AOAZ

WORLD MARITIME UNIVERSITY

Malmö, Sweden

COMPUTER-ASSISTED LEARNING:
Its uses and applications
in
maritime education and training

BY

CHUN, WAH-TAK BRUCE

Hong Kong

A dissertation submitted to the World Maritime University in partial fulfillment of the requirements for the award of the degree of

Master of Science
in
Maritime Education and Training
(Nautical)

DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not be necessarily endorsed by the University.

(Signature) ______________________

(Date) October 21, 1994

Supervised by:

Prof. Peter Muirhead

Inmarsat Professor of Maritime Education and Training

World Maritime University

Assessed by:

Prof. Günther Zade

Vice Rector/Academic Dean

World Maritime University

Co-assessed by:

Dr. Bernhard Berking

Professor

Fachhochschule Hamburg

ACKNOWLEDGMENTS

First of all, I would like to express my gratitude to Prof. Peter Muirhead for his comments and advice throughout the research period. His patient and continuous supervision has been invaluable in finalizing this paper.

I also wish to thank Dr. Bernhard Berking of Fachhochschule Hamburg for his helpful analysis of my research outline at the initial stage. His advice has stimulated my thoughts in the final revision of the outline that has guided this study.

Special thanks also to Lieutenant Mark Stafford and Lieutenant Mark Gandolfo, from the United States Coast Guard, for their assistance in collecting research material. Their contribution was valuable to this study and it would not have been easily accessible outside the States without their help.

I would like to convey my gratefulness to Mr. Samar Singh of the Hong Kong Polytechnic and Mrs. Susan Wangeci Eklöw of the World Maritime University library for their time and effort in reviewing my draft paper. Their comments and advice have been valuable in improving the document during the final stage.

I would also like to express my appreciation to the academic staff and library staff of the World Maritime University for their continuous support to this research and to Mr. Clive Cole, especially, for his assistance in proof reading my paper.

In addition, I wish to take this opportunity to thank my parents and fiancée for their moral support during my studies at the World Maritime University.

ABSTRACT

Computer-assisted learning (CAL) is rather new in maritime education and training (MET). Research has demonstrated that computer programs can be used in MET. However, there is a lack of theoretical support. Should the computer be used at all? Is it beneficial? How far can CAL be taken into MET?

In this paper, the capability of CAL in helping the student to learn is evaluated. The suitability of CAL for MET is examined. The opportunity of providing a better solution or option to MET with CAL is investigated. The roles and potential of CAL are also discussed.

The definition of CAL is made at the beginning of the paper. A classification of eight modes of CAL is suggested and their typical strengths and weaknesses are commented upon.

The paper is oriented from a theoretical viewpoint. The theories underpinning the use of computers in the teaching or learning process are investigated.

Arguments are put forward concerning the general scope of MET. The possible use of CAL in MET is then discussed. A set of criteria for evaluation purposes is suggested and two existing maritime CAL programs are evaluated.

The advantages and limitations of CAL in MET are established. The costs and cost-effectiveness of computer-based education are analyzed. The considerations determining the feasibility and suitability of CAL in MET are also discussed.

It is concluded that CAL is suitable for MET. However, its value is reliant on the proper use of this tool to advantage. The basic factors determining the admission of CAL include the cost-effectiveness and significant advantages over other teaching approaches.

Keywords:
CAL, MET, advantage, limitation, capability, cost-effectiveness, definition, classification, suitability, evaluation.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ABBREVIATIONS

CAI	Computer-Assisted Instruction
CAL	Computer-Assisted Learning
CAT	Computer-Assisted Training
CML	Computer-Managed Learning
ColRegs	The International Regulations for Preventing Collisions at Sea
CPA	Closest Point of Approach
EBL	Electronic Bearing Line
IMLA	The International Maritime Lecturers' Association
IMO	The International Maritime Organization
MET	Maritime Education and Training
OOP	Object-Oriented Programming
OOW	Officer of the Watch
TCPA	Time of the Closest Point of Approach

INTRODUCTION

Objectives of the Study

In recent years, the development of information technology has opened up a new range of opportunities to education. The reduction in price and the advances in technology of the computer, and computing, have offered the teacher and learner an alternative tool for teaching and learning purposes. Many instructional activities that in the past could only be achieved by using high-cost mini or main-frame computers have become possible and practicable using low-price micro-computer. Although computer-assisted learning appears as a promising technology to improve educational quality, the expectancies of the users are various. There are people who are unwilling to use computers in the teaching or learning process. There are people with very high, and sometimes unrealistic, expectations of the innovation. Probably, this reflects that there is a general lack of understanding of the technology and its usefulness in education.

Computer-assisted learning, apart from simulation, is rather new in maritime education and training. The information about the use of computer-based education in the maritime field is limited. There are several dissertations, written by senior colleagues of the World

Maritime University, aimed at investigating the use of computers in maritime education and training. These researches have demonstrated that computer programs can be used in the teaching and/or learning processes. However, there is a lack of convincing theoretical support to certain fundamental arguments. Should computers be used at all? Are they beneficial? How far can computer-assisted learning be taken into maritime education and training?

This study evaluates the capability of computer-assisted learning in helping the student to learn. It examines whether computer-assisted learning is more suitable for maritime education and training than conventional teaching methods. Furthermore, it attempts to find out whether computer-assisted learning can be used to provide a better solution or option to maritime education and training. It investigates the roles and potential of computer-assisted learning in the maritime education and training field in the years to come.

Methodology and Approach Used

To achieve the objectives set forth in this study, several fundamental areas are investigated. These areas include:

- the characteristics of computer-assisted learning;
- the theories of the learning and instructional processes;
- the nature of maritime education and training;
- the potential use of computer-assisted learning in the maritime field;

- the use of available maritime educational or training software; and
- the strengths and weaknesses of computer-assisted learning.

Since the terminology used to describe the use of computers in the teaching or learning process is rather confused, the meaning of computer-assisted learning is defined at the beginning of the study. The notions of different authors are drawn together to construct a definition of computer-assisted learning. Thereafter, the properties of computer-assisted learning are investigated. A classification of eight modes of computer-assisted learning is suggested and their typical strengths and weaknesses are examined.

Whereas one of the objectives of this study is aimed at providing the necessary theoretical support for the use of computer-assisted learning, the understanding of how a student can be taught and can learn are considered as the basic knowledge. The psychological underpinning of the use of computers in the teaching and learning processes are determined. The appreciation of these theories provides the necessary background to exploit the theoretical potential of computer-assisted learning.

Since the theme of this study is around the use of computer-assisted learning in maritime education and training, the characteristics of the field are studied. Arguments have been put forward to comment upon the conceivable scope of maritime education and training. The possible use of computer-assisted learning to tackle individual educational objectives is then discussed.

At this point, the potential use of computer-assisted learning in the maritime field is developed from a purely theoretical standpoint. In the light of gaining insight into the practical use of computer-assisted learning, a critical examination and evaluation of existing maritime computer-based software is performed. One of the packages under review is an award winning maritime education and training program. A set of criteria for the evaluation of the application is suggested to guide the assessment. Furthermore, these criteria are used to analyze the strengths and weaknesses of the software under review.

Based on the information and understanding above, the advantages and limitations of the use of computer-assisted learning in maritime education and training are established. To find out whether the use of computer-assisted learning is beneficial, the costs and cost-effectiveness of computer-based education is discussed. The study also attempts to lay down the basic considerations for the decision of whether it is suitable to implement computer-assisted learning.

To complete the study, a discussion is directed towards the possible impacts of computer-assisted learning in maritime education and training. This could provide an idea of the changes which may occur in the maritime education and training field if computer-assisted learning is to be used. Moreover, it could be used to determine if the implementation of computer-assisted learning, in particular maritime institutes or educational systems, is feasible.

Finally, the study concludes with an analysis and the findings. The question of whether computer-assisted learning is suitable for implementation in maritime education and training is discussed. The problems which may hinder the implementation of computer-assisted learning are summarized.

Scope and Limitations

This study consists very much of research into the literature aimed at unveiling the theoretical feasibility of the use of computer-assisted learning in maritime education and training. A number of theoretical arguments have been put forward. Moreover, the practical experiences of computer-assisted learning pioneers are reviewed. However, not every aspect of the use and application of computer-assisted learning is covered.

Since the use of computer-assisted learning in the maritime field is rather new, there is very limited information available about the topic. Many of the hypotheses are developed from the theories of learning and from the experience of the use of computer-assisted learning in general education. However, it is believed that the difference between maritime training and general education in this aspect is negligible.

The direction of the study is the understanding of the subject area as a whole. Therefore, there is no experiment which has been designed and performed to prove any particular theoretical notions. In fact, the time and resources available do not allow for an in depth investigation of the topic.

Since, this study considers the theoretical point of view, it attempts to incorporate the findings of psychology relating to learning and instruction as much as possible. However, a comprehensive study of learning theories alone could take several years to complete. Furthermore, the balance of the work has to be considered. Therefore, the research into this area is limited to the level that is perceived as fundamental to the understanding of the use and application of computer-assisted learning.

In this study, the attention has been focused on the use of developed computer-assisted learning programs. There is no discussion about the use of computer-assisted learning development tools. For instance, it would have been better if an investigation into the use of authoring tools could have been made. Furthermore, much of the attention has been placed on the use of CAL as an individualized learning tool. It would have been better if the use of CAL, in conjunction with the teacher, in the classroom could have been covered.

Two computer-assisted learning programs are reviewed in this study. These reviews provide an opportunity for a critical evaluation of the application of computer programs in maritime education and training. It would have been better if more applications could have been reviewed. However, the time available was not sufficient for an investigation into more applications if they were to be evaluated in detail. An experiment to test the usefulness and theoretical findings of these applications could also have been valuable. Nevertheless, it is not covered by this study due to the constraints of time and the complexity of the selection of target groups.

Cost-effectiveness can be shown to be one of the crucial considerations in the implementation of computer-assisted learning. Basically, the cost-effectiveness analysis is a quantitative measure of comparing one approach to another. However, concrete figures about the cost and effectiveness of both conventional teaching methods and computer-assisted learning are not easily assessable. Furthermore, these figures may vary from one institution to another. Therefore, the analysis is, again, based on a theoretical standpoint without a solid set of quantitative figures.

In the paper, it has been indicated that new assessment strategies are necessary in a computer-assisted learning environment. However, there is no further discussion about what these strategies could be. It would be valuable if a research into this area could have been conduced. However, it is not included in this study due to the constraints of time.

CHAPTER 1

COMPUTERS IN EDUCATION AND TRAINING

1.1 Defining CAL (Computer-Assisted Learning)

Computers have been used in education and training for decades. Various terms are used to define the ways a computer is used to assist students in the learning process. Very often, the differences between these terms are unclear.

1.1.1 CAL or CAI (computer-assisted instruction)

Romiszowski (1988) explains that the distinction between CAL and CAI is a result of the difference in terminology between the eastern and western sides of the Atlantic Ocean. In the United States, CAI is generally accepted as a generic term and refers to the uses of the computer in the teaching or learning process. In Britain, CAI is only regarded as the use of computer in the instructional process and it is considered as a subset of CAL.

1.1.2 CAL or CML (computer-managed learning)

The definitions of CAL and CML are rather confused. On the one hand, CML is referred to as a managerial and administrative tool for the teachers while CAL is defined as a learning aid for the student (McMahon, 1985).

Apparently, the distinction is based on the difference of target users, the teacher or the learner. On the other hand, CML is considered as the on-line management feature in an instructional process (Romiszowski, 1988). It is used to record and analyze information about an individual's learning process. It provides a description of a student's knowledge profile and learning strategy that is used to modify the instructional sequences either manually or automatically. Obviously, it is considered as a supportive function in CAL.

1.1.3 CAL or CAT (computer-assisted training)

In the views of Rushby (1985), CAL is distinct from CAT based on the difference in aims of education and of training. However, a student certainly can learn through both education and training. Therefore, the theoretical difference between them has no genuine practical interest (Romiszowski, 1988). CAL can be used to achieve both educational and training objectives. CAL and CAT are identical in their practical uses.

1.1.4 Facilitation and mediation

Gagné (1970) describes instruction as the arrangement of conditions that is intended to facilitate learning. CAL is one of the tools available to the teacher for the arrangement of favorable learning conditions. In these instructional processes, computer-based applications are used to ease and encourage student learning (Makrakis, 1987). The computer is used to mediate the information flows. Figure 1.1 is an overview of CAL and its relationship between CAI and CML.

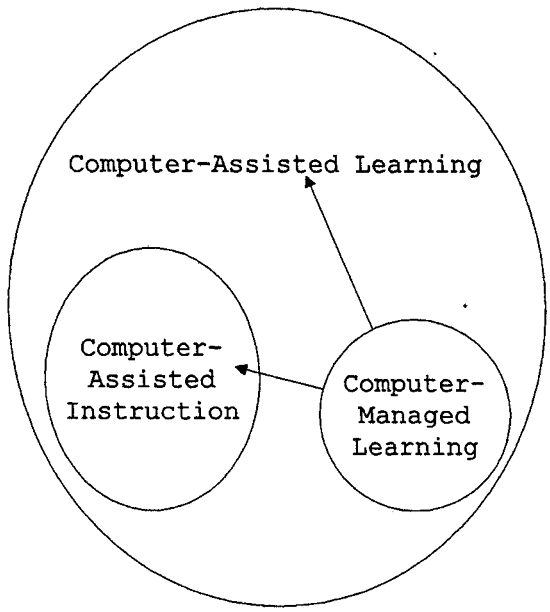

Figure 1.1: Relationship between CAL, CAI & CML

1.2 The Concepts of CAL

There are various ideas about the use of computers in education and training. Different authors suggest different models. For example, Taylor (1980) categorized the applications of computers in education into tutor, tool and tutee; Rushby (1985) classified the uses of CAL into drill-and-practice, tutorial, simulation, modeling and browsing. Despite the extent of these classifications, the uses and applications of CAL can finally be divided into two main types, the instructional and non-instructional uses.

1.2.1 Instructional use of CAL

The instructional uses of CAL are the applications of computers in a structured communication. A computer is used to mediate the information flow between a source and a learner. The underlying ideas are closely related to the concept of communication and its influence on education (Romiszowski, 1986).

Communication is the interchange of messages between a source and a destination through a channel of communication (Hills, 1986). A model consists of various parts of an educational communication process is shown in Figure 1.2. Since each element of this process would affect communicational performance, the effectiveness of a chosen channel of communication would have significant impact upon the system.

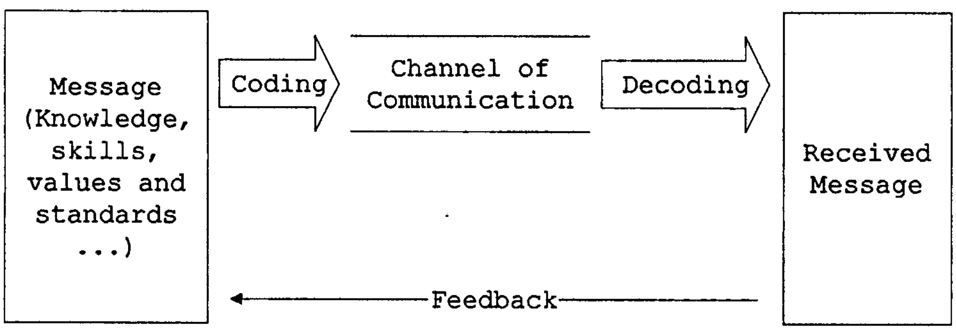

Figure 1.2: An educational communication process
Adapted from Teaching, Learning and Communication (Hills, 1986)

Verbal channel is one of the basic channel of communication used in formalized education. Since symbolic communication requires a higher level of conceptual pre-requisition, it is more difficult to understand than pictures (Dale, 1969). Various audio-visual aids have been used to extend the teaching or learning interchange beyond the limitation of verbal symbols. The computer can be another valuable tool. It offers a new range of possibilities in education. In the views of Salomon (1991), the computer is superior when it is compared to any other types of instructional technology. Figure 1.3. is a model of the use of the computer in an instructional process.

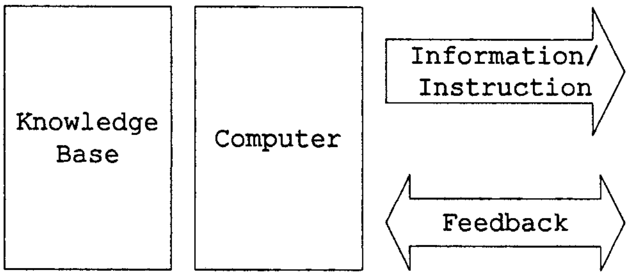

Figure 1.3: The use of the computer in an instructional process

1.2.2 Non-instructional use of CAL

The non-instructional uses of CAL are related to the applications of the computer as an instruction or information processor. The role of the computer becomes supportive. It provides the learner with feedback or information corresponding to his or her input. The computer is regarded as an intellectual magnifier.

It can be agreed that learning can exist with or without any formalized teaching. In Hade's views (1982), wisdom is the result of continuous evaluation of knowledge. This knowledge is generated by synthesizing information. The information itself is obtained by analyzing data. He suggests that learning is possible by hypothesis creation and testing, logical analysis and problem solving. Hade's model of intellectual development is shown in Figure 1.4.

