multimedia help system that can be produced economically and implemented in the actual educational situation and used by a large number of students. It is based on the following four notion: -

1. The context of an ARITHELP
This notion concerns the various contexts of an ARITHELP such as the capabilities and limitation of the educational technology employed, the nature of discipline and the constituents of knowledge.

2. The expert system paradigm
The expert system paradigm was used to capture human expertise and to replace a human expert and in practice provides assistance in problem analysis and evaluation. Tutoring and helping involve more than presenting information or help materials but requires the students’ actions and feedback.

3. The hypertext and hypermedia paradigm
The hypertext and hypermedia paradigm offered the link mechanism, which enable the system to link appropriate page to build a larger ARITHELP system. In addition, it provides navigation to avoid the user from getting lost in hyperspace.

4. Human computer interaction considerations
The system should consider the interface design to provide an easy way of interaction between the user and system. Thus, it also must maintain simple and instinctive interface.
4.2.1 An Initial Framework of context for an ARITHELP design

The notion of context has been an issue of research in various aspects of intelligent systems such as knowledge management, natural language reasoning and so on [Patel, et-al, 1998]. In ARITHELP, the notion of context has been employed in knowledge representation and system architectural aspects to improve student computer interaction and to provide more effective tutoring and helping strategies. An initial and a broad framework of contexts are presented to encourage a broader perspective in the use of educational technology and this may also be helpful in any reassessment of the traditional system [Patel, et-al, 1998]. The initial framework attempts to address some of the key aspects of an educational system. There are various contexts used in designing ARITHELP, which can be classified into three categories such as interactional context, environmental contexts and objectival context. These contexts are essential for designing a better and more usable intelligent multimedia help system.

![Figure 4.1: The contexts of an ARITHELP](image)

31
4.2.1.1 Interactional context
The interactional context constitutes the interaction between an ARITHELP and a student. The aim of this context is to accommodate the notions of cooperation, explanation and incremental knowledge acquisition. The research so far [Patel, et-al, 1998] points to the notion of context being employed primarily with respect to the tasks of plan recognition, knowledge structuring, knowledge representation, reasoning and discourse management. This context can improve the human computer interaction and provide more intelligent feedback by the system.

4.2.1.2 Environmental context
The environmental context are those that surround the design and implementation of ARITHELP. Environmental context in ARITHELP have to be described by the student, the learning goal, the learning environment and practical application environment where learning results will be employed in due course. The component in environmental context is shown below:-

- Student ( student capabilities and motivation)
- Teacher (teacher preferences and outlook)
- Discipline ( the nature of subject discipline)
- Characteristic of knowledge (the characteristic of domain knowledge)
- Characteristics of medium (the capabilities of the computer hardware and software employed as a tutoring and helping medium)
- Social environment ( an environment in which the ARITHELP is designed and used)

1. Student
There are three types of student to be considered which is the beginner, intermediate and advanced. The first thing to consider is their knowledge on using the educational computer system especially multimedia system. Next will be their exposure to the discipline and how much knowledge and help content they require in order to understand the subject. Lastly, the user’s personal background such as age experience, socio-economic background, prior education is also considered.
2. Teacher

In a traditional environment, the teacher may have different teaching styles, workload and performance. These factors will affect their performance in teaching and helping students. In order to make the system consistent in giving tutor and help, a human teacher should be incorporated in the design of ARITHELP. The aim was to recognize the different teaching styles, record teaching styles adopted in the design and enable adaptation to suit the implementing teacher. Due to the different teaching styles of educational designers and implementers, two important factors were be noted:-

i. The instructional methods used.

ii. The human brain does not change rapidly and can be used by the computer technology in delivering the help and learning materials.

3. Discipline

The nature of the discipline being taught will determine the teaching or helping methods adopted and technology employed for the purpose of teaching and giving help. There are many disciplines that use the intelligent system such as mechanical engineering, law, psychology, accountancy and mathematics. For such disciplines, multimedia oriented symbolic representation is necessary. A discipline's subject matter and the degree to which its practice is regulated contribute significantly to the way it is taught. The nature of discipline and the level of its learning provide very useful contexts for designing an ARITHELP. In task oriented disciplines where the processes of observation and learning by doing are major components of learning, the multimedia and virtual reality based domain content representation adds a rich context to the information and is similar to the well received methodology of the traditional education [Patel, et-al, 1998]. Because ARITHELP is based on the hypermedia links, there is alternative set of links to apply different teaching style.
4. Characteristics of knowledge
There are many classifications of knowledge in expert system such as procedural knowledge, conceptual knowledge, meta-knowledge, heuristic knowledge and structural knowledge. The types of ARITHELP knowledge is considered by looking at the domain knowledge being transfer to the system. This knowledge can be categorized as procedural knowledge because there are some rule to be considered in providing teaching and helping materials.

