

A CBI MODULE AND USER GUIDE FOR TEACHING ORGANIC CHEMISTRY

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TEACHING ORGANIC CHEMISTRY

By

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A Project

Submitted to the School of Graduate Studies

in Partial Fulfilment of the Requirements

for the Degree

Master of Science (Teaching)

McMaster University

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MASTER OF SCIENCE IN TEACHING (1999)
(Chemistry)

McMaster University
Hamilton, Ontario

TITLE: A CBI Module and User Guide for Teaching Organic Chemistry

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NUMBER OF PAGES: viii, 90

ACKNOWLEDGEMENTS

I wish to express my sincere thanks to my McMaster advisors, Dr. Sandra Crux for her patience, guidance and amazing command of the English language, and Dr. Brian McCarry for his help and encouragement throughout this project.

I would also like to acknowledge and express my appreciation to Nancy Nelson, the author of *Private School*, for her continued support in answering my numerous questions and inquiries, and to Jean Leforge for her editorial skills.

Very special thanks also goes to my family: to my children Leslie, Brett and Ryan, for their patience and understanding while I worked on my project, and to my husband, Doug, the largest thank you, for giving me the support and encouragement to see this project to completion.

ABSTRACT

This project presents the development of a lesson design format on “Introduction to Organic Chemistry” for CBI – computer-based instruction. The design is to be used with the authoring program, *Private School*, an intelligent delivery system database.

The community college system has experienced many changes over the past few years. The changing political, economic and social climate has forced the community college system to re-examine how courses are delivered. Along with this, employers are demanding computer-literate students. There is a need for teachers to look at alternative delivery methods such as CBI. The addition of Computer-based learning to the chemistry curriculum at the community college is designed to do just that. CBI enhances student learning by providing an alternative delivery methodology for studying chemistry concepts, which can be abstract and difficult to comprehend.

Computer-based learning has been slow to be implemented at community colleges. This lesson, designed for the computer courseware database, *Private School*, offers community college teachers a framework to use for their own curriculum initiatives, thus allaying some of the fears and anxieties associated with computer technology.

Throughout the development of the computer-based instructional package, teacher involvement is critical. The success of such a teaching medium depends upon the

commitment of the teacher/designer. The monitoring of student learning and of student progress must be built into the design.

The instructional development model of Kemp, Morrison and Ross was used as the foundation for making decisions about instructional objectives, content, learning activities, resources, learner characteristics and student evaluation. The curriculum was then used as an example for the User Guide to help teachers with the development of their own CBI. This project describes 5 phases for the implementation of CBI into community colleges: teacher familiarization, instructional design, data entry, student familiarization and student evaluation and progress.

CBI can provide resources for learning which are effective, richer, available for longer hours, and open to a wider range of college students. CBI also provides students with greater control over timing and pace, and there is more likelihood of resources suiting their style and stage of each student's learning.

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CHAPTER 1

Introduction

As a community college chemistry teacher, I have become aware of the trend towards the use of computer technologies, particularly in the education of environmental engineering graduates. There are many reasons for this trend, and the most significant among them is the fact that graduates need training in all aspects of computer technology in order to succeed in the workplace of the future. A second important reason is the direction the Ontario community college system and Conestoga College, in particular, is taking with respect to the integration of computer instruction in courses.

The Community College Setting

Over the last few years, the community college system has had to examine how it does business in a climate of major economic, social, and technological change. The system has had to deal with decreased government funding, a fluid workforce and the demands of employers for more computer-literate graduates. The college system has been forced to develop creative methods for the delivery of programs while having to cut costs, reduce program delivery hours, increase class sizes and lay off faculty (Strategic Plan, 1995). The system has also had to maintain a learning community comprised of faculty, instructional designers,

technologists, administrators, support staff, software developers and graphic artists (Dudgeon, 1995).

In 1993, in response to the factors mentioned above, the College Standards and Accreditation Council (CSAC) was created. An outcome of Vision 2000 (a college-wide strategic plan) was the introduction of generic skills into college programs. Generic skills were defined as “particular life skills standards essential for both personal and career success;” – one such generic skill was computer literacy.

The generic skills relevant to this project involve: (1) knowing how to use a wide variety of computer hardware and software and other technological tools appropriate and necessary to the performance of tasks; (2) being able to collect, analyze and organize relevant and necessary information from a variety of sources; and (3) managing the use of time and other resources to attain personal and/or projected goals.

The college system’s vision of computer-literate graduates must be met, therefore, through creative instructional methods designed by the faculty to enhance student learning and to achieve the required outcomes set down by CSAC. Over the last few years I have spent a great deal of time searching the literature, the internet and instructional models and materials on how best to prepare my students given those outcomes and the generic skills students will need.

However, during the examination of the literature (which will be discussed in more detail in Chapter 2), it became obvious to this researcher that two of the main reasons computer technology has not been used more often in community college programs are:

1. the attitude and hesitancy of some instructors to use new instructional technologies; and
2. the lack of appropriate user-friendly instructional software programs.

However, once I discovered the computer courseware database developed by Nancy Nelson entitled *Private School*, an Intelligent Delivery System (hereafter referred to as an IDS), it became obvious to me that both of these impediments could be overcome. The reason these difficulties could be overcome was because the core of this database, the IDS, provides the framework for the development of individualized instructional modules. This framework is based on overall themes or topics, lessons and activities, the latter are designed to meet the objectives of the lessons. Because of this format and the structure of this program, I decided to use this platform as the software framework for an instructional method that teaches organic chemistry using computer technologies.

The Problem

The key motivation for this research project was the need for a computer-based instructional format to teach organic chemistry in a way that prepares environmental engineering community college graduates for the workplace. Many

students find chemistry concepts abstract and difficult to comprehend. A computer-based instructional package was envisioned as an ideal medium to provide students with the analogies and models needed to help them grasp these concepts thereby enhancing student learning through experiential learning opportunities. A related concern was that this type of computer framework approach may be slow to be implemented because of instructor fears and anxieties about using computer technology in an instructional context.

The Purpose of this Project

Given these issues, the rationale and purpose for this project was to develop an easy-to-use computer instructional lesson format for organic chemistry that did not threaten the inexperienced computer user, but provided the knowledge, skills and hands-on learning experiences that would enhance student learning. To accomplish these goals, *Private School*, an IDS database, would be used in conjunction with the instructional development process presented by Kemp, Morrison and Ross (1998) (hereafter simply referred to as the Kemp model).

The module topic and user lesson procedures (presented in Chapter 4) would provide an example of a computer-based learning package that could be used by new or inexperienced teachers for their own courseware development purposes. As an additional outcome, I foresaw that I could become a computer technology mentor to new instructors within the community college setting.

Theoretical Models

Although *Private School* provides the immediate framework for developing a module topic in organic chemistry and will be the basis for much of the discussion and presentation in this project, it is the Kemp instructional development model that provides the instructional structure for the module development process, such as making decisions about instructional objectives, content, learning activities, resources and student evaluation. The roles of these theoretical models will be outlined in detail in Chapter 3; the background and rationale for using CBI and the IDS *Private School* will be discussed in Chapter 2.

Definition of Terms

Computer-based Instruction (CBI)

Computer-based instruction, CBI, is any instructional methodology that uses a computer as the focal point for instructional delivery. With CBI, instruction is provided through the use of a computer and software which guides a learner through an instructional program. Computer-assisted instruction (CAI), which is also the delivery of instruction through the medium of a computer, is an alternative term for computer-based instruction. Computer-assisted learning, (CAL) is the use of a computer as an adjunct tool to aid in a traditional learning situation. The computer is a device to assist the instructor during the instructional process, like a blackboard or handouts. For this project, CBI and CAI will be used

interchangeably to describe the use of a computer and software for designing a curriculum module.

Intelligent Delivery System (IDS)

An IDS is a self-adapting system designed to deliver an individualized computer-based learning package to every learner. The IDS determines the best presentation method for the learner, adjusts for reading speed, reading level, amount of text displayed, amount of advice given to learner and type of feedback. For example, the IDS would adjust the reading level for a student whose first language was not English. In the context of this project, it refers specifically to the delivery method chosen for the development of the organic chemistry module.

Macro-Adaptive Environment

Some learners benefit from instruction provided one way while others learn more if instructed in a different way (Shute, 1993). A macro-adaptive environment is a system that anticipates the learner's requirements and then presents the instructional material accordingly. The IDS used in this project for the development of the instructional learning module has the built-in capability of adapting to the learner.

Multimedia

Multimedia refers to the combination of text, graphics, animation, sound and video to present information to the user via the computer. A multimedia package will encourage the user to interact with it so that they can navigate through the information in the order they want, click on objects on the screen to

reveal further information, or answer questions.

Organic Chemistry

The chemistry of carbon compounds other than carbonates, cyanides, carbon monoxide and carbon dioxide is called organic chemistry. What makes organic chemistry unique is the ability of carbon atoms to bond to one another strongly to form long chains, rings and 3D structures. Theoretically, this results in an almost unlimited number of organic compounds.

Module

An introductory chemistry course may include a number of subject areas, such as acids and bases, equilibrium, nomenclature, redox reactions, chemical reactions and organic chemistry. For the purpose of this project, each of these subject areas will be called a module. A module is equivalent to 8 hours of classroom instruction. The development of the module, organic chemistry, will be used as the example for the CBI module design.

Topic

In the context of this project a “topic” refers to the various units on the module theme “Organic Chemistry.” The topic example that will be presented in Chapter 4 is the first of six related to organic compounds, entitled “Introduction to Organic Chemistry.”

Lessons

Lessons relate directly to each topic and involve decisions about objectives, content, resources and evaluation. A lesson is the material that would

be covered in a regular class. For example, a lesson would be naming alkanes.

Activities

Activities are the techniques instructors use to teach the lesson to the student, thereby meeting the instructional objectives and outcomes set out in the lesson phase. What the student views on the computer screen has been called ‘an activity.’ This could be a filmstrip showing how to name alkane chains.

Chapter Summary

This chapter has been an introduction to the background for this research, a statement of the problem, the rationale for the project, definitions used throughout the work and a brief overview of the two theoretical models that provided the instructional justification for the development of the CBI module “user-guide” procedures presented in Chapter 4.

Since CBI is becoming increasingly necessary in community college settings, Chapter 2 will be a selected review of the literature on the types and characteristics of software that were available and why *Private School* was chosen as the IDS. Chapter 3 will describe how the Kemp model influenced the CBI module instructional development process and the role of *Private School* in that process, while Chapter 4 will be an example of a module “user-guide” for instructors. Lastly, the project summary and recommendations for further study will be presented in Chapter 5.

CHAPTER 2

Review of the Literature

This chapter presents a selected review of the literature on the types and characteristics of CBI from the perspectives of both a learner and a teacher. In so doing, it provides the theoretical rationale for the objectives of this research, namely, the development of an approach using an IDS and CBI platform that can be used by college teachers and will help to alleviate community college instructors' fears and anxieties about using computer technology in their teaching. Furthermore, CBI can enhance student learning activities and outcomes.

