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# *The effects of computer aided thinking (CAT) software on students' achievement and learning experience*

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# The Effects of Computer Aided Thinking (CAT) Software on Students' Achievement and Learning Experience

By

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## ABSTRACT

This study examined the effect of computer-aided thinking (CAT) on students' achievement and learning experience in studying a biochemistry[1] unit. CAT offers different activities, tasks and questions according to the learner's thinking style based on the mental self-government theory. The aim was to investigate the effectiveness of using CAT with the thinking styles feature on students' achievement and learning experience over computer aided instruction (CAI) without the thinking style feature when both teaching methods were used to replace the traditional chemistry instruction.

A study was conducted to standardize the Sternberg-Wagner Self-Assessment Inventory of thinking styles for the United Arab Emirates (UAE) environment. The study showed that the thinking styles inventory was reliable and valid for use in identifying the thinking styles among a sample of UAE high school students.

The development of the CAT system went through two phases. The goals of the first phase were to provide computer-aided learning material for two chemistry lessons, Oxygen and Ozone, to explore how students would respond to it with regard to their learning experience and to get feedback from the students to help build the CAT system which embeds the thinking style theory in the second development phase. Finally, an experiment was conducted using two randomly selected groups of students. One group studied the lessons using CAT and individuals were offered learning activities based on their thinking styles. The other group studied the lessons using CAT but without the thinking style feature.

At the end of the experiment, quantitative and qualitative data were gathered and then analyzed. The results showed that learning with the CAT tool during the period of this experiment had significant effects on the experimental students' learning experience. This research is the first known study to explore the way that thinking styles can be used to sequence teaching material and activities for the purpose of individualized instructions. The research will inform UAE in helping teachers improve the learning process by conducting student-centred teaching.

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[1] Biochemistry refers to the field concerned with studying the chemical reactions which take place in bodies of living things in addition to the compounds formed by them.

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**CHAPTER 1**

**INTRODUCTION**

**1.1    Background**

Computers have imposed themselves on different fields of modern life.  The increase in the capabilities of computers, along with reduced cost, has influenced various forms of computer-delivered instruction (Brown, 2001).   This can be seen in education as well as in other disciplines (Passerini 2000).

The computer is considered one of the most important technologies to be deployed in the educational domain over the past twenty years due to its wide ranging capabilities. The computer is used in the educational field in many ways. It can be used by management to organize school matters (like setting the schedules of different subjects, financial work, assessment, files, and employees and students affairs), or by teachers as an assisting technique in instruction, or to perform different kinds of teaching and learning activities. As an instructional tool it combines the characteristics of many technologies into a single technology.  It integrates text, picture, sound, animation, movie clips and provides control over the presentation of the material. While other educational technologies may be capable of achieving certain and specific goals, a computer can be programmed to support and deliver many different instruction patterns. Another main distinction between computers and other technologies is their ability to interact with the learner (Caffarell 1987) thus making learning an active process. When used well, the computer can be a very powerful educational tool (Bell et al. 1998).

In the literature, several acronyms are used to describe educational software including: computer-based instruction (CBI), computer-aided instruction (CAI), computer-based teaching (CBT) and computer-aided learning (CAL) (Lambert et al. 1997).  It is possible to have nine acronyms if a word is picked from each of the following three groups:

- Computer;
- Based, Aided, Assisted;
- Learning, Teaching, Instruction.

Many educators have made a distinction between the three terms: learning, teaching and instructing. For instance, Anderson and Burns (1989, cited by Al Khalili et al. 1996) concluded that teaching is part of instruction. However, all nine possible acronyms represent learning 'from' and 'with' computers, which has been the primary use of computers throughout the history of educational computing. Learning from and with computers involves programming the computer to inform and instruct the student, to direct the activities of the learner toward the acquisition of pre-specified knowledge or skills, and help students construct knowledge.

Since the advent of microcomputers and instructional software for education, computer-assisted instruction (CAI), computer-assisted learning (CAL), or computer-based instruction (CBI) has provided a supplemental instructional method in schools (Parr 2006).

## 1.2    Computers in the UAE

### Use of Computer as a Subject

The Ministry of Education in the United Arab Emirates sought to include the teaching of computers as an obligatory subject in 1989. Thus, computer subject is taught to $10^{th}$ and $11^{th}$ grade students two periods a week. The focus in the curriculum was on computer literacy. In the year 2000/2001 computers were introduced to intermediate grade students. While the goal for the intermediate students remained as computer literacy, the goal for secondary students was advanced to networking, internet, web design and applying computer applications in everyday use. Currently, students from $1^{st}$ to $9^{th}$ grade have computer classes once a week based on self learning multimedia material.

### Use of computer as an Educational Mean

The UAE Ministry of Education started using computers as a learning tool in different subjects in the school year 1997/1998. The 12th grade science major students were provided with educational software for physics and mathematics. The arts major students were provided with educational software for Arabic and English subjects. Most of them were drill and practice programs that were based on the behaviourism

principle, the reinforcement of stimulus-response association. The quality of the programs was poor (Hasan 2002).

**The Electronic Future Project in Abu Dhabi Educational Zone**

Abu Dhabi Educational Zone has started the Electronic Future Project, which is considered to be the first of its kind in the region. The project aims to develop methods of education and means of teaching through using advanced technology and modern electronic knowledge tools, and through creating a new mechanism to facilitate the communication process among all those involved in the educational process: administrators, teachers, students, and parents. The project's document declares that one of the goals of the Electronic Future Project is to provide a rich educational environment, which will enable students to extend their understanding and improve their creative and critical thinking skills and their ability to solve problems and make decisions. Other goals include improving the teaching and learning process, developing and improving the acquisition of knowledge and skills, thus creating a society able to face the challenges of the Information Technology Age (Greaves 2004).

Bork (1979) predicted that by the Year 2000 the major way of learning at all levels, and in almost all subject areas, will be through the interactive use of computers. Although this is not completely fulfilled, using computers in education deserves continuing attention. However, it should be mentioned that if the computer is to be effective, educators should match the CAI type to the intended learning goals (Rowland 1988).

**1.3    Motivation for the Research**

In any computer-aided learning systems, the learners should be considered the core of the educational process by giving them the opportunity to respond to and interact with the academic materials, and taking individual differences into account. This enables the learners to progress according to their individual pace of learning (Al E'naizi 1989). The computer has the potential to facilitate development of students' decision-making/problem solving, data processing skills, and communication skills. Through the computer, students may gain access to extensive knowledge and broaden their exposure to diverse views and perspectives; hence, providing students the opportunity

to become active participants in an increasingly global and interactive world (Whitworth & Berson 2003).

Since teachers started using computers to support the teaching of different subjects, researchers have tried to find out the effect of their use on students' achievement. The effectiveness of the computer in classroom settings is supported by many studies in different subject areas including: science (Brophy 1999), mathematics (Tseng 1999; Chang 2000), social skills (Stern and Repa 2000), concept understanding (Glickman 2000), reading (Soe et al. 2000), writing (Goldberg et al. 2003), Biology (Soyibo and Hudson 2000), and chemistry (Yalcinalp 1995).

Coley et al. (1997) reviewed the research on the effectiveness of educational technology in U.S. schools and found that studies showed students in technology-rich environments experienced positive effects on achievement in all major subject areas from preschool through to higher education and for both regular and special-needs students. Coley concluded that the research strongly supports the use of technology as a catalyst for improving the learning environment.

Kadiyala and Crynes (1998) reviewed and summarized the research findings on computer assisted instruction over the fifteen years preceding their research. Many of the studies they reviewed were themselves reviews and meta-analyses, which cover hundreds of studies. The interest of their review was to gather hard statistical evidence about the use of information technology for better learning, time on tasks, costs, and learner/teacher attitudes. The study covered a range of student types and subject matter but excluded disability related learning/teaching studies:

- Mathematics (Interactive Algebra I, II & III at college level and for Grades 1-12)
- Science (Grades 1-12)
- Social Science (Grades 7-12)
- Microprocessor systems and interfacing (Electrical and Computer Engineering students)
- Language Arts (Reading and writing) (Grades 1-12)
- Combined subjects

- Vocational training

- Information processing, communication and presentation skills (Grades 4-6).

- Surgical Nursing (Undergraduate level)

- Dental study (Undergraduate and advanced level)

- Pharmaceutical and Allied Health Occupation education (Undergraduate level)

The research findings strongly support the use of technology as a catalyst for improving the learning environment. Educational technology has been shown to stimulate more interactive teaching, effective grouping of students, and cooperative learning. A few studies, which estimated the cost effectiveness, reported time savings of about 30%. At first, professors can be expected to struggle with the change brought about by technology. However, they will adopt, adapt, and eventually learn to use technology effortlessly and creatively.

One of the subjects that many students consider complex is chemistry which has implications for the teaching of chemistry today. Many of the concepts studied in chemistry are abstract, and are inexplicable without the use of analogies or models. The primary barrier to understanding chemistry is that chemistry instruction occurs predominantly at the abstract symbolic level (Dorothy 1999). In science texts for elementary schools, some of the first concepts presented include concepts such as elements and compounds, and chemical and physical changes. The distinction between elements and compounds cannot be easily made without resorting to explanations using molecular models representing compounds and elements.

How can computers be used to enhance chemistry learning?
Computers can be used at various points within the chemistry curriculum including but not limited to:

- Displaying simulations. Computer simulation is especially appropriate when experiments are difficult, expensive, time-consuming, or dangerous to perform.

- Using animations and videos, e.g. animations of molecular concepts. Textbooks lack the capability of displaying dynamic processes. Because they create images of chemistry by using words, tables, graphs, and still photos, but

they are missing the dynamic element, which is so important in understanding chemical processes and concepts. Animation and video are exactly the domains in which computers are most capable of performing (Dori' and Barnea 1993).

- Exercise and feedback to assessing the student's level of comprehension.
- The growing number of databases specifically oriented to chemistry (e.g., periodic tables and chemical structure systems) means that data can be quickly transferred among various applications. For example, element properties can be copied from a periodic table database and pasted into a spreadsheet, and the final output graph embedded within a word processor document. This integration of applications can catalyze student interest and activity (Bell et al. 1998).

The use of the computer can potentially enhance students' understanding, make learning an active process, provide cost benefits and improve learning efficiencies.

The current study proposes a new way to use the computer to enhance learning in general and chemistry learning in particular.

## 1.4 The Problem Being Studied

Our world recently witnessed huge information challenges with political, economical, social, cultural, and educational dimensions. These information challenges with their various dimensions formed the basis from which launched many calls for the necessity of reforming the educational system with all its inputs, processes, and outputs, especially because the current system is very slow when it comes to the amazing acceleration of information and communication technology. Accordingly, many countries are racing towards reforming their educational systems in order to prepare their citizens for a techno-guided universe, e.g. Hong Kong, Taiwan, China, Korea, Japan, Singapore, Australia, New Zealand, Canada, and UAE (Loong 2003, Al Mousa 2002). These reforms have gained enormous political and financial supports in various developing and developed countries worldwide. Millions, if not billions of dollars, are spent on developing technology plans in order for change to take place in the new educational model, which is based on technology and on providing networks,

computers, and educational programs in general and higher education. For example, the USA spent 6.9 billion in 1999 to provide public schools with networks and computers (Kleiman 2000). The new model calls for a change from a teacher-guided model, from one which considers the book as the only source of knowledge, into a learner-guided model dependent on different sources.

Abu Dhabi Educational Zone undertook this challenge by starting the Electronic Future Project. What has already been accomplished in this project can be considered a contribution. The electronic solution presented by the project has to overcome some of the current problems in the teaching process. The most important problems include (1) the dependence of the educational practices inside the classroom on old assumptions about learning and how it takes place, and (2) using teaching methods that neither meet the needs of all learners nor consider their individual differences like their thinking styles and their preferable learning styles. By way of illustration, lecturing and rote learning is the common method used by most teachers in Abu Dhabi schools (Haidar 2000). E-learning in the Electronic Future Project can achieve its goals if it adopts modern theories which will lead to fundamental changes in education (Al Saleh 2002). One of the changes could be based on student's mental model where the students are considered the core of the teaching process. E-learning needs to make students the basis for teaching and instruction by introducing teaching that harmonizes with their needs, way of thinking, and preferred style of learning. Accordingly, there is a need to explore how the computer can be used to vary between teaching methods and tailored for individual differences of learners.

This study is important for three reasons. The first is the scarcity of local studies which focus on using the computer in teaching scientific subjects in general and chemistry in particular that support the Educational Zone's project in Abu Dhabi. The second is the unavailability of international studies that use the computer in introducing the content based on the student's thinking styles according to Mental Self-Government Theory (Sternberg 1997). This study is considered the first in this respect although there are some studies which explore computer-assisted teaching based on learning styles of the student. The third is that although there are some teachers who know how to individualize teaching and provide differentiated curriculum for students according to students' preferences. However, the minority of

these teachers does not have the time to individualize the instruction or differentiate the standard curriculum, nor resources to provide lessons that integrate text, pictures, sounds, graphics, animation, and video. Accordingly, this study was conducted to investigate the effectiveness of educational software that can help teachers individualize the teaching and present student-centred learning in accordance with the student's thinking style based on the mental self-government theory, and to determine the effect of such a tool has on student achievement.

Why the mental self-government theory?

- The theory of mental self-government is considered one of the newest theories that help in academic enhancement. The goal of the theory of mental self government is to integrate the various approaches of understanding styles, and to provide new directions for theory applied to educational practice. It has been found to be useful in classroom settings. The literature on styles indicates that teaching with students' thinking styles in mind improves students' academic performance, enhances their achievement, and helps to predict school achievement (Costa 2001), (Sternberg and Grigorenko 1995, 1997; Cilliers and Sternberg 2001; Zhang and Sachs 1997; Zhang and Sternberg, 1998).

- Robert Sternberg, the theorist who developed the theory of mental self-government, is a well known scholar in psychology. After extensive research in different theories on styles (e.g., learning styles, cognitive styles, and personality styles) he proposed his theory of the mental self-government (Sternberg 1997).

- The theory has not yet been explored in the field of educational software.

- An educational model called School Wide Optimum Model (SWOM) has been developed as part of this project. SWOM focuses on teaching the students in harmony with their mental model. The students' mental model is their profile that consists of the students' thinking style, learning style, and zone of proximal development (ZPD). This study enables the author to explore one aspect of the student's mental model which has not been experimented.

## 1.5    Importance of the Study

The importance of this study springs from the role it plays in introducing learning which goes in accordance with learners' thinking styles by using the computer.  The way in which the computer presents the material to the learners differs according to their thinking styles based on the Mental Self-Government Theory.  Although there is some evidence of success when the theory is applied in the classroom, to the best of the author's knowledge there is no previous study that has dealt with computer-based learning using the theory.  The studies about the theory are detailed in chapter 4.

The importance of this study can be listed as:

- This study is the first of its kind that deals with teaching biochemistry using educational software that distinguishes the teaching method according to the learners' thinking style based on Mental Self-Government Theory.  This study may uncover the effectiveness of this method in designing educational software and its positive impact on students' learning.

- This study goes along with education development in the UAE that calls for the necessity of using the best ways of teaching that harmonize with the student's mind (Al Sharhaan 2000).

- This study conforms with the development related to information technology in Abu Dhabi Educational Zone.  The educational software used in this study was designed to assist students in their learning.  Furthermore, it is assumed to help most of the teachers who do not know how to individualize teaching according to students' thinking styles, and to provide differentiated lessons that integrate text, pictures, sounds, graphics, animation, and video clips.  This helps to achieve the goal of Abu Dhabi Educational Zone in its pioneering project of the electronic future.

- The study highlights the role of the teacher as mentor and guide in the teaching process inside the classroom, not as the only source of knowledge.

- An educational model called School Wide Optimum Model (SWOM) has been developed and its exploration and investigation is of strong personal interest to the author.  SWOM focuses on teaching the students in harmony with their

mental model. The Students' mental model is their profile that consists of the students' thinking style, learning style, and zone of proximal development (ZPD). Some studies have been conducted in respect to designing software based on student's learning style and ZPD level, e.g. Clariana (1997), Ross and Schulz (1999), Luckin and du Boulay (1999), and Arroyo et al. (2003). On the other hand, the thinking styles based on the mental-self government theory has not yet been adopted by any educational software and no study has been conducted. So, this study enables the author to explore one aspect of the student's mental model which has not been experimented and fills in the gap of using the SWOM mental model components in software design.

- This study attempts to investigate the issue raised by Chen (2002) that empirical evidence indicates that not all learners can benefit from hypermedia learning, and that research into individual differences suggests cognitive styles have significant effects on student learning in hypermedia programmes. Therefore, the importance of this study dwells in exploring the possibilities of presenting a solution to educational software in order to be effective in teaching all students.

## 1.6  Contributions

In this study an educational computer program named CAT (Computer-Aided Thinking) was developed to be used by 12th grade students in learning biochemistry lessons. The program adapts a theory of thinking styles called the Mental Self Government Theory. This theory states that people have preferred ways of thinking. It suggests thirteen different thinking styles. The main three thinking styles, which are the legislative, judicial, and executive, were used in the design of the program in this study. The program was used to individualize the students' learning experiences by offering different tasks and activities which meet the needs of each of the three thinking styles.

The study showed that the computer can help teachers in assessing students' preferred styles of thinking, then delivering the teaching material according to their styles to help them learn effectively. Offering the activities tailored to students' thinking styles

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through the computer caused the students to more likely like the teaching method contained in CAT and more likely know their preferred way of learning. In order to improve students' achievement significantly, it was not enough to just provide students with different activities that match their thinking styles, instruction and assessment have to be included in the matching process too. The study also showed that the use of computers in classroom learning enables teachers to spend time guiding, facilitating, advising and discussing with students.

## 1.7    Structure of the Thesis

The thesis has nine chapters. Chapter two is a literature review in the general area of CAI. The research on styles and their relevance to CAI is discussed and highlighted in this chapter. Chapter three focuses on the Mental Self Government Theory. Chapter four describes the methodology used in this project. Chapter five provides the details of the process of standardizing the self-assessment inventory of thinking styles for the UAE environment. Chapter six describes the phase 1 prototype implementation and study. Chapter seven elaborates on the CAT system concept and design. Chapter eight presents the main case study and the results. Finally, chapter nine summarizes the thesis, states the contributions and conclusions, and proposes future area of research. The structure of the thesis is given is Figure 1.1.
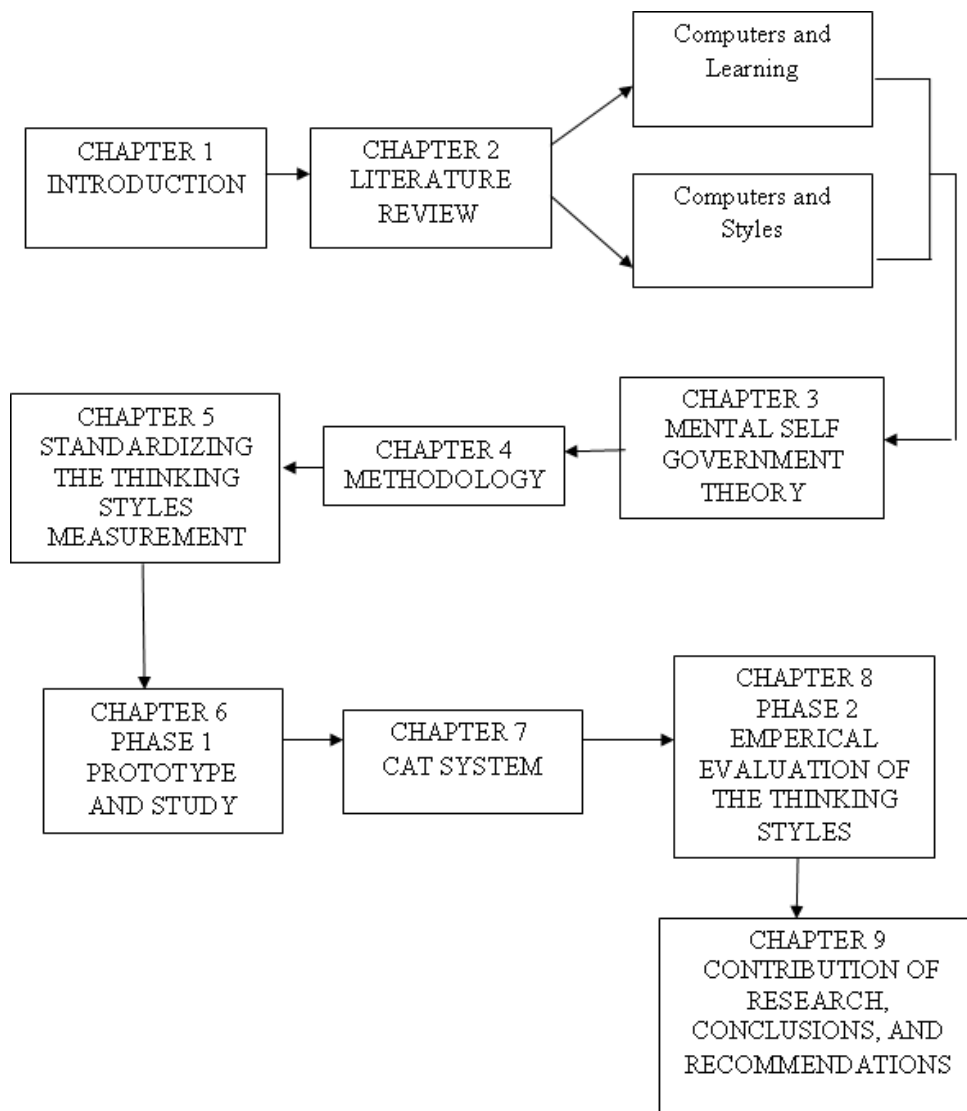
Figure 1.1: Structure of the Thesis

# CHAPTER 2
# LITERATURE REVIEW

## 2.1 Computer-Aided Learning

### 2.1.1 Review of Previous Studies and Findings

Existing research on how computers in the classroom affect academic achievement offers varying conclusions. Some research indicates that computers may aid achievement. Other research concludes that computers are of questionable effectiveness. However, it should be mentioned that Joy and Garcia (2000) cautioned researchers and instructional designers when interpreting results of media comparison studies, and stated that findings of no significant difference are often misinterpreted. If a researcher has not carefully controlled the most likely factors explaining variance in student achievement then it is unlikely that a significant difference between experimental and control groups will be found. Likewise, if a significant difference is found in poorly designed research then it may be that the result of one or more uncontrolled variables, such as a specific method of instruction, was presented to the experimental group only. Any media comparison or design that fails to control the variables, such as the size of the control group and the experimental group, and variance between the two groups such as prior knowledge, learning styles, ability, instructor effects, method of instruction, and learner familiarity with technology, may produce inconclusive or susceptible results (Joy and Garcia 2000).

The available studies and findings which were conducted in the 80s regarding the effect of using CAI on students' achievement vary. Kulik et al. (1983) analyzed 48 studies on the effects of computer-based teaching on secondary students in mathematics and science. Thirty-nine of these studies reported better scores on final examinations for students with computer-based teaching than those in conventionally taught classes. The other nine studies reported that students in conventionally taught classes did better in their final examinations. Later, Kulik et al. (1985) analyzed 28 studies that examined the effectiveness of CAI with elementary students. CAI related

instruction appeared to improve student achievement on average by 0.47 standard deviations over students receiving conventional instruction.

With the aim of demonstrating that computer assisted learning can provide better instruction in community colleges, O'Shea (1983) cited a project called the Timed-shared Interactive Computer Controlled Information Television Project (TICCIT) that exerted a significant positive impact on student achievement in both mathematics and English composition. Students who completed courses under the TICCIT program generally attained higher post-test scores than similar students in lecture classes. The final evaluation concluded that the TICCIT program had confirmed the potential of assisted instruction as an effective resource in student learning.

The efficient use of computers in education in terms of its effect on students' motivation, attitude, confidence, and achievement has been the focus of various studies. Wise (1986) conducted a study on the effect of the use of computer simulation on achievement and attitudes of secondary school students in physics. The following teaching strategies were compared: 1) simulation before using the lab, 2) simulation after using the lab and 3) traditional teaching using the lab. Three classes from 10th grade were randomly allocated to the different strategies. The results showed that students who used computer simulation before the lab and after the lab scored higher than the students who used only the traditional teaching method.

In a meta-analysis of 38 published and unpublished studies and reports, and 44 dissertations, Roblyer et al. (1988) concluded that computer applications had been efficiently used in education and they have an undeniable value and an important instructional role to play in classrooms in the future. Price (1989) conducted a survey and observed student progress in a middle school science project where CAI was used as a tutorial and research tool. It was concluded that the use of CAI in this way encouraged an overall improvement in motivation and interest in the science research project. In the same year, Yaakub (1989) conducted a meta-analysis of the effectiveness of computer-assisted instruction in technical and training. The purpose of the study was to quantitatively analyze a group of studies that individually investigated the effectiveness on achievement of CAI in technical education and training as compared to traditional instruction, with the intent of determining the

overall effectiveness of CAI in this field. Relevant studies were selected from major databases in the civilian and military sectors. Yaakub (1989) concluded that CAI that involved higher order learning in technical education and training was more effective than traditional instruction. On average, students in the CAI class would outperform their colleagues taught in the traditional manner by 0.35 standard deviation. Intelligent computer-assisted instruction (ICAI) was significantly more effective than non-intelligent computer-assisted instruction for higher order learning in technical education and training. This finding provides support for the benefits of using ICAI in teaching higher order subject matter and higher order skills.

Lane (1990) conducted a study in Tennessee University in the United States aimed at using computer in simulating costly, accurate and dangerous experiments. The study showed that the computer was very effective in complementing the lab's role in performing experiments of Quantum in physics, but it does not replace it.

Ryan (1991) analyzed the results of 40 independent studies that looked at the effects of CAI in reading and mathematics in elementary schools. Ryan found that CAI raised academic achievement on average by 0.309 standard deviations.

In a comprehensive study, Kulik (1994) conducted a meta-analysis of 12 CBI meta-analytic studies based on 546 individual studies. He reported that students learned more in less time when they received computer-based instruction, and that students liked their classes more and developed more positive attitudes when their classes include computer-based instruction. These findings suggest that students who engaged in CBI performed significantly better than students who did not. However, Kulik (1994) found in some studies, CBI did not have positive effects in every area.

Pressley (1995) cites many studies, e.g. Braasell (1987), Linn & Songer (1991), and Mokros & Tinker (1987), which indicate that microcomputer-based laboratory experiences not only increase student comprehension of science materials and graphic skills, but also increase student confidence in their knowledge and skill. Wood et al. (1995) cites numerous studies (e.g., Malouf 1988, Relan 1992, Yang 1992), which indicate that with properly designed activities; motivation actually increases when computers are used in instruction.