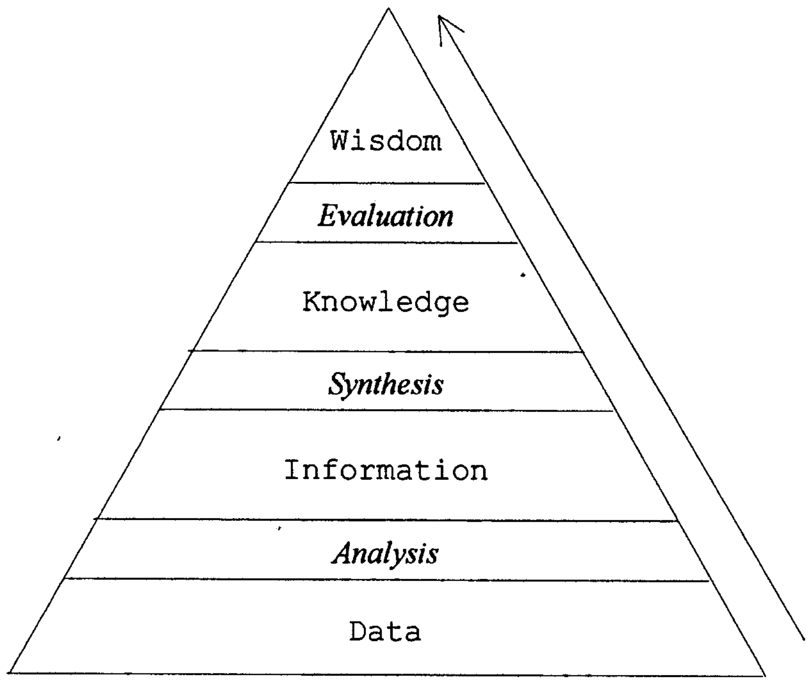

Figure 1.4: Hade's model of intellectual development
Source: Literacy in an information society (Hade, 1982), In <u>Education Technology 22-8</u>

In this area, computers can be used as a platform in testing hypothesis, and in performing analytical tasks and problem solving. The computer provides results in the form of feedback to the learner almost instantaneously. It offers the learner an opportunity in extracting general rules and principles through the learning process.

The computer can also be used as a data or information processor. The computer becomes an information filtering and processing tool. It in turn relieves a student from these processing tasks. It frees the students to think and develop their intellectual capacity. It is capable of extending the 'mental capacities' of the user and this capability is unique

(Salomon, 1991). Figure 1.5 is a model of the use of the computer as an analyzing and processing tool.

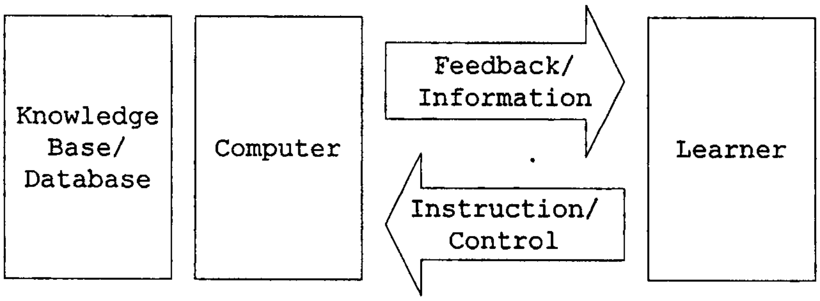

Figure 1.5: The use of the computer as an analyzing and processing tool

These learning activities may be done equally well without the computer. However, the power of the computer to manage and manipulate data largely improves the speed in separating and processing relevant information. Tests of solution or hypothesis can be made almost instantly. Therefore, the student's time and efforts can be better used.

1.3 CAL Modes of Delivery and Interaction

The computer is being increasingly used in education and training. Various models of CAL modes have been introduced by different authors. Some of these classifications take a macro view of CAL while the others may be limited to the instructional uses of the computer.

In this study, eight modes of CAL are identified and discussed. They are namely: testing, drill-and-practice, programmed tutorial, conversational tutorial, simulation, modeling, programming and inquiry. The classification is arranged in a sequential order based on the level of the learner's control. Figure 1.6 is an overview of various modes of CAL and the corresponding level of the learner's control.

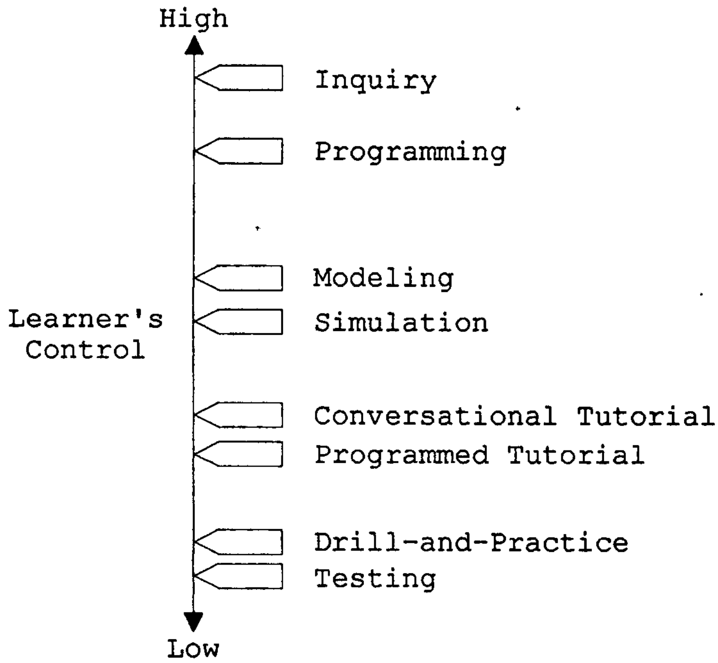

Figure 1.6: An overview various modes of CAL and the corresponding levels of the learner's control
Adapted from Computer-assisted Learning (Rushby, 1985), In <u>The International Encyclopedia of Education</u>

Word-processing is frequently considered as a mode of CAL. Apparently, word-processing is closer to a computerized utility in which writing is simplified or becomes easier. Unlike database inquiry, word-processing does not provide any direct learning materials to the user. Many reports on the successful application of word-processing have been found in disciplines such as language learning. However, the extent of the improvement is somewhat related to the features of the program that provide spell checker, thesaurus and grammar checker. Another feature allows the computer to manipulate the contents with ease. These properties make using computer word-processing more productive and creative than working with pen and paper. The on-line supportive features are virtually implemented as a computerized writing tutor. The ease of manipulation is an inherent characteristic of the computer. Apparently, word-processing itself offers just a bit more than a typewriter. It may be a valid method in creative writing. However, the student probably learns nothing more than what he or she did know if simply writing in a word-processing program without any on-line support. Therefore, it is hardly convincing to consider word-processing as a mode of CAL.

A similar argument is also applied to the use of spreadsheets in the learning process. A spreadsheet is used to sort, analyze and manipulate data. It is also being used as a tool for hypothesis testing. The use of spreadsheet in turn promotes understanding of and insights into the information. However, the spreadsheet, in this case, only acts as an interface of inquiry, modeling or programming. The spreadsheet is the front-end of various CAL modes rather than a mode of CAL on its own.

One may argue that an instructional game is a mode of CAL. In fact, many computer games have been developed to achieve certain learning objectives. Programs that promote fluency in typing, strategies in combating and planning of city are several examples where games are used to provide learning experiences. Basically, they are drill or simulation programs using a game-like environment. In other words, the game-like interface is used to furnish CAL. It is, therefore, not being considered as a mode of CAL.

1.3.1 Testing

Testing refers to the use of a computer to assess the knowledge and skills a student has previously acquired (Romiszowski, 1986). The computer-based tests are able to trace, score and analyze the results of the student.

To an extent, the test mode is similar to drill-and-practice. The distinctions between them are obvious in two aspects. Firstly, test mode places the emphasis on assessment rather than drilling to excellence. Secondly, the feedback provided to the student by each mode is different. In test mode, correctness of an answer may not be immediately reflected and the student may not be given a chance for a second attempt. If a second trial is allowed, the weighting between the first and second attempts would be different.

Computer-based testing is relatively easy to use and produce. It can be used to reduce the burden of routine objective tests. A major advantage of using computer-based testing is its capability to collect and process individual performance data. This information can be used to generate a learning profile of individuals. Instructional guidance or suggestions can then be made to overcome the deficiencies of the student. Computer-based testing can also be easily adapted to the various intellectual levels of individuals. Questions with a balance between difficulties and stress can be provided, thus better motivating the student to learn.

Since computer-based testing involves an element of luck, it is of limited value as a standard measurement of an individual's performance. It is also limited to the applications of the lower level of cognitive objectives. In other words, it is somewhat useless to assess how a student thinks. Another weakness of test mode is that the test itself delivers neither knowledge nor skills.

1.3.2 Drill-and-practice

Drill-and-practice is the use of the computer to deliver self-paced exercises in which responses are required from the learner (Rushby, 1985). In drill-and-practice, feedback is immediately provided to the learner after each response. It is designed to provide exercises on the knowledge and skills the student has acquired. The aim of any drill-and-practice program is perfection. If a student fails to provide the correct response, more attempts may be allowed before the correct response is shown.

A profound strength of computer-based drill-and-practice is the ability to provide endless exercises at a student's own pace. It is possible to arrange adapted exercises according to the learner's progress and learning style. The adaptive nature combined with immediate feedback can enable a student to learn more effectively.

A major pitfall of drill-and-practice is its limitation in application. Similar to test mode, it is limited to the lower levels of cognitive objectives. Drill-and-practice can be used to learn routine and repetitive tasks. However, it is rather confined to the development of basic skills and the reinforcement of essential knowledge.

1.3.3 Programmed tutorial

Programmed tutorial is similar to programmed instruction in which learning material is presented to the student step by step at the individual's learning pace (Romiszowski, 1986). The computer-based tutor is programmed to lead the student through a particular topic in the most efficient and easy way. The format of the programmed tutorial is either linear or branching. It may utilize an objectives-based or a task-based approach.

A linear programmed tutorial provides a close analogy to programmed printed materials. Its usefulness has been criticized as no better than a book's. However, the ability of the computer to generate special effects and coordinate other media may justify its application.

In a branching program, the computer-based tutor can be designed to branch any number of alternatives based on the pace and direction of the student. It offers a wide range of possibilities that can be difficult to implement with conventional teaching methods.

The major advantages of the programmed tutorial are individualization and self-pacing. The computer is capable of tracking the student's progress. At the same time, it can provide the learner with immediate feedback. With the assistance of an artificial intelligence system, it can be very adaptive. An analytical model of the learning process can be developed to tailor learning experiences to the student according to his or her learning style.

One of the problems associated with the programmed tutorial is the difficulty in development. Unlike the human tutor, a computer only follows defined rules. It is relatively complex to formulate the criteria used to analyze a student's learning pace and style. Furthermore, the pre-specified routes are based on the assumptions of the planner. It is based on the perception of the designer about the subject. The learner may not visualize the information in the same way as the designer does. Therefore, effectiveness may be reduced.

1.3.4 Conversational tutorial

The conversational tutorial is another form of tutorial that aims to achieve higher order cognitive objectives such as abstract concepts and conceptual schemata (Romiszowski, 1986). The focus of the conversational tutorial is placed on the reasons behind a particular response. In a conversational tutorial program, a response of any given problem is not commented on as right or wrong but is analyzed for further in depth questioning or reasoning.

By exploring the implications of a problem through the conversational tutorial, the student can gain insight into the subject matter. This deepens the understanding of the materials and promotes higher cognitive objectives. Ideally, the student can gradually master a topic through the dialogue. At the same time, the student's cognitive profile can also be obtained by analyzing the responses during the interaction.

The main problem of a conversational tutorial is its difficulties in predicting all possible responses a student might make. Therefore, it will be very difficult to formulate further layers of questions or problems. Furthermore, the response components of a dialogue, such as the response matrix, can be very complex. It requires conscious thought and effort. It takes a considerable amount of time.

1.3.5 Simulation

Computer-based simulation is the use of the computer to emulate a real-life condition, situation, system or phenomenon in which learning experiences can be developed (Romiszowski, 1986). It has been used in almost every educational and training context. Behind a simulation program, there is an interactive knowledge-based system that governs the behavior of the computer (Rushby, 1985). Figure 1.7 is a model of simulation mode. Simulation is frequently used to provide alternative experiences when real-life learning experiences are not feasible due to reasons such as cost, accessibility or safety.

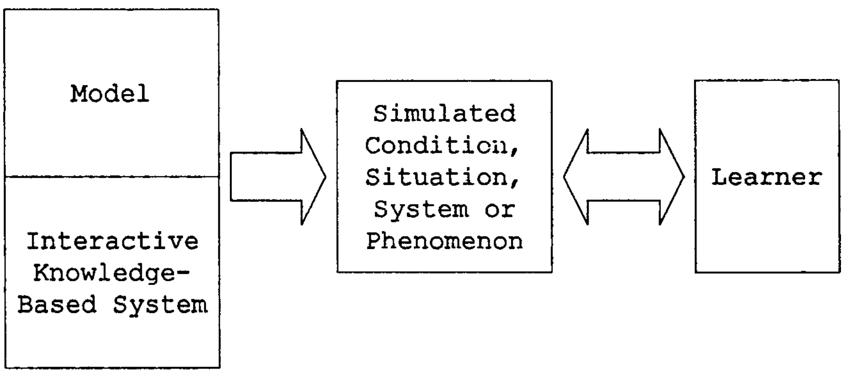

Figure 1.7: A model of simulation mode
Adapted from Computer-assisted Learning (Rushby, 1985), In The International Encyclopedia of Education

One of the advantages of computer-based simulation is its ability to provide certain types of learning experiences that are not normally feasible. The students are enabled to obtain real-life experience in a much shorter time through the simulated reality. It can also be used to acquire problem solving and decision making skills. It offers the student an opportunity to recognize mistakes and learn from experience. Simulation can be very useful in attitude development that has proven relatively ineffective in traditional classroom learning. Although simulation may be difficult to program, it is rather simple to plan from the instructional viewpoint (Romiszowski, 1986).

One of the major problems of using simulation is the transferability. The experiences gained through simulated reality are not necessarily totally transferable to real-life situations. Since simulation is an abstract and simplification of reality, there is a risk of misconception. Therefore, the successfulness of a simulation program relies heavily on proper initial orientation and follow-up. Yet, another drawback of simulation is the time required from both the teacher and the student. A suitable exercise takes time and effort to select and a simulation practice very often needs several hours to complete.

1.3.6 Modeling

Modeling is another feature of simulation (Romiszowski, 1986). It is also built upon an interactive knowledge-based system (Rushby, 1985). While the analogue is specified by the instructor in simulation, the analogue in modeling is to be constructed by the learner. In other words, the student has to teach the computer, by setting rules, to simulate a real-life condition, situation, system or phenomenon. Through this process, the student learns by trying to determine the underlying rules of a particular behavior. A model of the CAL mode of modeling is shown in Figure 1.8.

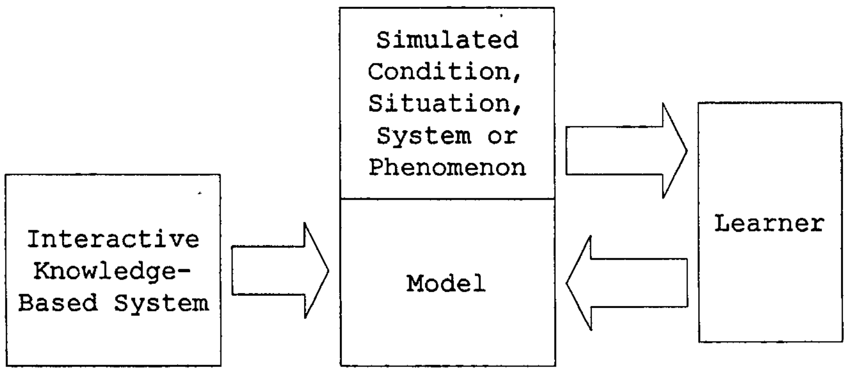

Figure 1.8: A model of the CAL mode of modeling
Adapted from Computer-assisted Learning (Rushby, 1985), In <u>The International Encyclopedia of Education</u>

In contrast to simulation, the offer of modeling is not surrogated real-life experiences but pure cognitive development. It provides a unique opportunity for the student to learn a particular process in-depth. It also fosters the development of concepts. The use of modeling can lead to a full comprehension and mastery of the subject.

The major drawback of modeling is its requirement of programming knowledge. The mastery of the programming language itself does not contribute directly to the main learning objective. The time and effort required are somewhat wasted. However, the development of object-oriented programming (OOP) may change the situation. The use of objects instead of codes in programming may reveal the full potential of the modeling technique.

1.3.7 Programming

Programming is the use of a computer programming language in solving problems (Romiszowski, 1986). It involves analytical and logical thinking. The effect of learning through programming is twofold. First, the student may develop particular programming skills. At the same time, transferable problem solving and creative skills can be developed (Papert, 1980).

The usefulness of programming in problem solving and logical thinking has been uncertain. Many educators argue that programming has a general value in both areas. However, this view is not shared by every teacher (Romiszowski, 1988).

Although the effectiveness of programming is not clear, it does shift the focus of factual learning to perceptual learning. The use of programming is aimed at higher levels of cognitive development. Furthermore, the learning process itself is highly motivational.

The uses of programming do suffer from some problems. The effectiveness of programming is very difficult to analyze. Furthermore, it is not something that would be found immediately useful in education.

1.3.8 Inquiry

Inquiry is the use of computers as a data retrieval system to obtain necessary information from an organized database for a particular learning objective (Romiszowski, 1986). It uses the power of the computer in information storage, retrieval and processing to ease the learning process. The student can learn through the collection, manipulation and evaluation of information.

The use of inquiry is not necessarily based on the computer. However, a computer offers enormous speed improvement over other methods. Computer inquiry, with the support of CML, can be designed to deliver appropriate materials to the student according to his or her background knowledge. It can be a very flexible individual learning system.

One of the advantages of computer-based inquiry is the saving of time. The time and effort of the student can be better spent on the assimilation of new information and the achievement of learning objectives. It is also capable of enhancing the development of investigative skills and strategies.

However, the effectiveness of inquiry into the learning process at large depends on the learner's perception. It will only be a useful tool in the hand of a student who knows how to discriminate information. The massive information flow may overwhelm a student and eventually the specified learning goal may not be achieved.

CHAPTER 2

THE THEORETICAL BASIS OF CAL

2.1 The Underpinnings of CAL

In the view of psychologists, human beings are considered as either active, passive or interactive to their environment (Bigge & Shermis, 1992). Active people are self-motivated. They are driven by their instincts. In contrast, the behavior of passive people is influenced by both their environment and heredity. Their changes are determined by both environmental and biological factors. Psychologically interactive people are constantly interacting with their physical and social environment. Their characteristics are the result of their interaction with the environment.

The belief of the effectiveness of CAL in enhancing human learning is based on an assumption that people are either neutral-passive or interactive (Bigge & Shermis, 1992). It reflects the behaviorists' and the interactionists' viewpoints. The mental disciplinarians and self-actualization theorists, who assume people to be active, appears to have limited interest in using CAL.