5. Characteristics of medium
ARITHELP is developed based on the multimedia, hypermedia and hypertext technologies. These technologies may require additional hardware and software to make it available to run the system such as speaker, sound card, high speed CPU and multimedia software (ToolBook II Instructor).

6. Social Environment
Currently, the multimedia system is running at the standalone PC because it requires high disk capacities to make a copy. Now that the CD-ROM can offer a potentially global scope for an educational system especially multimedia systems. The CD-ROM allows the user to run the system anytime and anywhere.

4.2.1.3 Objectival Contexts
The purpose of ARITHELP is not only to assist in the teaching and learning of a discipline but also to assess the acquisition of knowledge gained through these activities. According to the traditional learning methodology, a syllabus is drawn consisting of all subject knowledge and assessment that is considered essential. This syllabus acts as a model in teaching and assessment takes 30% to 60% of the syllabus. The teacher can evaluate the performance of a learner through this assessment to ensure their teaching and helping is effective. If low performance is acceptable, it implies that imperfect knowledge of a discipline is acceptable for assessment purpose.
This is an interesting guide that can be used in designing and developing an educational help system. Such comparison between teaching and assessment method helps in the design of usable intelligent multimedia help system. In order to design the system, a question that need to be considered is whether the syllabus coverage, helping materials and assessment can increase learning by a student. Since the acquired knowledge can only be demonstrated through assessment, the assessment strategy strongly influences a student's learning activities. As the assessment practices are widely accepted, helped and practiced, they are ingrained in the educational system and provide powerful contexts within which the whole educational system operates. Therefore, the objectival contexts is important and should be taken into consideration when designing an educational system whether it is a traditional system, intelligent tutoring system and intelligent multimedia help system.

4.3 REASONING METHOD

ARITHELP used rule-based reasoning as a method to represent knowledge. Rule-based reasoning entails encoding a set of rules about the domain knowledge. It contains much of the problem solving knowledge. Rules are the form IF condition THEN action. Condition of the rule is usually the fact. The action of the rule can include actions that affect the outside world, test another rule and add new rule to the system. Rule-based can be either goal driven using backward chaining to test whether some hypothesis is true or data driven using forward chaining to draw new conclusions from existing data. ARITHELP uses the goal driven backward chaining method. This is because the system can ask questions that are relevant to a hypothesis solution instead of collect information about the problem from the user by asking them questions.

By using a goal driven rule-based method, ARITHELP has a set of possible solution to the problem that might be asked. Once the user asks for help, the system will first check to see if the question matches with the rule in its working memory. If the first rule is not matched, it will look to the next rule until the conclusion for the question is obtained.
Following is shown the example of rule using in the system:

to handle enterfield
    if _locked of self = TRUE
        get ASYM_DoGenericTextFeedback (self, "<questionLocked>")
        oldSys = sysSuspendMessages
        sysSuspendMessages = TRUE
        focus = NULL
        sysSuspendMessages = oldSys
        break enterfield
    end
    _lastText of self = text of self
end

to handle leaveField
    if text of self <> _lastText of self
        send evaluate to self
    end
    forward
end

to handle keyChar x
    conditions
        when x = 13 or x = 9
            send evaluate to self
            if x = 9
                forward
            end
        when x = 27
            text of self = _lastText of self
        else
            forward
    end
end

notifyAfter make
    if target = self
        activated of self = false
    end
end

to handle evaluate
    if not ASYM_CompareByCase(_lastText of self, text of self)
        if _locked of self = TRUE
            send ASYM_RegisterResponse self, text of self to self
            text of self = _lastText of self
        else
            _lastText of self = text of self
            send ASYM_RegisterResponse self, text of self to self
        end
    end
end

This rule is written to decide the correctness of the value entered by the user on the space provided in the system. The system will give the feedback to the user according to the value entered. If the value is correct, the system will display a message that guide the student to the next step. Otherwise, if the answer is incorrect, the system will show the mistake done by the student and ask them to enter another value.
4.4 SELECTION OF IMPLEMENTATION TOOLS

In order to develop the system, an investigation is done to select appropriate software. There are several critical areas to consider a development tool for ARITHELP. The following aspects were considered:

1. Authoring environment
2. Price
3. Support for text, graphics, animation and sound.
4. Extensible architecture.
5. Multimedia application environment

4.4.1 Authoring environment.

The authoring environment is one of the most important areas of consideration. Typically authoring environment come in two varieties which are those icon-based with drag and drop flowcharting and those which are object-oriented which requires scripting. Graphically based tools tend to be easier to use and have the specific benefit of providing an overall view of the project’s structure. Scripting tools are often better suited to developers familiar with traditional programming in order to produce a powerful system. For the computer-based lessons and tutorials that are being developed, an important consideration is the flexibility of the tool interactivity. This includes capabilities such as clicking or touching, time-outs, recording the number of tries, text input, key-press detection, click able objects, push buttons, scroll bars and moving objects.