Christmann et al. (1997) conducted a meta-analysis of the effect of CAI on academic achievement in secondary education from 1984 to 1995. The research indicated that for the 12 year period (1984 to 1995), secondary students exposed to CAI showed higher academic achievement than 57.2% of those students exposed only to traditional instruction. However, the researchers concluded that CAI had a greater effect in the 1980s than it did in the 1990s (through to 1995).

The literature also has support for CAL in medical education. Lambert (1997) concludes that despite the improvement in learning attributed to CAL is not sufficiently large to be pedagogically important, there appears to be agreement that CAL has potential to be a major component of future medical education.

Reeves (1998) reviewed the literature examining the effectiveness and impact of technology and media as educational tools in K-12 schools around the world. He organized the studies in his review along two dimensions: Studies which examine the use of technology to convey instructional material (e.g., instructional television, computer-based instruction) which he referred to as learning "from" media and technology, and studies that examine the use of technology as cognitive tools (e.g., databases, multimedia presentation software) which he referred to as learning "with" media and technology to support the development of high-order mental skills. A limitation of this review, as Reeves stated, is that the vast majority of the published research on the effectiveness of media and technology in schools was conducted in English-speaking countries such as Australia, Canada, the United Kingdom, and the United States of America. Reeves concluded that computers as tutors have positive effects on learning as measured by standardized achievement tests and are more motivating for students. On the other hand, intelligent tutoring systems have not had significant impact on mainstream education because of technical difficulties inherent in building student models and facilitating human-like communications. Furthermore, the use of computer-based cognitive tools is also shown to be an effective aid in the development of higher-order learning skills. This is particularly true when the cognitive tools are employed within a constructivist classroom context.

Al Mutairi (1998) conducted a study to explore the effect of using a computer program in science on 6th grade students' achievement in Riyadh, KSA. The sample consisted of 60 students. The outcomes of the study showed that there were statistically significant differences in the averages of students' achievement between the two groups in favour of the experimental group in understanding and remembering according to Bloom taxonomy (Bloom 1956). There were no differences in the application level.

In an evaluation of a multimedia project that took place in an elementary school over an extended period of time, Penuel et al. (2000) reported that both the observation results and the performance task findings suggest that the multimedia project has made a significant difference in teaching and learning. Students learn not only technology skills but also academic content, critical thinking, problem solving, and teamwork skills.

Roschelle et al. (2000) reviewed literature examining effective educational applications of computer-based technology. Over 80 sources are cited in their study, referencing articles that examine the use of computer technology in a broad range of contexts. The subjects of these studies range from pre-kindergarten to 12th grade students, and vary considerably on a wide range of other demographic characteristics.

Overall findings of the review indicate that computer-based technologies are potentially effective instructional tools.

Lowe (2001) reviewed several meta-analyses from the 1980s and 1990s and concluded that each of the reviewed meta-analyses showed a small positive effect over conventional instruction. However, he interestingly stated that research indicates that the CAI advantage is reduced to an insignificant level when CAI and conventional instruction are delivered by the same instructor. The review also concluded simulation and tutorials as supplements to conventional instruction appear to be the most effective. This is supported by Emerson and Mosteller (1998) who concluded that hypermedia functions best as a supplement to, rather than a replacement for, good teaching.

There are many studies that supported small positive effects. Christmann and Badgett (2000) analyzed data from 26 studies comparing the academic achievement levels of college students who had classes that used traditional methodology with those of college students who had classes in which CAI was used as a supplement to traditional methodology. They found that typical student achievement moved from the 50th percentile to the 55th percentile when exposed to CAI. In a different age group, Blok et al. (2002) analyzed published quantitative studies in English and Dutch that dealt with the effectiveness of using computers to teach reading to children aged 5 to 12. Their meta-analysis found a small positive effect of computer-assisted beginning reading instruction compared to instruction without CAI. The effect was much larger for English language than for Dutch, possibly, according to them, because CAI helps students address the difficulties of English spelling and letter-sound relationships. Holdich and Chung (2001) developed an interactive computer tool 'HARRY' to assist, share and guide children aged 7-11 years develop their narrative writing skills. The tool helped students in the writing process (brainstorming, planning, composing, transcribing, reviewing, revising and editing). Using 'HARRY' solved the problem students have in coping with several tasks simultaneously, by taking over the task of remembering, giving students time to reflect, then presenting different aspects of the process when requested. The model of the writing process that underpins 'HARRY' is the same as the model adopted by mature writers except that the editing process is a separate and final stage of the writing process. The researchers concluded that 'HARRY' effectively combines the four models that are essential to the task of teaching writing.

Barhoom (2002) conducted a study in which the objective was to know the effect of using CAI on 10th grade students' achievement in geosciences and environment, the scientific stream, and on their attitudes towards the computer in government schools supervised by the Ministry of Education in Jordan. The sample of the study consisted of 92 students (boys and girls). The study outcomes showed statistically significant differences in the achievement in favour of the experimental group. The study also showed that students had positive attitudes towards the computer.

Finally, in a more recent analysis, Goldberg et al. (2003) conducted a meta-analysis of 26 studies conducted in 1992–2002 focused on the comparison between k-12 students

writing with computers vs. paper-and-pencil. The results of the meta-analyses suggest that, on average, students who use computers when learning to write are not only more engaged and motivated in their writing, but they produce written work that is of greater length and higher quality.

In contrast to Lane's (1990) study, Wood et al. (1995) concluded, as a result of some studies in science that computer-based instruction is no more effective than traditional laboratory exercises, and that computer-based instruction should only be used as a supplement to regular instruction and with the guidance of a teacher. Huxford (1999), in a study comparing traditional instruction modes with a CAI mode, argued that the results suggest CAI is not as useful for instruction as previously believed. In the study, college students from the different groups did not perform significantly differently on measures of cognitive and affective learning. In contrast to Al Mutairi (1998) findings, Clinkscales (2002) conducted a study to examine the effectiveness of computer-assisted instruction compared to the traditional instruction of a classroom teacher in mathematics. The students did not show any significant difference in retaining the information taught. Overall, the results suggested no significant difference between the two methods of teaching. Clinkscales concluded that both methods have positive features that bring the best out of instruction. In support of Clinkscale's (2002) conclusion, Jenks and Springer (2002) reached the same conclusion that CAI appears to be at least as effective as conventional instruction. In answering the question: Is CAI an effective teaching tool? Jenks and Springer (2002) suggested that the answer should be, "Yes. But don't throw out conventional instruction for CAI". This is because the literature further suggests CAI is best delivered as a supplement to conventional instruction. Furthermore, Chen (2005) conducted a study to examine whether the use of computer-assisted instruction in EFL (English as a Foreign Language) grammar instruction could improve student learning outcomes and reduce beginning EFL students' written error rates. The experiment was conducted at a private college located in southern Taiwan. The major finding on overall error rates demonstrates that there was no statistical difference between the control group and the experimental group. However, findings on individual error categories suggest that CAI as an instructional aid may have produced a significant effect on reducing students' error rates in the error category of nouns and prepositions. Although the supplemental CAI program in this study did not produce

statistically significant effects on reducing beginning EFL learners' overall written error rates, no evidence was found suggesting that CAI had a negative effect on learning. Chen concluded that CAI as a supplement to traditional instruction learning could be at least as good as traditional instruction. Furthermore, Parr (2006) reviewed the literature on computer-assisted learning, particularly its effects on learning outcomes with respect to literacy and numeracy. He concluded that the literature on computer-assisted learning does not provide a clear picture of the value of this form of learning. Parr added that the analyses of quantitative measures of outcomes seem to imply that computer-assisted learning, on average, is no more effective than other types of interventions and may be less so. However, results with respect to enhanced learning outcomes are variable. He gave some reasons for that such; partly because of the nature of the research; partly because of the constantly changing and varied nature of computer-assisted learning but, more likely, this is because of widely varying contexts and the complex and interactive influences operating when computer-assisted learning is introduced into such contexts.

## 2.1.2 Different Uses of Computers in Computer-Aided Learning

### 2.1.2.1 Tutorial Mode

- Linear tutorials: These tutorial programs present the pages one by one similar to a printed textbook. The time consumed to finish the lesson content differs from student to student. It depends on the student's speed and the feedback the tutorial offers in response to the student's errors (Al Mousa 2002). The evaluation of student responses by the computer presents no problem as long as they are expected to match the given answer exactly. The teaching material is relatively easy to change, and one can accumulate statistics on students' performance (Jonassen 2000).

- Branching tutorials: These are unlike linear tutorials in the way that the student's response is used to control the material that is presented next. The lesson content that is presented to the student depends on their progressing speed. The purpose of these programs is to provide new knowledge to the

student. Hence, branching tutorials encourage rote learning. They consider learning as the acquisition of knowledge rather than experience and knowledge construction. The efficiency of instruction has priority over the quality of learning (O'Shea 1983).

### 2.1.2.2 Generative Computer-Assisted Learning

Generative systems are drill and practice programs that are oriented towards providing a drill rather than a tutorial, and therefore do not compete with the branching programs (O'Shea 1983).

### 2.1.2.3 Simulations

One of the most widely used techniques of computer-aided learning is simulation, or computer as a laboratory. The use of computer simulations for science teaching, as Perkins et al. (1995) cites, is increasing steadily. When the computer simulation is used as a laboratory, it allows for multiple repetitions of experiments and for student redesign of experiments. It provides students with the opportunity to do experiments that otherwise would be either too expensive, too dangerous, time consuming or too costly to carry out in the classroom (Perkins et al. 1995, Pressley 1995). With simulations, students can observe chemical reactions, body movements in different settings, or detect energy generated from an atomic bomb. The simulation approach is based on the educational philosophy "learning by seeing" (O'Shea 1983). Virtual reality is one of the promising simulation programs.

### 2.1.2.4   Educational Games

In edutainment programs, learning objectives are embedded in the form of games. It encourages students' exploration, imagination, and solving problems.

### 2.1.2.5   Problem-Solving Programs

They are applications that aim to develop thinking and the ability of analyzing problems. The educational philosophy of the problem-solving approach is 'learning by doing' (O'Shea and Self 1983).

### 2.1.2.6  Dialogue Systems

These systems construct a dialogue with the student in a natural language, where the system asks and the student answers and vice versa, with the emphasis on gaining knowledge by the student.

The teaching strategy is similar to the Socratic dialogue instructional method. O'Shea and Self (1983) and Al Mousa (2002) raise four problems with dialogue systems:

- These kinds of systems are very costly programs.
- They may take a considerable time to understand and respond to a natural language.  This may effect the tutorial interaction.
- Writing dialogue programs requires man-years of expert programming. Teachers cannot do this task.
- They need highly sophisticated techniques in order to be able to engage in meaningful tutorial dialogue and let the computer to converse freely in natural language.  So, in addition to artificial intelligence techniques, they need natural language recognition systems.

### 2.1.2.7  Computer as a Tool for Thinking and Knowledge Construction

Jonassen (2000) argues, from a constructivist perspective, that the ways in which computers are used in schools should change from their traditional roles of computer-as-teacher to computer-as-partner in the learning process.  This new role replaces the learning from computers and learning about computers with the learning with computers, which means using the computer as a tool to learn with.  This tool will support:

- Knowledge construction.
- Explorations.
- Learning by doing.
- Learning by conversing.
- Learning by reflecting.

### 2.1.3  The Inappropriate Use of Computers as Instructional Media

In their study "A View of the Research on the Efficacy of CAI", Jenks and Springer (2002) concluded that the way CAI is delivered can impact its effectiveness.

Steinberg (1991) finds in a survey of over 213 CBT packages that 82% of them used page turning during more than half of the course.  In 38% of the packages surveyed, no questions were asked.  71% of the packages that included questions were multiple choice, 23% matching and 59% true-false.

One of the most extreme views towards CBI was Clark's (1983) view.  In his article, "Reconsidering research on learning from media", he concludes that there are no learning benefits to be gained from employing specific media to deliver instruction and that media do not influence learning under any conditions.

He uses 'vehicle' as a metaphor for media that deliver instruction but do not directly influence student achievement any more than the truck that delivers our groceries and causes changes in our nutrition.  Only the content of the vehicle can influence achievement.

In response to this:  First of all, Roblyer's (1988) meta-analysis study was conducted in two years time after Clark's article and published in 1988, and had a different conclusion.  Secondly, the inappropriate use of computers as instructional media, which Steinberg found in the survey mentioned earlier, is the reason that Clark considered different media, with the computer being among them, as a vehicle and a truck that delivers with no influence.  As a matter of fact, vehicles differ in size and power, which make a difference in their usefulness.  If the content is appropriate then the influence would vary with the various vehicles which deliver it.  Thirdly, the generalization that media is delivery vehicle for instruction and does not directly influence learning is defeated by the use of the book as an instructional media.  The book, throughout history, is vehicle which has strong influence in people's learning. Computers and books are similar in a way.

Moreover, computers have features that are not found in books, like the interactivity with human.  Books cannot recognize the reader's mental model, whereas an appropriate computer package can meet different mental models needs.  Computers are -at least- a step ahead of books in respect to this.  Finally, theorists like Vygotsky (1986) and Bruner (1966) place large emphasis on the role played by culture and its

systems of symbols (e.g. its language, sciences, books, diagrams, pictures, and other artifacts) in forming the child's intelligence. Such systems have a dynamic, structuring effect on learning and development.

Underwood (1990) states that the difference between Clark's views and the findings in favor of computers might be simply accounted for in term of the poor experimentation in the studies Clark considered. Critical variables, such as the impact of individual teachers and the matching of groups, have been widely ignored.

### 2.1.4  How are the Computers Used in Teaching and Learning?

**Computer as a Productivity Tool**

One of the usages of computers is to help students, teachers, and administrators to produce work and accomplish some tasks. Word-processing, computer-aided design, graphics and paint programs are some examples of productivity tools (Jonassen 2000).

**Computer as a Management Tool**

Teachers employ the computers when they are devising lesson plans, when it is time to calculate grades, when they maintain students' files, or when they organize the daily work. Computers help teachers and administrators in managing the school organization. Spreadsheet and database packages are some examples of management tools.

**Computer as a Subject**

Students take classes to learn about computers so they build their computer-related skills and knowledge. They are taught about the hardware components and functions of the computers, and how to program the hardware using different computer languages like BASIC. Learning about computers is called computer literacy (Al Mousa 2002).

**Computer as an Enrichment and Entertainment Tool**

Teachers use the computer as a remediation or enrichment devise, and some send students to the computer lab to play with game software when they have finished their assignments or as a reward for good behaviour (Wood et al. 1995).

**Computer as a Learning Tool (Computer-Aided Learning)**

Teachers use the computer in their classrooms to enhance the delivery of the curriculum and the learning materials for students who would otherwise lose interest in subjects that are taught by traditional methods. The main purpose of using computers as a learning tool is to enhance students' achievement and develop their thinking skills.

### 2.1.5  Using CAI in Chemistry - Studies and Findings

In the field of chemistry, studies have reported using computers to assist students in a variety of ways. Summerville (1985) explored the effect of using the method of learning by CAI on the achievement of tenth grade students in chemistry and their learning pace, compared to the traditional method. The results showed that learning which used CAI happened faster than learning which used the traditional method. On the other hand, the study did not show statistically significant differences in the achievement of the two groups participated in the study. Similarly, Wainwright (1985) conducted a study to investigate the effectiveness of a CAI Package in supplementing teaching of selected concepts in high school chemistry unit on writing/naming of chemical formulas and balancing Chemical Equations. Findings showed that the use of the microcomputer materials did not contribute to more effective learning (the control group's scores were significantly higher on an achievement test than the CAI group's mean). Furthermore, there were no significant interactions favouring either CAI or control activity for students of differing cognitive levels. Williamson and Abraham (1995) showed that computer-based animations of molecular-level events shown in a lecture environment significantly improved student performance on a logical thinking test (0.50 effect size). There was no effect on attitude or course achievement. Malak (1995) conducted a study aimed at finding out the impact of using computer-assisted learning method on the achievement of 10th grade students in chemistry, compared to the traditional method of teaching. The study showed that there was no statistically significant difference in students' achievement in chemistry that can be contributed to the method of teaching or gender. Likewise, Harrold and Newton (1998) reported that enhancement of student examination performance had not been demonstrated when using computer-based tutorials as instructional tools in biochemistry and medicinal chemistry courses. They concluded that the length and manner in which students used the tutorials might have

prevented the detection of real performance differences across user and nonuser groups. In contrast, Rowry (1994) conducted a study to find out the effect of using the computer with the video disc on the achievement and attitudes of secondary-grade students in chemistry. The results showed the achievement of the experimental group was higher than the control group. However, the method of using the computer with the video disc had no impact on students' scientific attitudes towards chemistry. Yalcinalp (1995) examined the effect of computer-assisted instruction (CAI) on students' understanding of chemical formulas and mole concept, and their attitudes toward chemistry and CAI. Results reported that students who used the CAI accompanied with lectures scored significantly higher and demonstrated significant improvement in attitudes compared to the control group who received similar instruction through recitation hours. Furthermore, Al Omar (2002) conducted a study aimed at investigating the effect of computer on immediate and later achievement of 10th grade students in chemistry, scientific stream. The outcomes showed that there were statistically significant differences in the immediate achievement in favour of the experimental group. These differences occurred as a result of the teaching method. There were also statistically significant differences in the later and delayed achievement in favour of the experimental group. Other statistically significant differences in the immediate achievement went in favour of the girls because of sex factor.

## 2.2    Computers and Styles

Pask and Scott (1972, cited by O'Shea and Self 1983) distinguish between serialists, who learn in terms of a series of items related by simple links, and holists, who learn as a whole forming more complex structures. They developed two kinds of training programs, one for serialists and the other for holists. Both programs delivered the same strictly relevant information. It was found that a student learned effectively if given a program which matched their sort of competence, serialist or holist, but did not do so if there was a mismatch. To sum up, Pask and Scott showed that it is possible to detect differences in cognitive style and to devise teaching strategies to suit an individual with a given sort of competence. Effort needs to be made to address learning theory and the needs of the students (Hood 1994).

The next part of this chapter provides the research on styles and indicates what the research tells about CAI and human psychological aspects, e.g. learning style, zone of proximal development (ZPD), cognitive development level, cognitive style, and thinking style.

### 2.2.1 Theories of Styles

The concept of style is not new in psychology. Styles have been studied in psychology of personality, cognitive psychology, and in areas of applied psychology (e.g., educational psychology and organizational psychology) (Sternberg 2001b). Various authors have developed their own models about differences in the ways in which people perceive, process, and conceptualize information.

Some authors have labelled these styles as cognitive. Others have referred to them as learning styles, or studying styles. Others have called these differences types of personality. And others have considered them to be thinking styles.

Among the theories of styles, Sternberg (1995, 1997, 2001b) has distinguished three principal styles.

### 2.2.1.1 The Cognition-Centred Styles

A movement came into prominence in the 1950's and early 1960's with the idea that styles could provide a bridge between the study of cognition (how we perceive, how we learn, how we think) and the study of personality. The movement was called the cognitive-styles movement. Some of the main cognitive styles are field dependence-independence, impulsivity-reflectivity, levelling-sharpening, equivalence range.

### 2.2.1.2 Personality-Centred Styles

Personality-Centred Styles are also an attempt to understand styles but in a way that resembles the conceptualization and measurement of personality than of cognition.
The main personality styles are Theory of Psychological Types and Energic Theory of Mind Styles.

### 2.2.1.3 Activity-Centred Styles

Activity-centred theories of styles are more action-oriented than cognitive- or personality-centred theories. They tend more to be centred around kinds of activities people engage in at various points in their lives, such as schooling and work. This approach tends to focus on styles of learning; therefore the theories in this approach have probably had the most direct application in the classroom.

Some of the main activity-centred styles are learning styles and teaching styles.

### 2.2.1.4 Mental Self-Government

Building on the previous work, Sternberg (1997) proposed a model that integrates the various approaches of understanding styles into a single theory, which he named Theory of Mental Self-government. The goal of the theory is to provide new directions for theory applied to educational practice. The model of mental self-government addresses the question of how intelligence is organized or directed. When applied to intelligence, the metaphor of mental self-government generates 13 thinking styles, or stylistic ways of approaching the world. The basic idea of the theory is that people, like societies, have to organize and govern themselves. The kinds of governments we have in the world are mirrors of the mind. These governments reflect different ways in which people can organize or govern themselves.

### 2.2.2 CAI and Styles

### 2.2.2.1 CAI and Learning Styles

In his study considering learning styles in computer assisted learning, Clariana (1997) stated that matching instructional delivery to students' learning style preferences should positively impact student achievement. Involving three different CAL experiences and different learner populations in his study, a general shift occurred in learning style towards concrete experience and active experimentation as described by Kolb (1984) learning style model. Clariana recommends that developing truly individualizing computer assisted learning should be guided by research relating learning style preference and achievement. Ross and Schulz (1999) explored the area

of learning styles and human-computer interaction. More specifically, they examined the influence of cognitive learning styles, as measured by the Gregorc (1982) Style Delineator, on both achievement and human computer interaction behaviour. Their findings indicate that certain forms of CAI may not accommodate all learners equally, and concluded that CAI, as an instructional methodology, may not be the most appropriate method of learning for all students. Therefore, educators should remain cautious when using the computer as a learning tool. Just as teachers need to use a variety of approaches to meet the diverse needs of their students, educators should be aware that CAI may not be the learning medium of choice for all students. Regarding the issue of designing hypermedia that appropriately considers individual learning skills differences, Song (2002) discussed 10 studies that investigate interactions between students' learning skills and their use of different forms of instruction. Song concluded that theories of learners' characteristics associated with learning in a hypermedia system have been weak and the body of knowledge regarding individualizing instruction using hypermedia is incomplete. Hence, research on the interaction between learners and hypermedia, and including strong learning theory in developing instructional interactive hypermedia are needed.


## 2.2.2.2 CAI and Zone of Proximal Development

The Zone of Proximal Development (ZPD) is concerned with how best to help learners learn. Vygotsky (1978) described ZPD as the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or collaboration of more capable peers. ZPD requires collaboration or assistance for a learner from a more able partner. The need for a more able learning partner arises from the belief that the activities, which form a part of the child's education, must be beyond the range of their independent ability. The learning partner must provide appropriately challenging activities and the right quantity and quality of assistance. Luckin and du Boulay (1999) stated that ZPD is a useful theoretical construct for educational software design and can be interpreted in a manner, which is informative to the software design process. They confirmed, according to the empirical evaluation study undertaken with a class of 10-11 year old children, the viability of the partnership role allocated to the computer system. Their study explored the ways in

which computers might be able to fulfil the collaborative partnership role required by ZPD. A system called VIS (the Vygotskian Instructional System) that adopts the role of a more able assistant for a learner and uses the learner's ZPD to individualize instruction was developed. VIS is part of an interactive learning environment called the Ecolab, which is an implementation of the Vygotskian design framework. Ecolab aimed to help children aged 10 -11 years learn about food chains and webs.

In support of Luckin's conclusion, Arroyo et al. (2003) showed that computers could be programmed to adapt instruction to individual students and select appropriate problems to fit the student based on their ZPD. They developed a computer-based tutor called Animal Watch that uses artificial intelligence techniques to provide individualized math instruction for 9-12 year olds based on the student's ZPD. Animal Watch was used by 350 5th and 6th grade students in rural and urban schools in Massachusetts in controlled lab experiments carried out over 3 years. They concluded that Animal Watch has been well accepted by students and teachers, and it has shown to have improved student attitude towards mathematics.

### 2.2.2.3 CAI and Cognitive Development

Piaget (1970) theorizes that the learners, being active biological organisms, continuously interact with their environments. Through this interaction they gain their knowledge and this leads to changes in their cognitive structure. They do not passively record what they sense; instead they actively transform and organize sensory impressions into their cognitive structures. During the 1960s and early 1970s, Piaget's theory was the dominant theory of cognitive development in the fields of developmental psychology and education (Byrnes 1996). Piaget's work influences today's classroom, particularly the elementary and preparatory grades (Al Khalili et al. 1996). Constructing meaning based on one's interpretation of the data, as Piaget asserted, is at the heart of scientific inquiry (Costa 2001). Piaget (1967, 1970) concluded that there exist stages of cognitive development. His theory offers a detailed and specific account of universal stages in human development, which provide a possible explanation as to when and how a child is ready to learn or develop specific forms of knowledge and understanding. The theory leads to the claim that a child's ability to understand what is said to them and, in turn, their ability to use

language informatively, depend upon their stage of intellectual development. Piaget et al. (1969) considered these stages as sequenced stages as a child cannot proceed to a stage unless they pass through the preceding one. The ordering of the stages is constant, although the age at which each stage occurs may vary with the individual because of their degree of intelligence and social environment. The structure of children's thinking at each stage is distinctive and the same for all children at that stage, but different from that of children and adults at other stages. The significance of what children learn is a direct function of their stage of development.

Arroyo et al. (1999 a & b) used Piaget's notion of cognitive development to improve a tutor's reasoning ability. An objective of this study was to see what benefits an intelligent Help system could provide. In addition, they investigated the benefits of the intelligent Help component when the student was at a particular cognitive level. MFD (Mixed numbers, fractions and decimals) is an intelligent tutoring system (ITS) for teaching fractions, decimals and whole numbers to elementary school students in Massachusetts. The researchers tested MFD with 60 sixth grade elementary school students over three days. Each student had a total of three hours using the system. Students were randomly divided into experimental and control group. The experimental group used a version with intelligent hint selection, which determined the appropriate amount of information to provide in a hint, and with intelligent problem selection, which selected problems with an appropriate difficulty level. The control group used a version with intelligent problem selection but received no feedback other than a prompt to try again after an incorrect response. The researchers found that knowledge of a student's cognitive level is a valid predictor of their performance in using an ITS. Furthermore, an ITS can use the knowledge of a student's level of cognitive development to enhance its teaching.

## 2.2.2.4 CAI and Cognitive Styles

Abu Jaber and Qutami (1998) investigated self-efficacy of computer skills and cognitive thinking style and found higher self-efficacy scores for students with abstract cognitive thinking style than those with concrete and iconic thinking styles. They concluded that this might be attributed to higher theoretical experiences and

knowledge.  Riding and Grimley (1999) stated that the interaction between cognitive styles and the mode of presentation affects learning performance.  They conducted a study to explore the relationship between cognitive style and the performance on the use of multimedia and traditional materials in learning science topics.  Cognitive Styles Analysis was used to determine a student's position on two fundamental cognitive styles – Holist-Analytic and Verbal-Imagery.  Multimedia instructional materials were used.  The study pointed to the need for material designers to be aware of style and to focus on the learning design features of the packages they are producing as well as the quality of the technology.