2.2 Skinner's Theory of Learning

2.2.1 Operant conditioning and shaping

According to Skinner (1968), any response that is followed by reinforcement, especially the positive ones, tends to be repeated. The reinforcement is considered as contingent since the presentation of the reinforcing stimulus is dependent on the response. The technique used in this reinforcing process is called operant conditioning.

In operant conditioning, the most important stimulus is the one immediately following the response. It strengthens the tendency of occurrence of that particular behavior. Timing in operant conditioning is a critical factor. In Skinner's view, the reinforcing stimulus must be presented immediately after the response. Skinner's model of behavior control is shown in Figure 2.1.

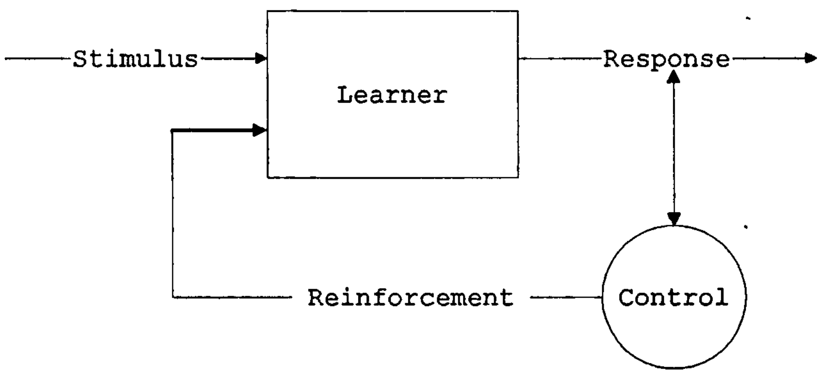

Figure 2.1: Skinner's model of behavior control
Source: Designing Instructional Systems (Romiszowski, 1981)

Skinner believes complex behavior can be changed by using a technique called shaping. In the view of Skinner, complex behavior is composed of a chain of simpler behavior. It can be modified towards the desire by reinforcing the closer successive approximated behavior. In other words, by the selective reinforcement of behavior that is increasingly closer to the desire, complex behavior can be taught.

2.2.2 Programmed learning

For Skinner, teaching is the arrangement of contingencies in which the students learn the behavior that will be useful for them in something that might happen in the future. In his view, proper scheduling of contingencies of reinforcement is one of the most important factors of effective teaching or learning. He believes learning can be improved if the information to be learned is presented in small steps, feedback is immediately provided and the process is self-paced. Since the frequency of reinforcement is so high, it is considered beyond the capacity of a human instructor. Skinner believes instrumental aids such as teaching machines have to be used.

Skinner's approach to programmed learning has incorporated the following basic principles of his theory:

1. the materials must be divided into small steps and presented in an orderly sequence;
2. the responses required from the student must be open and obvious so that reinforcement or corrective measures can be made;
3. feedback must be immediately provided after the responses; and
4. the program must be self-paced, the student should be allowed to proceed at his or her own pace.

The technique of programmed learning was not pioneered by Skinner. It can be traced back to the development of a testing machine by Sidney L. Pressey in the early 20s (Hergenhahn, 1988). However, the idea did not become popular at that time.

2.3 Bruner's Free Discovery Learning

2.3.1 Internal process of learning

In Bruner's view, acquisition of knowledge is an active process. Individuals learn by actively constructing and reconstructing their knowledge and by relating new information to the ideas already known to them (Bruner, 1966). For Bruner, a human being is an information processor, thinker and creator rather than a passive recipient. Bruner's model of knowledge acquisition process is shown in Figure 2.2.

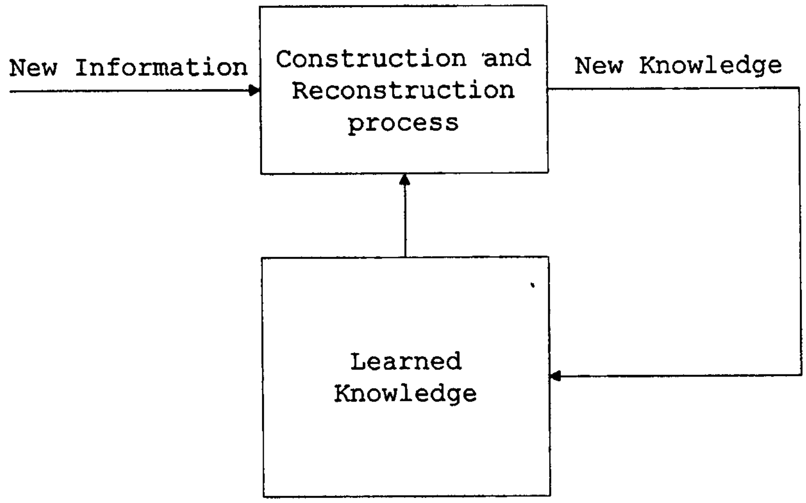

Figure 2.2: Bruner's model of knowledge acquisition process
Adapted from Towards a Theory of Instruction (Bruner, 1966)

Bruner believes learning is a process consisting of acquisition of new information, transformation of knowledge, and evaluation of relevance and acceptability. Effective learning takes place when the optimal level of uncertainty and ambiguity is created. An individual will then actively connect things and combine them into structures to reduce these unpleasant feelings. This constructive process infers hypothesis and evaluation. The individuals are relating new data to the model of their own world. The process is believed to occur through a sequence of decisions that require goal-directed mental events.

2.3.2 Learning to learn

Bruner believes human beings learn best through thinking. In his view, intrinsic motivation is far more important than extrinsic stimulus. Therefore, students should be allowed to learn what they want to learn in the way they choose. They should be given the opportunities to learn problem-solving skills with problems which have inherent interest to them. He contends that education should concentrate more on unknown and speculative things using knowledge as a basis. Instruction should be designed to activate, maintain and direct the process of alternative exploration.

2.4 Landa's Theory of Instruction

2.4.1 Algorithmic and heuristic operations

Landa believes that there must be some form of mental operations performed before a problem can be solved (Romiszowski, 1986). These intellectual activities are defined as algorithmic and heuristic operations. They are considered as either rule-following or open-ended procedures. The learning of problem-solving involves not only knowing how but also when to use appropriate cognitive skills. Landa contends that there is a greater need to be aware of these mental processes than the observable behavior.

In the view of Landa, the mental operations involved in solving a particular problem may not be fully known to any individual. Therefore, effective instruction through proper planning must be based upon analysis. An instructor must know all the detailed mental operations involved in a problem-solving process before he or she can actually teach. Furthermore, the instructions of problem solving must be planned in a way that these internal processes can be checked.

2.5 Bandura's Social Learning Theory

2.5.1 Observational learning

In the view of Bandura (1977), individuals may learn from both direct and indirect experiences. Bandura contends anything that can be learned through direct experience can also be learned by observation. Individuals may learn simply by observing the consequences of the behavior of the others. It can be direct observation of someone's action or indirect observation such as reading from a book.

In Bandura's view, individuals are constantly modeling their existence on the lives of others whose behavior yields desirable results. At the same time, they are avoiding the modeling of the undesired. The variables influencing the observational learning processes are attention, retention, reproduction and motivation as shown in Figure 2.3.

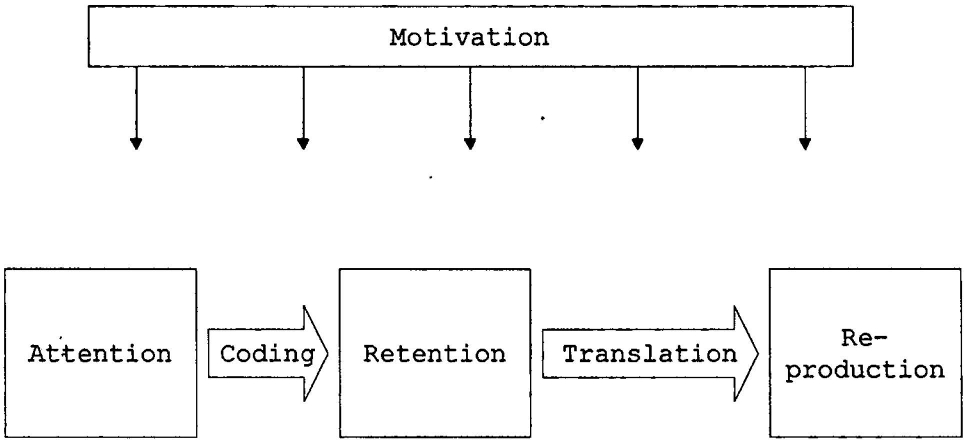

Figure 2.3: The three phases of the observational learning process
Adapted from Social Learning Theory (Bandura, 1977)

Attentional phase

The observers are believed to learn only what they have observed from a model. The learners will only pay attention to the relevant stimuli. The apparently irrelevant parts in the model and the noises from the environment are ignored. The consciousness of the learners to a particular event is believed to be dependent, to an extent, on their sensory capacities, their alertness and the model's characteristics.

Retentional phase

The observed information must be retained in the learner's memory if it is to be learned. This process involves cognitive operations to codify the information symbolically into the memory. Bandura believes the observed behavior is either verbally or imagery stored. Furthermore, verbal codes are considered more important than visual symbols.

Reproductional phase

A behavior may be learned cognitively by the learners through observation. However, practices are needed to translate this learned information into response patterns and actions. In the reproduction phase, Bandura believes the observers are constantly comparing their own behavior to the cognitive representation of the observed model. If any discrepancy is observed, remedial actions will then be taken until the observers satisfy themselves with their own performance.

Motivational process

Similar to other behaviorists, Bandura believes the consequences following a behavior have their influences on the tendency of occurrence of that particular behavior. However, his explanation is different from Skinner's. In Bandura's view, reinforcement creates expectation and incentive. This in turn affects an individual's decision to perform or not to perform the same behavior under similar conditions. If the consequences are encouraging, an individual is expecting to have the same reward. Therefore, there is an incentive to act in the same way on similar occasions.

2.5.2 Abstract modeling

Human beings are constantly experiencing a wide range of modeling experiences in which rules and principles are derived. Very often, common rules or principles are learned from observing various models' performances. In the abstract modeling process, it is believed that general rules and principles can be observed and then extracted by the learner from a diversity of situations with common underpinnings. Bandura believes that the rules and principles learned by individuals from these processes are transferable to other situations, even the ones that have not been experienced before.

2.5.3 Reciprocal determinism

In the view of Bandura, an individual, the environment and his or her own behavior are constantly interacting and determining each other. The individual's actual environment is derived from the potential environment depending upon his or her behavior. The influence of the environment through reinforcement upon individuals depends on how they act within it. In other words, the environment of an individual will change according to the way he or she acts within it. However, the environment will also influence his or her subsequent behavior. Bandura believes all these components may not be equal in strength. One factor may have more influence than others at any particular time.

2.6 Gagné's Model of Learning

2.6.1 Categories of learning

Gagné (1965) classified learning into an eight categories' hierarchy consisting of signal learning, chaining, verbal chaining, discrimination learning, concept learning, rule learning and problem solving. The model proceeded from very simple conditioning types of learning to complex problem solving. It embraced many other concurrent behaviorist's theories as well as cognitive theorist's ideas.

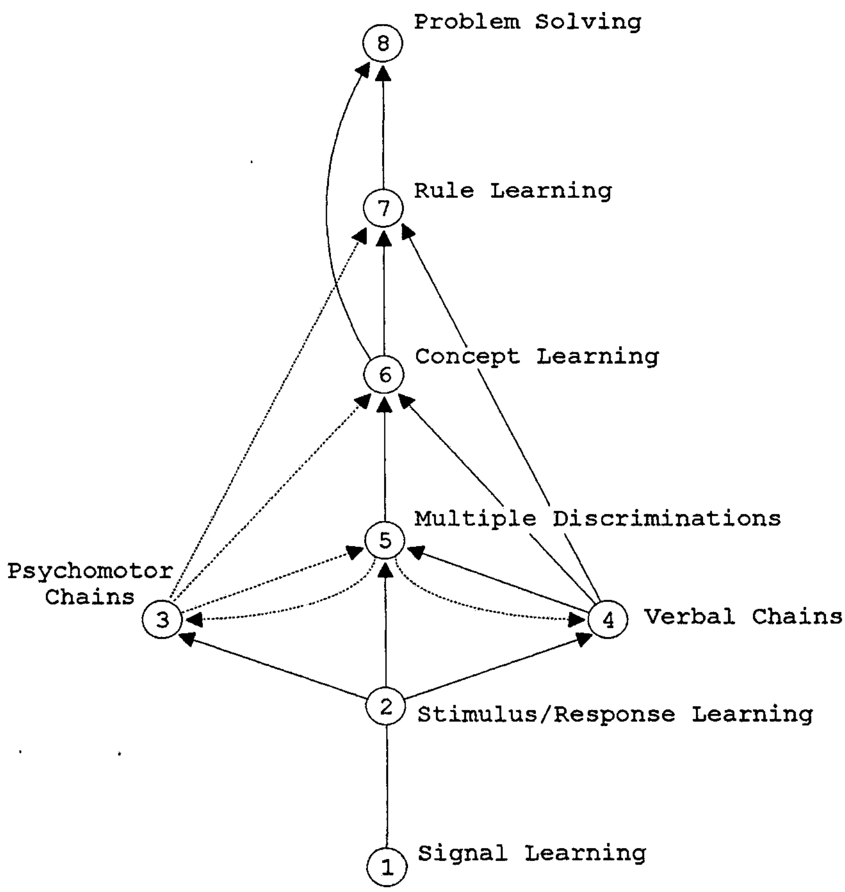

Figure 2.4: Gagné's hierarchy of learning categories
Source: Designing Instructional Systems (Romiszowski, 1981)

In the view of Gagné, the success of higher-order learning is preceded by the lower order one. As shown in Figure 2.4, a particular learning category is either always (solid arrows) or occasionally (dotted arrows) a prerequisite to the learning of the others.

2.6.2 Model of learned capabilities

In the 70's, Gagné considerably changed his thinking towards a theory even more eclectic in nature (Romiszowski, 1981). Gagné revised and expanded his early model of learning into five major types of learned capabilities namely: intellectual skills, cognitive strategies, verbal information, motor skills and attitudes (Gagné & Briggs, 1974; Gagné, 1985). The model is summarized in Figure 2.5. Each of these categories has its distinct features and requires different conditions to achieve favorable outcomes.

Capability	**Example**
Intellectual Skill	Demonstrating symbol use, as in the following:
Discrimination	Distinguishing printed letters
Concrete Concept	Identifying the spatial relation "underneath"
Defined Concept	Classifying a "family"
Rule	Demonstrating the agreement in number of subject and verb in sentences
Higher-order Rule	Generating a rule for prediction
Verbal Information	Stating the provisions of a convention
Cognitive Strategy	Originating a solution for the problem
Motor Skill	Printing a letter or figure
Attitude	Choosing to listen to particular music

Figure 2.5: Categories of learned capabilities
Source: The Conditions of Learning (Gagné, 1985)

For intellectual skills learning, Gagné places the emphasis on the importance of the prerequisites which pertain to the new skills to be learned. The subordinates included in this category are hierarchical in nature. It proceeds from discriminations to concepts, rules and higher-order rules. It is considered that intellectual skills are interdependent. They are built upon basic forms of learning such as associations and chains.

Gagné believes the prerequisites required for verbal information learning are intellectual skills. These skills are considered as the elements that enable comprehension and interpretation of new information. He suggests the new materials have to be related to the knowledge structures of the learners to produce effective outcomes.

Cognitive strategies are defined as the abilities of individuals to activate and regulate their own internal processes such as attending, learning, remembering and thinking. Each specific learning requires relevant intellectual skills. External conditioning of cognitive strategy is considered as an exercise of indirect influence over something that is internally controlled. Practically, it can be achieved by encouraging the students.

Motor skills are the abilities of individuals to coordinate and perform physical activities. They are likely to improve by continued practice. Gagné considered that the learning of motor skills may require the availability of learned part-skills and procedural rules.

Attitudes are defined as individuals' internal mental states which influence their choice of action. For attitude learning, Gagné recommends the use of a model, either a real or imagined respectable person. He believes attitudes of individuals can be modified by displaying desired behavior in conjunction with positive reinforcement.

2.6.3 The processes of learning

The learning events in Gagné's revised model are based on the information-processing theories of cognitive theorists such as Anderson and Norman. He believes it is the basic form of the learning process. The model consists of various phases as shown in Figure 2.6.

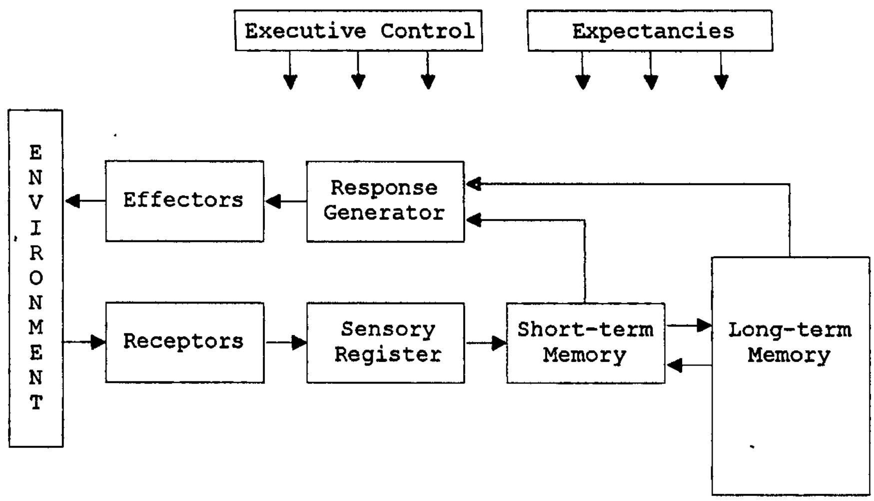

Figure 2.6: The information-processing and memory model
Source: The Conditions of learning (Gagné, 1985)

Gagné's explanation of the model is summarized as follows:

When the learner's receptors are being stimulated by the environment, the information is transformed into neural pulses to the sensory register and last for several hundredths of a second. The entire registered pattern is then selectively transformed into inputs to the short-term memory. Apparently, this discrimination process, selective perception, is dependent on each individual.