By discussing issues related to those two components, the review in this chapter also explains why *Private School* was selected as the CBI platform for the instructional development unit on "Organic Chemistry" in a community college "environmental engineering" setting.

Learners have increasing access to computers and on-line services from home as well as from school; it is expected that they will demand more sophisticated resources and alternative ways of learning that suit their changing lifestyles (Welsh, 1998). It is critical, therefore, that instructors in the college system keep pace with (and perhaps even in front of) these changes because as Sowell (1996) says, "computer-based hardware-software combinations offer teachers and students attractive possibilities not attainable through texts by taking

into consideration the learner and the implementation of the computer-based instructional package”(p. 160).

The examination of CBI and *Private School* will be considered first from the learner’s perspective and will discuss how the levels of learning or domains, learning styles, learner activities and learner evaluation impact on learning effectiveness. Next, CBI and *Private School* will be reviewed from the perspective of community college teachers, specifically, how teachers’ anxieties and inexperience using computer technologies can impact on the use of CBI in the instructional development and implementation processes.

Enhancing Student Learning

Linking Learning to Experience

Many of the students in the community college system are adult learners, who bring a considerable amount of knowledge and experience that has been acquired both formally and informally. When designing a CBI package, teachers want software that can easily accommodate the learners’ different levels of experience and knowledge acquisition. Studies have shown that multi-media approaches improve recall as well as comprehension of course material, increase motivation and interest and advance the development of cognitive skills (Fifield & Peifer, 1994).

The primary mission of education should be to produce competent people -- people who are able to apply their knowledge under changing conditions. One

way to produce that competence is to have students acquire their knowledge (and skills, understandings, attitudes, values, and interests) in the context of their application (Knowles, 1980). Computer technologies reinforce Knowles' idea of the whole person approach to learning; in the case of CBI, self-direction, learning through experience and student-centred rather than teacher-centered learning are encouraged and promoted.

The study of organic compounds is ideal for student-centered learning because, as Gabel (1999) states, many of the concepts studied in chemistry are abstract and are inexplicable without the use of analogies or models. The complexity of chemistry requires the frequent use of mathematical symbols, formulas and equations that express relationships at the macroscopic and microscopic levels. Since chemistry instruction occurs simultaneously on an abstract level and on symbolic and microscopic levels, a student must be capable of associating abstract principles with models and analogies. Likewise, the model must be associated with symbols.

The use of unfamiliar materials in chemistry instruction appears to be an additional barrier to conceptual understanding. For example, when students don't recognize the name of a chemical compound they are not learning on the macroscopic level. Students live in a macroscopic world of matter; things have mass and occupy space. If learning activities are not in a context the students can identify with and understand, they do not perceive chemistry as related to their surroundings.

A study by Phelps (1996), for example, indicates that using materials familiar to college students has beneficial effects in the understanding of abstract concepts. If there is no schema in a person's long-term memory to which a new concept can be connected, the student will probably not understand the concept. On the other hand, if something exists in memory to which the new concept can be related, then learning will probably occur. It is thought that analogies can take on this function, but in order for them to be effective, the student must understand the analogy and see the link between the concept being taught and the pre-existing familiar concept in long-term memory. Concepts can be observed at the macroscopic level, but can only be explained at the particulate level. Students have experienced water expanding upon freezing but do not understand why. *Private School's* capability of a computer simulation of water molecules rearranging themselves as the temperature decreases assists the student's understanding of this concept.

As information grows, however, there will be a need to become specialized, requiring an increased use of technology. For example, Williamson and Abraham (1995) found that students understand the particular nature of matter better when using computer simulations than when using still diagrams such as pictures and transparencies.

Computer technology allows students to integrate applications fairly easily. For example, element properties can be copied from a periodic table database and pasted into a spreadsheet, and the final output embedded within a

word processor document. This integration of applications can increase students' interest and activity and improve computer skills (Stoner, 1996).

When designing instructional courseware, it is important that the approaches to the new technology provide a more flexible curriculum. For many students, the primary need is not to gain yet more information to digest, but to integrate the information into their own personal experiences. Therefore, as suggested previously, it is imperative to use new computer courseware technology as an aid to learning.

The Role of Learning Styles

Computer technology can be very useful in helping students understand many of the more difficult concepts of chemistry. Computer approaches offer a means to present the material in a number of different ways that can best meet the students' needs by recognizing and accommodating a wide range of learning styles through the choices a student makes. The Myers-Briggs Type Indicator, Kolb Learning Style Model, and Keirsey-Bates Learning Style Model are just a few ways to categorize learning styles (Lawrence, 1982; Kolb, 1984; Keirsey & Bates, 1984).

Chemical reactions represent a new and foreign language to the student. Traditionally, these materials are presented on an overhead or a blackboard with a starting chemical formula and a product chemical formula. The reaction is verbally described to the student but the student is left to his/her own cognitive

abilities for visualizing the reaction that is occurring. Computer animation of the chemical reaction and reaction mechanism is used to bring the reaction to “life.” The student will actually witness the specifics of the reaction occurring. A set of practice questions can be added to the program to quiz the student’s understanding of chemical reactions. Along with the simulation an audio recording could be incorporated to help auditory learners. Further reactions could be available to the student who needs more examples to help with their understanding of the concept. In this way, computer-based instruction can accommodate the different learning styles of the student.

Gladwin, Margerison, and Walker (1992) reported that, in teaching science, CBI can be useful in coping with limited resources, furthermore, students reported that they liked CBI and laboratory simulations. When using well-designed software, students considered there was a significant gain in learning compared to traditional methods of teaching (Cruickshank, 1983; Alesandrini & Rigney, 1981). Additionally, CBI gave students significant job-readiness skills and improved chances of gaining employment (Fahy, 1989).

When we learn, two things must happen. First, we have to pay attention to what we are perceiving, be it a new skill or new information; second, we must process that information in such a way so as to allow new learning and skills development to take place (Kolb, 1984). For example:

- Some people favour problem-solving and learning by concretely experimenting (e.g., learning-by-doing or using the facts as they are

presented). They prefer to deal with situations in very personal and concrete ways. These people also tend to perceive by sensing and feeling, often taking an intuitive approach to decision-making; they function well in structured situations where they can take the initiative.

- Other people like to perceive by conceptualizing in a global, holistic or graphic manner. They prefer to think by analyzing, intellectualizing and building theories to understand their experiences. They take a scientific approach to problems and often excel in unstructured situations (Ellis, 1999).

While people approach problem solving in the above ways, they also have a number of ways they prefer to process information:

- Some people favour to process information by actively experimenting, by actively jumping in when they start doing things, and they look for practical ways to apply what they've learned. Generally, these people are risk takers and are results-oriented.
- Others favour processing by reflectively observing and pondering what is going on; they are often able to see several different points of view, and they can generate many ideas to explain how something may happen (Ellis, 1999).

Students have different ways of attending to the information they need to process; some prefer listening, some prefer writing information down in a sequential order, others prefer visualizing and making maps and diagrams, while

others have a tactile (touching) or kinesthetic (movement) preferences. Dunn and Dunn (1993) have found that when students are introduced to new and difficult material through their preferred perceptual method, they perform significantly better than they do using other methods.

Some CBI approaches are fairly narrow in their focus and ability to adapt the delivery of instructional material to the student's learning style. Other software packages such as *Private School* have the ability to modify how material is delivered to the student. By measuring the deviations from the "normal" sequence of topics, the extent of use of supplementary resources, and the amount of time spent on each type of resource, the program will adapt the presentation of new material to the learner's preferred information processing and learning styles.

Multiple Intelligence Theory

Computer technologies and courseware software can be designed to interface with any or all of the eight intelligences: verbal and linguistic, logical and mathematical, visual and spatial, musical and rhythmic, bodily and kinesthetic, interpersonal, intrapersonal, and naturalist (Armstrong, 1994; Lazear, 1999). Multiple Intelligence Theory (MI) makes its greatest contribution to education by suggesting that teachers need to expand their repertoire of techniques and strategies beyond the linguistic and logical ones predominantly used in the classroom.

All people possess the ability to utilize language, this is known as verbal and linguistic intelligence. Logical-mathematical intelligence involves the ability to mentally process logical problems and equations. How we comprehend shapes and images in three dimensions is referred to as spatial intelligence. Musical intelligence is our ability to perform and comprehend musically. Each person possesses a certain control of his or her movements, balance, agility and grace, which is known as the bodily-kinesthetic intelligence. The ability to interact with others, understand them and interpret their behaviour is known as interpersonal intelligence. Similar to interpersonal intelligence, intrapersonal intelligence is our cognitive ability to understand and sense our “self.” Intrapersonal intelligence allows us to examine our being – who we are, what feelings we have, and why we are this way. The naturalist intelligence is a person’s ability to identify and classify patterns in nature. Naturalist intelligence may be seen in the way we relate to our surroundings and the role each part of our surroundings plays (Carvin, 1999). *Private School* can be used to incorporate word text (linguistic), illustrations (spatial), sound score (musical or linguistic), and video data (bodily-kinesthetic and other intelligences) into a module project.

In reviewing the literature on MI theory, it has been shown that it can be used as a basis for selecting and designing instructional modules for organic chemistry, although most CBI will be limited to a visual format with the inclusion of audio information. *Private School* can, however, incorporate word text

(linguistic), illustrations (spatial), sound score (musical or linguistic), and video data (bodily-kinesthetic and other intelligences) into a module project.

Activities and Evaluation

A number of activities and methods for evaluation will be discussed to show how CBI will be evaluated as an instructional tool to enhance student learning compared to standard methods.

Activities

For example, two-dimensional and three-dimensional computer animations provide more realistic representations of chemical structures and processes than static visual aids and model thinking skills, such as three-dimensional imaging; these are the kinds of skills we want our students to develop (Fifield & Peifer, 1996). Another immediate benefit to using CBI when teaching organic chemistry is that instructors and students are permitted to do things that are just not possible with any degree of practicality by any other means, such as:

- the use of coloured graphical displays to illustrate concepts far more elegantly and rigorously than most teachers can draw on the blackboard;
- the exploration of screen displays by moving a cursor, or by animation techniques provides dynamic modes of instruction which are almost impossible with a textbook;

- the charge displacement in a molecule induced by the approach of another can be simulated on screen and elaborate calculations of some complexity can be performed accurately; and
- elaborate calculations of some complexity can be performed accurately and quickly to illustrate a point – the effect of changing particle mass on the probability of barrier penetration when exploring the role of different parameters in quantum-mechanical tunneling. (Gladwin, Margerison & Walker, 1992).