Another fundamental cognitive style – the field dependent/field independent, in relation to Computer-based Instruction was the focus of Hall's (2000) study.  The purpose of the study was to determine the effects of interactivity in a hypermedia environment on the performance of students with different cognitive styles.  A computer program was created to reveal performance differences (time and accuracy) between cognitive styles (field independent/field dependent) by providing three different levels of interactivity (mandatory, optional, and no interactivity) for geography students completing a series of map-like jigsaw puzzles.  The program randomly assigned each participant to one of three treatments and measured the time taken to complete the given tasks and the number of attempts made to complete tasks, i.e. accuracy.  Field dependent learners were expected to solve the puzzles more quickly and accurately when they were able to interact with the jigsaw puzzle.  Although the program was constructed according to field dependence-independence theory, no statistically significant performance differences were found between field dependent students assigned to different levels of interactivity provided.  To explain this result, the researcher stated that the puzzles might have been simple enough that the interactive organizational aids were unnecessary regardless of the learner's cognitive style.  Furthermore, the treatments themselves may have been ineffective for an unknown reason such as the presence of an unrecognized, confounding variable or a relationship between some aspect of the hypermedia program other than the interactive treatments and cognitive style.  The results of this study suggested that the design and implementation of an instructional treatment to assist field dependent learners might be more difficult than suggested by the literature describing field

dependent students' characteristics and needs.  The study concluded that attempting to use the traits of field dependent learners to guide the creation of a computer-based environment's structure and learner controls and measure performance outcomes experimentally has not been entirely fruitful.

Triantafillou et al. (2003) provided evidence that adaptivity based on a student's cognitive style could be beneficial for the observed learning outcomes.  An educational program called AES-CS (Adaptive Educational System based on Cognitive Styles) was developed to accommodate students' cognitive styles in order to improve students' interactions and learning outcomes.  The main characteristic of the AES-CS is that it can adapt to the cognitive style and to the level of knowledge acquired by the student.  An empirical study was conducted to evaluate the effectiveness of AES-CS.  Fourth year undergraduates studying "Multimedia Technology Systems" took part in the study.  Students were domain novices and had not used hypermedia based instructional environment for any other course.  They were divided into experimental group (36 students) and a control group (30 students).  The experimental group studied using AES-CS; the control group studied using traditional hypermedia based environment.  Statistical analysis indicated that the experimental group (AES-CS) performed significantly better than the control group.  These findings showed that AES-CS, which was designed to be adapted to individual cognitive style, can be an effective tool to support and promote learning.

### 2.2.2.5   CAI and Thinking styles of the Mental Self-Government

Nachmias and Shany (2002) suggested that virtual education can provide opportunities for different kinds of learners, though such opportunities may be greater for some kinds of learners than for others.  They asserted that assessing students' thinking styles helps educators predict which students can be expected to perform better in virtual courses.  They conducted a study to examine the relationship between students' performance in a virtual course and thinking styles, gender, and ICT experience, and showed that performance in the virtual course was positively correlated with a number of thinking styles, some of which showed a stronger correlation than others.  No correlation existed between the students' gender and the other variables.  To further explain, students with a liberal thinking style might well

become active users of asynchronous communication channels, while students whose thinking styles are global, local, internal, or external are likely to perform well in tasks related to searching for information and integrating various pieces of information in their work.

Lin et al. (2001) carried out a study that aimed at examining how feedback formats (specific vs. holistic) and executive thinking styles (high vs. low) affect web-based peer assessment. They proposed that future web-based peer assessment adopts a specific feedback format for all students. The study results indicated that while students with high executive thinking styles significantly improved over two rounds of peer assessment, low executive students did not improve through the cycles. In the second round of peer assessment, low executive students receiving specific feedback significantly outperformed those receiving holistic feedback. In receiving holistic feedback, high executive thinkers outperformed their low executive counterparts. In addition, high executive students contributed substantially better feedback than their low executive counterparts.

## 2.3 Summary

The efficient use of computer in education in terms of its effect on students' motivation, attitude, confidence, and achievement has been the focus of various studies. Using the computer to enhance students' achievement is a debatable and controversial issue. The statistical significant differences in achievement due to the method of teaching by the computer vary. In reviewing the literature on CAI, most research occurred in the 1980s and even recent meta-analyses have included studies from the 1980s. The bulk of elementary students in the examined studies used mainframe-terminal configurations, rather than microcomputers. Much of the computing was text-based and non-graphical (Jenks and Springer 2002). For the most part, the computer programs reviewed in previous meta-analyses were developed before 1990 and tended to emphasize drill and practice (Coley et al. 1997). Media comparison research has passed through developmental stages. Many of the 80s studies suffered from problems of internal and external validity because of specification and design error. In the 1990s, a shift was observed toward improvement in the internal design of computer delivery in experimental comparison

studies, which is attributed to better-controlled laboratory research (Joy and Garcia 2000). Uncontrolled variables, such as the variance between the control group and the experimental group including prior knowledge, learning styles, ability, instructor effects, method of instruction, and learner familiarity with technology, may produce inconclusive results (Joy and Garcia 2000 and Underwood 1990). The duration of treatment and group sizes are critical variables in many of the studies examined in the meta-analyses of CAI and students' achievement (e.g. the design flaw of too short treatment periods could reduce the effects of CAI, CAI could be more effective if used in individual or small group settings) (Liao 2004). The design and development of the CAI is a factor impacting the results of many studies exploring the CAI effectiveness (Chen 2005). The inappropriate use of CAI caused the different views regarding the CAI's benefits and reliability in the teaching and learning process. Research indicates that how CAI is used affects its effectiveness (Kulik et al. 1983, Kulik et al. 1985 and 1986, and Lowe 2001). Kulik (2003) identifies important factors that have influenced the change between studies done prior to 1990 and to those conducted subsequent to 1990. Findings of effectiveness of instructional technology for student learning show dramatic changes in computer to student ratio, access to the internet in schools, multimedia computers to students, ratio of students to internet connected computers, teachers are better prepared than they were in the 1980s to integrate technology with classroom instruction.

Most of the above meta-analyses and reviews of past meta-analyses indicate that CAI is generally effective in education environments for a broad range of student ages, though it does not have positive effects in every area in which they were studied. Using CAI increases learning pace compared to the traditional method. Students usually learn more in less time when they receive computer-based instruction. Students improve their acquisition of practical skills, which are considered necessary for science subjects. Students like their classes more and develop more positive attitudes toward computers when their classes include computer-based instruction. However, it should be mentioned that meta-analysis is designed to provide general statements that summarize the findings of a number of studies on a particular topic. This type of study is a useful technique to explain observed patterns in the data and seems to produce results that are useful, but need some sort of firmer empirical

support to confirm their accuracy. That is, the results of meta-analysis study need to be confirmed via studies that employ more rigorous experimental designs (Kulik 1994).

Although knowledge regarding the issue of individualizing instruction using computer is incomplete (Song 2002), developing individualized learning using CAI is a promising field. Research on the interaction between learners and computer is in demand. Effort needs to be made to address learning theory and the needs of the students (Hood 1994) and in applying this knowledge in developing instructional interactive hypermedia. It is argued that to omit learning style consideration in any system that claims to be an integrated learning system is a serious defect that will greatly limit the effectiveness of such a system (Riding 1998). Hence, considering students' characteristics such as cognitive style, learning style, developmental stage, thinking style, and ZPD in the creation of computer-based environments is of high importance. CAI may not be the learning medium of choice for all students, however if CAI is designed and developed according to student's characteristics then students may learn more effectively.

Only two studies were identified that considered the mental self-government theory in the use of computers for learning (Nachmias and Shany 2002, and Lin et al. 2001). The first study investigated how thinking styles effected students' performance in a virtual course, while the second study explored how thinking styles and feedback format interactively effected student learning in web-based peer assessment. Neither study explored the way that thinking styles can be used in the design of learner models for the purpose of individualizing instruction. No known study has been conducted to explore using computer in teaching according to learners' thinking styles based on the mental self-government theory, and the effect of this on achievement.

A final word to say is that CAI appears to be at least as effective as conventional instruction. Thus, using CAI as a complete replacement for conventional teaching may seriously weaken its effectiveness. Computer-based education should be used to enhance and supplement rather than replace conventional teaching methods (Emerson and Mosteller 1998 and Lowe 2001).

# CHAPTER 3

## MENTAL SELF-GOVERNMENT THEORY

### 3.1    A Description of the Theory

The mental self-government theory states that people have preferred ways of thinking, which metaphorically map onto different aspects of the organization of government (Sternberg 2001a).  Governments have different forms, functions, levels, scopes, and leanings.    A form of government may be monarchic, anarchic, hierarchic, or oligarchic, and it may act legislatively, executively, or judicially.  It may function at a global or local level.  Government may also assume either an internal (domestic) or external (foreign) scope of affairs, and it may tend to lean toward either the liberal or conservative end of the spectrum.  According to the mental self-government theory, the various styles of government we see in the world are external reflections of the styles that we can find in the mind.  Thus, in order to understand the styles of thought, we can look at aspects of government for a sense of what is internally as well as externally possible (Grigorenko and Sternberg 1995).

A style is a preferred way of thinking and expressing or using one or more abilities (Sternberg 2001b).  It does not reflect how well someone can do a task, but how much the person enjoys doing it (Sternberg 2001a).  People use their intelligence in different ways.  It is intuitively obvious that the way a person approaches tasks depends on many things: level of intelligence, personality traits, and the difficulty of the task.  Another variable affecting task performance is style.  A style is neither a level of intelligence nor a personality trait, but rather an interaction of intelligence and personality that brings the two psychological structures together.  Thinking styles are at the interface between the domain of abilities and the domain of personality.  Different people with the same level of abilities may have different styles of thinking.  Thinking styles refer to the ways in which people choose to use or exploit their intelligence as well as their knowledge.  Thus thinking styles are not abilities, but rather how these abilities, and the knowledge acquired through them, are used in day-to-day interactions with the environment.  Simply put, styles are not how much intelligence one has, but how one uses it (Grigorenko and Sternberg 1995).

Sternberg (1994) emphasizes a person does not have one thinking style, but a profile of styles.  It means that one shows varying amounts for different styles, but is not locked into any one style.  One can vary ones style to suit different tasks and situations.  Further, ones profile varies over the course of a lifetime, i.e. ones style profile is fluid not fixed.  Also it is important to note that some find it easier to switch among styles than others.

**3.2 Theoretical Frame**

The understanding of thinking styles relies on a main idea in the mental self-government theory.  The idea states that different kinds of authorities and governments in the world are not haphazard.  Rather, they are an outer reflection of what goes on in individuals' minds and thus represent alternative ways of organizing our thinking.  Therefore, the kinds of governments we can see are a mirror of our minds (Sternberg 2001a).

According to the mental self-government theory, styles can be divided into five categories (Sternberg 1997, Grigorenko and Sternberg 1995, Sternberg and Grigorenko 1995, and Sternberg 2001a): function, form, level, scope and leaning.  Each category has its own styles, as shown in Figure 3.1.  The theory consists of 13 styles in total and they delineate a cognitive profile of how people direct their intelligence.
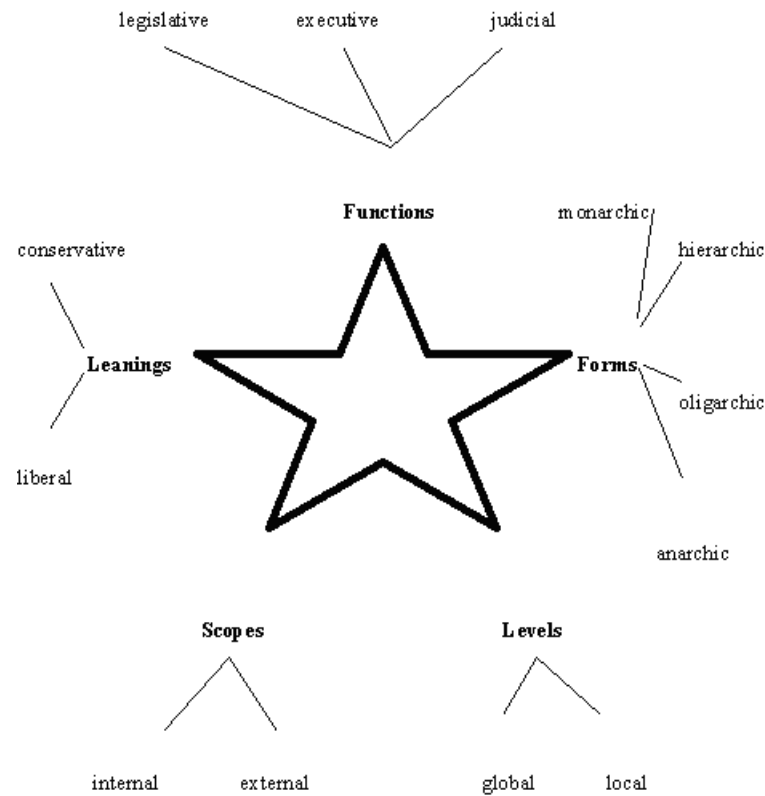
Figure 3.1: Dimensions of Thinking Styles

## 3.3 Definitions of Thinking Styles

**Functions:** The mind carries out legislative, executive and judicial functions, just like governments.

The legislative function of the mind is concerned with creating, formulating, imagining, and planning. This style characterizes people who enjoy doing these functions. The legislative persons generally like to formulate their own activities, create their own rules, do things in their own way, and build their own structures when deciding how to approach a problem. They prefer tasks that are not pre-structured or prefabricated

The executive function is concerned with implementing and doing. This style characterizes people who are implementers. The executive persons generally like pursuing activities structured by others. They prefer to follow rules, and they often rely on existing methods to master a situation. They prefer that activities be defined and structured for them, and prefer tasks that are prefabricated, such as solving word

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problems, applying rules to already structured engineering problems, giving talks or lessons based on others' ideas, and enforcing rules.

The judicial function is concerned with judging, evaluating and comparing. This style characterizes people who like to evaluate rules and procedures; who like to judge things; and who like tasks in which they analyze and evaluate existing rules, ways, and ideas. People with a judicial style prefer activities that exercise the judicial function, such as writing critique, giving opinions, judging people and their work, and evaluating programs. The judicial person generally likes to judge the products of others' activities, or judge others.

**Forms:** The forms of mental self-government resemble forms of government. Just as there are four main forms of governments, there are four major ways that describe how individuals govern themselves: monarchic, hierarchic, oligarchic, and anarchic.

Monarchic**:** a single goal of doing things predominates. A monarchic person focuses single-mindedly on one goal or need at a time. This style characterizes persons who like to focus on one task or aspect of that task until it is completed.

Hierarchic**:** This form allows for multiple goals with different priorities. A hierarchic person likes to do multiple things within the same time frame, setting priorities for getting them done. This style characterizes persons who allow for multiple goals, each of which may be given a different priority. They enjoy dealing with many goals, although they recognize that some goals are more important than others; they have a good sense of priorities, they tend to set priorities and to be systematic in their approach to solving problems.

Oligarchic**:** This form allows for multiple equally important goals. An oligarchic person likes to do multiple things within the same time frame, but has difficulty setting priorities for getting them done. This style characterizes people who allow for multiple goals, all of which are roughly equal in importance. They like to do multiple things within the same time frame but have difficulty setting priorities for getting the things done. Oligarchic individuals like dealing with multiple and often competing goals of perceived equal importance, but they tend to experience conflict and tension

when they are forced to assign priorities.  Competing goals keep oligarchic individuals from completing tasks, because everything seems equally important to them.

**Anarchic:** This form is anti systematic.  The anarchic thinking style is characterized by a preference for activities that lend themselves to great (sometimes too great) flexibility of approaches.  Anarchic stylists tend to be motivated by a potpourri of needs and goals that are often difficult for themselves, as well as others, to sort out.  They are often simplifiers who are intolerant, and too flexible, in that they may believe that anything goes.  People with an anarchic thinking style have trouble setting priorities because they have no firm set of rules upon which to base these priorities.  An anarchic person does not like rules, procedures, and formal systems.  This style characterizes persons who do not like to be tied down to systems, rules, or particular approaches to problems.  Often they oppose existing systems.  They tend to take a random approach to problems and draw connections other people would not make.

**Levels:** Government exists at multiple levels: federal, state, county, city, and so on.  In essence, the levels of government suggest that individuals may vary in their concern for detail.  Thus one can distinguish between global and local styles.

**Local:** A local person prefers dealing with details and with concrete issues.  They overlook the forest for the trees.  This style characterizes persons who prefer tasks, projects and situations that require engagement with specific, concrete details and that often require considerable precision to execute.  The person with this style appreciates the very small matters that the global person avoids.  Localists are often down-to-earth and oriented toward the pragmatics of a situation.

**Global:** In contrast, a global person prefers to deal with the large picture and with abstractions.  Metaphorically, they tend to see the forest, but do not always consider the trees that constitute it.  This style characterizes persons who prefer problems that are more general in nature and that require abstract thinking.  The global person likes to conceptualize and work in the world of ideas.

**Scope:** Governments need to deal with either internal (or domestic) and external (or foreign) affairs. Similarly, mental self-government needs to deal with internal and external issues.

**Internal:** This style characterizes persons who prefer tasks, projects, or events that allow them to work independently of others. Their preference is to be on their own, and they do not like group work or any form of cooperative learning. Internalists tend to be introverted, task oriented, distant, and both less socially sensitive and less interpersonally aware than externalists. Essentially, their preference is to apply their intelligence to problems or ideas in isolation from other people.

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**External:** In contrast, this style characterizes persons who prefer tasks and activities that allow them to work with other people through interaction at different stages of progress. Their preference is to be with others. They like group work. Externalists tend to be extroverted, people oriented, outgoing, socially more sensitive, and more interpersonally aware than internalists. They seek problems that either involve working with other people or are related to these other people in some way.

**Leanings:** Governments can have various political leanings. Optimally, these leanings are represented on a continuum from right wing to left wing. Two major regions of leanings will be distinguished: conservative and liberal. The two leanings of government suggest that individuals vary in their degree of adherence to pre-existing rules or structures – that is, in their degree of mental liberalism and conservatism.

**Liberal:** The liberal thinking style refers to a preference for tasks and projects that require going beyond existing rules and procedures, as well as situations that allow substantial change. A liberal person likes to do things in new ways and to have change in their life. The person with this style seeks ambiguous and uncertain stimuli and becomes bored when things never seem to change. This style characterizes persons who like to go beyond existing rules and procedures and who allow substantial change from the way things are currently done. Unlike in the legislative style, the new ideas do not have to be their own.

Conservative: In contrast, the conservative thinking style refers to a preference for tasks, projects, and situations that require adherence to existing rules and procedures. A conservative person prefers traditions and stability. This style characterizes persons who prefer familiarity in life and work, and to follow traditions. Unlike in the executive style, they may like to come up with their own ideas but the ideas are based on accepted customs.

### 3.4 General Characteristics of Thinking Styles

Individuals tend to choose the styles with which they feel comfortable with regard to managing their affairs. If they are flexible enough in using these styles, they will try, with different degrees of success, to adapt with thinking styles that each situation requires. The flexible usage of Mental Self-Government Styles justifies the diversity in thinking styles.

Thinking styles are the product of the interaction between the individual and what surrounds them. An individual who follows a particular style with a certain task in a certain situation may follow a different style with a different task in a different situation. Furthermore, some individuals prefer particular styles in a certain stage of their lives, but other styles in a different stage.

### 3.5 Factors that Affect the Change of Thinking Styles of Individuals

**Culture**

Culture plays an indispensable role in the progress or stability of styles which individuals use in various societies. Some cultures would value some styles more than others. For example, some communities encourage the legislative style and free thinking which produces creative work. Other communities would hinder this thinking.

**Gender**

Social upbringing of children qualifies them to be what their father wants them to be according to their own views, not to reality. A male's role will be different from a female's according to our beliefs. Also, what we'll consider as acceptable behaviour or as unacceptable behaviour will also differ depending on gender. The difference in

styles between males and females is due to factors like making distinctions between them since the moment they are born. In his book, Thinking Styles, Sternberg (1997) points out some differences in styles between males and females. One of these differences is that males are more disposed to the legislative, the internal, and the liberal styles, while females are more inclined to the executive or the judicial, the external, the conservative styles. These outcomes signal the current situation, not what the situation might be or what it must be like.

**Age**

Sternberg (1997) points out that children generally prefer the legislative style before they go to school. Their creative thinking is then encouraged and developed in an unstructured and open environment. When children go to school, the idea of encouragement and creativity becomes less because they have to adhere to specific and fixed rules and values. In addition, the teachers decide on what students should do, and in most cases, students do what they are asked to do. Students who do not abide by the school's rules and limitations will be looked at as unqualified or unsuitable to be at school, or as violators of school's laws.

**Parenting Styles**

What parents encourage and reward is reflected in their children's thinking style. The child also imitates the thinking style shown by one of their parents. In addition, the way parents respond to their child's questions during childhood reflects the thinking style that the child will develop. Therefore, children are more likely to develop the legislative style if their parents encourage them to ask questions and to search for answers by themselves. On the other hand, children will be inclined to the judicial style if their parents encourage them to compare, to analyze, and to judge things.

**Education and Occupation**

Education and occupation play a vital role for students to acquire a particular style over another one. Some jobs encourage certain styles. The contractor, for example, prefers thinking styles that a simple worker who chooses to work under their command doesn't prefer. The majority of schools in most parts of the world may prefer the executive, local, and conservative styles (Sternberg 1997). Children at these schools will be considered smart if they perform what they are required to do in the correct way.

**3.6 Previous Studies**

Despite their few numbers, studies that have explored and analyzed thinking styles within the frame of mental self-government theory have been applied in the USA, South Africa, and Hong Kong.

Sternberg (1997) made a factor study of data taken from the application of Sternberg-Wagner Self-Assessment Inventory on samples of students at Yale University, USA. Although statistical data were not included in the study, after statistical analysis using factor analysis method, Sternberg found that there are five factors underlying mental structures: adherence to structure, engagement, scope, level and distribution of time.

**Adherence to Structure:** He concluded that there is a relation between the liberal style and the legislative style. Another relation exists between the conservative and executive styles. For example, people who are liberal tend, on average, to become legislatives, while conservative people tend to become executives. Those who are liberal or legislative tend not to be conservative or executive and vice versa.

**Engagement:** He compares the oligarchic and the judicial styles and suggests that people who are priority-setters are inclined to the judicial thinking style.

**Scope:** Like adherence to structure, people with internal and external styles are on average on opposite ends of a continuum and this continuum is largely unrelated to other styles.

**Level:** He compared between the local and global styles. This factor was predicted and suggests that the local and global styles are at opposite ends of a continuum. And that this continuum is largely unrelated to other styles.

**Distribution of Time:** In this factor, he focused on the hierarchical style. He compared individuals and found that there are differences among individuals with regard to the degree to which they are hierarchical and that this degree is not related to other styles.

Sternberg pointed out that the results of the statistical analysis generally supported his mental self-government theory. The factors adherence to structure, scope and level were predicted and consistent with the theory. The engagement and distribution of time factors were not predicted and the engagement factor remains unexplained.

**Styles in the Classroom**

Teaching that fully takes into account students' styles of thinking and learning will improve students' academic performance and produce achievement superior to that does not take their styles into account (Costa 2001). Thinking styles clearly have many implications for optimizing learning and teaching. Without an understanding of thinking styles, we will continue to operate in ways that are educationally ineffective, even counterproductive. Educators will eventually come to see that understanding, identifying and developing thinking styles are tasks as important as understanding, assessing and developing intelligence (Cilliers and Sternberg 2001).

The following four studies were conducted by Sternberg and Grigorenko (1995, 1997) about thinking styles in classrooms. The first study addressed teachers, the second one focused on thinking styles of students, the third one dealt with the interaction between teachers' styles and students' styles, and the fourth study investigated the relations between styles and achievement.

The first study involved 85 teachers (57 female and 28 male) in four private and public schools in the USA. The main variable in the study was thinking styles. Other variables included grade level taught, age of teachers, subject area taught, and ideology. The results of the study pointed out that teachers teaching higher-grade

levels were disposed to the executive style of thinking, while teachers teaching lower grade levels were apt to the legislative style of thinking. This result was justified by stating that teachers of higher grades were forced to follow a particular curriculum while teachers of lower grades didn't have such a situation. The results also indicated that older teachers are more disposed to local, executive and conservative than younger teachers who are disposed to the legislative and global styles. This difference is due to cohort effects. Experienced teachers were more executive and conservative than were less experienced teachers. Results also showed that science teachers are inclined to be local and less liberal whereas humanities teachers are inclined to be liberal and non-local thinking. This is probably because science teachers focus more on local details of science rather than the overall image of scientific research. Finally, the study showed that teachers tend to match the stylistic ideology of their schools. Needless to say that teachers prefer schools which suit their ways.

The second study involved 124 students (51 female and 73 male) aged between 12 and 16, distributed among the same four schools of the previous study. The objective of the study was to identify correlation of styles with two demographic variables: social economic status (estimated on the basis of parental education) and birth order. Results of the statistical analysis indicated that socio-economic level related negatively to the judicial, local, conservative and oligarchic styles. The results also indicated that students who are later-born siblings tend to be more legislative, liberal and hierarchal than earlier-born siblings. Finally, the results indicated that students tended to match their teachers' styles.

The third study aims to answer the question: Does students' performance get better in classrooms where their styles match their teachers' styles? The results of the study confirmed that students' performed better and were more positively evaluated by teachers when their thinking styles harmonized with those of their teachers. The study showed patterns of correlation between styles and academic achievement that differed widely across schools. Different students will be evaluated differently, depending on the school in which they enrol. This is because clearly what is valued in one environment may not be valued to the same degree in another.

The fourth study was to investigate the relations between styles of thinking and achievement. The main question of the study was: When abilities are taken into account, do styles still predict academic achievement? 199 high school students (146 female and 53 male adolescents) from USA and South Africa who attended the Yale summer introductory psychology course taught over a period of four weeks took the assessment of thinking styles. They also took a test of abilities based on Sternberg's triarchic theory of human intelligence. This test required students to use memory, and analytical, creative, and practical skills. The course was taught in a way that emphasized memory, analytical, creative and practical abilities. At the end of the course, students' achievement in the course was assessed in terms of memory, analytical, creative and practical skills. The researchers concluded that thinking styles add significantly to abilities in predicting school achievement.

Zhang and Sternberg (1998) conducted a study to examine if certain thinking styles would predict academic achievement over and above the participants' self-rated abilities. Furthermore, to explore the relationship between the participants' self-rated abilities and their academic achievement scores. The sample chosen constituted of 622 freshmen from the University of Hong Kong (261 males, 361 females). Students were chosen from 9 faculties. The thinking styles inventory was used to assess the participants' thinking styles. The participants also took a test of abilities based on Sternberg's triarchic theory of human intelligence. The three kinds of abilities assessed were analytical, creative, and practical. The achievement measure was the participants' scores on the Advanced-level tests in 13 subject areas. The study found that thinking styles were reasonable predictors of academic achievement over and above self-rated abilities. Results from this study indicated that the thinking styles inventory was reliable and valid for use in identifying the thinking styles among a sample of university sample. A second major finding of the study was the gender difference regarding the relationship between achievements and thinking style. A third major finding of the study was the relationships between the students' self-rated abilities and their academic achievement in certain areas of study. The results suggested school might not be ideally serving girls or students who perceive themselves to be creative.