If no further process is made, the transformed information in the short-term memory is believed to persist for up to twenty seconds. Due to the limited capacity of the short-term memory, about seven items of information, new items will simply replace the old ones if the limit is exceeded.

The information in the short-term memory is then encoded into the long-term memory. It is a process that transforms perceptual features into conceptual information. The resulting conceptual entities are then stored in various organized structures ready for future use. The storage in the long-term memory is conceived as permanent. However, its accessibility is influenced by phenomena like interference and forgetting.

During the retrieval process, cues are either internally generated or externally provided to link the search with the stored entities. The matched information is then reorganized and fed into the short-term memory conceived as a working memory.

In the working memory, the learned information may be combined with other inputs to generate new conceptual entities. It may be used as input to activate the response generator to organized responses. These responses in the form of patterns or procedures will then direct the effectors to perform. In cases like automated skills, the input signals to the response generator are likely to be transformed from the long-term memory directly.

The final link of the process is the feedback from the environment. It provides confirmation of something being learned. This external event serves as a reinforcement that makes the learning permanently available.

Executive control and expectancies are part of the long-term memory. They are believed to have influences on all phases of the information flow. They determine the learner's particular learning approach. The executive control could influence a learner's decisions upon various internal information processes. The expectancies could affect motivation. In each stage of the information process, the learner is required to select the appropriate strategy and it is considered as the function of both executive control and expectancies.

2.6.4 A theory of instruction

Gagné believes dissimilar learning outcomes have their special properties and organizations, and require different conditions to achieve favorable results. However, he believes that instructional events for all learning outcomes are the same. His sequential events of instructions are summarized in Figure 2.7.

Internal Process	**Instructional Event**
Reception	1. Gaining attention
Expectancy	2. Informing learner of the objective
Retrieval to working memory	3. Stimulating recall of prior learning
Selective perception	4. Presenting the stimulus
Semantic encoding	5. Providing learning guidance
Responding	6. Eliciting performance
Reinforcement	7. Providing feedback
Retrieval and reinforcement	8. Assessing performance
Retrieval and generalization	9. Enhancing retention and transfer

Figure 2.7: Internal processes and corresponding instructional events.
Source: The Conditions of Learning (Gagné, 1985)

2.7 The Influences on CAL

Skinner is considered as one of the leading contributors to mainstream computer-centered education (Bigge & Shermis, 1992). One of the most important aspects of his theory is the role of reinforcement. The technique of shaping has been used in most of the linear computerized learning programs today, especially in drill and practice, and programmed tutorial modes. The programmed learning technique itself may not be as powerful as Skinner predicted. However, this systematic strategy of teaching has had significant influences on education and on CAL.

In Bruner's view, learning is an intrinsic reconstruction and extrapolation process in which new and old information is reorganized. Meaningful learning is learning to use knowledge to discover the unknown. The most importance aspect of education is the cognitive development of the learners rather than the subject matter. Bruner's contributions have had their influence on the instructional designs of explanatory and exploratory levels of learning experiences (Bigge & Shermis, 1992). His free exploratory discovery learning theory is underlying many simulation, modeling, inquiry and conversational tutorial programs of CAL.

Landa views problem solving as a set of standardized procedures. The major concerns relate to the reasons behind any mistake. Similar to Skinner, Landa contends the necessity for deep analysis of the learning processes. However, Landa's interests are the internal operations of the learner rather than the external behavior. His structure-diagnostic programs can be delivered in various instructional methods. Nevertheless, it is considerably better if CAL is used due to the enormous processing speed that a computer can provide. Landa's suggestion is reflected in the design of conversational or diagnostic types of tutorials as well as the proposition of artificial intelligence.

Bandura's theory has stimulated many investigations in an attempt to better understand the ways of human learning. With the advance in technology, the computer serves as a valuable platform for inquiry and thus a complex model can be built. Through careful planning, Bandura's theory can be used in a wide range of instruction from information to skills, to problem solving and general principles. His observational theory is reflected in various kinds of learning activities designed for the simulation mode of CAL.

Gagné's hierarchical classification of learning has had a significant influence on the thinking and practices of instructional design (Richey, 1986). It has covered the concerns of both the instructional process design and the outcome's evaluation. He is considered as another leading psychologist in computer-centered education (Bigge & Shermis, 1992). Gagné always attempts to identify the rules that are related to the achievement of particular educational objectives. In his earlier works, he had moved the design of programmed instruction away from a strictly behaviorist viewpoint to incorporate various cognitive positions. In his later contributions, he has moved even closer to the viewpoints of cognitive psychologists. However, Gagné always insists that the learning outcomes have to be defined in behavioral terms.

His notions appear as a rather successful marriage of behaviorist and cognitive viewpoints. Many instruction designers find this very attractive. Gagné's detailed account of the internal and external conditions of learning has found its way into many instructional designs including CAL.

CHAPTER 3

THE POTENTIAL OF CAL IN MET

3.1 The Nature of Maritime Education and Training (MET)

Referring to Webster's Third New International Dictionary (Gove (Ed.), 1981):

- maritime is used to describe something that is 'of or relating to navigation or commerce on the sea;'
- education refers to 'the act or process of providing with knowledge, skill, competence, ... especially by a formal course of study, instruction, or training;' and
- training is 'the development of a particular skill or group of skills ... in an art, profession, or occupation.'

Accordingly, MET is a formalized process of providing knowledge, skills, and competence which are related to navigation or commerce on the sea. Training appears to be an integral part of education. In essence, educational training aims at developing the skills in a profession or occupation.

For years, MET has been closely associated with the training of seafarers. Much attention has been placed on the preparation of ship operators. However, it could be considered that MET should include the education and training of, inter alia, hydrographers, brokers, naval architects, surveyors, engineers, shipping managers, port operators and agents.

MET could be viewed as a somewhat vocational oriented instructional activity. The results of the education system are, or at least, the competent work-forces for the industry. One may argue that MET is very much related to the development of the lower levels of cognitive objectives of the learner. This means MET, and seafarer training in particular, only involves the achievement of educational objectives of knowledge and comprehension. The work-forces are only required to apply their knowledge in practical uses. It refers to comprehension as described in Bloom's taxonomy of cognitive domain.

The keyword apparently is 'competence' that frequently appears in all types of discussions about MET. Competence refers to 'the quality or state of being functionally adequate or of having sufficient knowledge, judgment, skill, or strength' (Gove (Ed.), 1981). It is the ability and capability to do things well and effectively.

Obviously, being competent requires more than knowledge. The elements of competence have been generalized as knowledge, proficiency, experience and attitudes (Sørlie, 1994). The element of experience may be out of the scope of education and training. Learning experiences at school will not be the same type of experience as Sørlie stated. The rest may be classified in general educational terms as knowledge, skills and attitude. Perhaps a more well known classification, the taxonomy of educational objectives suggested by Bloom and his colleagues, can be used. The taxonomy is divided into cognitive, affective and psychomotor domains.

The generic term knowledge includes knowing and comprehending materials in the cognitive domain. It also encompasses the understanding of operational procedures in the psychomotor domain. Skills embrace intellectual skills and motor-skills. Attitude is the internalization of behavior (Krathwohl, et al., 1964). It is explained in affective domain.

According to Bloom (1956), higher levels of cognitive objectives are built upon the lower ones. However, the highest level of educational objectives in the cognitive domain, evaluation, is frequently preceding all the lower levels of cognitive behavior. For instance, the evaluative process may occur before the acquisition of new knowledge and a new effort in comprehension or application.

Referring to Krathwohl (1964), affective behavior is very often based on the intellectual development in the cognitive domain. Even at the lowest level of affective objectives, receiving, cognitive skills such as comprehension and analysis may heavily influence the individual's willingness. As Scheerer explained, behavior is composed of motivation, emotion and cognition (cited in Krathwohl, et al., 1964, 45). It is impossible to separate these components from one another.

Furthermore, both cognitive behavior and affective behavior have their influence over psychomotor performances. They determine the performance standards which an individual will use in every single step of an execution of motor-skills (Romiszowski, 1981).

Certainly, MET is not only related to the development of knowledge and comprehension. Indeed, it is much more than that. Merely for the development of a positive attitude towards the profession, the higher levels of cognitive objectives have to be achieved.

3.2 The Rationale of Using CAL in MET

The advances in hardware and software technologies have opened a wide range of new possibilities in recent years. Developments of the interactive compact disc and multimedia computer are promising in the improvement of education quality. Numerous publishers have begun to distribute literature and information in digital form. In the maritime field, the International Maritime Organization (IMO) is one of these examples and Lloyd's is another. These developments are changing the way people access and interact with information. The revolutionary impact of computer and CAL cannot be ignored.

It is recognized that there is a gap between conventional MET practices and real-life experiences. Apparently, the technical staff both afloat and ashore appear to have deficiencies in the ability to put their knowledge to use (Underwood, 1992). The demand for a better integration of theory and practice is obvious. The exploration of educational utilities to provide such a link is needed. Taking the advantages of information technology development, computers are becoming more affordable. CAL could play an important role.

Apparently, deficiencies in MET of many countries are partially caused by the shortage of resources, human resources, such as capable maritime lecturers, in particular. On the one hand, identification and development of suitable staff are imminent. On the other hand, investigation of available methods to utilize existing man-power has to be made. CAL, among others, is one of these opportunities to improve educational quality. It could be a valuable tool.

Continuous on-the-job training is needed regardless of the quantity of shore based education (Brindle, 1992). However, the quality and ability of the trainer at the work-place are varied since he or she may not be prepared to perform training tasks. Furthermore, the workloads and time constraints in modern shipping simply make this training approach less practicable. CAL may provide the necessary support to ensure the desirable outcomes at the work-place.

The primary method used today to assess and certify competence has been commented upon as an approach that is based on inference (Underwood, 1992). It is criticized as being inappropriate for the maritime world. It in turn infers a need for an alternative assessment approach. The possible use of a marine simulator to assess officers' competence is being suggested and discussed at IMO. CAL may be capable of tackling part of this problem as well.

It is generally recognized that there is a global shortage of qualified ships officers (ISF/BIMCO, 1990). The shortage of potential candidates for nautical related professions is also apparent (Colcough, 1992). Despite the efficiency of the traditional training schemes, these are becoming too lengthy. Due to the shortage and costs of man-power, ships will continue to operate with small numbers of crew (Horrocks, 1990). Increasingly, new technology will be used on board. This all translates into greater training needs and the costs (investment) become even higher. CAL may be capable of serving as a means to minimize the training time and costs.

Seafaring is no longer considered as a life-long career. A properly structured career path and education scheme are urged (Houssin, 1988 & Zade, 1990). However, being over qualified may de-motivate individuals. The use of modular courses leading to higher academic recognition is one of the possible solutions. Nevertheless, the nature of seafaring may not allow regular shore-based studies. A proper education and training method, which can be adapted to the characteristics of the profession, is needed. CAL, in conjunction with telecommunication technology, may offer a unique solution that has never been possible before (Muirhead, 1994).

The development of information technology has affected almost all industrial, commercial and domestic activities. It is certainly transforming shipping. More and more applications of information technology are being used aboard and ashore. A computer literate work-force is becoming essential. There can be no better way to become computer literate than working with a computer. In fact, using computers to learn can serve a twin-goal. It enables the student to achieve defined educational objectives and promotes prevalent computer literacy.

To a large extent, nautical studies are built upon many basic ideas of other disciplines supplemented with a 'relevant nautical twist' (Colclough, 1992). Indeed, the difference between ordinary education and MET should not be over-stated. In general, research into the use of CAL in ordinary education indicates a consistent improvement in levels of achievement. The training body in aviation has also reported that CAL does shorten the learning time, with a higher retention rate (Wahren, 1992). Recently, a bridge resource management course was developed by one of the aviation training centers for the maritime industry. The result of the program is encouraging (Harmelen et al., 1993). In this course, CAL has been intensively used. Therefore, it is sensible to assume CAL could improve MET.

3.3 The Possible Uses of CAL

3.3.1 In the cognitive domain

Cognitive objectives are connected to the acquisition of knowledge and the development of intellectual abilities and skills (Bloom, et al., 1956). The domain is further divided into six sub-classes extending from the lowest to the highest level of objectives. The sub-classification is summarized in Figure 3.1.

Class name	Brief description
Knowledge	The recall of previously learned information
Comprehension	Ability to understand the meaning of materials being communicated and to make use of them
Application	Ability to use abstractions in new and concrete situations
Analysis	Ability to breakdown material into its elemental components so that the organizational structure and/or relationship can be clarified and understood
Synthesis	Ability to put pieces of ideas together to produce or deviate a new whole
Evaluation	Ability to make quantitative or qualitative judgment on the value of materials for a specific purpose

Figure 3.1: Sub-classifications in the cognitive domain
Adapted from Taxonomy of Educational Objectives: Book 1 Cognitive Domain (Bloom, et al., 1956)

Knowledge

Knowledge refers to the remembering of previously learned materials (Bloom, et al., 1956). It may be considered as an important learning outcome in many ways. It is very often regarded as basic to all other purposes of education and training. It is the stepping stone to all other higher levels of intellectual development. In current MET systems, knowledge has been regarded as the primary index of the level of competence.

CAL has proved valuable in knowledge transfer using various CAL modes. The techniques in use can be of exposition, such as drill-and-practice, or exploratory, such as inquiry. While simulation can be used for the learning objectives such as behavioral or procedural knowledge, modeling can be utilized for the educational objectives such as analysis and synthesis. However, the effectiveness of different modes varies. In drill-and-practice and programmed tutorials, the transfer rate is generally high. However, the retention rate may not be as good as in the discovery or exploratory type of learning experiences such as simulation and inquiry. Nevertheless, drill-and-practice and tutorial types of CAL benefit from the ease with which they can be implemented as an assessment system. Quantitative objective data can be easily obtained for analysis in the light of instructional improvement.

In the field of education and training, there is always certain knowledge which is considered as basic or primary. The use of CAL, even drill-and-practice, would be more effective than the traditional teaching methods in this area. The most critical consideration could be how to present the information appropriately.

Comprehension

Comprehension can be regarded as one of the most important learning outcomes in general education as well as MET. The majority of teachers will agree that the student should be at least able to make sense out of the learning experience, learn meaningfully and make use of the knowledge in the future. Comprehension is the lowest level of this type of learning outcome. It is the ability to understand the meaning of materials and to be able to utilize this knowledge in similar situations (Bloom, et al., 1956).

Apparently, not each CAL mode is capable of promoting this type of intellectual ability in the MET system. For example, drill-and-practice may have limited use in this area. A programmed tutorial may be capable of providing a suitable learning environment. The bottom line is that the program should be able to present the information in a way that the meaning can best be understood by the student.

In exploratory level, conversational tutorial, simulation, modeling and inquiry are all capable of promoting different aspects of comprehension in MET. Conversational tutorial seems to be the most appropriate mode. The analytical and logical guidance provided by a program could eventually lead the learners to work their way towards the desired outcomes. However, simulation and modeling do have their unique capabilities. They are able to provide an artificial environment in which the learner can visualize, restructure and classify the learned knowledge.

Application

Application as defined in Bloom's taxonomy refers to the ability to use theories, principles, ideas or methods correctly in the problem situations that a student has not experienced in the learning process (Bloom, et al., 1956). In the maritime field, the importance of application objectives is obvious. Although the products of MET are self-evidently vocational oriented, there are too many unexpected situations which may occur in the working environment simply because of the anomalous amount of variables in this dynamic system.

In this sub-category, simulation appears as the most applicable mode. It is capable of offering a student an opportunity to trial and apply learned abstraction in a risk free environment. It provides a chance to the learner to practice the skills of restructuring and classifying experiences considering the abstraction being applied.

To a certain extent, both programmed and conversational tutorials can be useful. On the one hand, tutorial can provide supervision to a learner in practicing how to tackle problems. On the other hand, it can be used to assist a student in learning concepts and generalizations that are readily transferable to other areas.

Analysis

The educational objective of analysis places the emphasis on the ability of the individual to breakdown material into its elemental parts, and furthermore, the ability to detect the organizational structure and the interrelationship of the elements (Bloom, et al., 1956). Analysis can be considered as an inclusive comprehension or a preliminary evaluation.

Whether analysis is significant in MET can be controversial. If the products of an institution are the seamen who are expected to either stay at sea for life or perform other insignificant duties after sea service, educational objectives such as analysis may be considered a waste of resources. However, if the outcomes are expected to be real mariners who can manage the dynamic shipboard environment or people who will work ashore contributing to the maritime industry, the usefulness of analytical skills becomes apparent.

For higher levels of intellectual skills such as analysis, instructional uses of CAL appear to be of limited use. Conversational tutorial may be utilized to guide a student through an analytical process in a problem solving exercise. However, it simply serves as a necessary foundation for the development of analytical skills.

To develop a genuine analytical ability, the use of CAL modes such as simulation, modeling and programming would be better. The technique of using CAL is no longer instructional. CAL becomes a working tool in which the learner is able to observe and manipulate the problem situations. It offers the learner an opportunity to practice problem-solving in which analytical skills can be acquired.

Synthesis

Synthesis is the ability to draw elements or parts from different sources together to form a new whole (Bloom, et al., 1956). It places the emphasis on uniqueness and originality in the construction of new meanings.

The justification in promoting synthesis objectives at the higher level of MET is notable. The learning experience involving synthesis objectives implies a need for thorough understanding of the interrelationship of ideas and methods, and of the outcomes. It in turn cultivates better retention and generalization to other situations.

For the objectives of synthesis, CAL apparently is only capable of serving as a tool to collect and manipulate information, or an environment to test a hypothesis. CAL modes such as modeling, programming and inquiry can be used for these purposes. However, the task of supervision has to rely heavily on the human instructor.

Evaluation

Evaluation is referred to as the ability to judge the value of a given material or phenomenon for a specific purpose (Bloom, et al., 1956). Besides all other levels of cognitive behaviors, it involves the use of criteria.

Although evaluation is the highest level of cognitive behavior in the cognitive domain, its general usefulness cannot be overlooked. As mentioned previously, evaluation very often precedes all other cognitive behavior. The criteria that a learner would have used in an evaluative process may well affect other learning outcomes.

Apparently, the uses of CAL in this area are supportive. For the educational objectives of evaluation, CAL may be used to provide assistance in knowledge acquisition and comprehension. The computer is also capable of providing an environment in which application, analysis and synthesis can be tested. Inquiry may be useful to provide the necessary support in which a learner establishes the criteria of evaluation and the frames of reference.