Learning Evaluation

Practical evaluation methods are the norm for CBI platforms such as *Private School*. Drill-and-practice exercises and responses can be elicited using a variety of instructional methods such as multiple choice, true/false, match up, and hot-spots (links) on graphical images and menus. The most important advantage associated with these types of evaluation methods, according to Bull (1994), is the immediate feedback provided to the student, thereby enhancing learning. However, over and above the practicality of the drill and practice evaluation methods, the optimum use of CBI was found to be in problem-solving and discovery learning exercises, dialogues, games, tutorials, and simulations (Hathaway, 1990) – all consistent with *Private School*.

Reducing College Teachers' Anxiety

Community college teachers must be motivated to use computer software and there must be efforts to allay their fears and anxieties related specifically to the use of computer technology. Because most teachers do not have computer programming skills, the software must be easy-to-use and there must be reserve time spent on familiarization and development. Teachers also need time for the development of software resources such as: video clips, sound clips, graphics and hyperlinks.

Teacher Motivation

What motivates the drive for the widespread use of computer technology in colleges and universities? Kussmaul, Dunn, Bragley and Watnik (1996) say the number and variety of students and their interests have increased dramatically, straining the capabilities of colleges and universities. There has been a similar increase in academic knowledge, resulting in more disciplines and more information. Technology can help students take a more active role in their learning by allowing them to use different instructional modes or methods. Technology offers increased opportunity to students with handicaps. It can link teachers and students separated by distance and help overcome financial and logistical limitations.

Technology also enables teachers and students to draw on a rich variety of examples and materials at their own institution as well at other locations.

Students bring a wide variety of aptitudes, backgrounds, interests, learning styles, and motivations to our classes. A major challenge is, therefore, to motivate teachers to use the technology so that they can match their presentation of material to such a heterogeneous audience.

Teacher Anxiety

Micro-computers have had a significant impact in post-secondary education. In spite of the fact that almost all instructional programs and subject areas have been affected by applications of micro-computer technology, teacher anxiety is still a significant concern. Teacher anxiety is a major drawback to using the technology, and as Hazari (1991) states, the extent to which teachers accept and apply computer technology in their classrooms will have a marked influence on the institution's and educational system's transition into the technology future. From an Ontario community college perspective, this was one of the main thrusts recognized in Vision 2000 (1990).

Hazari (1991) points out the importance of teachers learning to use computers, particularly since technology has caused a change in education and it is necessary for educators to deliver a changing curriculum through the use of technology. As such, it is essential for teachers to accept computer use at a personal level. A primary objective of this project is to develop an approach that will also reduce anxiety to make this widespread usage possible.

However, change does not come easily. Marias (1975) makes the case that all real change involves loss, anxiety and struggle. New experiences are always initially reacted to in the context of some 'familiar, reliable construction of reality' in which people must be able to attach personal meaning to the experiences regardless of how meaningful they might be to others (Fullan, 1992). Real change then, for community college instructors, whether desired or not, represents a serious personal and collective experience characterized by ambivalence and uncertainty.

Teacher Preparedness

There is also the issue of teacher preparedness for change, a major stumbling block (usually through no fault of their own) to use even the basic potential of computers much less the more sophisticated tools such as artificial intelligence, interactive computer/laser disc configuration or interactive satellite communications. Also, the contemporary community college classroom staffing and management patterns do not allow teachers the time that is necessary for professional development and CBI familiarization.

Fabry and Higgs (1997) examine some of the barriers teachers experience that inhibit their effective use of technology. Besides teachers' attitudes and resistance to change, other concerns include funding and inadequate access. Teachers themselves identify the need for administrative support, adequate

funding, time, and training as essential components to change (Norum, Grabinger & Duffield, 1996).

Whatever the difficulties, to integrate technology into classroom practice, teachers must make two radical changes:

1. learn how to use the technology; and
2. fundamentally change how they teach.

Teachers are being asked to move away from relying on a teacher-centred approach and move towards a more student-centred approach (e.g., less reliance on lecturing).

Another way to look at the resistance to change, Marcinkiewicz (1994) suggests teachers avoid using computers because they fear a loss of status and hard-earned skills and do not have adequate knowledge. Since the introduction of microcomputers into schools there has been an undercurrent of teacher anxiety about computers because teachers worry about how computers will affect student learning and their own work. In fact, some teachers fear computers will replace them, while others fear losing control of classroom behaviour and outcomes. Since many teachers are likely to know less about computers than their students, the fear of embarrassment also acts as a major deterrent to acquiring the skills required to effectively use computer technology in the classroom (Budin, 1991).

Whatever the case, community college teachers must be empowered to make decisions about technology and must be given the time, the training, and the support to have the skills to make technology student-centred and

transformational. Even highly motivated technology-using teachers rank lack of time as among the most problematic barrier to integrating computers into courses. Teachers require time to experiment with technology, share their experiences with colleagues and attend technology-related in-service training programs (Bell, Gladwin & Drury, 1998).

Conestoga College, the college where this researcher teaches, has made a commitment to bringing technology into the classroom. There have been various workshops and time set aside in the spring semester to work on implementation of computers into the learning environment. However, even with this added support, there are still many teachers who are reluctant to involve themselves with the technology that is currently available.

Teacher Beliefs

Another major factor contributing to the slow implementation of computers into the classroom involves teacher beliefs and their views about learning and instruction and the effectiveness of computer technology in that process. In fact, Veen (1995) says that the most important factor affecting the use of computers in the classroom is teachers' beliefs regarding what should be in the curricula (content) and the way the subject should be taught (pedagogy).

Teachers also have beliefs regarding their role in the classroom and classroom activities, their personal views on education and on themselves as teachers. Teachers must be convinced that computer technology will enhance the

entire learning process before they change their practices; colleges need well designed CBI modules to show instructors the value of computer technology in the learning experience.

Selected Review of Commercially Available Software Packages

Computer-based Chemistry Instruction

There are many commercially available computer lessons, which cover most of the topics of an introductory chemistry course. Many of these contain pretty pictures, animations and interesting text, but much of it is covered equally well by a book or a videotape at much less expense and time. When evaluating courseware some aspects to be considered are: does the courseware have clear instructions for the user, does content fit the curriculum, is the educational content accurate and is the courseware simple and consistent in its operation.

ActivChemistry, 1997, by Benjamin Cummings, offers an interactive simulation of a chemistry lab. It explores the processes of chemistry, from test tubes to atoms. It is a click and drag navigating system. The pictures are static. There are no sound or video capabilities. When explaining pH, a scale is on half the computer screen and text is on the other half, much like any textbook. It does allow the student to perform a lab as if they were actually in the laboratory. For example, there is an icon to attach the bunsen burner to the gas and then move a beaker of water over it. A thermometer can be brought to the beaker to measure the temperature. This type of simulation might be useful for a chemistry course

without a lab component. However, I believe a set of lab experiments performed at home would be a much more valuable learning experience.

Interactive Chemistry Journey, 1997, Prentice Hall, incorporates pictures, sound, video clips and text. Questions are asked after each unit; if answered incorrectly hints are given. Unfortunately, the print is very small and often in green, which is difficult to see. There is a calculator and periodic table available for reference. This package does not include explanations of terms. In the lesson on equilibrium it gives examples of dynamic equilibrium and asks questions but never illustrates what dynamic equilibrium is. Interactive Chemistry Journey is good for reviewing topics but needs a reference text.

Unlike *Private School*, these stand-alone packages can not adjust to individual learning styles. They can not be customized to meet the individual learning group. For example, if the students are in an environmental engineering program, the examples can not be chosen from that field of study. Some of these packages are not pedagogically sound or designed from a learner's perspective. Learning objectives are not keyed into the content presentation. Cost is another factor to consider. A module, such as the ones mentioned above, could cost around \$100 US for a single topic. This could easily put them out of reach as a resource for the college teacher.

Authoring Packages

An alternative to the individually designed lessons is the use of commercially available authoring software. For example, Powerpoint is a great

tool for presenting information to a large class but does not have any individualized information built in. Within the presentation it would be helpful to have asides so the students who are interested in a particular topic can explore it further.

Toolbook II can create and deliver effective educational courseware. It contains pre-formatted templates and wizards, which enables you to plug in your own information. The interface is similar to Microsoft Office Tools with pull down menus. It offers templates from which to start. Unfortunately, the format is fixed. Font size and screen colour is set, which does not make the platform to have the soundest parameters for educational material. To develop 4 – 15 minute lessons will take about 250 hours.

Director is an excellent platform for developing your own computer-based curriculum. It enables the teacher to design excellent lessons incorporating sound, video, text, animation and graphics. Font size, screen colour and page layout can be varied. It costs about \$1000 US. The major drawback to this platform is the time required for development. About 20 hours are required to create a 2 minute lesson.

Private School contains all the components necessary for a sound pedagogically designed curriculum unit. The software has been designed with solid learning principles. For example, the designer is given a choice of screen colours, which have been proven to be most effective for reading and learning from a computer screen. This reduces the time required for making those kind of

decisions. It is also the only platform (to my knowledge) that contains an intelligence engine, which enables the program to adapt to the student's learning style. If the student has been identified as a linear thinker, when the student gets side-tracked or skips around the topics, a reminder message will appear to get the student back on track. The software has been designed for the teacher who does not have programming experience. A workshop was held at St. Lawrence College for faculty who were interested in learning how to design computer-based instruction. The morning was spent learning about *Private School* and by the afternoon the teachers had the tools to put together their own design. Just like the other authoring platforms it is time consuming. The key is to have well designed resources prepared. The whole module on organic chemistry would take at least 150 hours to input the data into *Private School* if it was thoroughly designed and much longer if not.

Chapter Summary

As discussed throughout this chapter, using computer technology can be motivating for the student and the instructor. It encourages faculty to look at what they are teaching and how they teach it. A selected review of the literature has shown that CBI can improve retention, increase motivation and assist students with visualisation of difficult concepts. The review also suggests that when teachers are selecting a software platform for a CBI package, a number of considerations must be met. Can the module be designed to meet the level of

learning required by the student and subject matter? Does the platform take into consideration the varied learning experiences and styles of the college learner? What types of activities best meet the needs and learning styles of the students? And, how will the students be evaluated?

Given the emphasis in the literature on learning, instructional development, the change process and teacher preparedness, *Private School* (an IDS and CBI platform), incorporates many of these considerations and characteristics. As well, *Private School* reduces the need for teachers to have any computer programming skills, offers a platform for the instructional developer to plan and implement CBI with minimal time and computer expertise, and is not difficult to use. Although a teacher must be comfortable using a word processor, scanner, video camera, and a digital camera, *Private School* is readily available with the costs already met for the acquisition of the software package.

I chose *Private School*, an IDS, as the CBI format, for all of the above reasons as well as the sound pedagogical and instructional development principles behind the implementation of this software. In other words, CBI can reduce community college teachers anxieties about using computer technology and it is able to increase learning effectiveness.

Chapter 3 will be a presentation on the two components involved in the instructional development process: the Kemp model framework used (Kemp, Morrison & Ross, 1998) and *Private School*, an IDS.