Zhang and Sachs (1997) conducted a study on Hong Kong University students. Their objective was to check the validity of the thinking styles measurement in Sternberg's Self-Government Theory. The study showed that the thinking style inventory defined by Sternberg's theory is also reliable and valid for identifying thinking styles of university students in Hong Kong. The researchers, then, calculated the differences between the following variables in the study: age, sex, college class, college major, school subject taught, travel experience and teaching experience. The results indicated that students thinking styles were statistically different as a function of such variables.

Grigorenko and Sternberg (1995) presented a detailed explanation on Self-Government Theory in its five dimensions: function, form, level, scope, and leaning, which include 13 thinking styles. In addition to these they presented cognitive styles and their relation to thinking styles.

Cilliers and Sternberg (2001) conducted a study aimed at assessing the thinking styles of the first year students measured at the University of Stellenbosch within a single academic year and to highlight possible implications of these styles for optimizing learning and teaching at the university. The study was conducted on a sample of 223 male and female students: 94 from the faculty of Arts, 100 from the faculty of Natural sciences, and 29 from the faculty of education. The measurement of the 13 thinking styles with the seven items has been applied to students. In addition to thinking styles variable, the study handled other variables like type of the college, sex, and language.

The results pointed out some statistical differences in thinking styles (executive, legislative, hierarchical, internal and conservative styles). These differences were related to the type of college and language. With regard to gender, there were no differences.

The previous studies addressed the thinking styles measurement according to self-government theory. These studies addressed both the measurement in relation to other variables and checking its validity. Furthermore, the measurement has been applied on samples from university and high school students, which are similar to the sample of this study.

### 3.7 Thinking Styles in Learning and Teaching Process

The idea of matching teaching and learning styles is not new. The goal is to offer one way to expand teaching methods and curricula to reach more students. This should be considered in the teaching-learning process, and the theory of mental self-government provides one basis for such a consideration (Sternberg and Grigorenko 1995).

Having a good impression of the learners' thinking styles, as well as capitalizing on this by providing and presenting the appropriate material according to the thinking styles is the job of effective educators. A textbook cannot recognize the student's thinking style. This creates a gap between the learner and the teaching tool - the book. But with appropriate designed software this problem can be bridged.

The function dimension of the mental self-government theory consists of three thinking styles, legislative, executive and judicial. These three styles are the most representative styles in the theory. Every student is dominated by one or more of the three styles in their self-government. Thus, exploring the dominant style shows the most important and main dimension in a student's cognitive profile and how he likes direct his intelligence and perform tasks. Every style has preferences in regard to instruction, assessment, question, skill, and prompt.

### Legislative Style

Legislative learners like to create, invent, design, or do things their own way and require little structure.

Legislative learners tend to do best on independent projects, essays in which they can express their own point of view, and unstructured activities.

Instruction:
Legislative instruction emphasizes projects and creative essays and other activities. Legislative learners prefer creative and constructive planning-based activities, such as writing papers, designing projects, and creating new business or education systems.

Assessment:

Legislative assessment emphasizes creative essays and performances.

Queries of instruction and assessment:

- Create…
- Invent…
- If you …
- Imagine …
- Design…
- How would?
- Suppose…
- Ideally?

**Executive Style**

Executive learners like to follow directions, implement, and do things and require little structure.  Executive students often get along well with their teachers because they willingly accept direction and guidance.  These students tend to do best on structured activities, such as multiple-choice tests, short-answer problems, and essays for which the topic is assigned.

Instruction:

Executive instruction emphasizes didactic lectures, reading and group recitation (for factual responses).

Assessment:

Executive assessment emphasizes multiple-choice and short-answer responses.

Queries of instruction and assessment:

- Who said?
- Summarize…
- Who did?
- When did?
- What did?
- How did?

- Repeat back…
- Describe…

**Judicial Style**

Judicial learners are concerned with judging, comparing, and evaluating things and people.  Judicial students tend to get along well with teachers so long as they do not start evaluating the teachers' behaviour in front of other students.  These students tend to do well on critical essays and analyses.

Instruction:

Judicial instruction emphasizes Socratic discussion, analytical essays and other activities, and group recitation for analysis.

Assessment:

Judicial assessment emphasizes critical essays and performances.

Queries of instruction and assessment:

- Compare and contrast…
- Analyze…
- Evaluate …
- In your judgment …
- Why did?
- What caused?
- What is assumed by?
- Critique…

Table 3.1 summarizes the three thinking styles and the corresponding preferences.  According to Sternberg (1997) and Renzulli (1997), different prompts in instructional assignments can lead to varying levels of compatibility for different styles.  As shown in Table 3.2, prompts like "who said…?", "Describe…" and "Summarize…" benefit executive students; prompts like "Compare and contrast…" and "Analyze…" benefit judicial students; and prompts like "Create" and "Invent" benefit legislative students.

Table 3.1: Thinking Styles and the Corresponding Preferences

|  | **Executive** | **Judicial** | **Legislative** |
|---|---|---|---|
| **Instruction** | Didactic lecture, silent reading to remember facts, memorization | Analyze ideas, reading for understanding, Socratic discussion | Design projects, thought-based questioning |
| **Question** | Solve a given math problem | Thought-based questions, questions that require analysis and judgment, multiple choice that require analysis, items that measure reading for understanding | Thought-based questions, projects & portfolio |
| **Test** | Short answer and multiple choice | Short answer and multiple choice, project and portfolios that require analysis, critical essay | Creative essays, no multiple choice |
| **Skill** | Summarize, memorize, describe | Compare, analyze, what cause, assumptions, evaluate what is right or wrong with a scientific experiment | Create , invent, imagine, design, if you |

Table 3.2: Varying Levels of Compatibility for Different Styles

| Legislative | Judicial | Executive |
|:---:|:---:|:---:|
| **Type of prompt** | | |
| Create | Compare and contrast | Who said? |
| Invent… | Analyze… | Summarize… |
| If you… | Evaluate… | Who did? |
| Imagine… | In your judgment… | When did? |
| Design… | Why did? | What did? |
| How would? | What caused? | How did? |
| Suppose… | What is assumed by? | Repeat back… |
| Ideally? | Critique… | Describe… |
| Compose | Weigh | Specify |
| Animate | Consider | Simplify |
| Develop | Review | Interpret |
| Write | Value | Clarify |
| Film | | |
| Devise | | |

**3.8 Summary**

The mental self-government theory states that people have preferred ways of thinking, which metaphorically map onto different aspects of the organization of government. The understanding of thinking styles relies on a main idea in the mental self-government theory which states that different kinds of authorities and governments in the world are an outer reflection of what goes on in individuals' minds and thus represent alternative ways of organizing our thinking. Therefore, the kinds of governments we can see are a mirror of our minds. A style is an individual's preferred way of thinking and expressing or using one or more abilities. A style is neither a level of intelligence nor a personality trait, but rather an interaction of intelligence and personality that brings the two psychological structures together. Thinking styles are at the interface between the domain of abilities and the domain of personality. Different people with the same level of abilities may have different styles of thinking. Thinking styles refer to the ways in which people choose to use or exploit their intelligence as well as their knowledge. Thus thinking styles are not abilities, but rather how these abilities, and the knowledge acquired through them, are used in day-to-day interactions with the environment.

According to the theory, thinking styles can be divided into five categories: function, form, level, scope and leaning. Each category has its own styles. The theory consists of 13 styles in total and they delineate a cognitive profile of how people direct their intelligence and use their abilities.

Individuals tend to choose the styles with which they feel comfortable with regard to managing their affairs. Some individuals prefer particular styles in a certain stage of their lives, but other styles in a different stage.

Several factors affect the change of thinking styles of individuals. Each plays a role in the progress or stability of the styles which individuals use. These factors are: culture, gender, age, parenting styles, education, and occupation.

Several studies that have explored and analyzed thinking styles within the frame of mental self-government theory have been applied in the USA, South Africa, and Hong Kong (Sternberg and Grigorenko 1995 and 1997, Zhang and Sternberg 1998, Zhang

and Sachs 1997, and Cilliers and Sternberg 2001).  These studies addressed both the measurement in relation to other variables and checking its validity.  Furthermore, the measurement has been applied on samples from university and high school students, which are similar to the sample of this study.  Other studies addressed thinking styles of teachers and students, the interaction between teachers' styles and students' styles, and the relations between styles and achievement.

Having an appreciation of a learners' thinking styles, as well as capitalizing on it by providing and presenting the appropriate material according to the thinking styles should be considered in the teaching-learning process, and the theory of mental self-government provides one basis for such a consideration.

# CHAPTER 4
# METHODOLOGY

## 4.1 Introduction

The purpose of the study was to examine the effects of using a software system called CAT (Computer-Aided Thinking), as compared to traditional software, on students' achievement as they learned a unit in biochemistry from the UAE $12^{th}$ grade curriculum. CAT provides students with different activities, questions and prompts that match their thinking styles based on the Mental Self-Government Thinking Styles Theory. This chapter presents an overview of how the study was carried out. It outlines the parts that constituted the study, and the phases the study passed through. The chapter contains sections about research hypotheses and questions, participants, treatment of instruments, research design and analysis method.

## 4.2 Phases of the Study

In order to achieve the purpose of the study, it was organized into two phases. The first phase consists of two tasks:

- Standardize and normalize the Sternberg-Wagner Self-Assessment Inventory of thinking styles for the UAE environment.

- Phase 1 prototype and study.

Chapters 5 and 6 discuss these two tasks in detail.

In the second phase the CAT system was developed and then was used in the main case study to explore the research hypotheses. Chapters 7 to 9 discuss phase 2 in detail.

## 4.3 Research Hypotheses:

The research hypotheses for the project are:

- Students who use CAT significantly outperform students who use traditional CAI on an achievement test.

- Students who use CAT are more likely to comprehend the knowledge contained in CAT.

- Students who use CAT are more likely to like the subject contained in CAT.

- Students who use CAT are more likely to know their preferred way of learning.

- Students who use CAT are more likely to like the teaching method contained in CAT.

- Students who solve activities in the sequence according to their thinking styles are more likely to understand the knowledge they learn and be motivated.

## 4.4 Design of the Study

### Method

For the study, the effect of the CAT system on students' achievement was determined using an experimental method. The results were analysed quantitatively and qualitatively.

### Subjects

The study went through two phases. In both phases all subjects who participated in the study were male students from Khalifa Secondary School in Abu Dhabi. The same chemistry teacher taught all the students in both phases.

In the first phase, 13 students from a $10^{th}$ grade class participated. The class was selected randomly.

In the second phase, the subjects were students from two 12th grade classes. There were 30 students in each class. Hence, the sample for the 2nd phase consisted of a total of 60 students. A class was selected randomly from the two as the control group and the other was the experimental group. The students in both the control and experimental groups were of mixed abilities. It is normal practice that at the beginning of the school year, the school administration would allocate students in both classes evenly based on the students' achievement in the previous year. However, during the school year and before starting the experiment, the students of both groups had taken four chemistry assessments on material learned so far in the academic year. The statistics of the tests mean scores, and standard deviations for

both groups were calculated and are presented in Table 4.1 below. T-test was performed to assess the mean difference between the two groups. Table 4.1 shows the groups statistics and t-test results. The results in the table show that there was no significant difference between the two groups. Therefore, by the time of the experiment, there was no significant difference between the two groups.

Table 4.1: Groups Statistics and T-test Results

|  | GROUP | N | Mean | Std. Deviation | t | Sig | |
|---|---|---|---|---|---|---|---|
| **TEST1** | Experimental Group | 29 | 13.07 | 4.978 | 1.591 | .118 | Not significant |
|  | Control Group | 25 | 11.04 | 4.286 | | | |
| **TEST2** | Experimental Group | 29 | 12.76 | 4.673 | -.074 | .941 | Not significant |
|  | Control Group | 26 | 12.85 | 3.977 | | | |
| **TEST3** | Experimental Group | 29 | 12.83 | 4.929 | -.752 | .455 | Not significant |
|  | Control Group | 26 | 13.73 | 3.832 | | | |
| **TEST4** | Experimental Group | 29 | 12.48 | 6.045 | -1.871 | .067 | Not significant |
|  | Control Group | 26 | 15.04 | 3.649 | | | |

**Setting**

The main experiment was conducted at the computer laboratory in Khalifa Secondary school. The principal of the school approved conducting the study in the school. The good relationship between the researcher and the school principal was the main reason to select the school. This had eased the process of conducting the experiment.

**Instruments**

Four instruments were used in the experiment.

- A questionnaire.

- The CAT tool containing the biochemistry lessons.

- Achievement test to measure the students' achievement of the assigned lessons. The researcher prepared the test in cooperation with the chemistry teacher who participated in implementing the experiment in Khalifa School.

- The standardized version of the Sternberg-Wagner Self-Assessment inventory on the Legislative, Executive, and Judicial Thinking Styles.

The instruments are described below.

**Questionnaire**

A student questionnaire was developed for the purpose of evaluating the effectiveness of CAT. The questionnaire was divided into two parts, as shown in appendix III and V). The first part consists of 25 items (the questionnaire in the first phase consisted of only 22 items). Four point Likert type scale was used in the questionnaire to evaluate the effectiveness of CAT: 4 for highly agree, 3 for agree, 2 for neutral, 1 for don't agree have been given in order to analyze the data. Although 5 point Likert would have been a lot better and in line with good practice, the outcome would not change if the extra option had been used. There are very few ticks in the "don't agree" choice so extending it to "strongly don't agree" would not have had any effect.

The second part consists of two open questions to gather students' comments and suggestions about CAT. After the first week of the experiment six students from the control and experimental group were asked to answer the questionnaire to ensure that all items were clear and understandable. Modification was done accordingly. At the end of the experiment students of both groups answered the questionnaire. No clarification was needed. Cronbach's alpha (Elliott & Woodward 2007) was calculated to confirm sufficient reliability of each of the subscales.

In order to explore the hypotheses 2 through 6 the questionnaire was designed to survey the learning experience dimensions as depicted in table 4.2.

Table 4.2: Questions to Explore the Hypotheses

| Learning Experience | Question Number |
|---|---|
| Comprehension | 2, 3, 6, 9, 19 |
| Passion for Subject | 8 |
| Preferred Learning Style | 5 |
| Teaching Method | 11, 12, 13, 15, 16, 23, 24 |
| Activities and Tasks | 1, 4, 10, 14, 18, 20, 22, 25 |

**CAT Tool**

The tool was given the name CAT (Computer Aided Thinking) because it was intended to aid students in their learning by matching activities to their thinking styles. CAT was developed using the programming language Visual Basic 6. It was chosen for the following reasons:

- It is easy to use on one hand and sufficiently powerful on the other to satisfy all the development needs in this study.

- User interfaces can be easily programmed.

- The researcher has considerable previous experience in this language.

Details of CAT are described in chapter 7.

**Achievement Test**

The researcher prepared an achievement test with the cooperation of the subject teacher. The test was designed to measure the achievement of the individuals who constituted the sample of the study after they had finished studying the content of the assigned material. The test duration was 45 minutes. The test included multiple choices, open ended, and true and false questions. The paper-based test is given in Appendix VI. In order to confirm the validity of the test, it was presented to six specialist evaluators who were specialized in methods of teaching chemistry and in measurement and assessment. The evaluators were asked to offer comments on the wording of the test and the coverage of the test. The final test was finalized after taking all the comments into consideration.

**Standardized Thinking Style Inventory**

The Sternberg-Wagner Self-Assessment Inventory of thinking styles (Sternberg 1997) was standardized to be used in the UAE for identifying the thinking styles among the sample of the study. The inventory is given in Appendix IV. Chapter 5 details the Standardization study.

# CHAPTER 5

## STANDARDIZING THE STERNBERG-WAGNER SELF-ASSESSMENT INVENTORY OF THINKING STYLES FOR THE UAE ENVIRONMENT

### 5.1 The Problem

The problem of standardization of psychological tests occupies a significant part in the history of psychology. This kind of research, standardization research, represents a particular category of scientific research in the field of educational, mental, and psychological standardization. The aim of standardization is to make the tests more suitable for the new circumstances. In the current context of the project, the challenge is to verify whether standard tests created in a different culture or education system is suitable for use in another. If the "standard" tests are not appropriate then what changes are required?

To limit the changes required, the starting point is to choose standardized tests that are least affected by cultural factors, the so-called culture-effect-free tests. Sternberg-Wagner Self-Assessment Inventory of Thinking Styles (Sternberg 1997), from Yale University in USA, has been chosen to be standardized in the United Arab Emirates due to the following reasons:

- The Assessment Inventory is one of the most modern instruments, which contains the various thinking styles. It is based on a scientific theory (Sternberg 1997), which constitutes the theoretical frame on which this study relies on.
- The Assessment Inventory is widely used and a lot of effort has already gone into standardizing it for different cultures like South Africa, and Eastern Asia. Therefore, the Assessment is already appropriate for a number of cultures (Zhang and Sternberg 1998, Zhang and Sachs 1997, and Cilliers and Sternberg 2001).
- The Assessment Inventory is related to developing students' learning methods at schools according to different ages. That is to say, the dominance of a particular style means the dominance of a particular learning method. Several

studies proved the effect of thinking styles on students in their classes (Sternberg 1997, Zhang and Sternberg 1998, Zhang and Sachs1997, Cilliers and Sternberg 2001, and Sternberg and Grigorenko 1995)

- The researcher has developed an educational model called SWOM, which focuses on teaching the students in harmony with their mental model. The Students' mental model is their profile that consists of the student's thinking style, learning style, and zone of proximal development (ZPD). This study serves a major educational goal for the researcher, which is to empirically check one aspect of the student's mental model - the thinking style.

- As far as can be determined from the literature, this is the first attempt to standardize the Assessment Inventory in an Arabic environment.

## 5.2  Setting

The director of Abu Dhabi Educational Zone approved conducting the study in nine schools in Abu Dhabi. The study was carried out at the beginning of the school year 2003-2004 in Abu Dhabi Educational Zone schools and continued to the end of the first term of the academic year.

## 5.3  Sample

Standardization of thinking styles measurement was carried on a random sample of 247 students (142 males, 105 females). Students who did not complete all the answers were excluded.

The sample was divided into two parts:

High school female students: 105 girls were chosen from four high schools:

- A'esha Bint Abu Bakr School: 30 students
- Um Ammar School: 25 students
- Al Wehda School: 25 students
- Palestine School: 25 students

All the schools are within the same educational zone and geographical area in UAE. The students are in the age range 15 to 18.

High school male students: 142 boys were chosen from five high schools:

- Abu Dhabi High School: 24 students

- Mohammed Bin Khalid School: 24 students

- Abu Dhabi Commercial High School: 31 students

- Al Mutanabi High School: 26 students

- Darweesh Bin Karam School: 26 students.

All the schools are within the same educational zone and geographical area in UAE. The students are in the age range 15 to 18.

**5.4 Instrument**

The study instrument consisted of Sternberg's Mental Self-Government Thinking Styles Assessment Inventory. The inventory measures 13 different thinking styles grouped under five categories: function (legislative, executive, judicial), form (monarchic, hierarchic, oligarchic, anarchic), level (global, local), scope (internal, external), and leaning (liberal, conservative). Every style consists of eight statements in which there are seven choices for the responses. Thus, the number of items in the measurement as a whole is 104 statements.

The study focused on the function and form categories only (seven styles) for the following reasons:

- There are too many statements in all five categories for the students to consider. Responding to them may need more than one class period; there will certainly be difficulty in implementing the assessment.

- From the researcher's point of view, the function of mental self-government is logically related to the forms.

- This study is an initial step to test the validity and reliability of the dimensions of Mental Self-Government Theory on the UAE environment. Other studies can be arranged to work on the rest of the 13 styles.

The measurement consists of 56 items distributed over seven styles, i.e. each style contains eight items. Each item has a choice of seven responses:

Extremely well, very well, well, somewhat well, slightly well, not very well, not at all well.

The students put a mark on their choice according to the instructions. Grades are given to the seven points on a graded scale according to the Likert scale (1-2-3-4-5-6-7). Grade 7 is given to "Extremely well" choice, and grade 1 to "not at all well".

**5.5 Validity**

To measure the validity of the thinking styles measurement three types of tests were used: internal consistency, correlation coefficient between styles, and factorial analysis.

The best way to identify the validity for tests at this stage is the validity of hypothetical construct. One of the most common ways to measure this type of validity is what is called "internal consistency" (Abu Hatab 1986). The vital criterion is the total degree in the scale itself. Al Sayed (1979) chooses to call this an "internal scale". The binary correlation coefficient has been calculated between each item on the scale (56 items) in the seven styles and total degree in the entire scale, as illustrated in Table 5.1. A Kolmogorov Smirnov test was performed to check data distribution. Table 5.5 shows that the data is multivariate normally distributed.

Table 5.1: The Validity of Internal Consistency for Thinking Styles Measurement for a Sample of 247

| Item | Style | Correl-ation | Item | Style | Corre-lation | Item | style | Correl-ation |
|------|-------|--------------|------|-------|--------------|------|-------|--------------|
| 1 | legislative | 0.28 | 24 | judicial | 0.23 | 47 | oligarchic | 0.36 |
| 2 | legislative | 0.16 | 25 | monarchic | 0.27 | 48 | oligarchic | 0.35 |
| 3 | legislative | 0.17 | 26 | monarchic | 0.21 | 49 | anarchic | 0.23 |
| 4 | legislative | 0.39 | 27 | monarchic | 0.17 | 50 | anarchic | 0.20 |
| 5 | legislative | 0.32 | 28 | monarchic | 0.26 | 51 | anarchic | 0.25 |
| 6 | legislative | 0.28 | 29 | monarchic | 0.30 | 52 | anarchic | 0.40 |
| 7 | legislative | 0.33 | 30 | monarchic | 0.21 | 53 | anarchic | 0.36 |
| 8 | legislative | 0.34 | 31 | monarchic | 0.26 | 54 | anarchic | 0.40 |
| 9 | executive | 0.25 | 32 | monarchic | 0.25 | 55 | anarchic | 0.38 |
| 10 | executive | 0.29 | 33 | hierarchical | 0.37 | 56 | anarchic | 0.45 |
| 11 | executive | 0.31 | 34 | hierarchical | 0.41 | | | |
| 12 | executive | 0.34 | 35 | hierarchical | 0.39 | | | |
| 13 | executive | 0.24 | 36 | hierarchical | 0.41 | | | |
| 14 | executive | 0.36 | 37 | hierarchical | 0.48 | | | |
| 15 | executive | 0.22 | 38 | hierarchical | 0.38 | | | |
| 16 | executive | 0.43 | 39 | hierarchical | 0.36 | | | |
| 17 | judicial | 0.29 | 40 | hierarchical | 0.42 | | | |
| 18 | judicial | 0.30 | 41 | oligarchic | 0.41 | | | |
| 19 | judicial | 0.38 | 42 | oligarchic | 0.28 | | | |
| 20 | judicial | 0.39 | 43 | oligarchic | 0.42 | | | |
| 21 | judicial | 0.30 | 44 | oligarchic | 0.26 | | | |
| 22 | judicial | 0.37 | 45 | oligarchic | 0.20 | | | |
| 23 | judicial | 0.23 | 46 | oligarchic | 0.31 | | | |

The above table shows that correlation coefficients for all the 56 items in the seven styles are significant at the level of 0.05 and 0.01. This indicates the validity of the measurement and, hence, not a single question was expunged.

The second test used was the correlation coefficient between the seven styles for the entire sample. Table 5.2 shows the correlation coefficient matrix for the entire sample.

Table 5.2: Matrix of Correlation Coefficients between the Seven Styles of the Entire Sample

|  | legislative | executive | judicial | monarchic | hierarchical | oligarchic | anarchic |
|---|---|---|---|---|---|---|---|
| **legislative** | ** | 0.434 | 0.410 | 0.222 | 0.364 | 0.132 | 0.362 |
| **executive** |  | ** | 0.491 | 0.190 | 0.497 | 0.180 | 0.263 |
| **judicial** |  |  | ** | 0.183 | 0.484 | 0.305 | 0.355 |
| **monarchic** |  |  |  | ** | 0.253 | 0.340 | 0.358 |
| **hierarchical** |  |  |  |  | ** | 0.440 | 0.399 |
| **oligarchic** |  |  |  |  |  | ** | 0.392 |
| **anarchic** |  |  |  |  |  |  | ** |

All of these coefficients are significant and positive at 0.01 and 0.05.

Needless to say that these correlations are evidence on internal validity of the seven styles.

Finally factoral validity has been calculated by calculating factor analysis on the sample of the 247 students. This analysis reveals the common factors, which compose the measurement. The following steps have been taken in the analysis (Abdoun 1990)

- Calculating the matrix of correlations for the measurement items 56 X 56.

- Applying first-degree factor analysis of Hotling by the computer using SPSS to get the factors that compose the measurement (implicit root for these factors is greater than one).

- To produce a psychological meaning to these factors, orthogonal rounding off in Varimax way for Kazor has been used. We depended upon Kazor's criterion, which identifies responses that reach 0.3 or more as functional responses. The result of factor analysis in this study has pointed out to the

presence of 17 factors as shown in table 5.3. The values of correlations ranged between 0.35 and 0.71, which are significant. Variation percentages of factors are 14, 6.8, 5, 3.9, 3.8, 3.4, 2.9, 2.8, 2.7, 2.5, 2.2, 2.2, 2.1, 1.19, 1.88, and 1.28.

- By looking at factor analysis and responses level table, we find that all the questions or the measurement's items have responses level higher than 0.3 according to Kazor's criterion on which this study relied in identifying the level of the responses to the questions. So, no question has been expunged. We also find that the levels of responses to the items of the first factor reached into 47 items out of the overall 56 items of the measurement. These responses encompassed most items of the measurement's seven thinking styles. Then, it was called "general thinking" because it covers the previous thinking styles.

Although we haven't addressed the other 16 factors, because we probably need other studies dealing with the other styles of the measurement within the frame of mental self-government theory in order to test their validity, the levels of responses to the items of the 16 factors have been as follows:

The second factor: the number of items in which responses exceed 0.3 was 21, the third factor 16, the fourth factor 11, the fifth factor 9, the sixth factor 9, the seventh factor 11, the eighth factor 5, the ninth factor 9, the tenth factor 8, the eleventh factor 4, the twelfth factor 8, the thirteenth factor 5, the fourteenth factor 8, the fifteenth factor 4, the sixteenth factor 2, and the seventeenth factor 2.