3.3.2 In the affective domain

The emphasis of affective objectives is placed on personal feeling. Affective objectives concern the establishment of value, preferences and attitude (Krathwohl, et al., 1964). The domain is also divided into a hierarchical classification of five sub-classes. It is the successive stages of an internalization process of affective behavior. The sub-divisions of affective domain are summarized in Figure 3.2.

Class name	**Brief description**
Receiving	The willingness to receive or attend to the existence of particular phenomena and stimuli
Responding	The active attention and participation to the phenomena
Valuing	The display of internalization and acceptance of certain behavior or phenomenon
Organization	Conceptualize different values and building a consistent value-system
Characterization	The total adoption of the internalized consistence value system

Figure 3.2: Sub-classification in the affective domain
Adapted from Taxonomy of Educational Objectives: Book 2 Affective Domain (Krathwohl, et al., 1964)

The rationales of pursuing affective objectives in MET have been briefly discussed before. The general term 'attitude' covers a range of affective objectives from responding to organization (Krathwohl, et al., 1964, 37). Furthermore, affective behavior is closely connected to the way that an individual perceives new information and tasks. The significance of affective objectives is clear. The needs of affective learning activities in MET cannot be overlooked.

The capabilities of CAL which may be observed in the affective domain are not so obvious as in the cognitive domain. For the lowest level of receiving and responding, CAL may be useful in facilitating effective presentations and reinforcing desirable responses. In fact, a computer program itself can be designed very effectively to stimulate receiving and responding.

In the higher levels of affective objectives, the support that CAL may offer is the assistance that aims to prepare an individual with the necessary cognitive skills such as analysis, synthesis and evaluation; in essence, utilizing cognitive objectives to achieve affective outcomes. Simulation, in particular, could play an important role. However, the actuality of the internalization process itself appears to be out of the capability of CAL. Evidently, it can be a more effective using technique involving social interaction such as group discussion.

Despite the shortcomings, the multimedia approach of CAL design could have its foreseeable impacts on the promotion of the educational objectives in the affective domain. It is recognized that video programs and motion pictures have their significant effects in the affective domain (Durham, et al., 1974). Taking the strengths of other media, CAL could provide a much better environment to achieve the desired affective objectives.

3.3.3 In the psychomotor domain

The objectives in the psychomotor domain are related to the learning of manipulative or motor skills (Bloom, et al., 1956). Psychomotor objectives are connected to the possession of practical tasks that require muscular action or neuromuscular co-ordination. Bloom and his associates did not get to the point where the objectives in this domain could be successfully sub-classified. Moreover, there is no widely accepted classification. Nevertheless, there have been several attempts. One of the classifications suggested by Romiszowski (1981) can be used as a guide. In his model, five sequential stages of physical skill development are described. It is modified and summarized in Figure 3.3.

Stages	Brief description
Acquisition	Learning what and how to do
Execution	Consciously applying knowledge to perform the operation in a step by step fashion
Transfer of control	Release of direct visual control by using other sensors
Automatization	Reduction of direct conscious efforts to the action
Generalization	Able to use the skill or its component parts to deal with unexpected or irregular occurrences

Figure 3.3: Five-stages development in psychomotor domain
Adapted from Designing Instructional Systems (Romiszowski, 1981)

Modern shipping involves a large amount of psychomotor performances, especially in the ship board environment. Motor-skills of various levels are required in the activities such as loading or unloading of a vessel, repair of an engine and launching of a lifeboat.

The lowest level in the psychomotor domain, acquisition stage, is akin to the knowledge and comprehension levels in the cognitive domain. CAL is capable of providing appropriate procedural and behavioral information to the learner. A computer program can effectively demonstrate a process and allow an individual to control it.

Beyond the acquisition stage, physical practice is needed in learning motor-skills. If CAL is to be used, the interface between the machine and the learner has to be changed. A mock-up object in which the task to be performed is needed. A marine simulator is one of the typical examples. Theoretically, a computer can be used to build almost any form of simulator. The justification largely lies in the comparison of costs between the simulator and the real thing. However, the capabilities of the CAL programs to record and analyze progress data give the simulator the upper hand.

3.4 The Uses of the Computer in Student Assessment

The main function of an assessment during a learning process is the identification of difficulties experienced by the individual. Thus, remedial action can be planned and provided to improve the achievement of the learner. At the end of the learning process, assessment is used as a grading system to accredit the individual's achievement and utilized as an aid to improving the program. In the maritime field, successfully passing an assessment is part of the basic requirement to become certified as competent.

During the learning process, the major advantage of using the computer to assess student performance is its ability to provide detailed and individualized feedback. The students can receive comments on their weaknesses. Furthermore, remedial actions can be suggested and provided. For the teacher, a CAL program is able to provide detailed results of each student for evaluation and planning. The computer can be programmed to process and analyze raw data into meaningful information on an individual's progress, weaknesses and strengths.

The computer program can also be used for the purposes of grading and certification. In general education, standardized tests are frequently used. They are very often generated and marked by computer. Certain national maritime administrations have employed computers, to an extent, in the process of certification of their seafarers. In general, the current computer-based testing practice utilizes the capacity of the computer to store questions and answers in multiple-choice form. These questions can be stored in the computer with various levels of difficulties. Test papers of different levels can be generated at ease. The test itself can proceed either on-line or off-line.

Using computer programs to evaluate essays for both style and content is possible (Page, 1985). In fact, the research findings are encouraging. However, current use of CAL application to assess essay type of responses appears to be limited. Marking essays using a computer requires a model essay together with the keywords of the subject and their synonyms. Furthermore, variables have to be defined in the program to emulate the human evaluation process. A number of strategies for scoring the correctness of the contents have to be used. In essence, an expert system will be eventually developed for the purposes of assessment of a specific subject matter.

The advantage of using computer-based assessment is the fairness and objectiveness that can be achieved. The performance of each individual is compared against a set of pre-determined criteria with a machine that is superb in tasks involving comparison and repetition. Subjectivity and errors can easily be eliminated using computer-based tests.

Since a computer program relies on pre-determined rules to operate, its uses are very much limited to the subjects which have ground rules that can be defined. In essence, computer-based assessment is more favorable to discipline areas of science than art. Another shortcoming of computer-based assessment is its limited ability in measuring creative and original works. However, the continuous development of artificial intelligence systems in computing may provide answers to these problems.

Apart from question and answer type of assessment, CAL offers another special feature that can be utilized in the assessment of learning outcomes. The computer can be used to provide an artificial environment in which an individual can perform various performance-based tasks. Whereas the computer program keeps track of all necessary operational indicators, the human assessor observes and evaluates observable behavior. It could enable the authority to assure the competence required.

CHAPTER 4

APPLICATIONS REVIEWS

4.1 The Criteria

The ability of a computer is largely dependent on the design of the software. Selection of software becomes one of the critical issues in computerization. This principle also applies to the educational use of the computer. For the purposes of CAL software selection, a set of criteria is suggested and summarized in Figure 4.1.

Criteria	Corresponding questions
Instructional characteristics	
Usefulness	Does the CAL program meet its stated or inferred purposes or objectives?
Accuracy	Is the content accurate?
Prerequisites	What are the prerequisites?
Effectiveness	Is the program instructionally effective?
Technical characteristics	
Affectivity	Is the software technically sound?
Ease of use	Can the software be easily used by the learner and the teacher?
Reliability	Is the program free of flaws?
Operational characteristics	
Strengths	What are the strengths of the program?
Weaknesses	What are the weaknesses?
Potentials	What are the potential uses?

Figure 4.1: Criteria for CAL software selection

4.1.1 Instructional characteristics

Usefulness

For a CAL package to be valid, it must be designed to achieve certain educational or training purposes. It should be able to accomplish what it is supposed to do. Therefore, the CAL program should be capable of fulfilling its stated purposes or objectives. If these are not explicitly stated within the program materials, the inferred ones should be met.

Accuracy

The content of a CAL package is important. If the content is not accurate, the aftermath can be enormous. To teach is not easy; to modify misconception even more difficult. It may outweigh all other justifications. Furthermore, the usefulness of the program may be discredited by the learner. This in turn creates a communication barrier stopping the student from receiving information.

Prerequisites

Learning can be more effective if the new information can be related to the existing cognitive structures of a student. Therefore, the knowledge of prerequisites is a crucial factor. It helps the teacher to decide the appropriate timing for using the CAL program for maximum effectiveness.

Effectiveness

In essence, CAL is the use of a computer program to mediate or facilitate learning. The effectiveness of a program to communicate with the learner is critical. The clarity and logic of presentation is one factor. The appropriate use of graphics, sound and color is another. Furthermore, the psychological underpinnings being used should also be considered.

4.1.2 Technical characteristics

Affectivity

One of the reasons for using CAL in education is its unique nature that is capable of stimulating effective learning. Therefore, a CAL program must be motivational and should be interactive. The learner should be allowed to control the learning pace and sequence, and effective feedback should be provided.

Ease of use

Since CAL is used to assist a student to learn for a specific educational purpose, the effort required to become familiar with the medium itself should not be overwhelming. It should be easy to use by the intended users. The program should be capable of allowing the learner to master the operation of the program comfortably within a reasonably short period of time. It should be easily employed and integrated into the curriculum by the teacher. Furthermore, a proper progress and performance recording mechanism for assessment purposes should be in place.

Reliability

The use of CAL should be free of frustration. Software bugs could seriously impede the effectiveness of the affective elements in an educational program. Therefore, the intended CAL package should be reasonably bug free. CAL programs should be reliable under normal use.

4.1.3 Operational characteristics

Strengths

The strengths of a particular CAL program would help the selector to appreciate the software's capabilities and potentials in educational uses. This in turn allows the teacher to use the program in an effective fashion. While enabling the user to attain the maximum usability, the recognition of a program's strengths would help the decision maker to justify the admission.

Weaknesses

The understanding of a computer program's weaknesses is crucial. The awareness of the weaknesses could help the teacher to better understand the program. It helps him or her to use the program more effectively or rather not to use it. At least, it would save the teacher from the aftermath that may be caused by these limitations. Furthermore, the findings are valuable for the improvement of the software.

Potentials

To yield the greatest cost-effectiveness, any CAL program should be utilized to its full potential. It will not be convincing if the possible uses of the software are not revealed. Furthermore, it could help the teacher to realize the true value of the software.

4.2 Rule of the Road (Version 1)

The 'Rule of the Road' is a program aimed to teach or test the student's knowledge and comprehension of the international collision avoidance regulations (ColRegs). The program comes with two different instructional modes, the test and tutorial modes. Referring to the definition of CAL modes in this study, the so-called tutorial is actually drill-and-practice. Random quizzes about the meanings and the practical applications of the ColRegs are used to pursue the stated objectives in the program.

4.2.1 The layouts

The program starts with the title screen in which the learner's experience of using the program is questioned. If the student has never used the program before, a single information screen about the program will pop-up and explain how to operate the program. This information is always accessible through the main menu.

Eight options are available in the main menu and five of them are exercises designed for a particular aspect of the ColRegs. They range from knowledge of the contents of the ColRegs to the uses of sound signals as shown in Figure 4.2. In each exercise, there is a second level of selections subdividing the topic into smaller units.

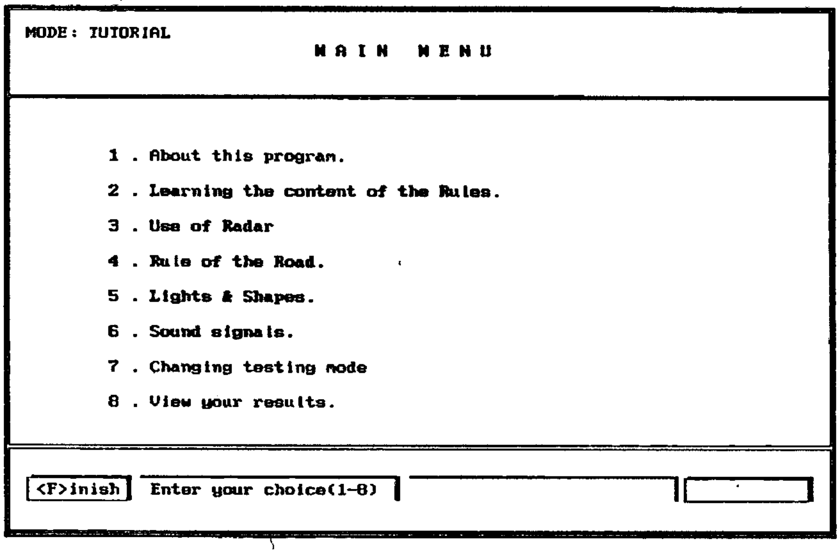

Figure 4.2: The main menu of the program 'Rule of the Road'

The first exercise, option two, 'Learning the content of the Rule' is a module just aimed at drilling the student in memorizing the aspects of various parts, sections and regulations of the ColRegs. A typical question is captured in Figure 4.3.

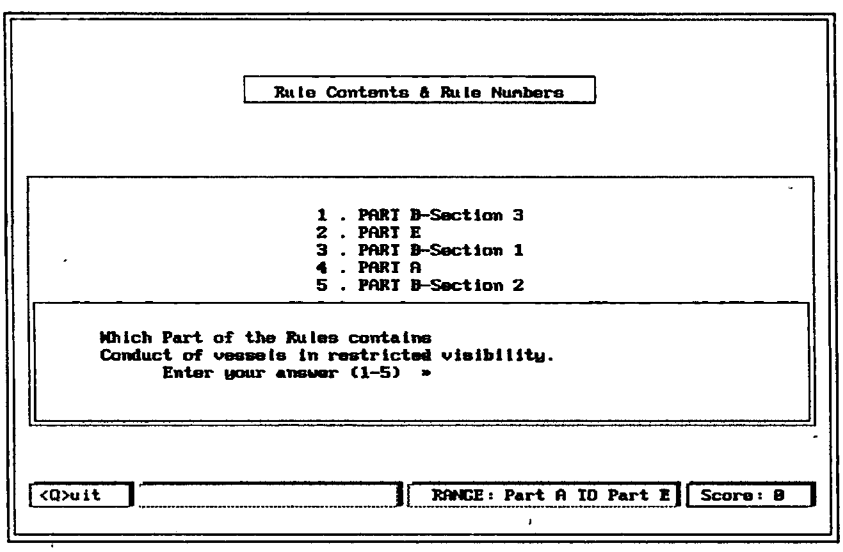

Figure 4.3: A typical quiz on the contents of the ColRegs

Exercise two 'Use of Radar' is a module concerning the student's ability to assess collision situations using Radar. Questions are systematically presented. The quiz covers the appreciation of closest point of approach (CPA), time of the closest point of approach (TCPA), aspects of the target vessel and the action to be taken if so required. In a multiple ship situation, a question about which vessel would have the smallest CPA is asked in addition to the standard question set. The illustration of one of the quizzes used is captured in Figure 4.4.

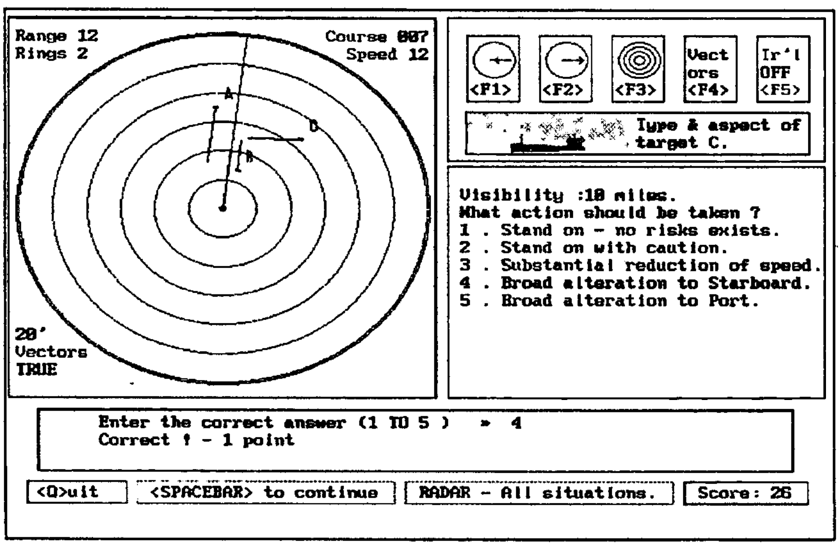

Figure 4.4: A typical quiz on the ColRegs using Radar as an information source

Exercise three 'Rule of the Road' is aimed at applied comprehension of the ColRegs. In the last unit, 'Collision situations,' group questions are also used to test the student's perception of collision avoidance procedures. Figure 4.5 illustrates one of the questions used in this section.

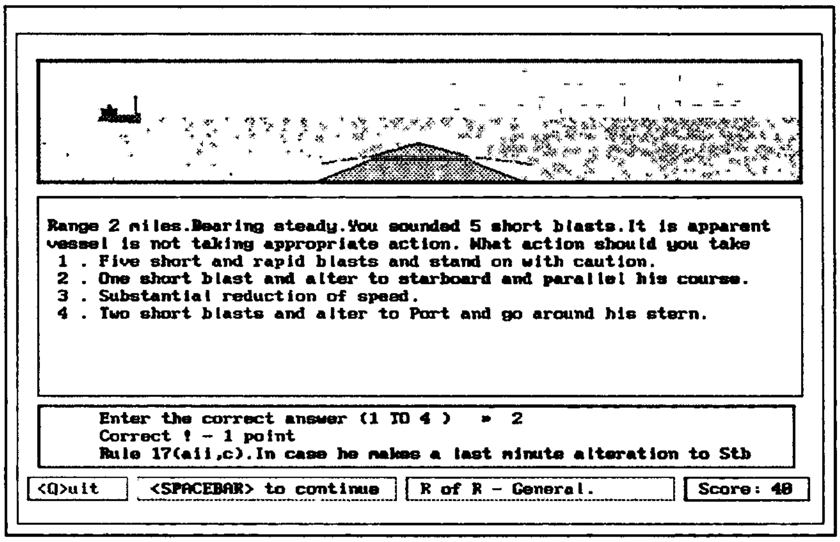

Figure 4.5: A typical quiz on the application of the ColRegs

The fourth and fifth exercises 'Lights and Shapes' and 'Sound Signals' are designed to test the student's understanding about the meanings of various lights, shapes and sound signals, and their implication for collision avoidance actions. In addition, the program also tests the knowledge of technical details of the subjects.