CHAPTER 3

The Module Lesson Development Process

The “Organic Chemistry” lesson development process involved the use and application of two separate theoretical structures. The first component involved the incorporation of the Kemp model and its theoretical framework to make and justify instructional decisions that have to be made to provide a strong pedagogical foundation. It is these decisions that will provide the lesson and activity format for inputting the lesson on “Introduction to Organic Chemistry;” the first topic in a broader module unit on “Organic Chemistry.”

The second component involved the application of the computer database courseware and IDS, *Private School*, to the first organic chemistry topic and lessons. Both theoretical models and processes will be discussed below.

Component One: Using the Kemp Model

There are nine elements in the Kemp model:

1. identifying the instructional problem or problems;
2. examining learner characteristics;
3. identifying subject content and analysing task components;
4. stating instructional objectives for the learner;

5. sequencing the content within the instructional unit for logical learning;
6. designing instructional strategies so that each learner can master the objectives;
7. planning the instructional delivery method;
8. developing evaluation instruments to assess objectives; and
9. deciding on instructional resources.

Each component will be discussed in relation to the development of a computer-based module topic and lesson format.

Identifying Instructional Problems:

In developing a computer-based module topic on organic chemistry, a major instructional problem was the fact that there was a demand placed on the student as well as on community college faculty to be versatile in the use of computers. Employers were demanding, and continue to demand, computer-literate graduates. One way for a community college to meet this demand and to deal with this identified instructional problem is to incorporate computer-based learning into the curriculum.

There were many generic computer packages available but I felt they did not meet the educational goals of the chemistry course for the environmental engineering student. For example, some of the software packages contained too much text that did not help in the understanding of difficult concepts, thereby

being no different than a textbook. Other computer packages gave only a cursory look at organic chemistry, the depth being very superficial. Still others were too complicated for the students to navigate. As a result, by designing this module topic format I determined that I would be able to develop an instructional approach that community college instructors could use that would best meet the needs of the adult student. As well, with the experience I would gain in the process, I thought I could help other college faculty become more comfortable with their own curriculum initiatives.

Learner characteristics:

The community college population is composed of many types of people. The majority of students are young adults directly from high school. About a quarter of the students are classified as mature, people who have been out of school for three or more years. Some students have come from the workforce and due to injury or layoffs return to college to upgrade their skills. Others had no motivation for post-secondary education when they were younger but now realize the importance of it. With this diverse population a wide range of experiences are brought to the classroom. Since all people learn differently, it is important to develop a curriculum that meets the needs of this diverse population. Learner characteristics were an essential component of this planning process. Therefore, when designing the topic and lesson phases (Chapter 4), attention was given to the characteristics, abilities and experiences of the learners in the environmental

engineering program. This information affected certain elements in planning, such as deciding on the selection of instructional objectives and related content, the depth of topic treatment and the variety of learning activities to meet the objectives.

Identifying Subject Content:

The knowledge base in organic chemistry is vast. When designing content for a lesson on “Introduction to Organic Chemistry,” the subject content must be defined in terms of introductory lessons, followed by more detailed activity layout and screen displays. For example, the following sequence provides an overview of the topic presented in Chapter 4.

Theme: Organic Chemistry

Topic 1: Introduction to Organic Chemistry (Organic compounds)

Lessons & Activities:

1. Definitions of Organic Chemistry
 - Organic chemistry
 - Oil spills
 - Definition of organic chemistry
2. Uniqueness of Carbon
 - Uniqueness of carbon
 - Molecular size of organic compounds
3. Bonding Arrangements

- Bonding arrangement of carbon
- Carbon bonded to four atoms
- Lewis structure of methane as an example
- Geometry
- Carbon bonded to three atoms
- Lewis structure of ethylene as an example
- Geometry
- Carbon bonded to two atoms
- Lewis structure of acetylene as an example
- Alternative bonding scheme

Thus, the lesson analysis used above can define the facts, concepts, principles, and rules, which need to be included in the final instructional format.

Instructional Objectives:

The fourth requirement of the Kemp instructional development model was the writing of the lesson's learning objectives or outcomes. In the case of the sample module lessons in Chapter 4, presenting the objectives provides three purposes; first, they offer a means to design appropriate instructional strategies; second, the instructional outcomes provide a framework for devising ways to evaluate student learning; and third, the outcomes will guide the learner when they access the module lessons.

Although the objectives are written in measurable behavioural terms, Bloom's Taxonomy was used to emphasize skills in the cognitive domain. Bloom labelled the lowest level knowledge, while the higher mental abilities were classified as comprehension, application, analysis, synthesis and evaluation. In this way, a means of deciding the optimum instructional strategy to master the objective can be determined and it enabled the establishment of objectives consistent with the instructional development process.

Sequencing Content:

The best order for delivering the organic chemistry module lessons was determined on the basis of assisting the learners to achieve the planned outcomes for the lessons; specifically, the content was sequenced in a concept-related sequencing, although *Private School* has the capability to guide the sequencing of material in a learner-related sequencing.

The content was initially sequenced by examining some of the current issues around organic chemistry, such as oil refining, oil spills, DDT, agricultural chemicals and polymers. While these concrete examples were used to pique the student's interest in organic chemistry, the remainder of the lessons were then organised by class relations and groups that are similar.

Designing Instructional Strategies and Delivery:

As with making decisions about how to sequence content, decisions had to be made about the best instructional strategies. This was particularly important given the fact that the students come to the college with varied backgrounds; some have a college diploma in technology, some have a general university degree, while others have a four-year honours degree, and some have very little chemistry background. The organic chemistry module was designed for students in the environmental engineering program who do not have a first year post-secondary chemistry course. These students are highly motivated and work well independently. As such, a well-designed instructional strategy for the module lesson had to find a way to provide meaningful relationships between the new knowledge presented in the instruction and the learner's existing knowledge.

Thompson (1991) described 5 ways computers can enhance the learning environment.

- First, learning can be made more practical, because there is great potential in computer simulation, control activities and word processing.
- Second, computers offer a greater flexibility than written material by allowing students to use different instructional modes or methods.
- Third, computers can improve the learner's access to learning by enabling a person with communication difficulties to be successful at

college -- thereby, enabling the college graduate to acquire the computer skills the workplace requires.

- Fourth, computers increase the focus on higher order skills by providing a mechanism to sequence content using Bloom's taxonomy.
- Fifth, it is possible to adapt the learning programs more nearly to the needs of the individual by customizing the resources provided to the student. Students with very little chemistry background will have the opportunity to extend their studies to help with abstract concepts.

Therefore, through the development of a lesson format on "Organic Chemistry," CBI offers many ways to present information based on the learner's performance and helps prepare the college graduates for the workplace.

Evaluation Instruments:

Another element of the Kemp instructional developmental model, which guided the development of the organic chemistry module, was deciding on methods of student evaluation. In essence, the instructional objectives dictate the selection of the activities and evaluation methods used in the module lesson format because they specify expected outcomes. As discussed previously, Bloom's taxonomy was used to write the instructional objectives, with the "acquisition of knowledge" as the central objective of the instructional program. Since this instructional development process involved the use of a computer-

based module lesson format, the cognitive-domain objectives were used to make decisions on evaluation.

Instructional Resources

The resources used are consistent with the Kemp model because they enhance learning and outcomes. The types of resources used in the module lesson format are all incorporated into the *Private School* database, including access to the Internet. (See Chapter 4). This will alleviate community college anxieties by being all-inclusive and user friendly.

Application of the Kemp Model

As mentioned in Chapter 1 and explained above, the Kemp model provided the structure and instructional development framework for developing the CBI module topic on “Introduction to Organic Chemistry,” one topic in an overall unit theme on “Organic Chemistry.” In fact, by incorporating the nine steps (as mentioned at the start of this chapter) into five phases, it became a major part of the process of developing the easy-to-use, computer-based module lesson format; this approach will enhance student learning while providing community college teachers with a non-threatening approach.

Component Two: The *Private School* Model

Private School is a computer-based, macro-adaptive learning environment into which standard digitally formatted curricular resources can be quickly and easily integrated to form courseware. The core of this IDS model is comprised of a user interface and the adaptive intelligence module. The user interface is a database front-end that displays the instructional material and then responds to the learner's actions. The adaptive intelligence module is made up of a set of Artificial Intelligence (AI) routines that monitor the learner's actions and adjust the presentation parameters. These two IDS components work together with cumulative learner data files and a relational database containing the instructional material in order to provide instruction that is individualized to match each learner's optimal study patterns.

IDS Structure

The IDS is structured much like a book. The course consists of an introduction, a set of lessons, and a final test. Lessons and activities are comprised of an overview, key concepts, special instructions, objectives and content, activities and evaluation techniques. The topic's lesson objectives form the basis on which the learner's mastery of the instructional material is measured.

There are four different aspects to the IDS adaptive intelligence module: (1) the study pattern intelligence determines the best presentation method for the learner; (2) the second intelligence aspect adjusts for learner characteristics such

as reading speed, reading level, the amount of text displayed, the amount of advice given to the learner, the type of learner control, and the type of feedback; (3) the assessment intelligence determines when the student has mastered the material; and (4) three conditions have to be met, such as the minimum number of questions that have to be asked, the calculated mastery level has to be equal to or exceed seventy-five and the last question has to be answered correctly. In order to adapt to all aspects of the IDS model, the IDS advisor provides ongoing individualized advice to each learner, much like a teacher, and acts as administrator and coach. In essence, then, this type of computer-based organizational structure is completely compatible with the format of the Kemp design model. One such topic, with its corresponding three lessons, was developed in Chapter 4.

Instructional Delivery

The instructional material delivered by the IDS is stored in its own relational database. The IDS uses the curriculum database contents to display instructional resources, to generate some of the IDS reference and navigational tools such as the table of contents and the keywords glossary, and to make hyperlink jumps (called hot spots) to related topics and lessons.

As well, the user interface for the IDS allows the learner to interact with the curriculum data and its design. Its design includes consideration for how the learner can use the IDS, how each type of instructional resource is presented to

the learner, and what tools and supplementary resources are offered to enhance and individualize the learning experience.

Application of *Private School*

Using both the Kemp model and *Private School* enables a teacher to design an instructional module lesson based on sound pedagogical principles, to take the learner's characteristics into consideration, to sequence the material in a concept-related manner, and to allow learners to investigate the new knowledge presented based on their own previous experiences.

Chapter Summary

The theoretical bases for the development of a CBI module topic and lesson format on "Organic Chemistry" was presented in this chapter. As discussed, the Kemp instructional development framework provides the basis for decisions made and applied to the computer format *Private School*, a platform that provides for individualized instruction, while being congruent with the instructional and evaluative skills required by the College Standards and Accreditation Council and Vision 2000.