Although the levels of responses for many questions have been poor, they exceed 0.3, another evidence of the measurement's validity. The study has not gone beyond first-degree factor analysis because it is aimed at testing the validity of the measurement's items. However, we still need a second-degree analysis in other studies to reduce the number of factors.

**5.6 Reliability**

Measurement's reliability has been confirmed by calculating Alpha coefficient using SPSS (Ghonaim 2000). This has been done by calculating the measurement's reliability if each item is deleted individually. This means that in case of deleting the

grade of the item, if the reliability coefficient is greater than Alpha reliability coefficient value for the measurement as a whole, the statement is poor and should be deleted from the measurement, while in case of deleting the grade of the item, if the reliability coefficient is smaller than Alpha reliability coefficient value for the measurement as a whole, the statement is important, reliable, and affects the reliability of the measurement as a whole, and, therefore, should not be deleted.

Considering the results of analyzing reliability using Alpha coefficient for thinking styles measurement, we find that the value of Alpha reliability coefficient reached up to 0.87, which is a high reliability coefficient. By comparing Alpha coefficient for each item and this overall coefficient, we find that the value of the 56 measurement items ranged from 0.80 - 0.86, which is fewer than the overall Alpha coefficient. This highlights the reliability of the measurement and items, so no item has been deleted.

Also, reliability has been calculated by using half-division which divides the sample's grades on the measurement into two parts: odd questions and even questions. By using Spearman Brown's equation, reliability coefficients for the seven styles and the overall degree of the measurement have been as follows:

Reliability coefficient in the first style (legislative) was 0.66, the second style (executive) 0.73, the third style (judicial) 0.82, the fourth style (monarchic) 0.66, the fifth style (hierarchical) 0.71, the sixth style (oligarchic) 0.78, and the seventh style (anarchic) 0.83. All of these coefficients are significant and positive, which is evidence of the measurement's reliability.

Table 5.3: Factors, Items Responses, Implicit Root and Variation Values

| Factors Items | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | .32 | | | | | | .34 | | .31 | | | | | .40 | | | |
| 2 | | | .30 | | .45 | | .50 | | .33 | | | | | | | | |
| 3 | | | | | | .30 | | | | .31 | | .32 | | .30 | | | |
| 4 | .41 | | | .30 | | | | | | | .35 | | | | | | |
| 5 | .40 | | | | .40 | | | | | .31 | | | | | | | |
| 6 | .40 | .30 | | | | | | | | | | | | .40 | | | |
| 7 | .41 | .32 | | | | .30 | | | | | | | | | | | |
| 8 | .44 | .33 | | | | | | | | | | | | | | | |
| 9 | .30 | | | .33 | | | | | | | | .40 | | | .30 | | |
| 10 | .40 | .40 | | | | | | | .30 | | | .33 | | | | | |
| 11 | .40 | | | | | .30 | | | | .44 | | | | .30 | | | |
| 12 | .44 | .34 | | | .30 | | | | | .30 | | | | | | | |
| 13 | .30 | | .50 | .30 | | | | | | | | | | | | | |
| 14 | .42 | | | | | | .30 | .30 | .32 | .30 | | .30 | | | | | |
| 15 | .30 | | | | .41 | | .30 | | .32 | .31 | | .30 | | | | .33 | |
| 16 | .50 | | | | | .30 | .30 | | | | | .30 | | | | | |
| 17 | .30 | | | | | | | .43 | | | | | | | .30 | | |
| 18 | .38 | .34 | | | | | | | .41 | | | | | | | | |
| 19 | .46 | .34 | | .30 | | | .31 | | | | | | | | | | |
| 20 | .48 | | | | | | | | | | | | | .30 | | | |
| 21 | .36 | | | .52 | | | | | | | | .30 | | | | | |
| 22 | .45 | | | | | | | | | | .30 | | | | | | .31 |
| 23 | .42 | | | .48 | | | | | | | | | | | | | |
| 24 | .37 | .34 | .38 | | | | | | | | | | | | | | |
| 25 | .30 | .45 | | | | | .31 | | | | | | .35 | | | | |
| 26 | | .33 | .40 | | | .30 | | | | | | | | | | | |
| 27 | | .30 | .51 | | | | .30 | | | | | | | | | | |
| 28 | | .40 | .41 | | | | | | | | | | | | | | |
| 29 | .30 | | .40 | | | .40 | | | | | | | | | | | |

*Continued on next page*

| Factors / Items | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30 | .30 | | | | | | | | | | | | | | | | |
| 31 | .30 | | | .36 | | .35 | | | | | | | | | | | |
| 32 | .33 | | | .35 | | | | | | .33 | | .30 | | | | | |
| 33 | .49 | | | | | | | | .30 | | | | | | .31 | | |
| 34 | .51 | | | .40 | | | | | | | | | | | | | |
| 35 | .50 | .30 | | .30 | .32 | | | | | | | | | | | | |
| 36 | .50 | | .30 | | | | | | .33 | | | | | | | | |
| 37 | .53 | .34 | .35 | | | | | | | | | | | | | | |
| 38 | .45 | | .32 | | | .30 | | | | | | | | | | | |
| 39 | .42 | | .33 | | | | | | | | .30 | | .32 | | | | |
| 40 | .51 | | .41 | | | | | | | | | | | | | | |
| 41 | .44 | | | | | | | | .32 | | | | .30 | | | | |
| 42 | .30 | .46 | | | | | | .40 | | | | | | | | | |
| 43 | .47 | | | | .31 | | .30 | | | | .30 | | | | | | |
| 44 | | .60 | | .30 | | | | | | | | | | | | | |
| 45 | | .49 | | | .30 | | | | | | | | | | | | |
| 46 | .34 | | | | .42 | | | | | | | | | | | | |
| 47 | .38 | | .34 | | | | | .40 | | | | | | | .31 | | |
| 48 | .35 | .30 | | | | | | .34 | | | | | | | | | .32 |
| 49 | | .46 | | | | | .30 | | | | | | | | | | |
| 50 | | .47 | | | | | | | | | | | | | | | |
| 51 | .31 | | .30 | | | .36 | | | | | | | | | | | |
| 52 | .46 | | .32 | | .30 | | | | | | | | | | | | |
| 53 | .37 | | | | | | | | | | .30 | | .30 | | | | |
| 54 | .50 | | | | | | | | | | | | | | | | |
| 55 | .47 | | | .31 | | | | | | | | | | | | .31 | |
| 56 | .53 | | | | | | | | | | | | | | | | |
| Root | 8 | 3.9 | 2.9 | 2.2 | 2.1 | 1.9 | 1.7 | 1.6 | 1.5 | 1.4 | 1.3 | 1.3 | 1.2 | 1.1 | 1.1 | 1.1 | 1 |
| variation | 14 | 6.8 | 5 | 3.9 | 3.8 | 3.4 | 2.9 | 2.8 | 2.7 | 2.5 | 2.2 | 2.2 | 2.1 | 2 | 1.91 | 1.88 | 1.82 |

## 5.7 Sex Differences

The study attempted to answer the following question: Are there any significant statistical differences between boys and girls with regard to the seven styles of the thinking measurement?

To answer this question, means (M) and standard deviation (SD) have been calculated. A t-test was performed. Table 5.4 shows the t-test results.

The table shows that there are significant statistical differences between the boys and the girls. These differences were in favour of the girls. They were better than the boys in five styles: the legislative, executive, monarchic, hierarchical, and anarchic. However the differences in the sixth style, the oligarchic, were in favour of the boys.

With regard to the last style, judicial, results in table 5.4 indicate that the differences between boys and girls are not significant. That is to say, there are no differences between the boys and the girls in this style.

Table 5.4: Boys and Girls Statistics and T-Test Results

| Sample ⟍ Styles | Boys' Sample (142) | | Girls' Sample (105) | | t | significance Level |
|---|---|---|---|---|---|---|
| | Means | Deviation | Means | Deviation | | |
| legislative | 44.81 | 10.29 | 45.64 | 5.30 | -8.195 | significant .05 |
| executive | 43.80 | 10.37 | 45.34 | 6.57 | 19.840 | Significant .01 |
| judicial | 40.10 | 10.76 | 40.50 | 7.35 | -6.733 | Not significant |
| monarchic | 39.10 | 10.95 | 41.81 | 10.51 | -18.868 | Significant .01 |
| hierarchical | 44.27 | 10.95 | 45.17 | 6.72 | -15.816 | Significant .05 |
| oligarchic | 42.04 | 10.70 | 40.79 | 7.65 | 11.167 | Significant .01 |
| anarchic | 41.43 | 9.69 | 43.06 | 7.10 | -6.097 | Significant .01 |
| Overall degree | 295,56 | 61.97 | 302.61 | 33.28 | 3.894 | Significant .01 |

Having differences between the two samples (boys and girls) in thinking styles is evidence on the measurement's reliability since it differentiates between individuals in the measured characteristic.

Table 5.5: Kolmogorov Smirnov Test

| sample | styles | legislative | executive | judicial | monarchic | hierarchical | oligarchic | anarchic |
|---|---|---|---|---|---|---|---|---|
| N | | 247 | 247 | 247 | 247 | 247 | 247 | 247 |
| Normal Parameters (a,b) | Mean | 23.51 | 19.97 | 20.1498 | 22.76 | 23.63 | 23.17 | 26.08 |
| | Std. Deviation | 7.06 | 4.84 | 6.05 | 6.27 | 6.03 | 5.05 | 7.04 |
| Most Extreme Differences | Absolute | 0.09 | 0.13 | 0.1 | 0.12 | 0.08 | 0.11 | 0.19 |
| | Positive | 0.07 | 0.09 | 0.07 | 0.06 | 0.06 | 0.09 | 0.08 |
| | Negative | -0.09 | -0.13 | -0.1 | -0.12 | -0.08 | -0.11 | -0.19 |
| Kolmogorov-Smirnov Z | | 1.46 | 2.16 | 1.6 | 1.89 | 1.36 | 1.85 | 3.13 |
| Asymp. Sig. (2-tailed) | | 0.02 | 0 | 0.01 | 0 | 0.04 | 0 | 0 |

a. Test distribution is Normal.
b. Calculated from data.

**5.8 Conclusion**

Efforts have gone into standardizing the Sternberg assessment inventory for different cultures, e.g. (Zhang and Sachs 1997, Zhang and Sternberg 1998, and Cilliers and Sternberg 2001). One major contribution of this study is that it was the first attempt to standardize the assessment inventory in Arabic culture.

The main objective of this study was to check the validity and reliability of the thinking styles measurement in Sternberg's Self-Government Theory (7 styles of function and form categories of the inventory). The study showed that the thinking style inventory (7 styles of function and form categories of the inventory) was valid and reliable for use in identifying the thinking styles among a sample of UAE high school students. This finding correlates with other studies which were carried out in Hong Kong, e.g. (Zhang and Sachs 1997, and Zhang and Sternberg 1998), and found

that the thinking styles inventory defined by Sternberg's theory is valid and reliable for identifying thinking styles of university students in Hong Kong.

The current study pointed out significant correlations between the seven thinking styles, which is evidence on internal validity of the seven styles. Finally, the results of this study indicate the presence of significant statistical differences between the boys and girls in five styles: legislative, executive, monarchic, hierarchic, and anarchic. This difference is evidence on the measurement's reliability. This result is supported by Sternberg (1997) who points out some differences in styles between males and females.

The results of standardizing the thinking styles measurement for the UAE environment will contribute to the reform in the UAE in helping teachers individualize instruction and provide student-centred environment in accordance with the student's thinking style. Hence improve the learning process.

The measurement will be used to determine the thinking styles of the students taking part in the subsequent experiment.

# CHAPTER 6

## PHASE 1 PROTOTYPE AND STUDY

### 6.1 Introduction

The CAT system has passed through two phases. The goal of the first phase was to use computers to provide two chemistry lessons about Oxygen to explore how students react with it in regard to time, comparison activities, ease of use, students' motivation and confidence, and learning with computer. This will provide feedback from the students to help build the CAT system, which embeds the thinking style theory in the second phase. To do this, the following study was conducted.

### 6.2 Method

**Subjects**

The sample comprised 13 students from a $10^{th}$ grade class (all boys) in Khalifa high school. The ages of the students ranged from 16 to 17 years at the start of the study. The class was selected randomly.

**Setting**

The experiment was conducted at the computer laboratory in IDRAC centre. The principal of the school approved conducting the study outside the school. The good relationship between the researcher and the school principal was the main reason to select the school. This had eased the process of conducting the experiment.

**Instruments**

Two instruments were used in the experiment.

- A questionnaire.

- The software program containing the two chemistry lessons about Oxygen.

**Study Procedures**

A team consisting of a chemistry supervisor, a chemistry teacher and the researcher prepared two lesson plans on Oxygen from the tenth grade chemistry curriculum. The team prepared all the narrations.

Topics of lesson 1 were:

1. The properties of the periodic table.
2. The properties of the sixth group (the oxygen group).
3. The oxygen position in the sixth group and the attributes of this position.
4. Comparison activities.

Lesson 1 consists of 27 pages as detailed in Table 6.1.

Topics of lesson 2 were:

1. Importance of oxygen for life.
2. Oxygen in nature.
3. Oxygen cycle.
4. Oxygen chemical properties.
5. Oxygen uses and benefits.
6. Comparison activities.

Lesson 2 consists of 18 pages as detailed in Table 6.2.

Table 6.1: Lesson 1 Details

| Page | Content | Image | Video |
|---|---|---|---|
| 1-4 | Introductory screens | Persistence to achieve goals | Building collapse |
| 5 | Lesson topics | | |
| 6 | Question about what students know about sixth group and what they would like to know | KWL graphic organizer | |
| 7-8 | Introducing the compare thinking skill | Compare thinking map and graphic organizer | |
| 9-12 | Presentation of the properties of the periodic table and the sixth group | Periodic table. Sixth group properties table. Oxygen Atom. | |
| 13-15 | Activity of comparing oxygen with other elements of the sixth group | Graphic organizer | |
| 16-17 | Interactive questions. | Animated figures | |
| 18 | Demonstration of some of the oxygen's properties | | Demonstration of the bond between oxygen and hydrogen in water |
| 19 | Question about what students has learned about sixth group. | KWL graphic organizer | |
| 20-24 | Thinking about thinking part of the lesson, questions about the compare skill to let students think about the compare and contrast skill. | | |
| 25-27 | Two activities to compare between types of bonds, and metallic and non-metallic. | Graphic organizers | |

Table 6.2: Lesson 2 Details

| Page | Content | Image | Video |
|---|---|---|---|
| 1 | Introduction to the Oxygen lesson. Scientist who first made experiments on oxygen. | Pictures of scientists and image of oxygen experiment. | |
| 2 | Oxygen in atmosphere. Oxide types. | Pictures and table. | |
| 3 | Demonstration of the oxygen cycle in nature. | | Animated image. |
| 4 | Based on the students' observation about the oxygen cycle, they are asked to come up with a conclusion. | | |
| 5-7 | Oxygen production. Students are asked to record their observations | | Demonstration of oxygen production in industry and inside labs. |
| 8 | The students are asked to summarize what he has learned. Furthermore, they are asked to identify new information versus known information from the lesson | Tables | |

| | | | |
|---|---|---|---|
| 9 | The students are asked to describe what interests them in the lesson. Furthermore, they are asked to identify ambiguous information.  They will then discuss this ambiguity with their peers or teacher and clear it up then write their comments in the space provided | Tables | |
| 10 | Oxygen's bond with metallic elements. The students are asked to note their observations after each experiment. | | Animated demonstrations of three experiments about Oxygen's chemical properties (Oxygen's bond with metallic elements). |
| 11 | Based on the students' observation, they are asked to come up with a conclusion about the Oxygen's bond with metallic elements. | | |
| 12 | Oxygen's chemical properties (Oxygen's bond with non-metallic elements). The students are asked to note their observations after each experiment. | | Animated demonstrations of two experiments about Oxygen's chemical properties (Oxygen's bond with non-metallic elements). |
| 13 | Based on the students' observation, they are asked to come up with a conclusion about Oxygen's bond with non-metallic elements. Finally, they are asked to compare between oxygen's bonding with metallic and non-metallic elements using the compare graphic organizer. | Graphic organizer | |
| 14 | The students are asked to note their prior knowledge about Oxygen uses. And then they are introduced to additional benefits and uses of Oxygen. | Pictures | |
| 15 | The students are asked to organize the information about the uses of the oxygen in the Venn diagram. | Venn diagram | |
| 16-17 | Two activities: Compare the properties of Oxygen compounds with metal and non-metal. Compare between human and tree respiration | Graphic organizers | |
| 18 | The students are asked to write an essay about: The importance of Oxygen and its uses. Oxygen life cycle in nature. | | |

Then a team consisting of four specialists helped develop a prototype of the program that automated the two lessons using Macromedia. The program was linear in nature. Each lesson was included in several pages like a book. The pages contained text, sound tracks and animations. The students had to log in using their usernames and passwords.

The program incorporated control buttons for the student to move around the lessons. Figure 6.1 shows the first screen of the first lesson.

- Two buttons to stop and start the sound track.
- A button to go to the beginning of the lesson.
- Two buttons to go to the previous or the next lesson.
- Two arrows to move within the lesson, one screen at a time.
- A counter showing the page number.
- Four Info buttons to show the periodic table, the properties of the Oxygen group and graphic organizers.
- A button to exit the program.



Figure 6.1: The First Screen of the First Lesson with the Buttons

The program was tested to ensure that there were no running or typographical errors. The team reviewed the content and narration tracks, and then corrections were made

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to ensure validity. Appendix II shows the details of the program screens. The purpose of this prototype was to be used by the students and get feedback from them to help build the CAT system in phase 2.

An experiment was conducted on a group of 13 tenth grade students from Khalifa high school in Abu Dhabi to use the software prototype in learning the lessons. The students went to a computer lab located outside the school. The teacher's role was only to guide the students and answer their questions. All the activities and tasks used in the program were comparison tasks. The group of students studied the assigned material using the software. Student worked on their own computer for the entire period of the experiment, which continued for ten days. During this period, the students went to the lab to learn using the program four times. They spent one hour each time using the system. The total amount of time spent by each student was four hours. A questionnaire for the students was developed for the purpose of evaluating the effectiveness of the prototype. The questionnaire is given in Appendix III.

The questionnaire was divided into two parts. The first part consisted of 22 items. The second part consisted of two open questions to get students' comments and suggestions to enhance the program. All the data in this part of the questionnaire was read through to obtain a general sense of the information and to reflect on its overall meaning. Then the data was organized into categories. The frequency of each category was determined. This data were used to explain students' answers in the first part of the questionnaire. The students' feedback was used to help build the CAT system in phase 2.

## 6.3 Questionnaire Results and Analysis

Table 6.3 below shows the students' comments and suggestions.

Table 6.3: Students' Comments and Suggestions

| Frequency | Comments | Item |
|---|---|---|
| 1 | - The explanations were not enough, i.e. experiments must be explained comprehensively. | Explanation |
| 9 | - Pictures and animations with the text and voice helped understand the lessons. | Information |
| 1<br>6<br>5 | - Questions must be put in the proper place.<br>- Could not type answers for all questions.<br>- Unexpected questions. | Questions |
| 4<br><br><br>2 | - Instructions were unclear, i.e. the experiments must be numbered so we can know which one is being explained at any moment, and filling the tables.<br>- Video were unclear | Clarity |
| 1<br>6 | - Add useful comparisons.<br>-Minimize the comparisons because they are tiring. | Activities |
| 5 | - Time was not enough to do all the lessons in the software at ease.  We were in rush. | Time |
| 1<br>5<br>1<br>1<br>2<br>1<br>1<br>1<br>3<br>4<br>1<br>1<br>2<br>6<br>1<br>1<br>9<br>2<br><br>3<br>8<br>1 | -Very good<br>-  Good<br>- Perfect<br>- Fantastic<br>- Beautiful<br>- helpful<br>-  Lengthy<br>- Lacks the teacher's jokes<br>- Beneficial<br>- Exciting<br>- Helps in thinking<br>- Helps acquire information<br>- Helps understand  (more than the book)<br>- Enhances students' learning<br>- Helps memorize lessons<br>- Better than the teacher in the class<br>- Must be in all subjects.<br>- Must be in all schools.<br>- Must be uploaded to the net to be used by every one at any time.<br>- All the lessons must be automated.<br>- Must be used from day one of the school. | Rating |

The students' comments on the rating item, as shown in Table 6.3, gave a general impression that the program was accepted, although half of the students, as shown in the activities item in Table 6.3, did not feel comfortable about the activities in the program, which mainly were comparisons. Six of the students did not agree that they were highly motivated and confident to complete all the tasks and activities in the program, as shown in Figure 6.2.
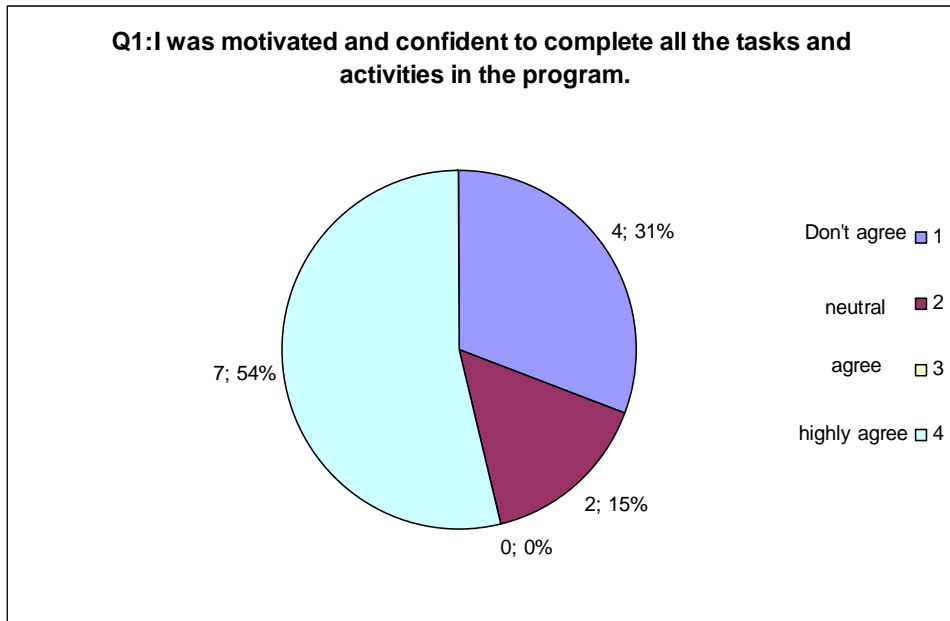


Figure 6.2: Motivation and Confidence

Only two students agreed that the tasks were too difficult that they could not complete them, five were not sure, and six did not agree, as shown below in Figure 6.3.
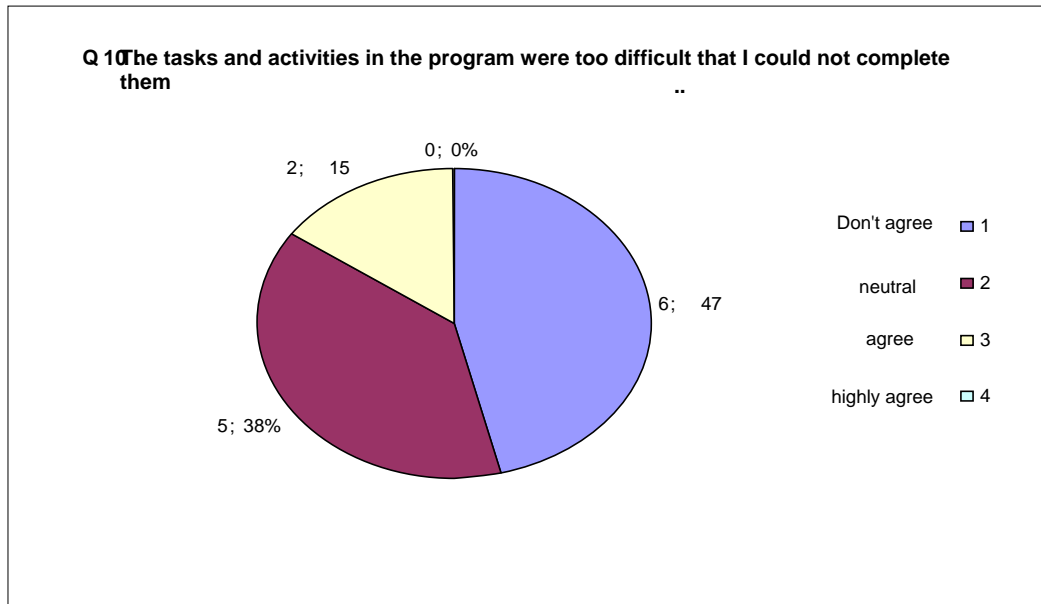


Figure 6.3: Tasks and Activities Completion

All the students commented that the program was easy to use, as shown in Figure 6.4 below.
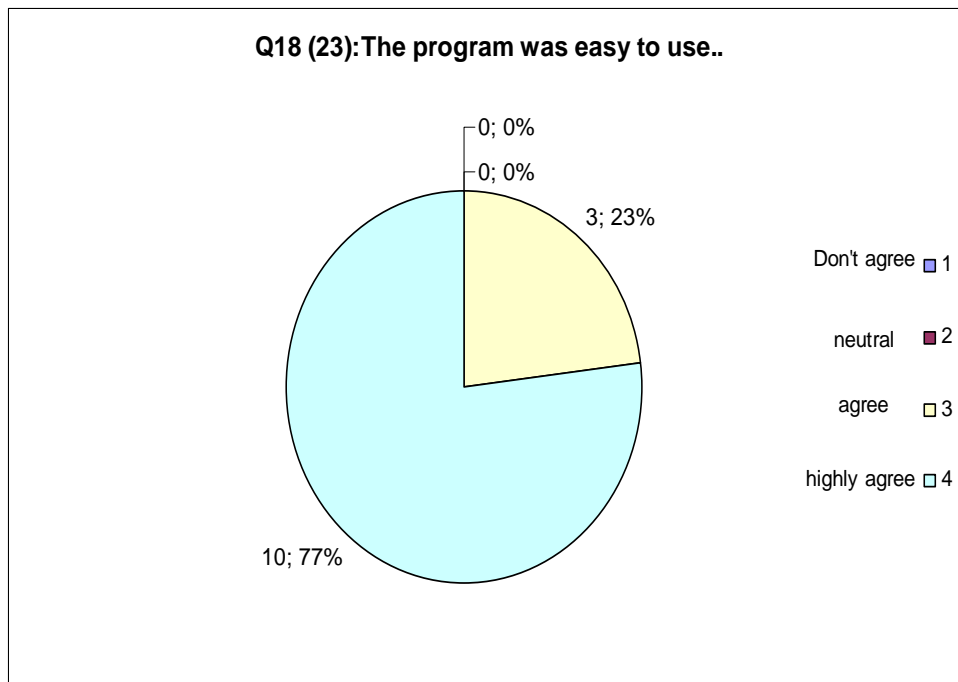


Figure 6.4: CAT and Ease of Use

No one felt bored while using the program, as shown in Figure 6.5 below:



**Q16:I felt bored while using the program..**

0; 0%
0; 0%
4; 31%
9; 69%

Don't agree ▪ 1

neutral ▪ 2

agree ▫ 3

highly agree ▫ 4
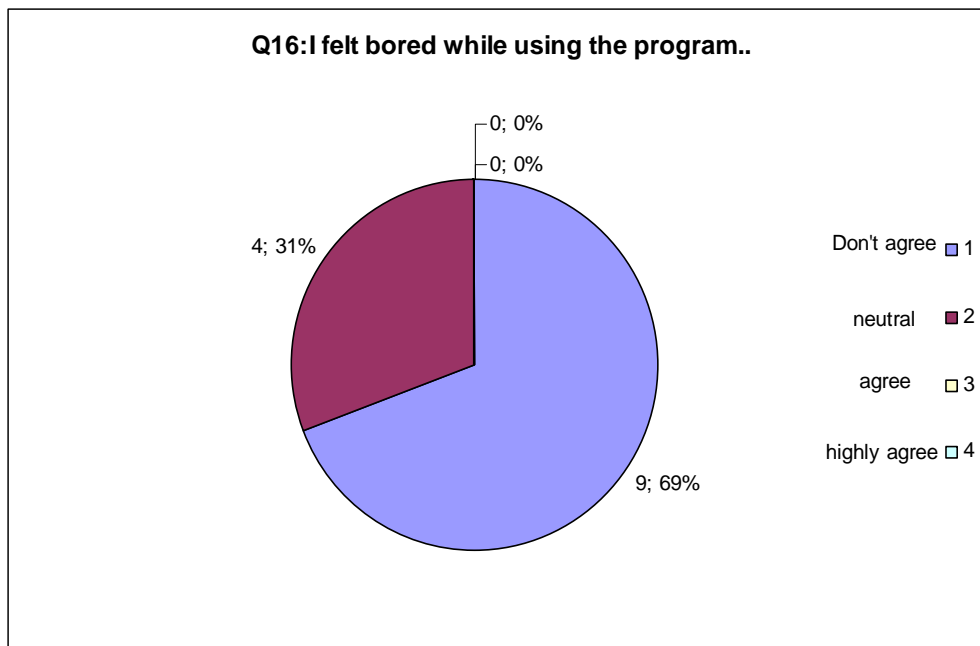
Figure 6.5: CAT and Boredom

## 6.4 Discussion of Results

Half of the students did not feel comfortable with the compare activities, while two of them could not complete the activities because of difficulties. A possible reason was because the comparison was not their preferred way of thinking. If the activities were tailored to every student's preferred way of thinking the results might change.