4.2.2 Instructional characteristics

Apparently, the program is capable of achieving its stated objectives. Different areas of the ColRegs, especially operational aspects, are well covered by the application. So far, the contents of the program are accurate. However, there is one error observed in the program. The inaccuracy is not a mis-presentation of content but an incomplete question as shown in Figure 4.6.

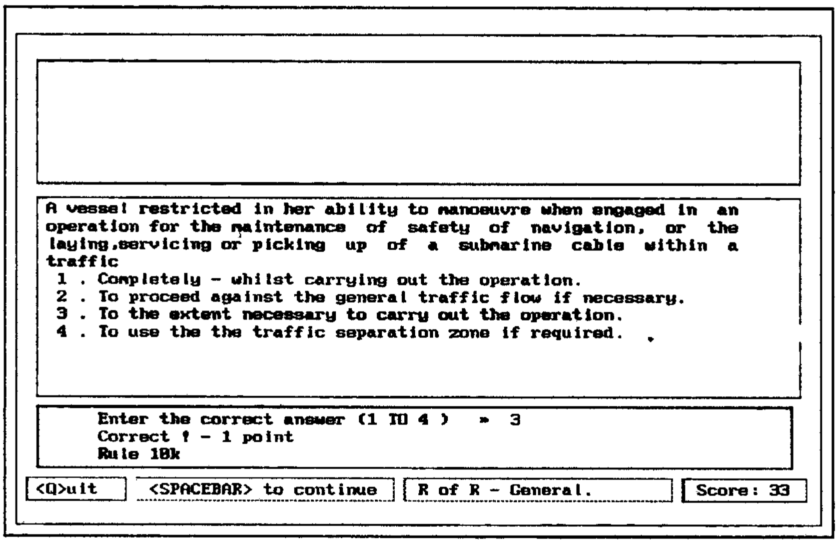

Figure 4.6: An error observed in the program 'Rule of the Road'

The question should have been completed as '...within a traffic separation scheme is exempted from complying with rule 10...'

While the subject is rather well contained in a single program, prerequisites are still required. Before using the program, a student should have understood the definitions of terms such as power-driven vessel, stand-on vessel, underway and making way. An understanding of vector system and its applications in radar plotting and collision avoidance are also essential. Certainly, the student should be familiar with nautical slogans such as port, starboard, ahead and astern.

4.2.3 Technical characteristics

In general, the presentation of the materials is clear and logical. For example, an exercise would start with a single ship situation and gradually increase to a situation involving three target vessels. Sequential questions are also used whenever they are needed. The layout of the questions is neat and tidy. The English language used in the program is simple and straight forward. Graphics, colors and sound are effectively used to present the materials and questions as well. For instance, action taken by the target vessel is demonstrated by using animation.

The program utilizes both reinforcement theory and programmed learning technology. The questions are divided into the small steps whenever applicable. The correct answer is always presented to the student after each question. No time constraint is imposed and the learner is totally free to control his or her learning pace.

Apparently, the questions used in the program are very well designed. It is very much the drill-and-practice style of programming but the quizzes are so constructed to test comprehension. Answering the questions feels like a challenge. This is in turn very motivating. Other affective elements like the scoring system and ending comments are also used intensively in the program.

The operation of the program is straight forward and simple. Most exercises in the program can be easily controlled by the space bar, the 'Q' key and the numeric keys. In the exercises using Radar display, additional keys are used to control the Radar. No user menu came with the university's copy. However, the program is easy enough to handle without any printed reference in a few minutes time. So far, there has been no operational problem encountered in the trial period.

To integrate this program into a curriculum is rather easy. Provided with necessary prerequisites and access to hardware, the software is readily applicable.

4.2.4 Operational characteristics

In test mode, the test results are automatically recorded and saved as a text file. The instructor is able to access information such as who had which test, and when, and the scores using any text editor or viewer. The program is designed not to record any result of a test with six questions answered or less. Unfortunately, one of the units in the module 'Lights and Shapes' about the signals used in clear visibility will then never be recorded since the total number of questions is only six.

Since the test records are written in text format and saved in a file, this data can be directly transferred into another computer program such as spreadsheet for student performance analysis. The difficulties experienced by a student and his or her weaknesses in a particular part of the ColRegs can be identified.

There are several points in the sections using radar display worth mentioning. Since the scale of the radar re-initiates at the six mile range at the beginning of each group of questions, the student needs to switch from one range to another to determine the existence of vessels. Indeed, it is a very good practice in using radar. Furthermore, the student is required to be conscious about the information on the screen. For example, the time factor of vectors and the speed of the ship will change from one set of questions to another. Trial maneuvering is also another useful utility encouraging the learner to test the best possible solution before taking action.

In the tutorial mode, the student is given a chance to repeat questions that are in error. However, two particular weaknesses are posed. Firstly, the question is truly repeated without any rephrasing or significant change. Apparently, rephrased questions are not prepared in the question bank. Thus, there is uncertainty whether the student is memorizing the previous feedback or really understanding the implication. Secondly, the repeating of the question is very often too close to the last attempt. Sometimes, it is restated immediately.

The units in the program are not divided as clearly as stated in the main menu. Instead, a student will find a question about two sailing vessels approaching each other in the unit concerning power-driven vessels. Likewise, questions about sound signals appear in the unit relating to lights and shapes. This may cause a minor frustration on the part of the learner since he or she may not be expecting this kind of question.

Whenever a question involves multiple possible answers, only one is counted as correct. Furthermore, there is a sign of inconsistency in determining the correctness of these answers. For example, a question about a vessel engaged in towing and restricted in her ability to maneuver. In this case, only the answer about the towing vessel is recognized as correct. In another instance, a question about a vessel engaged in mine clearance is again restricted in her ability to maneuver. This time, only the answer about restricted maneuverability is counted.

A hidden problem is observed in the part of the program involving collision avoidance situations in restricted visibility. After a student has successfully identified a target with the sound signals, the target is immediately shown on screen. A question about the action to be taken in restricted visibility is then asked. It may lead to a misconception that a vessel observed in radar and becoming visible to each other in restricted visibility should continue complying with the section of the ColRegs relating to restricted visibility. According to Cockcroft (1990, 141), it should have to comply with the section related to vessels in sight of one another once they are visible to each other.

Yet another possible misconception stimulus is noticed. In the program, risk of collision and close quarter situation are clearly defined using distance of CPA of less than one nautical mile and between one and two nautical miles respectively. Since the determinants of risk of collision and close quarter situation are numerous and could vary from one situation to another, there is as yet no universally accepted definition. In essence, the assumption used in the program may be genuine on one occasion and false on another.

Despite the shortcomings, the program would be very useful in the training of officer trainees and junior officers on the ColRegs. The straight forward design of the software makes it extremely user-friendly. The learner would have no difficulty to learn with this program independently. Unfortunately, the program offers only a bit more than a set of flash cards does. Solely deploying this program to teach the ColRegs from the ground up appears to be insufficient. However, the program would be a valuable remedial tool.

While the program promotes a thorough understanding of the ColRegs, it does provide, to an extent, procedural guidance to the learner about collision avoidance. The program also provides practice to the learner in interpreting radar information regarding collision situation determination and avoidance. Furthermore, it is capable of demonstrating to the learner the usefulness of trial maneuvering function.

4.3 Officer of the Watch (Version 1, stand-alone version)

The 'Officer of the Watch' (OOW) is a personal computer based simulation program designed for the demonstration, training and testing of procedural knowledge of watch-keeping about collision avoidance. It provides a three dimensional virtual space in which the learner interacts with the environment.

4.3.1 The layouts

The program opens with a declaration and acceptance by the student of the statement requested. Once a student signs-on, a particular lesson within a course can be selected and executed. Figure 4.7 shows a sample exercise in action.

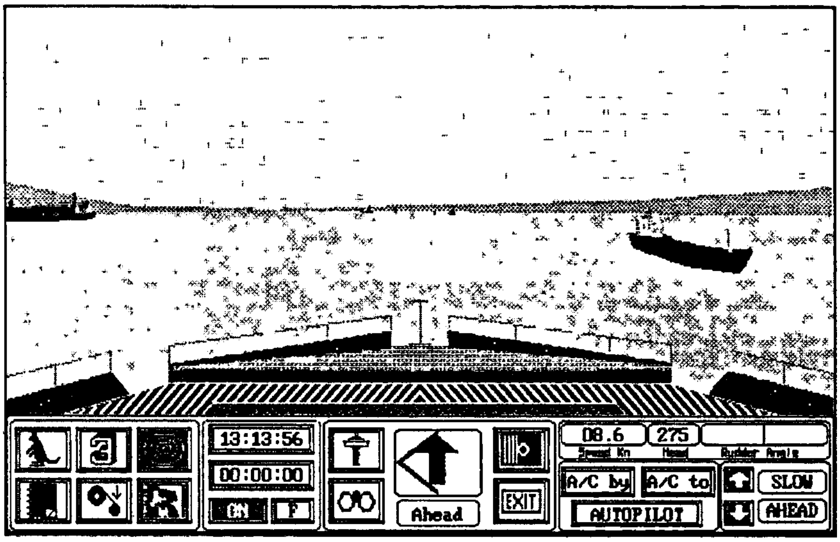

Figure 4.7: An OOW sample exercise in action

From the control panel, all the functions and equipment available in the program can be accessed. They can be enabled and disabled by the instructor during the lesson programming stage. On the left hand side of the panel there are radar, chart, exercise recorder and logbook controls. On the right hand side, indicators of ship's speed, course and rudder angle are provided together with the engine and steering gear control.

In the middle part of the panel is the viewing sector control that enables the learner to choose any one of the four views around the horizon. Along with the time indicators, buttons to summon the compass circle and binoculars are available. Furthermore, the expert system can be called upon to inquire about additional information and advice on any observed target. The loading of a new lesson, the starting and stopping of the exercise, and the termination of the program are also controlled by buttons in this area of the screen.

In addition, questions and dialogues can be used throughout any exercise at any time. Objects such as vessels and buoys can be chosen from a list and displayed on screen for questioning. The dialogue box can be used to guide the student or broadcast a message.

4.3.2 Instructional characteristics

Since the program is an environment that can enable a student to interact with a scenario, the usefulness of the program largely depends on the ways an exercise is designed. The ship models supplied with the program do respond similarly to the behavior of typical vessels. Graphics, color and sound in the program are well used. Although only one of the ninety degree bridge views can be observed through a window at any instant, the program achieves an acceptable level of fidelity.

The prerequisites required for any particular exercise vary from one to another. However, the dialogue box can be utilized to present any additional information needed for a particular lesson. Obviously, a student could benefit from prior understanding of the ColRegs and general maneuvering characteristics of ships before any attempt to practice with the program.

4.3.3 Technical characteristics

Basically, a learner is allowed to control every function and equipment available in the program. The student is allowed to start and stop an exercise any time. Since the program is designed as a simulator, information about the environment and own ship are constantly fed back to the learner through indicators, the scene and three dimensional objects.

The controls of the program are rather easy to operate. The basic input is done by using the pointing device. It can control almost every function of the program. In the case of sound signals, they can be easily sent by pressing the corresponding key on the keyboard.

To integrate OOW into an existing curriculum would not be effortless. A teacher has to design all lessons according to his or her needs and requirements using the optional course development kit.

There were two faults observed during the trial period. First, the dialogue box can be acknowledged anywhere on screen while it is only supposed to be confirmed by the button provided. It can be very frustrating if it just happens that a student is clicking the radar button, or others, when the message is going to display. Second, the program may not be able to load a second lesson. Occasionally, a message 'file deleted' appears in the file selection box denying the loading of a new lesson. The program has to be restarted and loaded again.

4.3.4 Operational characteristics

The program comes with a fairly comprehensive library of ship models. There are fourteen models available, ranging from yacht to very large crude carrier. At any instance, nine of these can be engaged in an exercise. These models can also be used as own ship.

A coastal area that includes configurations such as port, channel and traffic separation scheme is contained in the program. Exercises involving coastal navigation or port calling can easily be constructed. The depth contour in the area suggests a certain extent of reality. It will actually cause a vessel to go aground if so navigated. There are a number of navigational marks available to the instructor. They can be placed anywhere to form any specific coastal arrangement to meet instructional needs.

Apart from its capability to be used as a simulator, the program is also capable of providing drill-and-practice exercises. Multiple-choice questions can be drawn up with an option of using the target objects in the program. Since all objects are three dimensional, it can be manipulated by the learner to obtain a different view.

The expert system can be considered as a valuable utility in the program. The student can obtain target information as well as expert advice from the system. It virtually becomes an interactive tutorial system assisting the learner whenever it is needed.

In radar view, basic controls such as range scale, electronic bearing line (EBL) and anti-clutters are available. Functions for switching between north-up and head-up display in the relative motion view are also provided. Furthermore, the mouse cursor can be used as marking pen and eraser to plot the target manually. However, there is a lack of real utility that could enable a student to determine the best possible collision avoidance action. For instance, a tool for drawing straight line or EBL off-set which allows the configuration of vector diagram would be useful. It would allow a better estimation of the situation which would be based on calculation rather than relying on experience that involves no genuine problem solving skills. For new watch-keepers, the latter appears to encourage navigate-by-guess. Figure 4.8 is a typical radar display.

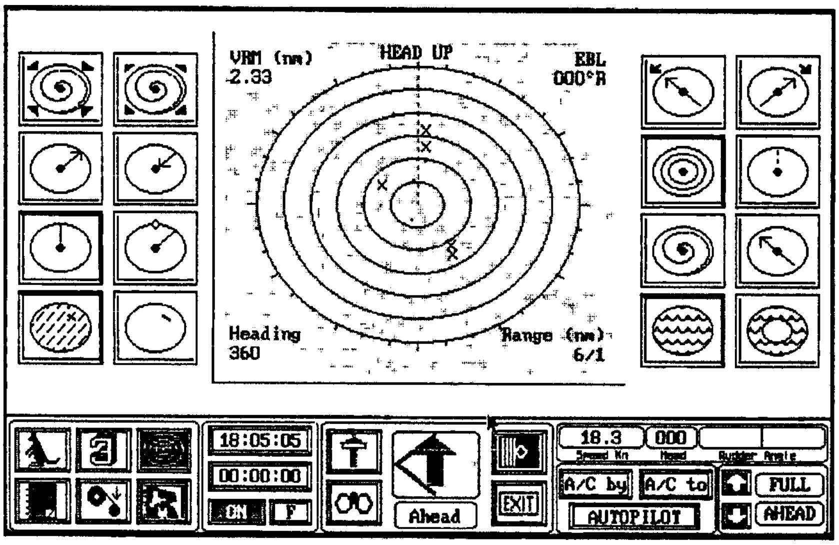

Figure 4.8: A typical radar display in the program OOW

The record keeping of bridge view in the program is quite detailed. It keeps track of all the actions a student takes. It includes the time and duration the student switched the window from one sector to another. It even contains data about the uses of binoculars. The exercise recorder records the tracks of all targets. It is helpful to assess how a student has performed. An example of the exercise recorder and binoculars view is shown in Figure 4.9. However, the monitoring in all other views is rather poor. For example, only the time when the student changes from another view to radar view is recorded. All other information such as which range scale the student has used and whether a target was plotted are totally ignored.

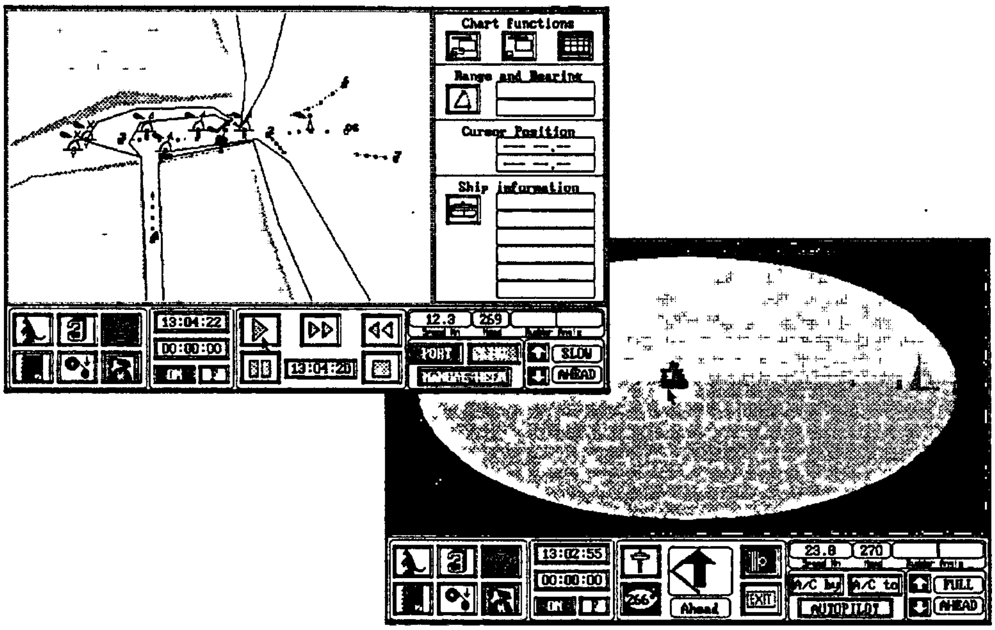

Figure 4.9: Exercise recorder and binocular views in OOW

When full log is selected within the logbook view, various aspects of the student's performance can be accessed. The information includes a record of activities such as engine movement, viewing sector and the use of binoculars. This information is also available in graphical presentation. However, interpretation of this information could be a lengthy and difficult process. Data has to be drawn upon from various screens as well as the exercise details to find out how, when and why a particular view or piece of equipment was chosen and used. Furthermore, this data cannot be saved as an exchangeable file to be used with other computer programs for analysis. A set of sample records is shown in Figure 4.10.