Chapter 4 will be an actual IDS module "user guide" from a community college instructor's point of view. It will be the first in a series of six organic chemistry topics, entitled "Introduction to Organic Chemistry." It will involve a series of five phases: (1) the teacher familiarization phase (with *Private School*);

(2) the instructional planning phase (with accompanying examples of lessons and activities); (3) the data entry phase; (4) the student user phase; and (5) the student evaluation and progress phase (e.g., teacher follow-up and feedback).

CHAPTER 4

CBI Module User Guide Procedures

The topic and lessons presented in this chapter are examples of what will ultimately be six topics on the theme of organic chemistry: (1) Introduction to Organic Chemistry, (2) Comparison of Organic and Inorganic Compounds, (3) Classification of Organic Compounds, (4) Hydrocarbons, (5) Derivatives of Hydrocarbons and (6) Polymers. All phases of the topics are consistent with the Kemp instructional design model as presented in Chapter 3. When followed in a step-by-step process, the module phases will allow instructors to input their lesson using *Private School*.

The topic that will be presented in this chapter (in a user guide format) is the first topic entitled “Introduction to Organic Chemistry” and will include five phases: (1) Teacher Familiarization; (2) Instructional Planning; (3) Data Entry; (4) Student Usage; and (5) Student Evaluation and Progress.

Each phase will begin with “special instructions,” followed by an “overview” of the rationale and procedures in that phase, followed by the “key concepts” used in each phase – concepts that instructors should be familiar with. There will be some overlap and repetition, however, within the various phases given the nature of what needs to be understood by teachers, what needs to be

done by teachers, what needs to be done by students, and the various components and procedures of *Private School*.

Introduction to the User Guide

Special Instructions

This user guide will simplify the process for creating curriculum-specific courseware for the classroom. It will offer a natural extension to a teacher's already prepared resources and delivery methods. Each phase will have this section to highlight and pinpoint what to do and what to watch for during the process.

Overview

This user guide is made up of 5 phases:

Phase 1: Teacher Familiarization;

Phase 2: Instructional Planning;

Phase 3: Data Entry;

Phase 4: Student usage; and

Phase 5: Student Evaluation and Progress.

Phase 1 examines what the teacher needs to do before designing a CBI module. Specifically, instructors must become comfortable with using a word processor such as Word or Wordperfect, a graphics program such as Corel Draw or Paint Shop Pro, camera, scanner, Internet, as well as *Private School-Author* and *Private School-Reader*, the components of *Private School*. Phase 2 describes the

kind of teacher decisions that go into the instructional planning for the lesson and activities of the topic, such as the title, description, overview, summary, evaluation, objectives and activities (using multimedia). Some of the parameters required by *Private School* such as mastery level, level of difficulty and cognitive domain are also decided during this planning stage.

However, once the instructional planning has been completed, Phase 3 involves entering the material into *PS Author*. For example, the instructor must enter all the data completed in Phase 2 and set up the remaining parameters for *Private School*, such as paper style and run mode.

While Phase 4 describes student familiarization with *Private School*, giving concrete suggestions on how the teacher can accomplish this process, Phase 5 examines student evaluation and progress. For example, throughout the lesson, practice questions and quizzes are incorporated into the instructional material to aid the students in learning the material as well as a means for immediate feedback. As well, at the end of the lesson and topic there are tests that the teacher can use to track student progress while checking student progress at regular intervals.

Key Concepts

The module on “Organic Chemistry” contains all the lessons and activities that comprise the curriculum. The example used in this project to illustrate this user guide is Topic 1: “Introduction to Organic Chemistry.” It is made up of three

lessons and a number of related and cross-referenced activities. Figure 1 illustrates the structure of the module. The main concepts in Topic 1 are as follows:

- A module represents one theme of the total curriculum. In this example, the module is Organic Chemistry, which is one section of the chemistry course for the environmental engineering technology students at Conestoga College.

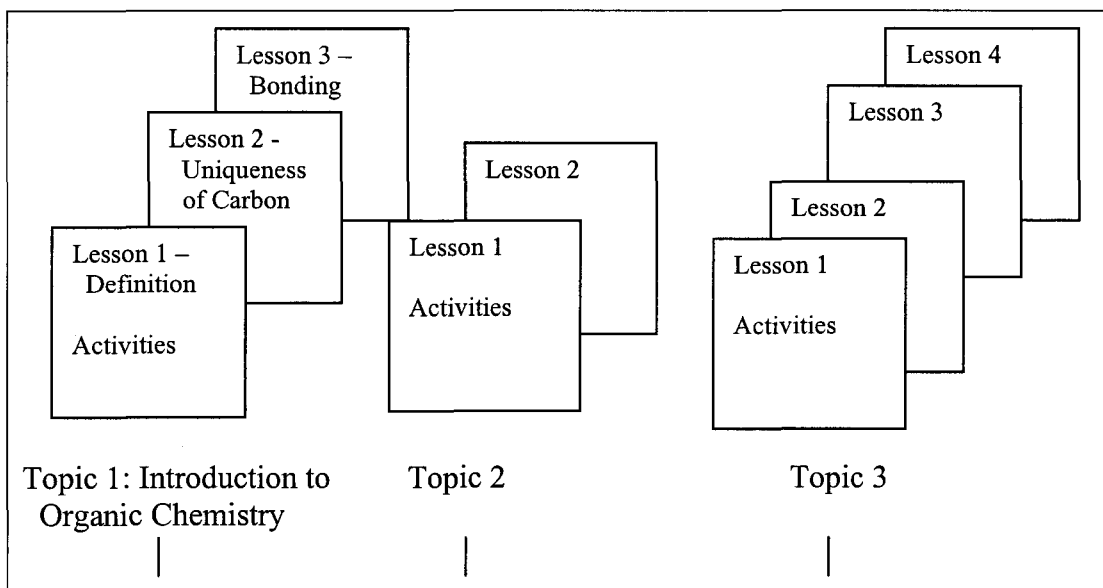


Figure 1: Structure of the Module

- A topic represents one component of the module theme, organic chemistry. There are six topics: (1) An Introduction to Organic Chemistry; (2) Comparison of Organic and Inorganic Chemistry; (3) Classification of Organic Compounds; (4) Hydrocarbons; (5) Derivatives of Hydrocarbons; and (6) Polymers. As mentioned previously, the first topic “Introduction to Organic Chemistry” will be used as the example for this user guide.
- A lesson can be thought of as the material that would be covered in a class. It has at least one objective and may have prerequisite lessons.
- An activity is the actual curriculum presented as a series of pages on the computer screen, each page with a set of resources to help the student learn the concept.
- A phase is one part of the instructional development package and the implementation of the CBI module.
- *PS Author* is a point and click authoring tool that guides the teacher through the creation of a *Private School* module.
- *PS Reader* is the runtime program that lets the student study the *Private School* module created using *PS Author*. *PS Reader* not only displays the multimedia curriculum in a clear and easy-to-use format, but also monitors the student’s actions and performance. Over time, *PS Reader*’s IDS gets to “know” the student and can then offer guidance to the student. It can even suggest strategies that can enhance the student’s learning potential (Nelson, 1998).

Phase 1: Teacher Familiarization

Special Instructions

It is very important that community college teachers feel comfortable working with the software and resource packages in order to maximize the multimedia approach to curriculum delivery. It will also save time during the data entry phase.

Overview

The teacher must become comfortable with a number of computer-related packages to use *Private School*. The richness of multimedia presentations comes from the variety of visuals along with audio and text that can be used to bring the material to the students. To begin with, teachers must become familiar with the key concepts, main components and the procedures of *Private School*.

Key Concepts

- *PS Author* is a Windows application. The teacher needs to possess the basic skills of working in a Windows environment such as: (1) understanding the parts of a window; (2) types of windows; (3) icons; (4) menu bars; (5) choosing and selecting items; (6) using a menu; (7) menu commands; (8) directories; (9) using a mouse; and (10) opening, closing and managing files.
- To make the lessons interesting to the students, the teacher needs to know how to browse the web, evaluate web sties and add web links to the curriculum.

- The teacher must be able to use a word processor that allows the document to be saved as an ASCII file -- the format that *Private School* uses for text.
- To enhance the visual part of the presentation, photographs are an ideal way to capture real life situations. For example, the lesson “Introduction to Organic Chemistry” uses a photograph of common organic compounds as an introduction. The teacher must have access to a good quality camera -- still life or digital -- to develop the visuals for the courseware.
- A colour flatbed scanner is required to digitize a photograph so it can be used within *Private School*.
- Any available graphics program can be used to create a diagram. It is important to keep the diagrams simple. The teacher needs to be able to create images, layer, add text, move and capture the graphic.
- The teacher uses a camcorder to record the video to be added to the curriculum. However, only a short segment of about 10 seconds should be used. A video capture card and capture software is used to convert the video to digital form and save it as an .AVI file.
- A sound clip using the sound recorder that comes with Windows or with a sound card can be used to add audio to *Private School*. The teacher needs to practice recording the sound clip before it is saved and used in *Private School*.
- *PS Reader* is the software that the student uses to run the module created by the teacher. The teacher needs to be familiar with what the student actually views. The teacher should use *PS Reader* to fully understand this software

from the student's point of view. *Private School* requires a Pentium 166 with a 16 MB RAM, 5 MB hard drive space for the program and more for the courseware, 640x480 SVGA video with 256 colour display, Soundblaster compatible sound card and Windows 95.

- *PS Author* is the authoring software that guides the teacher through the creation of the topic. It is while using *PS Author* that the teacher will need to use the files created with a graphics program, word processor, photographs and scanner, audio and Internet.

Phase 2: Instructional Planning

Special Instructions

The more detail that is included in this phase, the easier data entry will be in the next phase, Phase 3. If the teacher is working in a team, he/she must be very clear concerning his/her expectations and design decisions for the lesson and activities. Much time can be wasted having to edit the courseware.

When planning the instructional material, it is imperative to remember how the material is presented to the student. Small segments using a variety of instructional modes work the best. Teachers should keep things fairly simple the first time designing for CBI.

Overview

After becoming familiar with the tools required for preparing CBI, the teacher begins planning the topic. CBI uses a multimedia approach for delivering

information to the student. The teacher must rethink the presentation of the concepts using a more visual, small step approach. Since there is no immediate dialogue between the student and teacher while using *Private School*, the teacher must examine the curriculum from many approaches and consider a variety of presentation techniques in order to make the material clear to all students. The teacher must be creative with his/her planning to incorporate as many resources as possible to enhance student learning.

When instructional material is planned, two components must be written: (1) the curriculum design and (2) the *Private School* parameters. Curriculum design is much like what teachers are used to doing: writing titles, outlines, descriptions, overviews, summaries, evaluations, activities, available resources and objectives for the lesson. The *Private School* parameters are the general characteristics such as: mastery level, level of difficulty, nature of material -- theoretical or practical -- page appearance, and the student's thinking processes. These parameters guide *Private School* to assist the student's mastery of the material.

Key Concepts

Curriculum Design

Objectives: The objectives are written in measurable behavioural terms and each lesson can have up to four objectives.