Six of the students did not agree that they were highly motivated and confident to complete all the tasks and activities in the program. The reason could be that they did not consider the comparison activities as a preferred way of thinking and expressing. Another reason might be the type of the question they were asked. Thus five of the students commented that the questions were unexpected.

Nine of the students did not feel bored while using the program. This could be because of the easiness of using the program. Hence all students commented that the program was easy to use. It also could be because of the way that the information was presented to the students. Thus nine of them commented that adding pictures and the animations to the text and voice helped them understand the lessons. This goes in

harmony with the multimedia learning theory, which states that adding pictures to text enhances students' learning and helps them understand knowledge deeply (Mayer 2001).

Most of the students wanted all the lessons in all subjects to be automated. This could be because they found the program useful and beneficial for their learning. Hence, six of the students commented that the program enhances students' learning.

Only one student commented that the program is better than the teacher, which may indicate that the students accepted the teacher's new role of guiding them and answering their questions while they were using the program.

Five students felt that they were in rush while learning the lessons with the software. This might be because they were not comfortable with the compare activities they were asked to perform. Hence, they spent much time on these activities. Another reason could be the ambiguity of the instructions, as students commented, i.e. the experiments and filling the tables. A third reason could be that students were asked to record their observations, reflections, conclusions and answers by typing. Thus six students commented that there were too many questions to answer by typing.

**6.5 Conclusions**

The following conclusions were drawn from the results of the first phase:

- Activities have great influence on students learning, motivation and confidence. Thus, offering proper activities is an important element for students' learning.
- The compare activities match the way of thinking of some students and mismatch others.
- The easiness of using computer programs makes students feel excited and not bored.
- Adding still and moving pictures to text and voice enhances students' learning and helps them gain a deeper understanding of knowledge.

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- Time spent in typing answers should be considered in class timing when learning with software.

- Time is an important factor for software to have an effect on students' learning.

- Designing and developing educational software is costly and timely.

- Software should not replace teacher's role.

- Clear instructions and understandable and expected questions help students build motivation and confidence.

# CHAPTER 7

## THE CAT SYSTEM

### 7.1 Introduction

CAT is educational computer software that was designed based on the Mental Self-Government Theory. CAT has been designed to be a generic tool, therefore it can be used to present lessons related to any subject area; in humanities including languages, history and geography, as well as different scientific subjects like physics, biology, and geology. For the purpose of this study, CAT contains four lessons of the UAE 12th grade biochemistry unit. The way the content is presented differs according to the different thinking styles of students.

### 7.2 CAT and the Thinking Styles

CAT system was designed to individualize the learning experience to meet the needs of each of the three thinking styles: Legislative, Judicial, and Executive.

The three styles have been chosen to be the only styles embedded in the software design for the following reasons:

- The function dimension of the mental self-government theory consists of three thinking styles, legislative, executive and judicial. These three styles are the most representative styles in the theory. Every individual is dominated by one or more of the three styles in their self-government. Thus, exploring the dominant style shows the most important and main dimension in a person's cognitive profile and how he likes direct his intelligence and perform tasks.

- The purpose of the study was not to include all 13 thinking styles in Mental Self-Government Theory. Rather, it was to examine the effect of considering the learner's thinking style in delivering material using a computer. This could be achieved by only using the main three thinking styles in a proof-of-concept experiment. So, this study was an initiative step to test and verify one dimension of Mental Self Government Theory once applied in software design. Further studies may work on the other dimensions.

- It was rather hard for the researcher to embed all the thinking styles in the software design. This would have taken a very long time that the duration of the current study could not have handled. Added to this is the big effort that would be required to build the lessons database for each thinking style, the thing, which is beyond the scope of this study.

## 7.3 CAT and Activities

In the first phase, the comparison activities were not preferred by half of the students who used the software, which influenced their motivation and confidence. It was concluded that if the activities were tailored to every student's preferred way of thinking the results might change. This is the purpose of this study which was to test and develop the CAT system to individualize students' learning experiences by offering different activities and tasks to match students' thinking styles. The thinking styles theory was used and embedded in CAT design to help in this differentiation process.

The basic concept of the Mental Self-Government Theory is to utilize the students' thinking style to ease their learning and ensure that the students are learning in the way suitable for their thinking styles. The key principle is that in order for students to benefit from instruction, activity and test at least some of each should match their styles of thinking (Sternberg 1997). For the purpose of this study, CAT was designed to only utilize one of these aspects to meet the need of the legislative, executive and judicial thinking styles. The aspect was the activity. It was difficult to add the other two aspects, instruction and test, because it would have taken a very long time that the duration of the current study could not have handled. Further, it would require huge effort to develop the four lessons for each thinking style.

According to the thinking style theory, Sternberg (1997) suggests that different activities, questions, and prompts in instructional assignments can lead to varying levels of compatibility for different styles. Tables 3.1 and 3.2 illustrate the type of prompts and the corresponding thinking styles. By varying the type of questions, prompts and activities, the CAT tool can equalize the benefits to all of the students. Based on this, the CAT system was designed to analyze the function dimension of the student's thinking style, then create student's profile, and provide activities

compatible with the student's profile. The system was designed to provide the students with text and video clips showing the teacher explaining the content, and then it asks the student to do some tasks and activities. These activities match the student's thinking style.

For the purpose of this study, the experimental group's thinking styles were assessed. Then, by using a matching technique, different activities were delivered to the corresponding thinking styles. On the other hand, the control group used CAT program with out the thinking style matching technique, hence they were not provided with any kind of activities. They only had the feature of watching the video clips and reading the text. Hence the control group used CAT as traditional CAI. Both groups did not know about this difference while they were using the same program on the same machines. This setting helped minimize the Hawthorne effect (De Amici 2000). Table 8.6 illustrates the different features that both groups experienced with CAT.

The Tables 7.1 to 7.4 illustrate the different activities and the corresponding thinking styles in each of the four lessons. Every table contains a lesson. Each table has three columns – one for each style to show and compare the activities that was planned for different styles in each lesson.

Table 7.1: Different Instructional Assignments in Lesson1 for Legislative, Executive, and Judicial Students

| Lesson 1: Assignments & Activities for Legislative Thinking Style Students | Lesson 1: Assignments & Activities for Executive Thinking Style Students | Lesson1: Assignments & Activities for Judicial Thinking Style Students |
|---|---|---|
| **Video 1**<br>1- Define carbohydrates in your own way.<br>2- Develop a method that will simplify recalling the molecular formula of the carbohydrate substance, which has resulted from the photosynthesis process. | **Video 1**<br>1- Define carbohydrates.<br>2- What are the components of carbohydrates?<br>3- Describe the photosynthesis process. | **Video 1**<br>1- Analyze carbohydrates molecule into its components.<br>2- Why is starch considered a carbohydrate?<br>3- Why is water dissolution mentioned in defining carbohydrates? |
| **Video 2**<br>1- Imagine that you are a monosaccharide with six atoms, and that you want to introduce yourself. Write a letter to chemistry scientists introducing yourself to them.<br><br>2- Aldopentose and ketopentose wrote a letter to introduce themselves to each other. What would the letters possibly contain? | **Video 2**<br>1- What are the types of carbohydrates?<br>2- Explain the meanings of the following words: ketohexose, aldohexose and ketopentose.<br>3- Explain the benefit of ribose in the human body. | **Video 2**<br>1- Compare the presence rate of carbohydrates, which contain five or six carbon atoms in nature with other monosaccharides, and explain the significance of that.<br>2- Why is the group to which fructose belongs called ketohexose?<br>3- Compare between ketopentoses and aldohexoses. |

Table 7.2: Different Instructional Assignments in Lesson 2 for Legislative, Executive, and Judicial Students

| Lesson 2: Assignments & Activities for Legislative Thinking Style Students | Lesson 2: Assignments & Activities for Executive Thinking Style Students | Lesson 2: Assignments & Activities for Judicial Thinking Style Students |
|---|---|---|
| **Video 3**<br>1. Write an academic article showing the difference in structural formulae of monosaccharides.<br>2. Design a three-dimensional shape showing the solid state of glucose and fructose.<br><br>**Video 4**<br>1. If you were a newspaper editor and a chemist, write a press interview in which you ask and answer yourself about the physical characteristics of monosaccharides.<br>Example:<br>Question: What is the shape of a monosaccharide?<br>Answer: It takes the form of crystalline solids.<br><br>**Video 5**<br>1. If you were a newspaper editor and a chemist, write a press interview in which you ask and answer yourself about the monosaccharides being oxidization and reduction agents at the same time.<br><br>**Video 6**<br>1. Provide a report about an experiment that you conducted to show fructose's reduction to Benedict solvent although it is a ketone.<br>In order to get the Nobel Prize, connect this discovery to interactions that take place in our bodies. | **Video 3**<br>1. What is the percentage of glucose in the blood of the healthy human? What is its importance to human beings?<br>2. Describe the structural formulae of glucose, galactose and fructose.<br>3. Summarize the reasons of saccharides' diversity.<br>4. How do the ring shapes of glucose and fructose form?<br><br>**Video 4**<br>1- What are the physical characteristics of monosaccharides?<br>2- Which monosaccharides are sweeter?<br><br>**Video 5**<br>1- When are monosaccharides oxidization agents and when are they reduction agents?<br>2- What is the structural formula of sorbitol alcohol?<br>3- What are the factors pivotal for the product of monosaccharides oxidization?<br><br>**Video 6**<br>1- What is the role of aldehydes when they interact with Benedict's solvent?<br>2- How does the reduction process of Benedict's solvent occur when fructose solution is added to it? | **Video 3**<br>1. Why do humans get diabetes?<br>2. Although hexoses have one molecular formula, they are multiple and varied. What is the reason behind that?<br>3- Compare the structural formulae of glucose, galactose and fructose.<br>How are they similar?<br>How are they different?<br>What do you conclude from this comparison?<br>4- Analyze the process of the formation of the ring shape of hexoses.<br>5- How is glucose's ring shape different from fructose's ring shape in the solid state?<br>6- Monosaccharides exist in the form of an open carbonic chain. Present a critique to this statement.<br><br>**Video 4**<br>1- Why is it easy for monosaccharides to dissolve in water, whereas they do not dissolve in organic solvents.<br>2- Why is honey so sweet?<br><br>**Video 5**<br>1- Although sorbitol alcohol is sweet, it is used by people who have diabetes or who or on diet. What is the reason behind that?<br>2- What is supposed to be the effect of the monosaccharides reaction with sodium and tolin solution? Why do you think this hypothesis is true?<br><br>**Video 6**<br>1- In a lab experiment you found that fructose reduced Benedict's solvent. Submit a report in which you analyze the process.<br>2- What is the difference between glucose's reduction to Benedict solvent and fructose's reduction to Benedict solvent? What do you conclude about it? |

Table 7.3: Different Instructional Assignments in Lesson 3 for Legislative, Executive, and Judicial Students

| Lesson 3: Assignments & Activities for Legislative Thinking Style Students | Lesson 3: Assignments & Activities for Executive Thinking Style Students | Lesson 3: Assignments & Activities for Judicial Thinking Style Students |
|---|---|---|
| **Video 7**<br>1- Imagine that you are a disaccharide. Introduce yourself.<br>2- Design an outline to show the outcomes of water dissolution for sucrose, maltose, and lactose.<br><br>**Video 8**<br>1- Write a scientific story about a journey made by maltose until its dissolution producing Glucose. Provide an accurate scientific description of the dissolution process.<br>2- Design a proper way to get students understand how two glucose molecules condense to produce maltose.<br><br>**Video 9**<br>1- What will happen if sucrose solution is heated with concentrated hydrochloric acid, and the outcome is detected by Benedict's solvent?<br>2- Imagine that you are sucrose and speak about how you are produced in detail.<br><br>**Video 10**<br>1- Imagine a debate between lactose and maltose in which each one of them speaks about its self. Write down the debate.<br>    Example:<br>    Lactose: I am the product of the condensation of a glucose molecule and a galactose molecule.<br>    Maltose: But I am the product of the condensation of ….<br>    Continue the debate. | **Video 7**<br>1- What is the outcome of the condensation of two monosaccharide molecules?<br>2- What results from water dissolution of sucrose, lactose and maltose?<br>3- What is the general molecular formula of disaccharides?<br>4- Summarize the process of dissolution and formation of a disaccharide in a general molecular formula.<br><br>**Video 8**<br>1- Summarize the relation between glucose and maltose in a formula.<br>2- Describe the process of the condensation of two glucose molecules to produce a maltose molecule.<br>3- How does the impact of the presence of a group of unconnected aldehydes in maltose appear on its characteristics?<br><br>**Video 9**<br>1- Explain the process of the condensation of glucose molecule and fructose molecule to produce sucrose.<br><br>**Video 10**<br>1- How does lactose result?<br>2- Summarize the importance of lactose in mother's milk. | **Video 7**<br>1- Assess the given outline which shows the relation between disaccharides and monosaccharides, and assess its effectiveness in making students understand the relation. Provide the advantages and disadvantages.<br>2- What is the reason behind the name 'disaccharide'?<br><br>**Video 8**<br>1- Maltose reduces Benedict solvent. Provide an analysis for that.<br>2- Compare and contrast between glucose and maltose. Come up with a summary and a conclusion.<br><br>**Video 9**<br>1- how are sucrose and maltose different? Provide a useful summary from this comparison.<br>2- Why doesn't sucrose reduce Benedict solvent?<br><br>**Video 10**<br>1- What is meant by saying, "the link in lactose molecule is similar to that of the maltose's.' Are their any other similarities between the two? What are they?<br>2- What pluses does lactose have over glucose? |

Table 7.4: Different Instructional Assignments in Lesson 4 for Legislative, Executive, and Judicial Students

| Lesson 4: Assignments & Activities for Legislative Thinking Style Students | Lesson 4: Assignments & Activities for Executive Thinking Style Students | Lesson 4: Assignments & Activities for Judicial Thinking Style Students |
|---|---|---|
| **Video 11**<br>1- Design a method, which enables people to differentiate between polysaccharide carbohydrates and oligosaccharide carbohydrates.<br><br>**Video 12**<br>1- Innovate an alternative method to detect starch.<br>2- Generate alternatives and possibilities for uses of starch.<br><br>**Video 13**<br>1- You are cellulose, and you would like to apply for a job. Write down your CV.<br>Example:<br>Name: cellulose<br>Presence: …….<br>Continue the CV mentioning what you know about cellulose.<br>2- You have put magic glasses through which you can see molecular structures. You are examining a piece of cotton. What can you see in cotton's molecular structures? Describe what you can see.<br><br>**Video 14**<br>1- Write a letter to municipality chief telling him how to get benefits from cellulose. | **Video 11**<br>1- How does the molecule of polysaccharide carbohydrates result?<br>2- Describe the components of starch.<br>3- What is the general formula of polysaccharide carbohydrates?<br><br>**Video 12**<br>1- Describe the starch.<br>2- Summarize the importance of starch.<br><br>**Video 13**<br>1- Summarize the characteristics of cellulose.<br>2- Describe the cellulose molecule.<br><br>**Video 14**<br>1- What are the benefits of cellulose?. | **Video 11**<br>1- Use the graphic organizer to compare between polysaccharide carbohydrates and oligosaccharide carbohydrates in all aspects. Provide a summary of the comparison.<br>2- What are the similarities and differences between amylose and amylopectin?<br><br>**Video 12**<br>1- Following is an experiment to differentiate between white bread and toasted bread by detecting starch: It is known that starches, like bread are named thus because they have a high rate of starch, but is white bread the same as toasted bread?<br>Is the digestion of both the same?<br>To answer these questions we conduct the following experiment:<br>Instruments and materials:<br>Glass, some water, some Iodine, two pieces of white bread, spoon, knife, microwave, bowl.<br>Procedures:<br>1. Fill half of the glass with water.<br>2. Add a spoonful of Iodine to the water, stir them well, and pour the solution into the bowl.<br>3. heat a piece of white bread in the microwave till it becomes toasted.<br>4. Put one piece of white bread and the piece of toasted bread into the Iodine solution.<br>1- What do you think you are supposed to see now?<br>2- Why do you think Iodine was used in this experiment?<br>3- What is your opinion about this method in detecting starch?<br><br>**Video 13**<br>1- How is starch different from cellulose? What is the effect of this difference?<br><br>**Video 14**<br>1- Why is cellulose considered important in our lives? |

**7.4 CAT and Lessons**

In the current study four lessons were prepared according to the three thinking styles: Legislative, Executive, and Judicial. The theory illustrates how to individualize teaching to accommodate the thinking styles in regard to activities, assignments and tasks, which are presented to students. Table 3.2 (pp. 65) summarizes the three thinking styles and the corresponding preferences.

The researcher and the chemistry teacher who performed the experiment prepared the lessons for the two chapters from the biochemistry unit according to the Mental Self Government theory on Thinking Styles. These lessons were compatible with the preferred way of learning of each of the three thinking styles, the Legislative, Executive, and Judicial styles. Then these lessons were stored in the CAT database. The four lessons stored in CAT were about Carbohydrates. The biochemistry unit is given in Appendix VII.

Every lesson included four video clip sessions, except for the first lesson, which contained only two video clip sessions. Each video session was divided into five parts:

- Introductory questions: The lesson starts with a question asking the students about what they know about the topics of the lesson. For example: What do you know about biochemistry? It is an important aspect of learning to help students relate the new knowledge to what they already know, link new information with existing knowledge in meaningful ways (Brandt 1998), and integrate new experiences and interpretations with their prior knowledge (Jonassen 2000). Research has shown that students construct their own knowledge. Hence, good instruction draws upon that knowledge (Brown 1995).

- Lesson objectives: The objectives of the lesson are listed here to help students be aware of what they are going to learn from the video clip and know the things, which are expected from them. This helps them to be focused and guided while watching the video clips. For example: We will learn the following from Video 1: Biochemistry definition.

- Video clip:  The video clip shows the teacher explaining the objectives, which are mentioned earlier.  The clip varies in length.  Table 7.5 shows the duration of the clips attached to the lessons.

Table 7.5: Clips Attached to Lessons

|  | Lesson 1 | Lesson 2 | Lesson 3 | Lesson4 |
|---|---|---|---|---|
| Clip 1 | 7:30 min. | | | |
| Clip 2 | 9:24 min. | | | |
| Clip 3 | | 10:14 min. | | |
| Clip 4 | | 2:41 min. | | |
| Clip 5 | | 4:48 min. | | |
| Clip 6 | | 3:47 min. | | |
| Clip 7 | | | 8:06 min. | |
| Clip 8 | | | 4:36 min. | |
| Clip 9 | | | 3:44 min. | |
| Clip 10 | | | 4:44 min. | |
| Clip 11 | | | | 5:29 min. |
| Clip 12 | | | | 2:25 min. |
| Clip 13 | | | | 4:15 min. |
| Clip 14 | | | | 2:06 min. |

- Learning outcome:  The students are asked about what they have learned from the video clip in regard to the lesson objectives.  This helps students reflect on what they have learned from the video clip and whether they have achieved the objectives.   To obtain quality learning, students must be engaged in thoughtful atmosphere where they can reflect on their learning.  Reflective learning supports knowledge construction (Jonassen 2000).   In order for students to be self-directed learners, they should have the ability to know what they know and what they do not know (Costa 2000).

- Activities: Students are asked to perform some tasks and activities that relate to the lesson objectives.  These activities are tailored to the students' thinking styles.  The most effective learning occurs when we continually cycle through information, challenging it, and refining it.  Extending and refining knowledge is the aspect of learning that involves examining what is known at a deeper level.  Students should be engaged in activities that require a depth about content (Marzano 1992).   Learners learn best when learning tasks and

activities are clear and appropriate for their preferred way of thinking (Brandt 1998, Underwood 1990).

Throughout the video session there are some written instructions to guide the students what to do.

Both groups of the experiment experienced the same lesson sequence with the exception of the activity part, which was only presented to the experimental group. Table 7.6 illustrates the different features that the control and experimental groups experienced with CAT.

Table 7.6: CAT Features Used by the Students of the Control and Experimental Groups

| Group | Introductory questions | Lesson Objectives | Teacher Explaining Lessons in Video Clips | Learning outcome | Activities | Thinking Style Identification & matching |
|---|---|---|---|---|---|---|
| Experiment | Yes | Yes | Yes | Yes | Yes | Yes |
| Control | Yes | Yes | Yes | Yes | No | No |

**Pictures and Animations**

In the first phase, most students commented that adding pictures and animations to the text and voice helped them understand the lessons. In support to students' comments, the multimedia learning theory by Mayer (2001) states that adding still and moving pictures to text and voice enhances students' learning and helps them gain a deeper understanding of knowledge. Rieber and Kini (1991) concluded that when graphics and words are combined, the probability of recall is increased. Imagery studies attest that mental imagery can facilitate learning and recall of information (Paivio 1971, Rieber 1994). Based on this, it was decided not to include animations or pictures for content illustration. The exclusion of animations and pictures would help control the effects they might contribute to students learning while using CAT. The only effect, if any, in this case would be referred to the thinking style matching method. The CAT tool only contained the lessons text, explanations by the teacher in video clips, and different activities, questions and prompts for different thinking styles. The video

clips showed the teacher explaining the lessons as if they were in a traditional classroom.

**Lesson Sequence**

Table 7.7 contains the sequence of the first video session in the first lesson. The table has four columns – one for the control group, and the other three for the experiment group with the three styles. Appendix VIII describes the sequence of all lessons.

**7.5 CAT Quality Control**

With any CAI program, the quality of material presented is always an issue. According to Rushby (1997), three factors are essential to ensure that the CAI program meets acceptable standards: content is accurate and up to date, the program is tested to ensure no running errors, and the program is free from typographical errors.

CAT had met all three quality standards. A committee of two chemistry supervisors and two chemistry teachers verified the accuracy of content ensuring that it was up to date and in line with the curriculum. The researcher consulted five supervisors to verify the compatibility of the activities used in the program with the three thinking styles as stated in the theory.

The program was tested and all errors and bugs were found by a quality control group consisting of the researcher and two IT teachers in Khalifa school. These errors were addressed by the programmer. In terms of typographical accuracy, the same quality control group verified the textual consistency and grammatical structure. Modifications and corrections were made before the program was introduced to the sample students.

**7.6 Database Model**

The database used for the system contains different data related to the students, their thinking styles and lessons.

- Lesson_Th1 – Lessons Th3: are tables that contain three thinking styles along with their respective data of the lessons.
- Question Lesson: is used to store interactive questions related to each lesson

- Ranges: contains the variables that are used for thinking style calculations

- Th_Questions: is used to store the questions used for testing the thinking style

- User data: is used to store data about each user.

- User_Lesson: is used to store users answers to questions for follow-up

To ensure students are learning in an optimal way a rich environment was made available. The system contains the following data types:

- Rich Graphic to augment ideas.

- Flash Animation to clarify ideas.

- Video that contains lessons explained by teacher.

- Sound data.

- Normal text to include lessons text and instructions.

The system has containers for each of the mentioned data types. These containers are dynamically filled with suitable data based on lessons and thinking models. This method allows for ease of data access based on thinking model and allows teachers with no technical background to enter and edit lessons using the teacher interface.

**7.7 CAT System Data Flow**

When the students log in for the first time, CAT presents the Sternberg-Wagner Self-Assessment Inventory statements to the students in order to identify their dominant thinking style. The inventory consists of 24 statements distributed on the three styles: Legislative, Executive, and Judicial. The thinking style inventory is given in Appendix IV. Thus, each style contains eight statements. The statements were merged and presented in a sequence where each time it starts with a statement from one style starting with the legislative style then the executive and then a statement from the judicial style. Presenting the statements in this sequence, legislative statement; executive statement; judicial statement; and then back to executive statement; judicial statement; and legislative statement; and so on, forced the students to be accurate and careful in rating themselves how well each statement describes them. Each statement can be rated by choosing one of the following ratings on a scale of 1-7 where each rating corresponds to how well a statement describes the student: 1=Not at all satisfactory; 2=not satisfactory; 3=nearly suitable; 4=somewhat suitable;

5=suitable; 6=very suitable; and 7=perfect. The way the system was designed to evaluate the score is to add up the eight numbers the student writes down on each style. Then the system compares the three final scores. The highest score is considered to be the student's dominant thinking style. A flag corresponds corresponding to this thinking style is stored in the students' account in the database. Then the system leads the students to the content, which meets their dominant thinking style. It is possible that a student receives the same score for two or three thinking styles, which means that the student's thinking style is versatile. In this case, the system randomly chooses one of the thinking styles to be the student's preferred style.