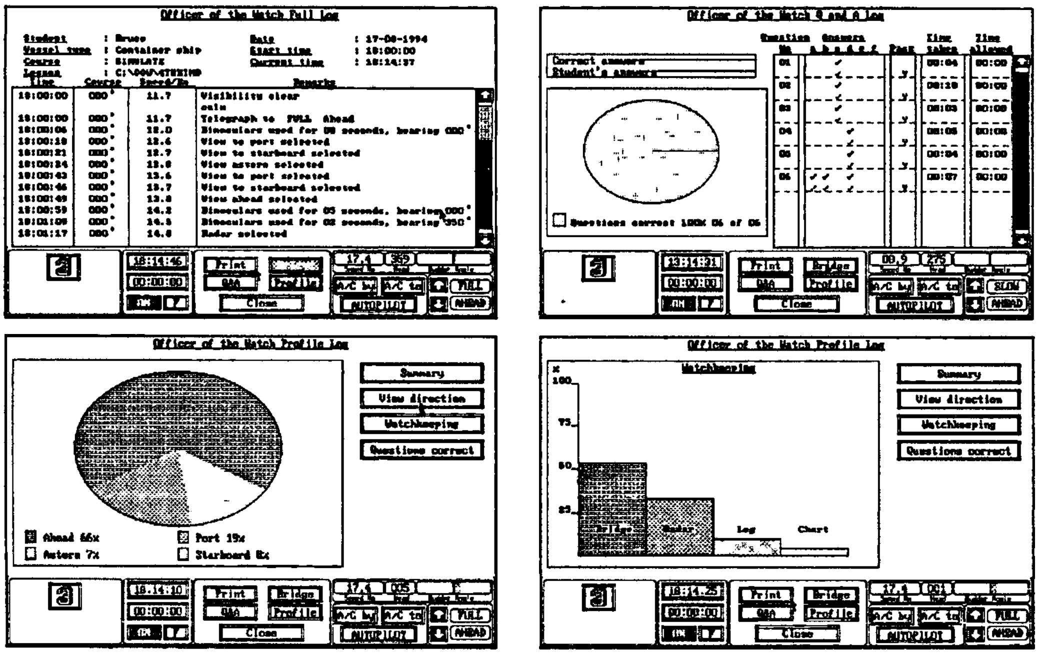

Figure 4.10: Sample records of a student's performance in OOW

Similar to many large scale simulators, the events within the OOW environment are driven by a timed reference. The scenario can be programmed relative to a time base. Unlike a large scale simulator, on-line intervention of the instructor is not available. All events in an exercise are fixed. It may pose no problem to new or trainee watch-keepers since they may simply follow all the instructions. However, if the trainee has maneuvered his or her ship from the plan of the exercise, the scenario may become something totally different. Without an on-line intervention or event driven mechanism, the lesson objectives may never be achieved.

In general, the program is capable of providing a reasonable learning environment in which a learner observes, and has practice in trial collision avoidance procedures. The software will be valuable in training or testing simple task components of watch-keeping and collision avoidance.

To an extent, the program can be used to provide exercises for problem-solving and bridge management skills. However, due to its limitations, the usage may be limited to the training of junior and trainee watch-keepers.

CHAPTER 5

AN ANALYSIS

5.1 Advantages and Limitations of CAL

The computer can be viewed as a versatile tool to enhance the learning process. In the early days, computer-based instructional software was criticized as electronic page turners with little more to offer (Jones & Winne, 1990). However, the situation has changed. The development of information and instructional technologies has allowed a new range of possible usage of the computer for instructional purposes. There are many advantages of using computer in the teaching or learning process. Similar to other instructional technology, however, there will always be some limitations.

5.1.1 Advantages

Unlike other media, computers can be used to present dynamic models, diagrams and pictures that would not be normally possible. CAL provides an easier way to highlight and focus on specific parts of materials. Various aspects of the material can be manipulated more easily. These focusing, highlighting and interactive capabilities would be difficult or sometimes unfeasible to achieve with conventional instructional technologies. These unique characteristics of CAL are able to stimulate more active student involvement and in turn promote more effective learning in the learning process.

By combining the strengths of various instructional media, the CAL system is capable of providing an interactive multimedia learning platform integrating text, sound, animation and video scripts. This largely extends the possible application of CAL. It can offer learning experiences to the student through different sensory channels. CAL allows a wide range of information, symbolic modes, learning activities and relations to be used. A variety of learning experiences from exposition to exploration can be provided. CAL is capable of providing a more comprehensive and flexible learning environment than conventional teaching practice. Even in the most basic forms of CAL programs, the logic of the computer allows highly sophisticated branching that no other instructional media can match.

Furthermore, CAL offers a unique opportunity to the student to experience the situations and phenomena that would be impossible or too dangerous in the real world. It can be used as a tool to bridge the instructional gap between theories and practices.

The truly individualization of learning experiences made possible with CAL is rather difficult to achieve in a conventional educational environment. With CAL, the students are allowed to control the pace, rate and sequences of their learning process. Theoretically, CAL is capable of varying the ways of presentation and tailoring learning activities according to the prior knowledge, learning strategy and personal preference of individuals. In essence, CAL can be a truly adaptive learning system. It could save a significant amount of learning time and achieve better outcomes compared with a conventional classroom.

The capability and usefulness of a CAL program in keeping track of all progress information on the student is fascinating. Immediate feedback based on the performance and responses of the learners can easily be provided with CAL. It is capable of providing a much higher rate of reinforcement than any human tutor could possibly achieve. It offers endless patience to a learner. Further, it provides a more positive affective learning environment, especially for the slower ones. Unlike with a human tutor, a consistent and reliable set of instructions can always be delivered with CAL regardless of time and place.

The consistence of CAL delivery makes the evaluation of the effectiveness of an instructional program easier. The optimal use of CAL requires an in-depth analysis of the subject matter. The content of a CAL program has to be laid down explicitly and the instructional strategies or sequences have to be definitely defined. Thus, the validity of any part of the program can be analytically studied by comparing the prevailing objectives with the student's final achievement. The weaknesses of the program, therefore, can be identified and remedied. In conventional classroom teaching, the deficiency in a program is rather difficult to isolate due to the fact that the instruction may vary from time to time.

CAL is capable of evaluating individuals' learning performances quickly and fairly. The responses of the students, the materials they have been studying and the feedback that has been provided can be thoroughly recorded and analyzed based on objective measures. Thus, detailed individual prescriptions and planning can be made. It can largely improve the achievement of the student since individualized learning experiences and remedial activities can easily be provided. At the same time, it relieves the teacher from routine objective tests. The time and effort saved can better be used in other areas such as planning.

Whereas CAL can be used by individuals to learn independently, it could foster better utilization of available teaching staff. A single instructor would be able to teach more students with the assistance of CAL. Furthermore, the expertise from different individuals in various specialized fields can easily be communicated and shared by the means of computer programs. Taking the advantages of interactive multimedia possibility and powerful cross-referencing capability, CAL can be used to convey information in a similar way as literature but better. It can be a valuable tool in tolerating the shortage of human resources.

Taking the advantage of tele-communication technology development, the computer nowadays can offer a variety of networking capabilities. Computer networks can be established not only locally but also regionally and globally. The use of computer networking in CAL design provides an entirely new educational frontier. A student may log in a computer network to communicate and interact with his or her peers in collaborative tasks. Although the operational cost is rather high at the present time, CAL in conjunction with tele-communication links can be a comprehensive, off-site learning tool.

The ability of the computer to search and process data is exceptional. It can search not only quicker but in the ways that are not possible with conventional media. It provides more effective access to information within a database. Furthermore, databases that have been less accessible before are becoming available to individuals through telecommunication networks. Taking the advantages of this development, CAL can be used to broaden a learner's information base. Teaching resources can be expanded beyond the locality of the educational establishment. CAL is capable of complementing human experts as a source of expertise in both subject matter and processes in a more economical way.

5.1.2 Limitations

One of the advantages of using CAL is the individualization of learning. However, there is a general lack of variety of software to meet different learners' needs. Since individuals may perceive and learn in very different ways, truly individualized CAL programs would be very complex to design. Correctly, the presentation approaches used in any CAL software are aimed at achieving the best outcomes. However, they are only the best ways which are known to or perceived by the programmer or the teacher. In reality, they may turn up with something totally irrational to the learners.

Whereas CAL can be used in the learning processes of various areas, it does not perform equally well in every domain. Apparently, the range of objectives for which CAL can be effectively used is limited. Even in the cognitive domain, the performance of CAL varies. It is more easy to implement CAL to teach at the lower levels. At the higher levels of educational objectives, the use of CAL remains heavily reliant on human intervention.

Furthermore, the performance of CAL varies from one subject area to another. Generally, CAL is only favorable in the subjects that can be broken down into definite steps or parts.

Although there is a rather wide range of applications available for MET, the qualities of these products are inconsistent. There is a general lack of high-quality software. In fact, many MET packages have just happened to be useful for educational purposes rather than being specially designed for them. There is nothing wrong with that. However, the objectives underlying the design of a CAL program and those of a commercial productive package could be very different.

Although, there are numerous well-designed CAL applications, there is also a rather high percentage of poorly written software. This in turn implies a high level of caution on the part of the teacher in software evaluation before any attempt to implement. Moreover, there is very limited information available to help MET teachers in identifying appropriate maritime CAL packages in the field. It is a limiting factor of the widespread application of CAL. MET teachers or administrators have to search, select and evaluate suitable CAL applications individually. The time and effort involved in these processes are significant.

One of the major limitations of CAL is its ability to assess original thought. Creativity may be suppressed by CAL, since software only works within its pre-defined framework following routines. The computer will only answer the responses that the programmer has anticipated. Creative or original thoughts that the designer has not anticipated may be ignored, or sometimes misunderstood.

While CAL is capable of recording all sorts of progress details at ease, these raw data can be difficult to handle. A meaningful summary could be more valuable to both the teacher and the learner. However, it is too often ignored in CAL design. The computer program may relieve a teacher in delivering materials. However, it may add a burden in another area at the same time. In fact, interpreting and analyzing these data meaningfully are complicated, repetitive tasks.

CAL learners tend to work alone. They interact with the computers. Eventually, the interaction with their teacher and others could become limited. Using a computer to learn may pose a risk of increasing social isolation. Although networking may provide a virtual link between different users, it is primarily served as a communication channel which does not offer much for social interaction.

Furthermore, using computers in education may lead to an over-reliance on mediated learning. There is a possibility of an imbalance between the different roles of enactive, iconic and symbolic learning in the intellectual development and acculturation (Hawkridge, 1983 & Percival, 1988). A proper mix of different types of learning experience is more desirable.

Computer architecture has yet to arrive at a single standard. Compatibility of software is a major problem. Software developed for a particular platform is not usually executable in another system. Although this limitation is partially solved by the advance of emulation technology, it is not free of frustration.

5.2 Costs of Implementing CAL

Despite the dramatic decline in price, the costs of computers are still relatively high, especially on a large scale. The hardware itself is relatively less problematic. However, purchasing the systems is just the beginning of the expenditure. Appropriate software is always needed.

CAL material design is a labor intensive and time consuming job. It can take up to several hundred man-hours to produce a single hour of quality CAL materials (Percival, 1988). Development of courseware would be very expensive especially for such a highly specialized field as MET. The population of maritime CAL users is relatively small. Consequently, the unit cost of any high-quality CAL program is likely to be high and the expenses of acquiring additional licenses for a whole class could be tremendous. Upgrading software also comes at a price.

Very often, commercially produced CAL packages may not meet the needs of an institution. Tailor made CAL software has to be produced in-house. Unless the programmers themselves are familiar with the subject matters, computer programming and instructional technology, a team consisting of these areas of expertise is more likely to be necessary. The time of development could be very long which in turn translates into higher costs.

Since the uses of CAL to learn and to teach demand a new set of intellectual skills, both the learners and the teachers have to be trained to make use of the technology. For the learners, CAL requires not only computer literacy but also a new way of information processing with a totally different storage system. For the teachers, it requires an understanding of how this technology can best be used. This requires additional training time and cost before the advantages of CAL can be fully realized.

The costs of maintenance, repair and technical support can be another major consideration. Technical staff is needed to maintain and support the system even with a small computer laboratory. In the case of a large scale computerized simulation facility, a support and maintenance team is required. Furthermore, hardware nowadays will become obsolete very quickly. Newly developed software often requires the use of modern equipment to reveal the advantages. There is a hidden cost of subsequent hardware purchases and upgrades.

5.3 Cost-Effectiveness

Although researchers are generally agreed that CAL could achieve better learning outcomes, there are also reports stating that CAL is no more effective than other methods. The findings seem to be controversial. Meta-analyses of comparative studies show significant advantages of CAL over human instruction (Kulik et al., 1980, 1982, 1984 cited in Romiszowski 1988). However, further analysis of these studies suggest that the achievement gained from using CAL is substantially reduced if the same teacher is responsible for both the CAL materials development and the conventional classroom teaching (Clark, 1985 cited in Romiszowski, 1988).

Basically, the effectiveness of any instructional medium, includes the human instructor, largely depends on the use of an appropriate technique (Romiszowski, 1988). For instance, two media with similar technological capabilities are used to teach a subject. The student backgrounds of both target groups are similar. If the instructional techniques required are within the capabilities of both media, and the subject is delivered to the corresponding target group using the appropriate techniques, the effectiveness is likely to be the same.

In essence, a good human instructor will be as effective as a good quality CAL program, or vice versa, provided that there is no technological advantage for one over the other. However, it is unlikely that a human instructor is able to provide the same kind of consistency and objectiveness in the instructional process as CAL at times. In fact, all instructional media as well as the human instructor are merely the vehicles that mediate the information flows in the learning process. The superiority of an instructional medium does not necessarily guarantee any improvement. The achievement of an individual is still reliant upon the uses of proper teaching methods appropriate to his or her needs.

It is not going to be convincing if the outcomes of using CAL are only as good as another medium. Moreover, the costs of CAL are apparently high. It may be noticed that the costings of conventional teaching methods and CAL are very different. The costs of providing a particular educational or training program to the student may briefly be divided into two parts. They are the development costs and the delivery costs.

The development costs of CAL are relatively higher since they involve extra capital investment and a computer programmer or programming team. They are in excess of the normal requirements of conventional teaching development. However, the delivery costs using CAL are often lower since the costs of human delivery are likely to be higher. Therefore, the total cost of development and delivery in both cases will be similar if the both courses are being used by certain number of students. At that point and beyond, the costs of using CAL to teach will become lower. It, therefore, becomes more cost-effective. The relationship is demonstrated in Figure 5.1.

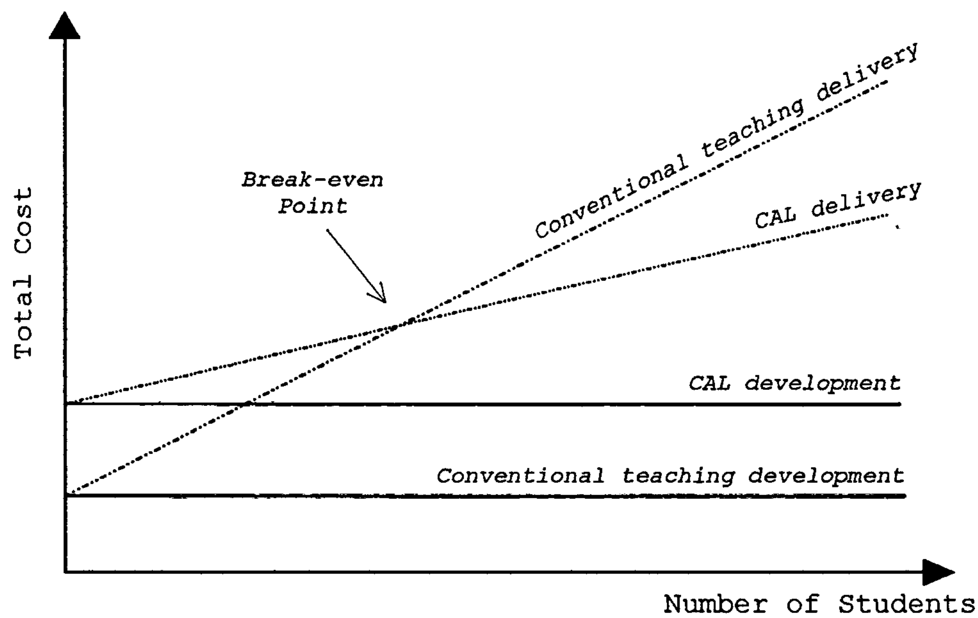

Figure 5.1: Cost relationship between CAL and conventional teaching method in regard to number of students
Source: Designing Instructional Systems (Romiszowski, 1981)

This principle is also applicable to the relationship between cost and time. The total cost of development and delivery of both alternatives will also be break-even at a point in the time scale. The relationship is demonstrated in Figure 5.2.

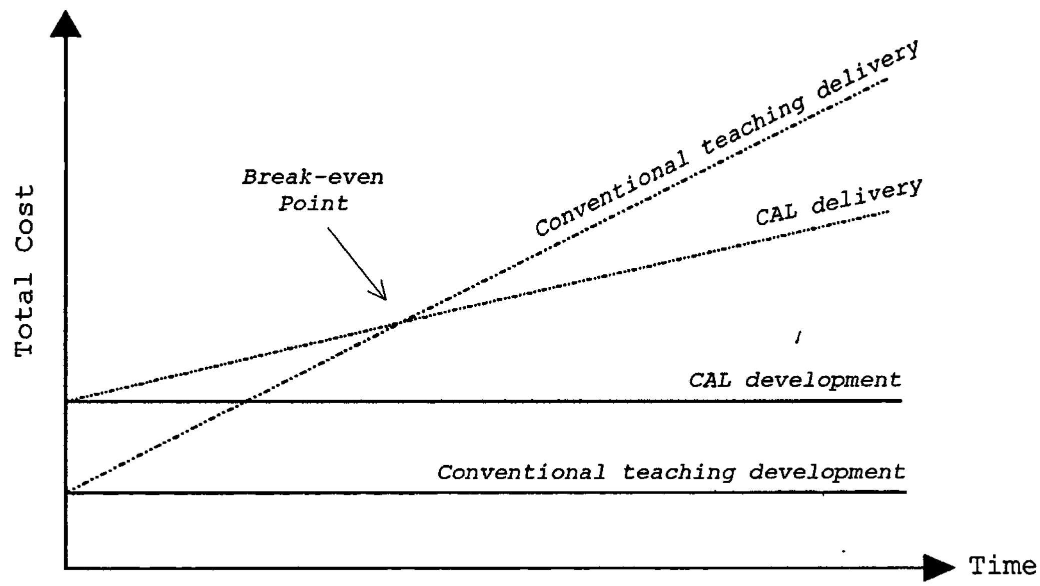

Figure 5.2: Cost relationship between CAL and conventional teaching methods in regard to time
Adapted from Designing Instructional Systems (Romiszowski, 1981)

In these diagrams, there are an assumption that the instructional programs of both delivery methods do not changing over a given period of time. Certainly, it is unusual. If the programs are going to be updated frequently, the situation is going to change. The costs of updating a CAL program are likely to be higher than conventional methods which is similar to the case in the initial development stage. The number of students and length of time needed to meet the break-even point will be further, perhaps sufficient to cause the use of CAL becomes insignificant in terms of cost-effectiveness.