ARITHELP requires the object-oriented and scripting authoring environment to produce a powerful system. Most of the functions in the system such as animation problem solution, practice question and intelligent help requires scripting to run it. This environment allows the implementation of these functions in the system.
4.4.2 Price
Multimedia authoring tools can range in price from several hundred dollars to thousands of dollars. In general, object-oriented, drag and drop packages is more expensive while scripting based tools cost less. The hardware requirements of the computer system being used for development will be determined by the sophistication of the application being developed. If the full range of multimedia types (images, sounds, animations and movies) is to be included, it is more costly because an additional capable machine is required.

This aspects should be considered because ARITHELP requires several multimedia features to be implemented such as sounds, animation and graphics. These components may require the additional hardware which is costly for the developer. A cheaper priced multimedia-authoring tool is considered to allow the system to be used by the target users.

4.4.3 Support for text, graphics, animation and sound
The authoring tool must be able to handle rich text, graphic animation and sound. Hypertext and equation editing capabilities may also be necessary. The development tool must also be able to handle the file formats of the media being used in the application.

These tools is required to support ARITHELP functions as a multimedia system and intelligent in interacting with the users. Otherwise, most of the system features cannot be implemented.

4.4.4 Extensible architecture
The multimedia tool must have an extensible architecture to perform the tasks such as Dynamic Link Libraries (DLE), Dynamic Data Exchanges (DDE), Object Linking and Embedding (OLE in the window environment).
4.4.5 Multimedia Application Environment

Based on the application to be developed, information to be conveyed, the user that will use the system and the quantity of interaction between the application and the user, an appropriate multimedia development areas were evaluated.

There are three typical multimedia application areas:-

1. Text-Based Applications
2. Interactive Applications
3. Wide Area Applications

4.4.5.1 Text-Based Applications

Many multimedia applications provide efficient navigation through a large resource of text-based information. These applications need to be searchable so that relevant information can be found easily and quickly. Development tools which cater to this type of application generally provide hypertext capabilities. Hypertext is similar to regular text except that it contains information pointing to another point in an application. The example of hypertext is Microsoft Windows Help. There are also a specific tools which provide good development environment for text-intensive application such as Microsoft Multimedia Viewer 2.0 which is a sophisticated information viewer with multimedia, hypertext and sophisticated capabilities, Adobe Acrobat which is another text-based package that have hypertext capable but has limited search capabilities.

4.4.5.2 Interactive Applications

The majority of multimedia applications fall into the category of interactive and graphical applications. These tools are fully capable multimedia tools which can handle all media formats as well as providing interactivity with the user. This is often desirable in an educational setting as it provides the ability to allow specific application to specific users as a function of responses. There are some tools which provide good development environment for interactive applications such as IconAuthor 4.0.2 from AimTech Corporation, Authorware Professional 2.0.1 from Macromedia, the Apple Media Tool and Programming Environment from Apple, Course Builder 4.0.9 from Discovery Systems, ToolBook Instructor from Asymetrix Corporation and Claris Corp’s HyperCard 2.2.
4.4.5.3 Wide Area Applications

A new area of multimedia applications is emerging with the purpose of providing information to an audience over a wide geographical area. This is in part being made possible via the Internet in conjunction with new technologies such as the World Wide Web (WWW) and Mosaic. One of the important capabilities of the World Wide Web is its support of hypertext, which allow users to maneuver quickly from one World Wide Web site to another with the click of a button. Information is made accessible on the World Web using a mark-up language called HTML (Hypertext Mark-up Language). This language provides the common protocol for proving rich-formatted text, embedded graphics, sounds, movie and hypertext. The cost to the information provider is the hardware cost of the server itself and the time devoted to create and update HTML documents.

Based on the multimedia application environment discussed above, an interactive application tool is chosen for developing an intelligent multimedia help system since the application can handle all media format and providing interactivity with the user. Among the tools in the Interactive Application, ToolBook Instructor is selected because of its flexibility, functionality and cost effectiveness. ToolBook Instructor is a courseware authoring system designed for a broad spectrum of course creators. It gives the courseware author, the tools needed to construct and deliver powerful multimedia based learning environments.