Figure 7.1 shows the system data flow.
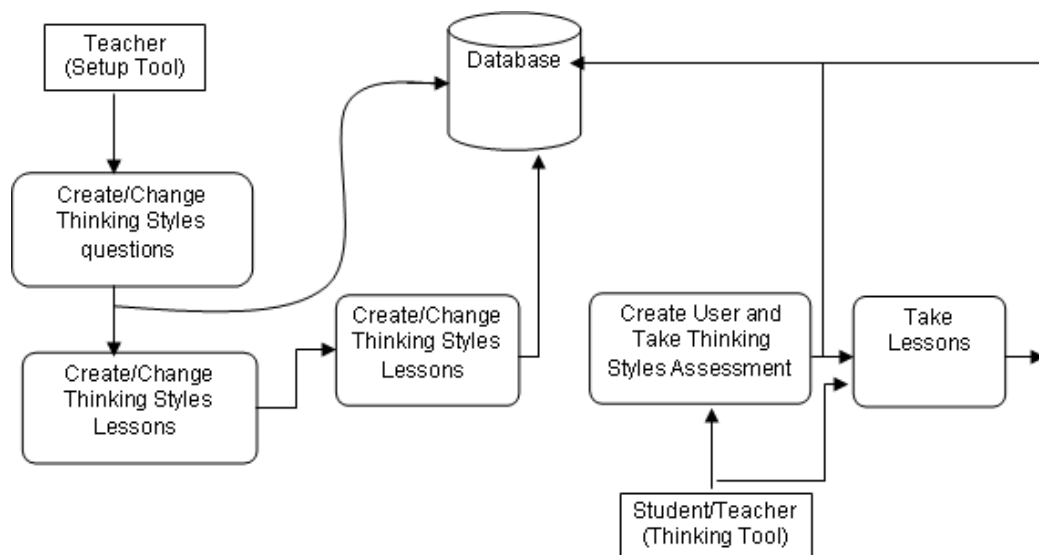


Figure 7.1: Data Flow Diagram

## 7.8 System Parts

The system consists of two parts.

- Teacher interface

  This part is called the "Setup Tool" which is used by teacher to setup the system and thinking models, as well as, creating different lessons for all thinking models. Figure IX.1 in Appendix IX shows the teacher interface screen.

- Student interface

  This part is called the "Thinking Tool" which is used by the student to login and take lessons prepared by the teacher. Figure IX.2 in Appendix IX shows the student interface screen.

These two parts are linked with one common database. The system user's guide is given in Appendix IX.

## 7.9 User Friendliness

The CAT was designed to be a user friendly tool so all students and teachers with no IT knowledge can use it with full confidence. A teacher can easily enter and save lesson contents for the three thinking styles. It includes all lesson contents in one screen. A student can read the lesson text, watch the teacher explaining the lesson in video clips, and see animation to clarify ideas, all in one screen too. On the same screen, all instruction statements were made clear.

## 7.10 Cost and Time Effective

CAT was designed as a generic tool, which made it cost and time effective. The researcher conducted a workshop for teachers of different subject areas including math, science, Arabic, Islamic studies, biology, and social studies. Two teachers from each subject participated in the workshop. The teachers were given explanation on how to use the CAT system. Then they were asked to compose a piece of a lesson related to their curriculum. All of the teachers agreed that:

- Teachers, regardless of their technical background, can use CAT in delivering lessons in any subject area; in humanities including languages, history and geography, as well as different scientific subjects like physics, biology, and geology.
- CAT allows teachers to easily compose lessons containing different data types in one screen with out the help of neither instructional specialist nor educational software developer.
- Researchers can conduct further studies in any subject using the same tool.

- Finally, CAT saves teachers' valuable time, and helps them have a new role to assist students effectively construct knowledge.

**7.11 Control**

CAT was designed to give the student full control of content, sequence, and pace. In addition, the student has control of all media type, i.e. video volume and sequence. Riding (1998) and Underwood (1990) state that computer learning system must consider the learners' style and give them control in order to be effective.

In the first phase the students raised some concerns regarding time, instruction, and questions. These concerns appeared to influence their motivation and confidence. CAT offered a key solution to overcome this negative influence - student control. Student control usually refers to the instructional features that allow students to make their own decisions regarding some aspects of path, flow or events of instruction (Williams 1997). Effective learning occurs when learners can learn in their own way and have some degree of choice and control. They learn better when they use their preferred learning and thinking styles, special strengths and intelligences, and when their interests are met (Brandt 1998, Renzulli 2001, and Underwood 1990).

Giving the student the control has the following benefits:
- It provides the students a way to tailor the learning environment to suit their needs and preference (Winser and Cheung 1996).
- It transfers the responsibility for learning from the teacher to the student. This, to some extent, can motivate the student (Brown 1997).
- It helps the students develop concepts understanding. They are able to get into as much depth as they feel necessary to enable them to perform the activities confidently (Stanton and Baber 1992).

On the other hand, student control can cause problems to some students especially those with little prior domain knowledge or low achievers (Brown 1997). They are not sure what should be learned, to what extent they should understand the content, and whether they are on the right track (Qiyun and Sum 2003). To avoid these

potential problems in CAT, clear instructions were written in every lesson, and lesson objectives were specified at the beginning of every lesson.

With the control feature, CAT can help students build motivation and confidence.

**7.12 CAT and Teacher Role**

CAT is not in a position to replace the teachers but to assist them. The involvement of CAT in the teaching and learning process provides a new role for the teacher. The teachers need to redefine their role, no longer is the teacher considered the sole provider of knowledge. Students have to take responsibility for their learning as they interact with the CAT system, using their lesson materials in their own preferred learning style. This puts the teacher in the role of an advisor, facilitator, helper, and a scaffolder who provides students with only necessary and sufficient help, allowing students time to work collaboratively to solve problems and make decisions, and hence they will be more involved in the learning process. Learners learn well when they have opportunities for social interaction. Most of students' knowledge comes through interaction with others, so teachers need to pay attention to the social setting in the classroom (Brandt 1998). According to Underwood (1990), cooperative computer activities lead to greater educational gains.

During the learning sessions, the teacher encouraged students in both groups to work in pairs or groups as they wished. Students in the experimental group were guided to work the activities together with students with similar thinking styles. Based on the conclusion in the first phase regarding the time spent in typing answers and that it should be considered, students in phase2 used paper-and-pencil worksheets to solve the activities.

Table 7.7: The Sequence of the First Video Session in the First Lesson

| Lesson1 | | | | |
|---|---|---|---|---|
| **Video 1** | **Control group** | **Experimental group** | | |
| | | **Legislative** | **executive** | **Judicial** |
| **Introductory questions** | What do you know about: biochemistry photosynthesis carbohydrates | What do you know about: biochemistry photosynthesis carbohydrates | What do you know about: biochemistry photosynthesis carbohydrates | What do you know about: biochemistry photosynthesis carbohydrates |
| **Lesson objectives** | We will learn the following from Video 1: 1- Biochemistry: a- definition b- the most common bio-compounds c- Their importance for living things 2- Carbohydrates: a- their source b- elements that compose them and their percentages. c- their structural formulae d- definition | We will learn the following from Video 1: 1- Biochemistry: a- definition b- the most common bio-compounds c- Their importance for living things 2- Carbohydrates: a- their source b- elements that compose them and their percentages. c- their structural formulae d- definition | We will learn the following from Video 1: 1- Biochemistry: a- definition b- the most common bio-compounds c- Their importance for living things 2- Carbohydrates: a- their source b- elements that compose them and their percentages. c- their structural formulae d- definition | We will learn the following from Video 1: 1- Biochemistry: a- definition b- the most common bio-compounds c- Their importance for living things 2- Carbohydrates: a- their source b- elements that compose them and their percentages. c- their structural formulae d- definition |
| **Video clip** | Now click on Video 1 button. | Now click on Video 1 button. | Now click on Video 1 button. | Now click on Video 1 key. |
| **Learning outcome** | After watching Video 1, what learning outcomes have you acquired about biochemistry and carbohydrates? You can replay the video anytime to make sure that you have learnt the previous outcomes. | After watching Video 1, what learning outcomes have you acquired about biochemistry and carbohydrates? You can replay the video anytime to make sure that you have learnt the previous outcomes. | After watching Video 1, what learning outcomes have you acquired about biochemistry and carbohydrates? You can replay the video anytime to make sure that you have learnt the previous outcomes. | After watching Video 1, what learning outcomes have you acquired about biochemistry and carbohydrates? You can replay the video anytime to make sure that you have learnt the previous outcomes. |
| **Activities** | ***** | - define carbohydrates in your own way. - develop a method that will simplify recalling the molecular formula of the carbohydrate substance which has resulted from the photosynthesis process. | - define carbohydrates. - what are the components of carbohydrates? - describe the photosynthesis process. | - analyze carbohydrates molecule into its components. - why is starch considered a carbohydrate? - why is water dissolution mentioned in defining carbohydrates? |

# CHAPTER 8

## PHASE 2 EMPERICAL EVALUATION OF THINKING STYLES

### 8.1  Introduction

This chapter contains the experimental design of this study and the analysis of the quantitative and qualitative data collected for this study.  The information is presented in five sections.  The first section presents information about the experimental design. This section also shows the two phases that the study has passed through.  The second section examines the post-test results and analysis.  The third section examines the questionnaire results and analysis. The fourth section discusses the results.  Finally, the last section summarizes the conclusions.

### 8.2     Experimental Design

The control and experimental groups were assigned randomly.  At the beginning of the experiment, the thinking style assessment test was taken by the experimental group. They learned the material using CAT based on their thinking styles.  Whereas the control group learned the same lessons using CAT as a traditional CAI.  Both groups studied three hours of chemistry per week for 2 weeks.  The achievement post-test was administered by both groups after they completed the lessons.

The experiment design is expressed as shown in Figure 8.1.

In this design, there are two groups: Group1 is the experimental group and Group2 is the control group.  R represents the random assignment of the groups, O1 represents the thinking style pre-test, X1 represents the treatment using CAT with the thinking style feature, X2 represents the treatment using CAT without the thinking style feature, and O2 represents the achievement post-test.  This design of the experiment helped to minimize the Hawthorne effect (De Amici 2000).

Group1        R  O1  X1   O2

Group2        R  __   X2   O2

Figure 8.1: Experiment Design

**Study Procedures**

Purpose of Phase 2:

- Develop CAT.

- Prepare lessons according to the thinking styles theory.

- Main case study.


Procedures:

- The CAT tool was designed as generic tool.  The tool was built to accommodate the three functions of the thinking style theory- the Legislative, Executive, and Judicial.

- The researcher visited the school from which the study sample was chosen and discussed with the principal the purpose of the study and its importance.  The principal approved to conduct the study in the computer lab in the school.  All the required facilities were provided.

- The researcher provided the chemistry teacher who would teach both the experimental and the control group with a thorough explanation about the CAT tool and how to use it.

- The researcher presented to the teacher a clear illustration of the Mental Self Government Theory in order to develop the lessons according to the theory.

- The biochemistry unit from the 12th grade UAE chemistry curriculum for the 2006/2007 academic year was selected to be the content, which would be taught to both groups.  This unit was the last unit in the chemistry textbook.  The biochemistry unit is given in Appendix VII.

- In order to consider the time factor that was raised by the students in the first phase, the unit was divided into four lessons.  Each lesson was designed to be studied in one hour.

- The teacher and the researcher developed activities for each lesson.  Based on the theory, the activities varied according to the three thinking styles: the Legislative, Executive, and Judicial.  The tables 8-1 to 8-4 illustrate the different activities and the corresponding thinking styles in each of the four lessons.

- Jensen (1997, 1998, and 2007) suggests using 12-15 minutes of direct instruction for grade 8-12.  Then the brain needs time for processing and rest.  Similarly, Kovalik & Olsen (2004) suggest 11-16 minutes of direct instruction and 5-8 minutes of video

clip. Based on this brain research, 14 video clips were produced to convey the ideas of the lessons in this study. The length of each clip was between 2-10 minutes. Three steps to creating the video clips were followed as suggested by Simkins et al. (2002):

- o Video recording the teacher explaining the four lessons. The total length of video recording was 73.8 minutes.
- o Digitizing the footage and editing the clips. Table 9-1 indicates the clips attached to every lesson.
- o And converting the digitized video into windows media video file.

- All developed lessons were stored into CAT. These lessons are detailed in the CAT content chapter.

- Computer lab where the study was conducted was equipped with 30 computers. CAT was installed into each computer. All computers were equipped with headsets.

- The teacher held a training session for students to acquire the skill of using CAT before embarking on the experiment.

- The teacher asked students of the experimental group to log into CAT and perform the Self-Assessment Inventory in order to identify their dominant thinking style. After, when the students logged in, the system took them to the lesson area according to their thinking styles. The students learned using the software and followed the instructions in every lesson. On the other hand, the teacher asked students of the control group to click on the "style4" button, which would take them to the lesson area.

- The experimental group studied the assigned material using CAT. Student worked on their own computers for the entire period of the experiment, which continued for two weeks. During this period, the students went to the lab to learn using CAT three days a week. They spent one hour a day using the system. The total amount of time spent by each student was six hours. Which made the time of CAT learning sessions one and a half more than it was in phase1. Increasing the time of CAT learning sessions was in response to students' concerns regarding lack of time in the first phase.

- The control group spent the same amount of time studying the lessons using the system, but without considering their thinking styles as it was pointed out earlier.

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- The teacher's role:

Emerson and Mosteller (1998) suggested that hypermedia is most effective when the learner is an active participant, the user makes choices and receives feedback, and group collaboration among learners is facilitated. Learners learn well when they get informative and helpful feedback. They must receive accurate, clear, useful and timely feedback about their performance (Brandt 1998, Perkins 1995). Feedback should not be limited to the correct answer; it should be analytical and come at the time when the students are interested and eager for it (Haidar 2000). The feedback they get allows them to further refine their thinking (Berman 2001), and proceed more effectively (Perkins 1995). This puts the teacher in the role of a helper and a scaffolder (Glatthorn & Jailaill 2000) who mediates only as necessary by providing them with sufficient help, allowing students time to work collaboratively, and hence they will be more involved in the learning process. CAT was not in a position to replace the teachers but to assist them. The involvement of CAT in the learning process provided a new role for the teacher. During CAT learning sessions, the teacher walked among the students, facilitating and providing scaffolds to guide them through their learning.

- Class setting:

Learners learn well when they have opportunities for social interaction. Most of students' knowledge comes through interaction with others (Brandt 1998). Underwood (1990) states that the research supports that students work better in groups. The work of Johnson, Johnson and Stanne (1985) suggests that co-operative computer activities lead to greater educational gains. In these groups, students become responsible for their own learning and for the learning of their colleagues. Knowledge becomes shared rather than private (Underwood 1990). The students of the experimental group were allowed to do the activities in groups. Similarly, the students of the control group were allowed to discuss the learning outcomes in groups.

- At the end of the experiment, both groups took the achievement post-test and answered the questionnaires.
- Data analysis:

The two groups involved in the study administered a post-test after they completed the biochemistry unit. Tables 8.1 and 8.2 show the test scores of both groups. This data was quantitatively analyzed. First, statistics of the mean scores were computed for the

two groups.  Second, SPSS was used to analyze the data using the T-test to determine whether the differences between mean scores were statistically significant.

The students of both groups answered questionnaire for the purpose of evaluating the effectiveness of CAT.  The questionnaire was divided into two parts.  The first part consists of 25 items to gather data related to the effects of CAT on students' learning experience.  Data was presented in bar chart format, and then discussed in the light to of the research hypothesis.  The second part consists of two open questions to gather students' suggestions and comments about CAT.  All the data in this part of the questionnaire was read through to obtain a general sense of the information and to reflect on its overall meaning.  Then the data was organized into categories.  The frequency of each category was determined.  Finally, these categories were organized under general themes.  This data were used to explain students' answers in the first part of the questionnaire.

## 8.3 Post-Test Results and Analysis

The post-test scores were collected after both groups finished the test.  The scores of both groups are presented in Tables 8.1 and 8.2.

Table 8.1: Test Score (Control Group)   Table 8.2: Test Score (Experimental Group)

| Student | Test Score (out of 40) |
|---------|------------------------|
| 1 | 18 |
| 2 | 20 |
| 3 | 30 |
| 4 | 11 |
| 5 | 19 |
| 6 | 24 |
| 7 | 27 |
| 8 | 19 |
| 9 | 19 |
| 10 | 15 |
| 11 | 10 |
| 12 | 22 |
| 13 | 20 |
| 14 | 37 |
| 15 | 20 |
| 16 | 27 |
| 17 | 26 |
| 18 | 24 |
| 19 | 21 |
| 20 | - |
| 21 | 28 |
| 22 | 19 |
| 23 | 22 |
| 24 | 30 |
| 25 | 25 |
| 26 | 39 |

| Student | Test Score (out of 40) |
|---------|------------------------|
| 27 | 12 |
| 28 | 29 |
| 29 | 37 |
| 30 | 4 |
| 31 | 10 |
| 32 | 36 |
| 33 | 24 |
| 34 | 25 |
| 35 | 21 |
| 36 | 10 |
| 37 | 10 |
| 38 | 36 |
| 39 | 23 |
| 40 | No |
| 41 | 36 |
| 42 | 22 |
| 43 | 8 |
| 44 | - |
| 45 | 18 |
| 46 | 6 |
| 47 | 7 |
| 48 | 13 |
| 49 | 33 |
| 50 | 37 |
| 51 | 35 |
| 52 | 9 |
| 53 | 16 |
| 54 | 16 |
| 55 | 9 |

The results of the post-test mean scores, and standard deviations for both groups were calculated and are presented in Table 8.3 below.

Table 8.3: Group Statistics

| Group | N | Mean | Std. Deviation |
|---|---|---|---|
| Control | 25 | 22.88 | 6.83 |
| Experimental | 27 | 20.07 | 11.32 |

Table 8.4 shows that there was no significant difference between the two groups, which means that using CAT did not raise the experimental group achievement significantly.

Table 8.4: Independent Samples Test

| | t | df | Sig. (2-tailed) |
|---|---|---|---|
| Equal variances assumed | 1.071 | 50 | 0.289 |

## 8.4  Questionnaire Results and Analysis

Mean scores and standard deviations for every item in the questionnaire for both groups were calculated and are given in Appendix I, as well as frequencies and bar charts.

Independent samples t-test was performed to assess the mean difference between the two groups.  Table 8.5 shows the T-test results.

The results in the table show that there was significant difference in two of the learning experience dimensions between the two groups in favour of the experimental group. The two dimensions are:  preferred learning style and the teaching method.   This provides sufficient and significant evidence to say that:

- Students who used CAT were more likely to know their preferred way of learning.
- Students who used CAT were more likely to like the teaching method contained in CAT.

Table 8.5: T-Test Results

| Sample<br>Learning<br>Experience | GROUP | N | Mean | Std. Deviation | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|
| Comprehension | experiment | 28 | 15.14 | 2.902 | -.568 | 39 | .573 |
| | control | 13 | 15.69 | 2.840 | | | |
| Passion for Subject | Experiment | 28 | 2.93 | 1.120 | -.865 | 38 | .393 |
| | Control | 12 | 3.25 | .965 | | | |
| Preferred Learning Style | Experiment | 28 | 3.04 | .881 | 2.979 | 39 | .005 |
| | Control | 13 | 2.23 | .599 | | | |
| Teaching Method | Experiment | 28 | 19.14 | 3.003 | -2.938 | 39 | .006 |
| | Control | 13 | 21.85 | 2.035 | | | |
| Activities and Tasks | experiment | 28 | 20.54 | 2.531 | -.003 | 39 | .997 |
| | control | 13 | 20.54 | 2.106 | | | |

Table 8.6 below shows the comments of both groups about the CAT tool.  Students' comments are organized into positive and negative categories under general themes. The upper categories are the positive ones; plus signs (+) are placed in the item column to reflect this.  The lower are the negative ones; minus signs (–) are placed in the item column to reflect this.  Some comments have both signs (+-), which means that they have positive and negative sides.  Placing plus and minus could also mean that the comment is an interesting idea, such as suggestions to enhance the tool.  These are placed in the middle.

Table 8.6: Comments of Control Group and Experimental Group

| | Control Group | | Experimental Group | |
|---|---|---|---|---|
| **Item** | **Comments** | **Frequency** | **Comments** | **Frequency** |
| Positives + | It is a new and unique way of learning | 1 | It is a good idea to learn from computer | 1 |
| + | It is great, the student can repeat the lesson many times at any time | 3 | It is a new way of learning | 1 |
| + | It is a good method to learn with computer | 1 | It should be in all subjects. | 2 |
| + | Lessons are easy to understand and memorize | 1 | The good thing is that student can repeat the lessons | 2 |
| + | It helps student understand better | 1 | The teacher in the program is just for me | 8 |
| + | All the lessons in curriculum must be automated. | 1 | Must be used all the year | 11 |
| + | Does not let you feel bored | 1 | Students should take the CAT CD to work at home | 2 |
| + | It helps the student rely on his abilities | 1 | does not let you feel bored | 1 |
| + | It presents the lesson in a clear and easy way | 5 | It helps student understand better and faster | 1 |
| **Learning with CAT** | | | All the lessons in curriculum must be automated. | 9 |
| +- | It can help but after having the lesson with the teacher | 2 | It highly helps after having the lesson with the teacher | 1 |
| -- | Not all the lessons should be automated, only one or two units | 1 | Must allow group work for discussion | 1 |
| -- | Can not replace the teacher | 6 | It should present more Information | 1 |
| -- | The way teacher explains in the program is not good, in the class is better | 1 | It should be used for younger grades and not grade 12 | 1 |
| -- | Having the lesson with the teacher helps understand better and allows ask questions | 1 | I cannot ask the teacher in the program | 1 |
| -- | | | It must focus on important topics | 1 |
| -- | I could not understand some topics | 1 | Lessons should not be automated | 1 |
| -- | | | It does not answer questions raised in student's mind | 4 |
| -- | Cannot learn the lessons from the computer, the teacher makes us understand better | 9 | The way of explanation is difficult | 1 |
| | | | The teacher is better | 1 |
| Negatives-- | | | Can not replace the teacher | 5 |

| | Control Group | | | Experimental Group | |
|---|---|---|---|---|---|
| **Item** | **Comments** | | **Frequency** | **Comments** | **Frequency** |
| Positive + + **Teacher Role** -- Negative - | Need teacher to explain while using the program | | 5 | Computer teacher (researcher) is great and patient After attending the program the teacher should hold a discussion The teacher must be there to understand the lesson | 1 2 1 |
| Positive + + + **Content** -- -- -- Negative - | Should be used for the hard lessons More  pictures and animations should be added Teacher in video explains very fast Video clips should be enhanced | | 1 11 1 1 | Video is fantastic Sound is clear Video helps understand easily Video is not clear Screen is not attractive Colours are not attractive Add sound effects Colourful pictures & animations should be added | 13 1 7 1 10 8 1 7 |
| Positive + **Activities and Tasks** Negative -- | It should include the questions which are in text book | | 4 | Activities are interesting, unusual, and a bit difficult Prefer to write activities answers in the computer not papers Let the program answer the activities Enhance the way activities is put forward Activities must be at student's level Activities must be more serious | 14 2 3 1 1 1 |
| - + -+ -- **Time** -- Negative -- | Time should be extended Program is a bit slow | | 1 1 | Break time should be included Time should be extended Time was not enough to do all the lessons in the software Time was insufficient to discuss all activities Program is a bit slow | 1 6 18 12 1 |

| Item | Control Group | | Experimental Group | |
|---|---|---|---|---|
| | Comments | Frequency | Comments | Frequency |
| Positive + | Beautiful | 1 | Beautiful | 3 |
| + | usefulUseful | 4 | Good | 6 |
| + | It is a new idea | 1 | usefulUseful | 1 |
| + | Good | 4 | Exciting | 4 |
| + | Very good | 1 | Very clear | 1 |
| + | Excellent | 1 | Fantastic | 1 |
| **Quality**  + | | | Clear | 2 |
| + | | | Appropriate | 1 |
| | | | | |
| | | | | |
| -- | | | Complicated | 1 |
| -- | | | Hard | 1 |
| | | | | |
| + | Very easy | 9 | Easy | 3 |
| **Ease of use** | | | | |
| -+ | | | Enhance the program to be easier | 1 |

**8.5 Discussion of Results**

As outlined in the Post Test Results section, there was no significant difference between the two groups in the achievement test. Several factors may have contributed to this result, however. Firstly, the literature indicates that the duration of treatment and group sizes are critical variables in many of the studies examined in the meta-analyses of CAI and students' achievement. The design flaw of too short treatment periods could reduce the effects of CAI (Liao 2004). Interestingly, as shown in table 8.6, 18 comments by the experimental students state that time was not enough to do all the lessons in the software, 12 comments state that time was insufficient to discuss all activities, and 6 comments state that time should be extended. So, it might be that the period of time using the CAT tool was not sufficient to have an effect on students' performance. The students needed more time to understand and cope with the method used in CAT. Therefore, a study where a greater number of students learn using CAT for a longer period of time maybe required to have a measurable quantitative effect on students' performance.

Secondly, Chen (2005) concludes that the design and development of the CAI is a factor impacting the results of many studies exploring the CAI effectiveness. The research attests that combining words, graphics, mental images, still and moving pictures, and voice, enhances students' learning, helps them gain a deeper understanding of knowledge, and facilitates learning and recall of information (Mayer 2001, Rieber and Kini 1991, Paivio 1971, and Rieber 1994). The comments received by both groups regarding this issue match this conclusion. E.g. ten comments of the experimental group state that screen is not attractive, 8 state that colours are not attractive, 7 comments state that colourful pictures and animations should be added, and 11 control groups' comments state that more pictures and animations should be added. So the design issue in this regard may have caused students to be less motivated to learn from the CAT system and consequently have reduced the system overall effectiveness.

Thirdly, since the only difference in treatment between the two groups was in the activities rather than activities, instruction and test, it is not surprising that there was no significant difference in student performance, although the literature had suggested

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that learners learn best when learning tasks and activities are clear and appropriate for their preferred way of thinking (Brandt 1998, Underwood 1990). The thinking styles theory indicates that teachers should consider three elements while teaching to improve students' performance. Students should be provided with these elements in a way that matches their styles. These three elements are instruction, activities and assessment. The differentiation method that CAT used was limited to just provide the students with different activities that match their thinking styles. Due to the reasons mentioned in chapter five, instruction and assessment were not used in the matching method.