Prerequisites: The teacher must specify any topics or lessons the student should have mastered before starting the current lesson.

Lesson Title, Overview and Summary:

The teacher writes a lesson title, lesson overview and lesson summary. The lesson overview describes how the lesson fits into the topic while the summary briefly reviews the material covered.

Activity: The lesson is broken into activities. An activity is the actual study content the student will see on the screen. The teacher designs the student activities that best teach the objectives to the student. Each activity needs a title. Each lesson can contain up to fifteen activities.

Resources: The teacher plans the resources for each activity, which may include: snapshots, video clips, audio clips, news stories, messages and slide shows. A slide show is used to demonstrate a process. A sequence of frames or images is displayed one at a time using a step-by-step example. This is ideal for showing the steps in a physical process or the steps required to solve a problem. Each image can have both a text description and/or narration.

Hotspot Resources:

Hotspot resources let the teacher provide additional resources to help explain specific words or phrases. These can be keywords, links to related web sites, video clips,

sound clips, snapshots, or hyperlinks. Keywords let the teacher add pop-up definitions to specific words or phrases on the activity. Each keyword can have an associated diagram that is displayed in the pop-up box. Web links let the teacher add sites that help explain the selected word or phrase. A video provides a student with the opportunity to see the concept or process in a real world context. A sound clip is a short segment of sound, music or spoken dialogue used to expand or explain the selected word or phrase. A hyperlink allows the student to jump from one activity to another related activity. All of these hotspot resources are automatically added to the index.

Evaluation: Since the delivery method is CBI, this limits the type of evaluation questions to multiple choice, true/false, or fill-in-the-blank. The teacher determines the best method to evaluate the learning objectives by writing practice, quiz, and test questions using these formats. Practice questions are available for the student to answer immediately after an activity is completed. These provide immediate feedback for the student to determine his/her own progress. Hints may be provided and feedback is used to explain why answers are correct or incorrect. Quiz and test questions are

used to measure how well the student has mastered the instructional material after each lesson and topic.

Private School Parameters

Nature of Material:

The teacher decides if the material is more theoretical or practical. A lesson is classified as theoretical if it focuses on the relationships between ideas and concepts, while a practical lesson might focus on facts and how they are applied. This guides the built-in advisor to help students prepare for the material in the lesson.

Level of Difficulty:

The teacher determines the level of difficulty of the lesson for the average learner. The level of difficulty may be classified as easy if it introduces some fairly simple ideas or concepts. Average difficulty might call on some previous knowledge of related material while introducing a few new ideas or concepts of its own. Challenging difficulty calls on extensive knowledge of previous material and introduces more complex ideas or concepts.

Cognitive Domain:

The teacher states the main type of thought processes the student must use to master the lesson. Aural or linguistic skills require the learner to process text, prose or verbal instructions. Mathematical or logical skills are used when the material is of a numeric form. Spatial or symbolic skills are necessary when diagrams, figures, or charts are used to convey the material. This guides the built-in advisor to help students prepare for the material in the topic.

Mastery Level:

The mastery level is the minimum mark the teacher will accept as an indication that the student has mastered the material in the lessons and topic. This mastery level is used during the quizzes and tests.

Examples:

As mentioned at the start of this chapter, the topic “Introduction to Organic Chemistry” will be used as an example to illustrate this “Instructional Planning” phase. This topic consists of three separate lessons and will illustrate where organic compounds are found in our environment as well as a brief discussion of the versatility and vast quantity of organic compounds and the bonding arrangements of carbon. See Figure 2 to follow.

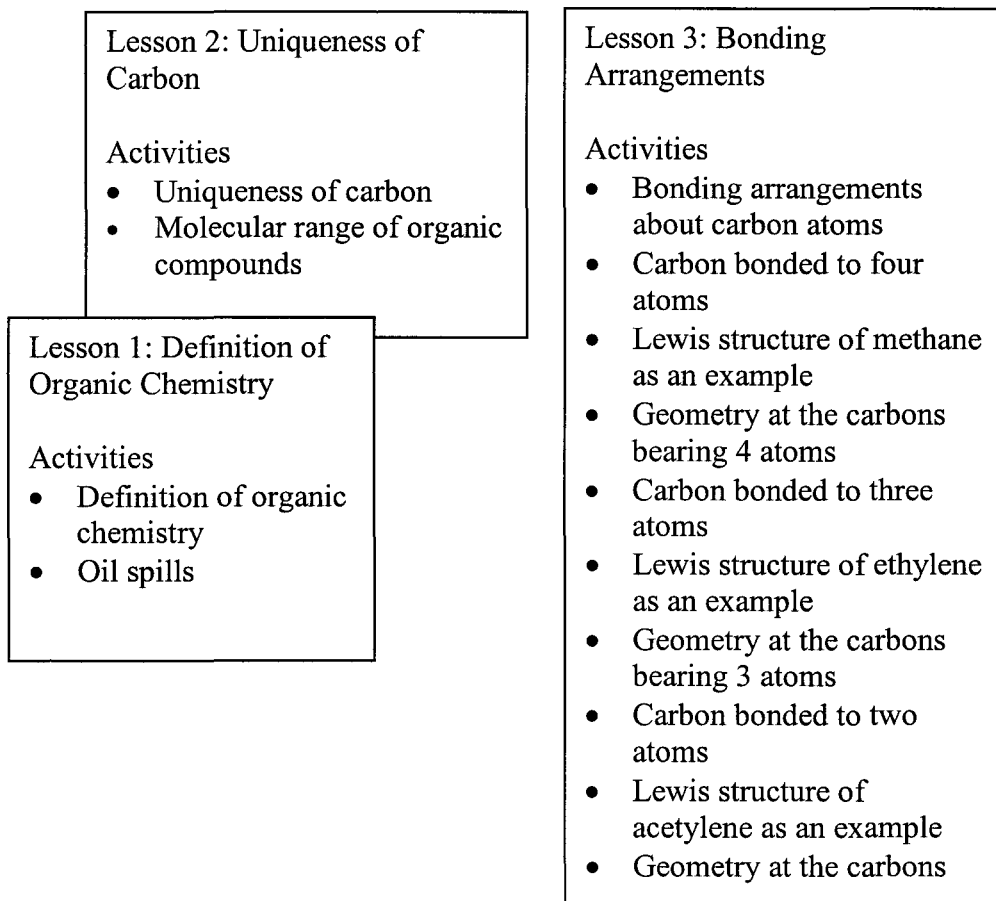


Figure 2: Lesson and Activities for Topic 1

Lesson 1: Definition of Organic Chemistry

Hints:

The lesson to follow is an example of the use of a scanned photograph. The same visual can be achieved with the use of a digital camera but the cost is much greater. If you plan to record the audio yourself, practice is needed. You might want to consider paying someone to do this to achieve a professional sound. In the second activity, a newsclip is used.

Private School actually does the formatting of the text to look like a newsclip. Placing a BITE in the text enables the learner to click on it to reveal more text.

Description:

As mentioned above, Topic 1 (Introduction to Organic Chemistry) is being used as an example so that community college teachers can follow the CBI and *Private School* process. The first lesson of this topic is “definitions.”

Objectives: On completion of this lesson the student should be able to:

- Recognize common commercial products as being composed of organic substances
- Define organic chemistry

Overview: By understanding the definition of organic chemistry, we can apply this to the world we live in.

Summary: Organic compounds all contain carbon. There are a few carbon-containing compounds not included in this description such as carbonates, cyanides, carbon monoxide and carbon dioxide.

Prerequisites: Understanding of the periodic table. Recognizing common elements and their chemical symbols.

TheoreticalDifficulty-easyAural/linguisticActivities

- (Organic Chemistry)

Visual: Snapshots – household or “man-made” organic chemicals-ASA, plastic toy, Vaseline, make-up, and nylons – “natural” organic chemicals – oil, gasoline, perfumes.

Text: What do all these compounds have in common? Bite: They all contain carbon.

Audio: The starting material for everything you see in this photograph is either natural gas, petroleum, or coal. Many of the common products that we use every day come from these substances.

- (Oil Spills)

Visual: Snapshot – oil tanker Exxon Valdez

Text: Newsclip – Oils spills and what is being done to prevent them and clean up after them.

Hotspot: Web link to oil spills, prevention and cleanup.

- (Definition of Organic Chemistry)

Text: The chemistry of carbon compounds other than carbonates (CO_3^{2-}), cyanides (CN^-), carbon monoxide (CO) and carbon dioxide (CO_2).

Evaluation: Quiz (Appendix A)

Lesson 2: Uniqueness of Carbon

Hints:

This lesson is an example of a slideshow where all three media: visual, text and audio are used together. The text changes automatically after the audio is complete.

Description:

The second lesson of the topic “Introduction to Organic Chemistry” is the “uniqueness of carbon.” This lesson develops further carbon’s ability to form large molecules. It gives more examples of the CBI and *Private School* process.

Objectives: On completion of this lesson the student should be able to:

- Identify organic compounds in nature
- Show the vast uses of organic compounds
- Identify why carbon is important to life.

Overview: Organic compounds are essential to all phases of life from fuels for heating, clothing and foods we need to sustain life.

Summary: Carbon has the ability to bond to form immense arrays and long chains.

Organic compounds can have very large range of molecular masses.

Prerequisites: Molecular weight and molar mass

Practical

Difficulty – easy

Aural/Linguistic and Spatial/Symbolic

Activities:

- (Uniqueness of Carbon)

Visual: Scanned pictures of molecular models of the three allotropes of carbon: diamond, graphite and C₆₀, Buckminsterfullerene.

Text: Carbon forms strong bonds with other carbon atoms resulting in the formation of molecules with long chains and rings of carbon atoms.

Bite-₂ Carbon is the only element able to form immense arrays of compounds.

Hotspots: When the model of diamond, graphite or C₆₀ is clicked upon, the name of the compound is revealed.

- (Molecular Size of Organic Compounds)

Slideshow made up of visual, text and audio:

Visual: Methane molecule and Polyethylene molecule

Text: (1) Methane (methane molecule is highlighted)

(2) Molar mass is 16 g/mol

(3) Polyethylene (polyethylene molecule is then highlighted)

(4) Molar mass is very large

Audio: While Frame (1) of text is on the screen, the student will hear: methane gas is the smallest organic compound with a molar mass of 16 grams per mole. Frame (3): Polyethylene is an example of a much larger organic compound.

Frame (4): It has a very large molar mass which varies depending upon the length of the chain.

Hotspot: Polyethylene – revealing polyethylene polymers are spun into fibres such as

Dacron and Fortrel. When made into Mylar particles, PET becomes the base for recording tape.

Evaluation: None

Lesson 3: (Bonding Arrangements)

Hints:

Lesson 3 is an example of the use of hotspots to make more information available to the student. The examples used throughout this lesson are linked to a more detailed description about each molecule. The development of the activities can be repeated with recurring themes.