Whereas CAL is at least as good as other instructional media, there are certain exceptional strengths with which other media cannot compete. Actually, the most effective way of using CAL to achieve the educational goals is to implement instructional designs that are not normally practicable or possible using the conventional teaching practices (Romiszowski, 1988).

One of these features is individualization. Certainly, programmed materials and the human tutor are able to offer the same kind of support to a learner in individualization. However, the latter has never been as comprehensive as CAL can be. To achieve the same level of effectiveness of CAL in individualized learning, conventional methods using programmed materials and tutorial support would become too time consuming and involve much higher costs. Whenever off-site education is needed, the additional advantages of using CAL are even more significant. CAL, together with telecommunication links or interactive compact discs, can offer a more effective and individualized way to learn than conventional methods.

Another profound strength of CAL over other instructional technology is its ability to simulate. Theoretically, a computer can be programmed to simulate any phenomenon, situation or system with a reasonable degree of fidelity. In many cases, it is either impossible or impracticable with other instructional media. In comparison to the possible use of a physical establishment or a real system, the costs involved in CAL simulation are very often lower with minimal loss of effectiveness.

One of the advantages of using CAL is its superb ability to perform routine objective tests and evaluations. It can be very cost-effective in comparison to teacher administered assessments. Besides the fairness and objectiveness of computer-based assessment, the enormous speed of computers in processing and analyzing performance will save a significant amount of time and effort. Criterion referenced assessment can be performed more effectively and less costly.

5.4 CAL or not CAL

Computer technology has led to an explosion of both information and access to information. This development may be viewed as another revolution in communication technology after the invention of the printing press (Amthor, 1992). CAL is capable of enriching the learning environment with the interactive power of the computer.

However, the ability of CAL to improve learning outcomes is different from one area to another. Likewise, the cost-effectiveness of computer-based learning experiences varies from case to case. The possibility of using CAL can be validated in two aspects, the likelihood of additional advantages or cost-effectiveness, or both. If there is a significant additional advantage over other instructional methods, the needs of CAL assistance are obvious. If using computers is going to offer better cost-effectiveness, CAL will become viable.

The possibility of using other instructional media to achieve the same objectives has to be considered. If there is an alternative way to achieve the same result, the cost-effectiveness of both media should be used to justify the admission. When the educational or training objective cannot be fulfilled without CAL, there is much need for it.

Furthermore, the significance of saving time in the learning process should be investigated. CAL is proven to be effective and time saving in certain areas. However, the necessity for time saving may not have the same weighting in every educational system. If time saving is crucial, CAL can lend the helping hand.

Another consideration is the need for consistency of instruction and assessment. If consistency is important, the use of CAL can offer extra advantages over conventional means. The use of computers to teach and test would ensure every individual could receive exactly the same learning experiences and the same evaluation standards.

The necessity for individualization is also an important factor to be considered. There may be a need for individualized instructional or remedial activities. There may be a demand for off-site learning opportunities. The use of CAL in these areas can be beneficial. CAL can offer a comprehensive and adaptive learning environment that is normally impracticable with conventional methods.

The frequency of program revisions or updates should be one of the concerns. It can be a most significant factor in the use of CAL. If the course content is going to be revised frequently, the costs of using CAL will become very high. The updating cost may outweigh all other positive advantages the CAL program is able to provide. In other words, it may not be cost-effective.

The success of any particular CAL program depends on various factors. Among other things, the individuals' perceptions towards CAL are crucial. Clearly, CAL is aimed at helping the teachers and the learners in the teaching and learning process. Lacking the active involvement and participation by individuals, the system will never achieve the purposes that are intended. The significance of individuals' attitudes towards CAL should not be overlooked.

Certainly, the availability of appropriate hardware and software is another influencing factor to be taken into account. Buying hardware requires a capital investment. This can be very high. If hardware is readily available and it is capable of meeting the requirement of the intended CAL program, it is more favorable for the implementation. The availability of suitable software is also important since the development of quality CAL programs can be very time consuming and costly. It will be more economical to use off-the-shelf software if it is available.

Furthermore, the availability of support staff is also important. Getting the full potential out of CAL requires capable personnel. The computer needs qualified staff to maintain it. In fact, it would be unwise to implement CAL without the required expertise in place.

5.5 The Impacts upon MET

By definition, maritime education and training is more related to the teaching of technical and commercial skills. It can be said that the curriculum of MET is more in the area of science. Many of the materials of MET can be analyzed and separated into definite sequences, which is thus a suitable condition for the implementation of CAL. The ability of CAL to improve current educational practice is convincing.

If CAL is going to be used in MET, the real challenge is how it can be incorporated into current MET systems to strengthen or remedy current teaching or learning practices. Existing MET curricula in many countries rely on conventional teaching and assessment methods such as lecturing and examination. While the IMO model courses are published for reference and used by MET institutions worldwide, the instructional approach taken in these documents again relies on lecturing. The time frame of lecturing can be very different to the one of CAL. In essence, a modification of the curriculum is needed to integrate CAL into the instructional process. There will be an imminent need of careful and thorough analysis of the existing MET curriculum. Definite sequences and performance standards of intended subjects have to be defined.

In the CAL environment, the role of maritime lecturers is going to change. The role of the teacher will be less of a provider of knowledge but more a facilitator of learning. The teachers have to give away part of their authority over student learning. They will assume roles as technicians, schedulers and advisers. The students will have more control over the information flowing around them. They will have to take more responsibility for their own learning processes. All these changes in roles require a change in individuals' attitudes.

CAL is capable of providing an environment in which competence can be objectively measured and assessed against a performance standard. It offers a new range of possibilities that enables maritime lecturers and administrations to evaluate the competence of individuals. This in turn demands a rational re-design of existing assessment and certification systems to make use of the advantages of CAL. This radical change in existing systems requires conscious effort and thought.

Taking the advantages of computer-based assessment, CAL may be found useful in many areas of the maritime field. However, a proper evaluative mechanism is required to assure standards and recognize the learning outcomes of a CAL system. The use of CAL introduces a new set of utilities in which different learning experiences are provided. In certain areas, the existing practice of evaluation will not be appropriate. For instance, it will not be suitable to use the results of conventional examinations to assess achievement in problem-solving which is attained in a simulation program.

CHAPTER 6

CONCLUSIONS

6.1 The Future Roles of CAL in MET

Introducing CAL into an educational or training institution is not a cheap exercise and indeed can prove to be very costly! However, the benefits of CAL in MET are evident in numerous areas. Simulation is obviously one of the areas that CAL offers additional advantages over other instructional media and methods. It works reasonably well in every domain. In fact, it has been used in MET for years. It can enable the MET institution to bridge the gap between theory and practice.

The primary role of MET is to ensure competence of its outcomes per se. MET institutions are responsible for providing and ensuring the learning opportunities required to, or at least, fulfill the minimum performance standard to their students. The need for a proper student's performance tracking and evaluation system and, to an extent, consistent instructional activities are self-evident. Individualized remedial action to correct any deficiency observed from a student is also needed to ensure the desirable outcome. CAL would offer enormous advantages over the other instructional media and conventional assessment methods in these areas.

CAL can also be a useful tool for the assessment of competence. If a reliable analytical method to interpret and evaluate the performance of the student is provided, CAL can be a powerful assessment tool. For instance, a simulator in conjunction with the human instructor can provide a much more comprehensive evaluation system for the assessment of competence. Moreover, the capability of CAL to handle all the necessary routine and repetitive objective assessment is outstanding. The teacher could then be freed to improve other areas that need more attention.

Clearly, there is a large amount of basic facts and essential knowledge to be taught. The ability to comprehend and apply knowledge to day-to-day operations is also one of the major concerns in the MET curriculum. In essence, much of the content in MET curricula can be systematically analyzed into definite sequences, and creative or original thoughts are not the primary concerns. It is, therefore, favorable for the implementation of CAL. Since this basic information is unlikely to change in a short period of time, instructional materials are not likely to change frequently. These materials may also be used by a large number of students. CAL could be more effective and cost conscious than conventional methods.

The demands for off-site education and training in the maritime field are increasing. The changes in the individuals' attitudes towards seafaring in recent years suggested that an opportunity for continuing education for future career development is required. Together with the necessity of guided on-the-job training, the need for an effective way of remote access to learning experiences is great. Conventional distance learning methods and programmed instruction have been used for some time. However, they lack the interactive nature of the computer and the adaptive characteristics of CAL. There is strong evidence that CAL can largely improve the feasibility and quality of off-site education. In conjunction with telecommunication systems, CAL can provide the necessary shore-based tutorial support that is relatively inefficient in maritime distance learning with conventional methods. The use of CAL in off-site MET education is an interesting area to be further investigated.

6.2 The Problems of Implementing CAL in MET

In comparing CAL with conventional teaching and assessment methods, the use of the computer in MET is more suitable in many ways. However, the attitude of individuals towards the use of computers in education and training is a fundamental concern. Teachers may feel that CAL threatens their professional existence. Those who are computer shy may actively work against any installations. There are people with computer anxieties who are unwilling to use CAL to teach or to learn. There are also computer enthusiasts who may have unrealistic expectations of computers or CAL. Changing individuals' perceptions about CAL may be the most difficult task.

Whereas CAL is capable of improving and remedying the practices of education and training, the optimal use of CAL requires a radical change in current MET systems. Besides the need for a thorough understanding of the educational objectives, the teaching strategies and assessment methods have to be adapted to the needs of this instructional method. This requires time, effort and will. Lacking a specifically structured curriculum, CAL will not be used to its full potential and capability.

Moreover, the variety and quality of available software in the MET sector are not sufficient to support any full scale implementation of CAL. Information about the quality and availability of CAL software in the maritime field is also very limited. Much in-house developed software may not be known to the public. Furthermore, there is a lack of independent reviews and reports of available maritime educational software. Trying to identify and implement CAL in maritime education and training at the present time can be full of frustrations and disappointments. May be, there should be a special interest group formed, for instance, under the International Maritime Lecturers' Association (IMLA).

Although CAL has been used in general education for some time, its application in MET is relatively new. Apart from simulation, the expertise in using computers to pursue educational goals in the maritime field is scarce. There is much more to be explored by the maritime educator and trainer to take the full advantage of this innovative technology. A great deal of effort is needed to reveal the true potential of CAL.

6.3 Final Comments

The predominant medium through which knowledge is grained nowadays is still printed materials. It is unlikely that CAL will be used in all instructional activities in the near future since conventional teaching methods are still relatively more effective or cost conscious in some areas. It is also pedagogically sound to use a variety of instructional methods when teaching.

However, the ability of CAL to improve educational quality is promising. Taking the advanced development of information technology, the computer-based learning environment is becoming better and better. The use of CAL is no longer restricted to the low levels of cognitive objectives. Nowadays, CAL can utilize the network and many other instructional media to provide an ideal learning environment that was not practicable before.

Although CAL is not entirely effective in every area, its value cannot be ignored. The feasibility of the use of CAL depends on two factors, the cost-effectiveness and the significant advantages over the other media or methods. CAL is a valuable tool if it is being used in a proper way.

Similar to other instructional media, CAL has its strengths and weaknesses. Its usefulness is reliant upon the proper selection, design and deployment of the educational software. There should not be any unreasonable expectation about such an innovation. At the same time, the potentials of CAL should not be underestimated. The future prosperity of CAL in MET resides in how the advantages of this tool can best be used.

BIBLIOGRAPHY

Adams, N. (1993) CBT or not CBT, Training (May 1993), pp.73-75

Amthor, G. R. (1992) Multimedia in education, Quality Computers (Fall Edition), pp.16-17

Bandura, A. (1977) Social Learning Theory, New Jersey: Prentice-Hall

Bigge, M. L. & Shermis, S. S. (1992) Learning Theories for Teachers (Fifth Edition), New York: HarperCollins Publishers

Bloom, B. S., et al (1956) Taxonomy of Educational Objectives: Book 1 Cognitive Domain, London: Longman

Brindle, C. A. (1992) Practical training at sea: On board training, The Second LSM International Manning and Training Conference, Singapore, October 12-13 1992

Bruner, J. S. (1966) Towards a Theory of Instruction, New York: W. W. Norton & Company

Colclough, G. (1992) Nautical education: A review of objectives and achievements, The Nautical Institute Conference on Education and Training for the Nautical Profession, Liverpool, UK, September 17-18 1992

Dale, E. (1969) Audiovisual Methods in Teaching, New York: Dryden Press

Durham, N. H. (1974) Selecting Instructional Media and Instructional Systems, Maryland: Charles Country Community College

Eldridge, J. H. (1993) Drawing the line- how far CBT can be taken into maritime and offshore training and testing, The Impact of New Technology on the Maritime Industries, Warsash, UK, September 13-15 1993.

Gage, N. L. & Berliner, D. C. (1984) Educational Psychology, Boston: Houghton Mifflin

Gagné, R. M. & Briggs, L. J. (1974) Principles of Instructional Design, New York: Holt, Rinehart & Winston

Gagné, R. M. (1965) The Conditions of Learning (First Edition), New York: Holt, Rinehart & Winston

Gagné, R. M. (1970) The Conditions of Learning (Second Edition), New York: Holt, Rinehart & Winston

Gagné, R. M. (1985) The Conditions of Learning (Fourth Edition), New York: Holt, Rinehart & Winston

Gove, P. B. (Ed.) (1981) Webster's Third New International Dictionary, USA: Merriam-Webster

Hade, D. D. (1982) Literacy in an information society, Education Technology 22-8, pp.7-12

Harmelen, J. V., et al (1993) Bridge resource management - Putting people first, The Impact of New Technology on the Maritime Industries, Warsash, UK, September 13-15 1993.

Hawkridge, D. (1983) New Information Technology in Education, Maryland: Johns Hopkins University Press

Heinich, R., et al (1989) Instructional Media and the New Technologies of Instruction (third edition), New York: Macmillan Publishing

Hergenhahn, B. R. (1988) An Introduction to Theories of Learning, New Jersey: Prentice-Hall International

Hills, P. J. (1986) Teaching, Learning and Communication, USA: Croom Helm

Horrocks, C. (1990) Views of a shipowner representative on maritime training and professional mobility of ship's officers, The Sixth IMLA Conference on Maritime Education and Training, Bremen, Germany, September 10-14 1990

ISF/BIMCO (1990) Final report: The worldwide demand and supply of seafarers, International Shipping Federation & The Baltic and International Maritime Council

Jones, M. & Winne, P. H. (1990) Adaptive Learning Environments: Foundations and Frontiers, Berlin: Springer-Verlag

Krathwohl, D. R., et al (1964) Taxonomy of Educational Objectives: Book 2 Affective Domain, London: Longman

Langhorne, M. J., et al (1989) Teaching with Computers: A Menu for the '90s, London: Kogan Page

. Makrakis, V. (1987) Computers in Education: Towards a New Pedagogy? Institute of International Education, University of Stockholm

McMahon, H. (1985) Computer-assisted Learning In Husen, T & Postlethwaite, T N (ed.) The International Encyclopedia of Education, Oxford: Pergamon Press

Muirhead, P. M. (1994) Satellite technology, computer aided learning and distance education methodologies: a new world of learning and training opportunities at sea, The Eighth IMLA International Conference of Maritime Education and Training, Oeiras, Portugal, July 4-7 1994

Page, E. B. (1985) Computer scoring of essays In Husen, T. & Postlethwaite, T. N. (ed.) The International Encyclopedia of Education, Oxford: Pergamon Press

Papert, S. (1980) Mindstroms: Children, Computers and powerful ideas, New York: Basic Book

Percival, F. (1988) A Handbook of Educational Technology: A Practical Guide for Teacher (second edition), London: Kogan Page

Print, M. (1993) Curriculum Development and Design, Australia: Allen & Unwin

Richey, R. (1986) The Theoretical and Conceptual bases of Instructional Design, New York: Nichols Publishing

Romiszowski, A. J. (1981) Designing Instructional Systems, London: Kogan Page

Romiszowski, A. J. (1984) Producing Instructional Systems, London: Kogan Page

Romiszowski, A. J. (1986) Developing Auto-instructional Materials: from Programmed Text to CAL and Interactive Video, London: Kogan Page

Romiszowski, A. J. (1988) The Selection and Use of Instructional Media, London: Kogan Page

Rushby, N. J. (1985) Computer-assisted Learning In Husen, T. & Postlethwaite, T. N. (ed.) The International Encyclopedia of Education, Oxford: Pergamon Press

Salomon, G. (1991) Computer in curriculum In Lewy, A. (ed.) The International Encyclopedia of Curriculum, Oxford: Pergamon Press

Skinner, B. F. (1968) The Technology of Teaching, New Jersey: Prentice-Hall

Slotte, G. (1992) Training and sea: A new strategy, The Second LSM International Manning and Training Conference, Singapore, October 12-13 1992

Sørlie, S. (1994) The shipowner/ship manager's education and training demands of manpower in the 21st century, The Development and Implementation of International Maritime Training Standards, Malmö, Sweden, March 15-16 1994

Taylor, R. P. (1980) The Computer in School: Tutor, Tool and Tutee, New York: Teachers College Press

Underwood, T. D. (1992) Training for competence afloat and ashore: time for reappraisal, Safety At Sea and Marine Electronics Exhibition and Conference 1992, London, UK, April 1992

Wahren, E. (1992) Application of airline crew management training concept in the maritime field, The Second LSM International Manning and Training Conference, Singapore, October 12-13 1992