Description:

Lesson 3 develops further the design of CBI by incorporating the use of visuals and audio to enhance the learning process.

Objectives: On completion of this lesson the student should be able to:

- Identify the three basic bonding arrangements associated with carbon in organic molecules
- Describe the characteristics of each bonding arrangement
- Show an example of each

Overview: The properties of organic molecules depend upon their structure. To help explain organic compounds, their geometric arrangement and bond angles are useful pieces of information to know.

Summary: Each carbon atom forms four covalent bonds to neighbouring atoms that can

be arranged as single, double or triple bonds.

Prerequisites: Octet rule, covalent bonding, hydrogen bonding, Lewis structures.

Theoretical:

Difficulty: Average

Aural/Linguistic and Spatial/Symbolic

Activities:

- (Bonding Arrangements about Carbon Atoms)

Visual: C-C single bond, C-C double bond and C-C triple bond

Audio: Carbon atoms exist in three basic bonding arrangements. One, carbon atoms can be bonded to four atoms or groups of atoms via four single bonds. Two, carbon atoms can be bonded to three atoms or groups of atoms. Here, there must be a double bond and two single bonds. Three, carbon atoms can be bonded to two atoms or groups of atoms. In this case, a triple bond and a single bond would be required.

- (Carbon Bonded to Four Atoms)

Visual: Methane molecule – the structural formula

Text: The simplest of all organic compounds is methane, CH₄.

Hotspots: Methane – revealing- is the principal component of natural gas.

- (Lewis Structure of Methane as an Example)

Visual: Lewis dot structure of methane (electrons from carbon are drawn in red and the electrons from the hydrogen are drawn in blue).

Audio: Methane is an example of an organic compound in which a carbon atom

forms four single covalent bonds.

Text: Carbon forms four single covalent bonds.

Graphic hotspots: Red dot – reveals – electrons shared from carbon atom.

Blue dot – reveals – electrons shared from hydrogen atom.

Text view hotspots: Covalent – reveals – covalent bond is the chemical bond

Between two atoms that share a pair of electrons.

Lewis structure – reveals – a diagram representing the valence electrons and

Covalent bonds in a molecular species.

- (Geometry)

Visual: Molecular model of methane molecule. H atom is white and C atom is black.

Text: Methane molecule adapts a tetrahedral shape to keep the four bonding pairs equi-distant from each other. Each H-C-H bond angle is 109.5° .

Audio: The bonds are oriented toward the four corners of an imaginary tetrahedron.

The carbon atom is at the centre. The bond angle formed from H-C-H is 109.5° .

Methane is an example of a hydrocarbon, a compound composed of only C and H.

It is also the simplest alkane, i.e., a hydrocarbon with only C-C single bonds. Topic 4 will discuss in detail the classification of organic compounds.

Graphic hotspots: White atom – reveals – white coloured atom denotes a hydrogen atom. Black atom – reveals- black coloured atom denotes a carbon atom.

Text hotspot: Tetrahedron – a tetrahedron is a regular four-sided solid, having congruent equilateral triangles as its four sides. Bond angles – reveals – the angle

formed by the bonds between two atoms that are bonded to a common central atom.

- (Carbon Bonded to Three Atoms)

Visual: Structural formula of an ethene molecule.

Text: Ethene or ethylene, C_2H_4 , contains a double bond between two carbon atoms and single bonds between carbon and hydrogen.

Hotspots: Ethylene – reveals- ethylene is used commercially as a plant hormone to induce ripening of fruit. It is also the starting material for the production of polyethylene, the most common plastic.

- (Lewis Structure of Ethylene as an Example)

Visual: Lewis dot structure of ethylene (electrons from carbon atom are drawn in red and the electrons from the hydrogen atoms are drawn in blue).

Text: Each carbon of ethylene can form a double and two single bonds.

Audio: Ethylene is an example of an organic compound in which carbon forms a double bond. Notice four electrons are shared between the two carbon atoms while only two electrons are shared between a carbon and hydrogen atom.

- (Geometry)

Visual: Molecular model of an ethylene molecule. H atom is white and C atom is black.

Text: Ethylene is trigonal planar. Each bond angle is approximately 120° .

Audio: Ethylene C_2H_4 , is made up of two carbon atoms and four hydrogen atoms.

Both carbon atoms and all four hydrogen atoms lie in the same plane. This geometric arrangement about each carbon atom is called trigonal planar. The bond

angles in the plane were about 120° . Ethylene is an example of an alkene (a hydrocarbon containing a C-C double bond), which will be discussed in Topic 4.

- (Carbon Bonded to Two Atoms)

Visual: Structural formula of an acetylene molecule.

Text: Acetylene, C_2H_2 , has a triple bond between the two carbon atoms.

Hotspot: Acetylene – reveals – acetylene is a gas used in welding.

- (Lewis Structure of Acetylene as an Example)

Visual: Lewis dot structure of acetylene (electrons from carbon atoms drawn in red and the electrons from the hydrogen atoms are drawn in blue).

Text: Carbon forms a triple bond in acetylene. The molecule is linear with bond angles of 180° .

Audio: Acetylene, C_2H_2 , forms a triple bond. Six electrons, or three pairs of Electrons are shared between the two atoms of carbon. This gives acetylene a linear Shape. Acetylene is an example of an alkyne.

- (Alternative Bonding Scheme)

Visual: $=C=$

Text: An alternative bonding scheme about a single carbon centre is the formation Of two double bonds. The simplest molecule showing this is alkene, $CH_2=C=CH_2$. The bond angle about the central carbon atom is linear; the H-C-H angle is approximately 120° .

Phase 3: Data Entry

Special Instructions

This data entry stage can be the most time consuming step when developing CBI. However, the more detail that goes into the planning, the faster and easier this process will be. At first, as with any new technique, a lot of time is spent getting familiar with data entry keystrokes. It is a good idea to have a large block of time, 100 hours set aside to concentrate on this. Graphics can be the most time consuming step to master especially if you haven't worked with a graphics package before. Just familiarizing oneself with Paint Shop Pro took 20 hours.

Overview

After the instructional material has been planned, there are two parts to the data entry: (1) preparing the resources for *Private School*; and (2) entering the data into *PS Author*. The resources must be prepared in a format that *Private School* is capable of using. Instructions will now be provided on how to prepare each resource file, followed by instructions on entering data into *PS Author*. For more detail see Nelson (1998), the user guide written to accompany *PS School*.

Preparation of Resource Files

Text Resources: The text is written using any word processor that can save documents as ASCII files. Each activity should be saved as a separate document.

Visual Resources: Any bitmap editing package or paint package can be used to create diagrams. A flatbed scanner is required to digitize photographs. A video capture card and software package is needed to grab still images from video. The still image is saved as a bitmap file (.BMP). Depending upon where the image is being used, a bitmap editing package is used to crop or resize the image as follows:

- standard image on text page: 220x200 pixels
- long image on text page: 220x290 pixels
- wide image on text page: 480x180 pixels
- small image on text page: 100x100 pixels
- graphics page image: 600x370 pixels
- for a news story: 167x140 pixels
- for a definition: 240x200 pixels (max)
- for slides: 300x265 pixels
- for snapshots: 200x200 pixels (min)
- 400x400 pixels (max) (Nelson, 1998)

The *Private School* palette (pscolour.pal) is then applied to the image and the image is saved as a bitmap file (.BMP).

Video Resources: Record the video using a camcorder. Select a short segment of about 10 seconds in length. Use a video capture card and use the capture software to convert the video to digital form. The *Private School* palette (pscolour.pal) is applied to the video. The video is saved as an .AVI file. If a digital video camera or screen capture recorder is used, the file is also saved as an .AVI file. A video editing program is used to apply the *Private School* palette (pscolour.pal) to the video and the video is resaved as an .AVI file.

Audio Resources: Record the sound clip using the sound recorder that comes with Windows or with a sound card. A sound card gives a clearer audio sound. A 10 second clip is a good length to use. The following parameters are recommended by *Private School*:

- voice recordings: 8 bit, 22 MHz, monotone
- music recording: 16 bit, 22 or 44 MHz, stereo

(Nelson, 1998)

The audio clip is saved as a .WAV file.

Data Entry into *PS Author*

Once the resources are compiled, the teacher is ready for data entry into *Private School*. *PS Author* is a point and click authoring tool that guides the teacher through the creation of *Private School* modules, topics, lessons, activities and evaluation. It walks the teacher step-by-step through the set-up of these components.

There are two views the teacher can use: the Planner and the Editor. The Planner guides the teacher through the set-up of these components. The Planner assists with setting lesson properties and entering lesson contents and test questions. The Editor view shows the actual data stored in the database. The Editor is important for fine tuning the module, for importing large quantities of existing text, spell checking whole sections of the module at one time or for correcting errors or omissions.

The teacher uses the Planner to enter the data into *PS Author*. Information is supplied when requested by the Planner. There is no need to be concerned with the format of the data that makes up the module. Once the teacher has set the format parameters for *Private School*, it remains consistent throughout the module design.

The Planner is organized much like a book. The teacher can move page by page through it by clicking on the page corners in the bottom left and right corners or pressing the Page Up or Page Down keys on the keyboard. By clicking on the tabs found across the top or down the right side of the screen, the teacher

can flip through the sections. By selecting the particular section from the list down the left side of the screen the teacher will be taken directly there.

For example, when entering data for the module “Organic Chemistry” the following keystrokes would be performed.

Entering Module Details

1. Click on the Module tab found down the right side of the screen.
2. Click in the Details box, which is listed down the left side of the screen.
3. Type in the Module Title (Organic Chemistry).
4. Click in the Description box and type in a short description of what this module is about. (This module will introduce the student to the vast field of organic chemistry. A comparison of inorganic and organic chemistry will be followed by a discussion of the classification of organic compounds. Uses of organic compounds and nomenclature will be introduced throughout the module.)

Defining the Module Operation

1. Click on the Module tab found down the right side of the screen.
2. Click in the Operation box, which is listed down the left side of the screen.

3. Select a run mode by clicking the radio button beside the desired option (study mode).

Defining Module Appearance

1. Click on the Module tab found down the right side of the screen.
2. Click in the Look box, which is listed down the left side of the screen.
3. Select a Page Appearance by clicking the desired sample page (textured).

Defining Mastery Level

1. Click on the Module tab found down the right side of the screen.
2. Click in the Mastery box, which is listed down the left side of the screen.
3. Slide the arrow up or down to point to the desired Mastery Level (75%).

In this easy-to-follow way, the data is entered into the Planner, a component of *PS Author*. Once the data is entered, using the Planner, the teacher is ready to fine-tune the module using the Editor. The teacher spell checks the data, proofs the study activities, and makes any required changes.

Then, once all the text, resources and program parameters are entered and proofed in *PS Author*, the teacher must set up *PS Reader* to run the module. To do this the *PS Reader* icon must be on the desktop for each module that has been created along with the command line for each icon pointing to its module.

If not using the operating system Windows 95, see *Private School User Guide* (Nelson, 1998). *Private School* will run under Windows 98. If using Windows 95, the following steps are completed:

1. Right click somewhere on the desktop.
2. Select shortcut from the New menu.
3. Click the Browse button and change to the c:\program files\ps school folder.
4. Click on the reader97.exe file.
5. Press OK.
6. Press the End key on the keyboard to move to the end of the command line.
7. Press the space bar and then type in the full path to the module (i.e. the drive and directories where it is stored). The complete command line should look something like: c:\program files\psschool\reader97.exe c:\modules\organicchemistry.psm
8. Press the Next button.
9. Change the Reader97 prompt to the name of the module (Organic Chemistry).

10. Press the Finished button.

PS Reader is now ready to be used. To use *PS Reader* double click on the module icon that is on the desktop.

Glossary of Terms

- An *ASCII file* is the type of file used for text.
- A “*Bitmap file*” (.BMP) is the type of file used for pictures.
- An *AVI file* is the type of file used for audio.
- The *desktop* is the workspace on the computer screen.
- A *document* is a file you create when you save your work in a program.
- An *icon* is a picture representing a program, disk drive, file, folder or other item.
- The *menu* is a list of commands that appears at the top of most windows.
- The *operating system* is the software that runs the computer. The operating system controls programs and hardware.
- The *path* is the means of navigating to a specific location on a computer or network.
- The *window* is the rectangular portion of the screen that displays an open program or the contents of a folder or disk (Microsoft, 1998).

Phase 4: Student Usage

Special Instructions

It is important not to assume that all students are computer-literate. The students all come to college with various backgrounds that might or might not include computer training. Some students, even if they have used a computer, might be hesitant about using such a program.

Overview

Once the module, topics, lessons and activities have been entered into *Private School*, it is now ready for student use. Just like the time it took the teacher to familiarize him/herself with *Private School*, it is important to spend time with the students and the software. Gather the students in a computer lab that has access to the module. Determine the computer literacy level of the students. If the students are very weak, the teacher will need to go over some of the preliminary computer knowledge needed to start the program and move around within it.

Once the students have the courseware running, spend time with them as they get to know the software, making sure they try to access the resources and built-in help. The students are now ready to use *Private School* for instructional purposes.

PS Reader can be installed on a network or system to which the students have access. The module can be copied onto CDs making sure all the files and

drivers are listed on the resources list. The CDs can be signed out from the library and taken home. In this way, the student can study at his or her own pace and at a time convenient to him/her. Also, the audio files can be played without the use of headphones.

Phase 5: Student Progress and Evaluation

Special Instructions

It is very important for the teacher to build into his/her work schedule the extra time needed to monitor student progress. The teacher does not have scheduled in-class time, but answering queries can take time. It is necessary to answer the questions as soon as possible so the student's progress is not hindered.

Overview

Even though the student works on his/her own when progressing through the courseware, the teacher needs to monitor the student's progress. The teacher should set times to meet with each student either in person, using e-mail, or over the phone. One of the main drawbacks to independent learning is the motivation factor. Quite often if a student does not have someone guiding him/her through the CBI, he/she will not keep to a routine and will find other things to do instead of his/her lessons. Only very highly motivated students will complete this form of instruction without any assistance.

Besides keeping the student on track, the teacher needs to find out if the student is having difficulty with any of the concepts. While planning the curriculum, the teacher has tried to envision many of the difficulties the student might experience. Until the courseware is used a number of times, there will always be some questions and need of further explanations. Initially, I envision the total time required for the teacher under this teaching scenario to be longer compared to the “normal” teaching time. Besides time required for student familiarization, there will be the time for monitoring, re-evaluation and changes to the courseware.

Lastly, the teacher needs to decide on the evaluation of the module. One possibility is to use the topic tests or module tests for marks. The student’s marks from these tests would be saved in a file the teacher could access. Another choice would be to have a test on the module at a scheduled time and location on campus. One benefit would be to help the teacher see which objectives the students were able to grasp and which areas were causing difficulties for the student.

Chapter Summary

This chapter has been an IDS module lesson “user guide” for the database *Private School*. Five phases were used to describe the steps the teacher and student must go through to prepare the instructional curriculum and be ready to use *Private School*.

Phase 1, “Teacher Familiarization,” took the teacher through the steps they need to perform before the actual lesson planning, such as being familiar with a word processor, graphics program, camcorder, scanner and computer terminology, as well as the IDS *Private School*, while Phase 2, “Instructional Planning,” discussed the writing of titles, overviews, summaries, objectives, activities and evaluation for the module. Besides the curriculum decisions, the teacher must determine certain parameters for *Private School* such as level of difficulty, cognitive domain, mastery level and nature of the material. An example, “Introduction to Organic Chemistry” was included in the latter phase to demonstrate the planning that went into preparing instructional material.

“Data Entry,” Phase 3, took the teacher through the steps of entering the data into *PS Author* and the authoring part of *Private School*, while Phase 4, “Student Usage,” looked at familiarizing the student with the database program, *Private School*. The last phase, Phase 5, “Student Progress and Evaluation,” guided the teacher in ways to monitor student progress and evaluate learning outcomes.

CHAPTER 5

Summary and Recommendations

Discussion

This project has been a presentation on the development of a CBI module topic format (as presented in Chapter 4) for use in the context of CBI. Using both the Kemp instructional development model and the CBI platform *Private School*, an IDS database, the module topic format involved five phases as applied to the first topic in a series of six topics on “Organic Chemistry” entitled “Introduction to Organic Chemistry.”

As discussed in Chapter 1, all those involved in the community college system over the past few years, have experienced significant changes and the results of restructuring due to political, social and economic factors. One such factor was the demand by employers for computer-literate graduates, particularly in the environmental engineering sector. Given this and other factors (such as decreased government funding), there had to be an examination of creative and alternative approaches to traditional course presentation (e.g., in this case organic chemistry) that provided graduates with the generic skills and the technological tools appropriate for the workplace.

As a result, the main problems underlying this project were: (1) a need for a computer-based instructional format that could be used with computer technology to teach organic chemistry; and (2) a means to alleviate community college instructors' fears and anxieties about using computer technology in their teaching.

When designing the sample topic lessons, learner characteristics, abilities and experiences were taken into consideration. A lesson analysis was used to define the facts, concepts, principles and rules and included. Along with the presentation of the content contained in the lesson, the unit learning objectives were written in measurable behavioural terms and content was sequenced in a concept-related approach. Moreover, lesson activities were used in such a way as to optimize the use of multimedia. As well, student evaluation was a combination of multiple choice, match-up, and true/false questions. The resources used in the activities included graphics viewing, video clips, audio clips, news stories, messages, filmstrips, sequences, snapshots and web links.

Conclusions

Computer technology can be an exciting learning tool for the student and teaching medium for the instructor. It invites teachers to examine what they teach and how they approach the process. Using *Private School*, an IDS database, lessons can be formatted in such a way as to incorporate the various backgrounds and skills of the community college student.

As mentioned throughout this project, CBI can provide resources for learning which are effective, richer, available for extended hours, and open to a wider range of college students. CBI also provides students with greater control over timing and pace, and there is more likelihood of resources suiting the style and stage of each student's learning. Teachers using CBI can expect to gain time to provide individual attention to students, as well as devote more effort to some other aspects of the teaching and learning process (Doughty, 1995). For all these reasons, CBI is an excellent tool to teach community college chemistry, a subject that contains many abstract and difficult concepts for the student to grasp.

The CBI five-phase lesson format (as seen in Chapter 4) serves the purpose of providing a concrete example for other college teachers, no matter what their subject area. This is an important consideration because all those involved in post-secondary education at the community college level see a need for student and teacher training and development in the use of such technology.

However, the sharing of that information across and within educational sectors must be improved. CBI takes a great deal of time and resources to be developed. The educational system simply cannot afford a number of piecemeal projects that are not effective teaching tools and are very costly for the system to develop and use. As well, using CBI means specific requirements such as the need for individual computers, the use of networks and file servers for software or communications, security and reliability of the system. In addition, the whole area of copyright laws and the use of the Internet must be clarified.

Nevertheless, even given these issues and considerations, CBI is a dynamic instructional and learning tool and I envision full-scale acceptance by community college teachers once they try it.

Recommendations For Further Study

This project was focused on the development of a module topic and lesson format suitable for a CBI database platform, in this case *Private School*; many other applications are possible. I would like to make the following recommendations for further study, namely that:

1. the CBI lesson data on “Introduction to Organic Chemistry” be inputted into the *Private School* database format;
2. once the data is entered, it be introduced to a group of students to evaluate;
3. there be further study to determine whether students have effectively achieved the learning objectives of this CBI application;
4. any needed revisions be made to the lessons in *Private School*;
5. the lesson and activity format be introduced to other community college teachers for evaluation for possible use in other subject areas; and
6. after improving the lesson format (based upon student and teacher feedback), the whole module on “Organic Chemistry” (all six

topics) be inputted into *Private School* – with the process of revision and evaluation being ongoing.

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APPENDIX A: (Sample Evaluation Questions)**Lesson 1: Quiz**

True/False

1. The following compounds are classified as organic compounds: C_2H_4 , $MgCl_2$, CO_2 , $C_3H_7NH_2$.
2. Organic chemistry deals with compounds of carbon.
3. The major sources of organic compounds are natural gas, petroleum, and sea water.
4. The main reason for the existence of millions of organic compounds is the ability of carbon atoms to bond together into long chains and rings.

Lesson 3: Quiz

True/False

1. The simplest compound composed of only carbon and hydrogen is called methane and has a formula of CH_4 .
2. To achieve the greatest separation, the four hydrogens of methane occupy the corners of the geometric shape called a tetrahedron.
3. Most importantly, organic compounds contain carbon-carbon covalent bonds.
4. The chief component of natural gas is methane.

5. Carbon can form single, double, triple, and quadruple bonds between two carbon atoms.

Topic Test:

1. The bonding in carbon-containing compounds is primarily
- a. ionic
 - b. covalent
 - c. magnetic
 - d. electrovalent
2. Organic compounds are characterized by containing _____ covalent bonds.
- a. carbon-hydrogen
 - b. carbon-carbon
 - c. both carbon-hydrogen and carbon-carbon
 - d. neither carbon-hydrogen nor carbon-carbon
3. Organic compounds can contain _____ bonds.
- a. only single
 - b. only double
 - c. only triple
 - d. single, double, or triple
4. Carbon almost always appears with _____ covalent bonds in organic compounds.
- a. 1
 - b. 2
 - c. 3
 - d. 4

5. The simplest hydrocarbon is methane. Its formula is _____.
- a. CH_4 b. CH_3
- c. CH_2 d. CH
6. The hydrogen on the methane molecule occupy the corners of the geometric shape of a(n) _____.
- a. cube b. tetrahedron
- c. octahedron d. icosahedron