All these factors, i.e. the limitation of the differentiation method, the short period of time in which the experimental students exposed to the CAT, and the elimination of combination of animations, images, graphics, words, colour pictures, and voice, possibly caused the insignificant difference between the two groups in the achievement test.

In spite of all this, the quantitative results in table 8.5 show that there was significant difference in two of the learning experience dimensions between the two groups in favour of the experimental group. The two dimensions are: preferred learning style and the teaching method. This provides sufficient and significant evidence to say that students who used CAT were more likely to know their preferred way of learning and were more likely to like the teaching method contained in CAT. This could explain the 11 comments received from the experimental students, which state that CAT must be used throughout the whole year, and 9 comments, which state that all the lessons in curriculum must be automated. On the other hand, 9 comments received from the control group state that they cannot learn the lessons from the computer.

Table 8.7 summarizes the results analysis in light to the research hypotheses.

Table 8.7: Summary of the Results Analysis

| No. | Research Hypotheses | Result |
|---|---|---|
| 1 | Students who use CAT significantly outperform students who use traditional CAI on an achievement test. | Learning with the CAT tool during the period of this experiment had no significant effect on the experimental group over the control group on the achievement test. |
| 2 | Students who use CAT are more likely to comprehend the knowledge contained in CAT. | Learning with the CAT tool during the period of this experiment had no significant effect on the experimental group over the control group on knowledge comprehension. |
| 3 | Students who use CAT are more likely to like the teaching method contained in CAT. | Learning with the CAT tool during the period of this experiment had significant effect on the experimental group over the control group on liking the teaching method in CAT. |
| 4 | Students who use CAT are more likely to know their preferred way of learning. | Learning with the CAT tool during the period of this experiment had significant effect on the experimental group over the control group on knowing their preferred way of learning. |
| 5 | Students who use CAT are more likely to like the subject contained in CAT. | Learning with the CAT tool during the period of this experiment had no significant effect on the experimental group over the control group on passion for subject. |
| 6 | Students who solve activities in the sequence according to their thinking styles are more likely to understand the knowledge they learn and be motivated. | Learning with the CAT tool during the period of this experiment had no significant effect on the experimental group over the control group on understanding the knowledge and their motivation. |

## 8.6 Conclusions

In phase 2, the thinking styles theory embedded in the CAT system was empirically evaluated by using the experimental method. The control and experimental groups were assigned randomly. This method was used to examine the effect of the thinking styles feature embedded in CAT on students' achievement and learning experience. It was not possible to only use one group to investigate the effectiveness of using CAT though using one group in two phases would considered good practice. The time allocated to conduct the experiment was the main reason not to do so. The experiment was conducted at the end of the academic year, so it was wise to select two groups to work at the same time rather one group, which would need longer period of time. In addition to this, the two groups were two different classes who were taught by the same teacher, the case in which the problem of not having enough students was eliminated. During the school year and before starting the experiment, the students of both groups were assessed on material learned so far in the academic year. The statistics of the assessments mean scores, and standard deviations for both groups were calculated. T-test was performed to assess the mean difference between the two groups. The results showed no significant difference between the two groups. Therefore, by the time of the experiment, there was no significant difference between the two groups. Both groups used the same computer machines. The experimental group learned the lessons saved in CAT based on their thinking styles. Whereas the control group learned the same lessons using CAT without the thinking style feature. Both groups studied six hours of chemistry during the period of the experiment. Students of both groups were unaware of the difference in the way CAT offered them the lessons' material. This arrangement helped minimize the Hawthorne effect (De Amici 2000). Uncontrolled variables, such as the variance between the control group and the experimental group including prior knowledge, ability, instructor effects, and method of instruction, may produce inconclusive results (Joy and Garcia 2000 and Underwood 1990). In this study the mentioned variables were controlled as described above.

At the end of the experiment as students completed all the lessons, both groups administered the achievement post-test to determine the effect of CAT on students' achievement. The post test data were quantitatively analyzed to explore the first hypothesis as shown in table 8.7. The students of both groups also answered the

questionnaire to evaluate the effect of CAT on students' learning experience. The questionnaire data were quantitatively and qualitatively analyzed to explore the hypotheses 2-6 as shown in table 8.7, and to provide evidence for the purpose of the study.

Using mixed methods allows better collection and analysis of data. Mixed methods employ both quantitative and qualitative research strategies for the purpose of cross-checking to arrive at confidence in the research findings from more than one viewpoint.

Although the literature on styles indicates that teaching according to students' styles improves their performance and enhances their achievement (Costa 2001, Sternberg and Grigorenko 1997, and Zhang and Sternberg 1998), the results of this study showed that learning with the CAT tool during the period of this experiment had no significant effect on the experimental group over the control group on the achievement test. As discussed in the Discussion of Results section, the factors of the limitation of the differentiation method used in CAT, the short period of time in which the experimental students exposed to the CAT, and the elimination of combination of animations, images, graphics, words, colour pictures, and voice, possibly caused the insignificant difference between the two groups in the achievement test. However the results also showed that learning with the CAT tool during the period of this experiment had significant effects on the experimental students' learning experience. It was found that students who used CAT were more likely to know their preferred way of learning and were more likely to like the teaching method contained in CAT.

The work described in this study represents only a first attempt to apply the thinking style theory to software design. Efforts should continue to incorporate the theory into the software design more effectively. In conclusion, the author believes that CAT is still in its developing stage. There are still many factors to be evaluated in determining the most effective way to exploit the capabilities of the CAT system to improve students' performance and learning. Therefore additional research is needed to determine the parameters, which make CAT an effective tool in future classrooms. Doubtless, CAT will eventually be devised, suited to each student's style.

# CHAPTER 9

# CONTRIBUTION OF RESEARCH, RECOMMENDATIONS AND CONCLUSIONS

## 9.1 Summary of Research

Educational reforms have gained enormous support in various developing and developed countries worldwide. Most new educational models are based on technology and on providing networks, computers, and educational programs in general and higher education. Furthermore such models call for a change from a teacher-guided model, and consider the book as the only source of knowledge, into a learner-guided model, which depends on different sources.

The current research addresses the main problems in the teaching process, problems including: (1) the dependence of the educational practices inside the classroom on old assumptions about learning and how it takes place, and (2) the use of teaching methods that neither meet the needs of all learners nor consider their individual differences like their thinking styles and their preferable learning styles. E-learning in the Electronic Future project in Abu Dhabi can achieve its goals if it adopts educational modern theory that will lead a change in education. This change is based on student's mental model where the students are considered the centre of the teaching process. E-learning must make the students the basis of teaching and instruction by introducing the teaching which harmonizes with their needs, way of thinking, and preferable styles of learning. Accordingly, there is a demanding need to explore how the computer can be used to vary between teaching methods so that we take into consideration individual differences of learners.

Building on style previous work, i.e. cognitive style, learning style, thinking style, Sternberg proposed a model that integrates the various approaches of understanding styles into a single theory, which he named Theory of Mental Self-government. The goal of the theory is to provide new directions for theory applied to educational practice.

The literature on styles indicates that teaching which considers students' thinking styles improves students' academic performance, enhances their achievement, and adds significantly to abilities in predicting school achievement.

A study to standardize the self-assessment inventory of thinking styles for the UAE environment was conducted. The study showed that the thinking styles inventory (7 styles of function and form categories of the inventory) was reliable and valid for use in identifying the thinking styles among a sample of UAE high school students.

Two reasons put this research of high importance. The first being the scarcity of local studies which focus on using the computer in teaching scientific subjects in general and biochemistry in particular that support the Educational Zone's project in Abu Dhabi. The second is the unavailability of international studies that use the computer in introducing the content based on the student's thinking styles according to the Mental Self-Government Theory. Accordingly, the study was conducted to investigate the effectiveness of the educational software CAT on student's achievement and learning experience. CAT offers different activities, tasks and questions according to the learner's thinking style based on the mental self-government theory.

The CAT system passed through two phases. The goal of the first phase was to automate two chemistry lessons - Oxygen and Ozone, to explore how students react with it in regard to the learning experience. Then to get feedback from the students to help build the CAT system which embeds the thinking style theory in the second phase. Based on the conclusions drawn in the first phase, major changes were made to the software design. For the purpose of this study, CAT was developed as a generic tool that contained four lessons of the UAE 12th grade biochemistry unit. The way the content was presented differed according to the different thinking styles of students. Hence, the program individualized the learning experience by offering different tasks and activities, which met the needs of each of the three thinking styles: Legislative, Judicial, and Executive.

Finally, an experiment was conducted on two groups of students. One group used CAT with the thinking styles feature. This feature, as mentioned earlier, presented the

lessons material according to student's thinking style. The other group studied the lessons without the thinking style feature. The purpose of the experiment was to investigate the effects of using CAT with the thinking styles feature on students' achievement and learning experience.

At the end of the experiment, quantitative and qualitative data was gathered and then analyzed. The results showed that learning with the CAT tool during the period of this experiment had no significant effect on the experimental group over the control group on the achievement test. However, The CAT tool had significant effects on the experimental students' learning experience. The experimental students were more likely to like the teaching method contained in CAT and more likely to know their preferred way of learning.

The next section summarizes the contributions of the research and what was found.

## 9.2 Contribution of Research

The study has revealed the following original contributions:

- It is argued that teaching according to students' styles improves their performance (Costa 2001) and to omit styles considerations in any integrated learning system is a serious defect that limits its effectiveness (Riding 1998). A major contribution of this research was to test this empirically.

- The research is the first known study to explore the way that thinking styles can be used in the design of learner model for the purpose of individualizing instruction and learning experience.

- The research is also the first in-depth study on the styles theory and CAI in the United Arab Emirates.

- The research will contribute to the electronic future project in the United Arab Emirates in improving teaching and learning process and enhancing students' creative and critical thinking, which is one of the goals of the project (Greaves 2004).

- Lecturing and rote learning is the common method used by most teachers in Abu Dhabi schools (Haidar 2000). The research will contribute to the reform in the United Arab Emirates in helping teachers conduct student-centred

teaching. CAT will help teachers individualize instruction and overcome the problem of knowledge and time.

- Efforts have gone into standardizing the Sternberg assessment inventory for different cultures, e.g. (Zhang and Sachs 1997, Zhang and Sternberg 1998, and Cilliers and Sternberg 2001). One major contribution of this study is that it was the first attempt to standardize the assessment inventory in Arabic culture. The current research contributes to the United Arab Emirates society a valid and reliable Arabic measurement to identify the thinking styles of UAE high school students.

- The research shows that computers can help teachers assess students' thinking styles.

- The research shows that when computers consider students' thinking styles during the learning process, students are more likely to like the teaching method offered and more likely to know their preferred ways of learning.

- The research shows that computers can help teachers save their time and use it effectively in the class room discussing with, guiding, and advising students if time permits.

- The research contributes in determining some parameters and factors, which involve applying the thinking style theory in the software design effectively, such as the combination of instruction, assessment and activities rather than activities alone. This opens the door to other studies to evaluate other factors to determine the most effective way to exploit the capabilities of the CAT system to improve students' performance and learning more effectively.

**9.3   Limitations of the Study**

**9.3.1 Limitations of the Experiment**

This study has limitations in its implementation as it is bound by the following factors indicated below.

- The students of two 12th grade classes in Khalifah Secondary School, Abu Dhabi Educational Zone – Abu Dhabi in the academic year 2006/2007 during the first semester.

- 12th grade male students; no female students were part of the study.

- Teaching two chapters from the Biochemistry unit taken from the UAE Chemistry 12th grade book for the 2006/2007 academic year during the first semester.

- Using the CAT educational software, which is based on three thinking styles of the Mental Self-Government theory. The three thinking styles are the Legislative, Executive, and Judicial.

- The differentiation method that CAT uses, which is providing the students with different tasks and activities that match their thinking styles.

### 9.3.2 Limitations of the System

- CAT is limited to identify only three thinking styles of the Mental Self-Government theory- legislative, executive and Judicial.

- CAT has no hint option to help students be on track.

- CAT does not offer help option or feedback to assist students correct their answers.

- CAT does not allow students to key-in their answers.

- The differentiation method that CAT uses is limited to just provide the students with different activities, questions and prompts that match their thinking styles.

- CAT does not offer any word processing font facilities like font, colour, or size.

- CAT does not automatically develop the teaching material according to the different thinking styles. The teaching material should be made manually and saved into CAT by the teacher.

- CAT does not offer help to assist teachers design the teaching material based on the thinking styles.

### 9.4 Summary of the CAT System Design

- CAT was designed to analyze students' dominant thinking style to offer them the content that matches this thinking style. Three thinking styles within the Mental Self-Government Theory were embedded in the CAT design. These

thinking styles were the function dimension in the theory that consists of three styles: Legislative, Executive, and Judicial.

- CAT was designed to introduce the different queries of instruction that go in accordance with the three thinking styles. The system individualizes the type of activities, questions, and prompts given to the student according to the student's thinking style.

- CAT was designed to be user friendly so all students and teachers with no IT knowledge can use it with confidence. It includes all lesson contents in one screen. A student can read the lesson text and watch the teacher explaining the lesson in video clips, all in one screen. On the same screen, all instruction statements were made clear.

- CAT was designed to give the student full control of content, sequence, and pace. In addition, the student has control of all media type, i.e. video volume and sequence.


## 9.5 Proposed Developments of the System

The following are some development suggestions to the CAT tool:

- Enhance the interface design to attract students.

- Add some word processing text styles and formatting facilities such as font, size, colour, and bold.

- Provide students with scaffolding buttons to receive hints, examples help and feedback.

- Add the instruction and assessment to the differentiation method.

- Allow the identification process to all of the 13 thinking styles of the Mental Self-Government theory.

- Give written and spoken descriptions of the thinking styles to help students understand the style notion and appreciate it.

- Add an option to allow the student to select any lesson associated with any thinking style other than his own identified dominant thinking style. Keep a log of the sequence of material accessed by the student. The way the student accesses and learns the material will inform the teacher about the students preferred thinking style. This could be another approach to determine

students' thinking styles other than using the Sternberg-Wagner Self-Assessment Inventory.

- Add FAQ menu where students can refer to answer their questions about the content.

- Provide the teacher with details about the thinking styles theory and examples for the differentiation methods associated with every style.

- Allow teacher to enter different types of questions and provide students with immediate feedback.

- Add text and voice to still and moving pictures.

- Allow students to type and save their answers in their accounts.

- Add INFO button to provide students with extra information about any topic for enrichment.

- Include puzzles and games for students' enjoyment.

- Allow students to share a network group work.

## 9.6 Recommendations for Future Research Involving CAT

- The Proposed developments of the system mentioned in section 9.5 were suggested to enhance the performance of CAT in order to enhance students' learning. One future area of research is to evaluate the influence the suggested developments of the system have on students' learning when learning with CAT.

- Conduct a study where a greater number of students learn using CAT for a longer period of time.

- Investigate the effects of the CAT tool on male and female students in different subjects and grade levels.

- Evaluate the effects of CAT on students with different thinking styles other than the functions dimension of the theory.

- Conduct a study where CAT integrates the activities, questions, prompts, instruction and test so that these critical aspects of teaching are presented to the students in accordance to their thinking styles.

- Conduct CAT study with a sample of students who preferred CAI as the best learning medium of choice. This minimizes the effect of learning and cognitive styles among the sample in regard to learning with computers.

**9.7 Conclusions**

This research details the design and effect of computer software called CAT on student's achievement and learning experience. The theory of thinking styles was embedded in the software design of CAT. The study concludes that offering the activities tailored to students' thinking styles through the computer causes significant effects on the experimental students' learning experience. The students were more likely to like the teaching method contained in CAT and more likely to know their preferred way of learning. However, due to the complexity of the thinking approach in the learning process, significant improvements in students' achievement using CAT during a short period could not be achieved by just providing students with different activities that match their thinking styles. Instruction and assessment should be included in the matching process too as the theory states. The study shows that using CAT helped the teacher offer different activities to different students at the same period of time. However, the teacher should practice the new role while students use CAT, which is to help and provide students with immediate feedback. Allowing students to work individually and in groups without the control of the teacher helped students be responsible for their learning. This study demonstrates that CAT architecture is sound, and indicates the potential of conducting future research to investigate, after making the suggested improvement, the effect of CAT on students' learning.

# REFERENCES

Abdoun, S. (1990). <u>Learning obstacles and their relation to its factors and causes.</u> Fifth International Conference for Statistics and Social Sciences. Ein Shams University, Cairo, Egypt.

Abu Hatab, F. & Othman, S. (1986). Psychological evaluation. Egyptian Angelo, Cairo, Egypt.

Abu Jaber, M. & Qutami, N. (1998). Students' self-efficacy of computer through the use of cognitive thinking style. <u>International Journal of Instructional Media, vol. 25.</u>

Al E'naizi, Y. (1989). An introductory to educational software design. <u>Education Journal, vol.1</u>:137-150.

Al Khalili, K. & Haider, A. (1996). <u>Teaching science in public education.</u> Dubai, UAE: Al-Kalam Publishing House.

Al Mousa, A. (2002). <u>Using information technology and computer in elementary education in the Arab Gulf states.</u> Riyadh, SA: Arab Bureau of Education for the Gulf States.

Al Mutairi, S. (1998). <u>The impact of using a computer software on achievement in science subject of sixth grade students in Riyadh city.</u> Unpublished master thesis submitted to the graduate faculty of King Saud University, Riyadh, KSA.

Al Omar, M. (2002). <u>The impact of educational computer on achievement of tenth grade students in chemistry.</u> Unpublished Master thesis submitted to the Graduate Faculty of AlYarmook University, Erbid, Jordan.

Al Saleh, B. (2002). <u>Technology and future school: myths and facts.</u> Paper presented at Future School Conference, College of Education, Saud University, KSA.

Al Sayed, F. (1979). <u>Statistical psychology.</u> Dar Al Fekr Al Arabi, Cairo, Egypt.

Al Sharhaan, A. (2000). Education Vision 2020. Abu Dhabi, UAE: Ministry of Education and Youth.

Arroyo, I., Beck, J., Schultz, K. & Woolf, B. (1999a). A useful prediction variable for student models: cognitive development level. Submitted to the International Conference on User Modeling, 1999.

Arroyo, I., Beck, J., Schultz, K. & Woolf, B. (1999b). Piagetian psychology in intelligent tutoring systems. In the Proceedings of the Ninth International Conference on Artificial Intelligence in Education. pp. 600-602.

Arroyo, I., Beck, J., Schultz, K., & Woolf, B. (2003). Learning within the ZPD with the AnimalWatch intelligent tutoring system. University of Massachusetts.

Barhoom, W. (2002). The effect of using computerized educational program on achievement in earth and environment science subject of tenth grade students. Unpublished Master thesis submitted to the Graduate Faculty of AlYarmook University, Erbid, Jordan.

Bell, M., Gladwin, R. & Drury, T. (1998). Implementing CAL in chemistry: Practical issues. Journal of Chemical Education, vol. 75, no. 6, pp. 781-785.

Berman, S. (2001). Thinking in context: Teaching for open-mindedness and critical understanding. In Arthur L. Costa (ed.), Developing Minds: A Resource Book for Teaching Thinking, (3rd ed.). Alexandria, VA: Association for Supervision and Curriculum Development.

Blok, H., Oostdam, R., Otter, M. & Overmaat, M. (2002). Computer-assisted instruction in support of beginning reading instruction: A review. Review of Educational Research, 72(1), pp. 101-130.

Bloom, B. (1956). Taxonomy of educational objectives handbook 1: Cognitive domain. New York: David McKay.

Bork, A. (1979). Interactive Learning. American Journal of Physics, vol. 47, pp. 5-10.

Brandt, R. (1998). Powerful learning. Alexandria, VA: Association for Supervision and Curriculum Development.

Brophy, K. (1999). Is computer-assisted instruction effective in the science classroom? Masters Abstracts International, vol. 37 (5), pp. 1302. (UMI No. 1393859).

Brown, J. (1995). Observing Dimension of Learning in Classrooms and Schools. Alexandria, VA: Association for Supervision and Curriculum Development.

Brown, K. (2001). Using computers to deliver training: Which employees learn and why? Personnel Psychology, vol. 54, pp. 271-296.

Brown, T. (1997). Multimedia in education: Learner control. Retrieved October 21, 2002, from http://scs.une.edu.au/materials/573/573_3.html.

Bruner, J. (1966). Toward a theory of instruction, NY: W. W. Norton.

Byrnes, J. (1996). Cognitive development and learning in instructional contexts. Needham Heights, MA: Allyn and Bacon.

Caffarell, E. (1987). Evaluating the new generation of computer based instructional software. Educational Technology, vol. 22, no. 4, pp. 19-24.

Chang, J. (2000). A field test of CAI software: MagicTree. Masters Abstracts International, vol. 38 (6), pp. 1438. (UMI No. 1399856).

Chen, L. (2005). Examining the role of the computer in EFL Instruction. Electronic Journal for the Integration of Technology in Education, vol. 4, pp. 30-63.

Chen, S. (2002). A cognitive model for non–linear learning in hypermedia programmes. British Journal of Educational Technology, vol. 33 (4), pp.449-460.

Christmann, E., Badgett, J. & Lucking, R. (1997). Progressive comparison of the effects of computer-assisted instruction on the academic achievement of secondary students. Journal of Research on Computing in Education, vol. 29(4), pp. 325-337.

Christmann, E. & Badgett, J. (2000). The comparative effectiveness of CAI on collegiate academic performance. Journal of Computing in Higher Education, vol. 11(2), pp. 91-103.

Cilliers, C. & Sternberg, R. (2001). Thinking styles: implication for optimizing learning and teaching in university education. SAJHE/SATHO, vol. 15, no. 1, pp. 13-24.

Clariana, R. (1997). Considering learning styles in computer assisted learning. British Journal of Educational Technology, vol. 28, no. 1, pp. 66-68.

Clark, R. (1983), Reconsidering research on learning from media. Review of Educational Research, vol.4, pp. 445-59.

Clinkscales, M. (2002). Computer-assisted instruction versus traditional classroom instruction: Examining students' factoring ability in high school algebra one. Unpublished Master thesis submitted to the Graduate Faculty of North Carolina State University, Raleigh, North Carolina.

Coley, R., Cradler, J. & Engel, P. (1997). Computers and classrooms: The status of technology in U.S. schools. Policy Information Report. Educational Testing Service, Princeton, NJ., Policy Information Center.

Costa, A. & Kallick, B. (2000). Discovering and exploring habits of mind. Alexandria, VA: Association for Supervision and Curriculum Development.

Costa, A. ed. (2001). Master Architect of Intellect. In Arthur L. Costa (ed.) Developing Minds: A Resource Book for Teaching Thinking, (3rd ed.). Alexandria, VA: Association for Supervision and Curriculum Development.

Dori', Y. & Barnea, N. (1993). A computer-aided instruction module on polymers. J. Chem. Inf. Comput. Science, vol. 33, pp. 325-331.

Dorothy, G. (1999), Improving teaching and learning through chemistry education research: A look to the future. Journal of Chemical Education, vol. 76, no. 4.

De Amici, D., Klersy, C., Ramajoli, F., Brustia, L. & Politi, P. (2000), Impact of the Hawthorne effect in a longitudinal clinical study: The case of anesthesia. Controlled Clinical Trials, 21 (2), pp. 103-114.

Elliott, A. & Woodward, W. (2007). Statistical analysis quick reference guidebook; with SPSS examples. Sage Publications.

Emerson, J. & Mosteller, F. In Educational Media and Technology Yearbook; Branch, R. M., Fitzgerald, M. A., Eds.; Libraries Unlimited, Inc.: Englewood, CO, 1998.

Ghonaim, A. (2000). Statistical Analysis of Data Using SPSS. Dar Qeba', Cairo, 2000.

Glatthorn, A. & Jailaill, J. (2000). Curriculum for the new millenium. In Brandt, R. (ed.) Education in a New Era. Alexandria, VA: Association for Supervision and Curriculum Development.

Glickman, C. (2000). The effects of computerized instruction in intermediate algebra. Dissertation Abstracts International, vol. 61(5), pp. 1773A. (UMI No. 9973965).

Goldberg, A., Russell, M. & Cook, A. (2003). The effect of computers on student writing: A meta-analysis of studies from 1992 to 2002. Journal of Technology, Learning, and Assessment, vol. 2(1).
Available from http://www.jtla.org/

Greaves, P. (2004). Abu Dhabi Educational Zone E-Learning & educational resources initiative: strategy framework. Official document presented to the Abu Dhabi Educational Zone, Abu Dhabi, UAE.

Gregorc, A. (1982). Gregorc Style Delineator. Maynard, MA: Gabriel Systems, Inc.

Grigorenko, E. & Sternberg, R. (1995). Thinking styles: In D. Saklofske and M. Zeidner (eds.), International handbook of personality and intelligence (pp. 205 –229). New York: Plenum.

Haidar, A. (2000). Science education reform in the UAE: Issues and challenges. Paper presented to Education in the UAE Conference. Dubai, UAE. Center for Curriculum Development.

Hall, J. (2000). Field dependence-independence and computer-based instruction in geography. A doctoral dissertation submitted to the Faculty of the Virginia Polytechnic Institute and State University.

Harrold, M. & Newton, G. (1998). Development and evaluation of computer-based tutorials in biochemistry and medicinal chemistry. American Journal of Pharmaceutical Education, vol. 62, pp. 24-30.

Hasan, M. (2002). Computers and IT in UAE's public education. Paper presented to the Technology in Education Conference. Sharjah, UAE.

Holdich, K & Chung, P. (2001). Developing a "computer tutor" to assist children aged seven to eleven years develop their narrative writing skills. Department of Computer Science, Loughborough University, Loughborough, UK.

Hood, B. (1994). Research on computers in chemistry education: Reflections and predictions. Journal of Chemical Education, vol. 71, no. 3, pp. 196-200.

Huxford, D. (1999). The relative efficacy of computer assisted instruction. Unpublished thesis, West Virginia University.

Jenks, M. & Springer, J. (2002). A view of the research on the efficacy of CAI. Electronic Journal for the Integration of Technology in Education, vol. 1, no. 2, pp. 43-58.

Jensen, E. (1997). Brain compatible strategies. CA: The Brain Store.

Jensen, E. (1998). Teaching with the brain in mind. VA: ASCD.

Jensen, E. (2007). Brain-based learning (the translated version). KSA: Jarir Bookstore .

Johnson, R., Johnson, D. & Stanne, M. (1985). Effects of cooperative, competitive, and individualistic goal structures on computer-assisted instruction. Journal of Educational Psychology, vol. 77(6), pp. 668-677.

Jonassen, D. (2000). Computers as mindtools for schools: engaging critical thinking, (2nd ed.). Upper Saddle River, NJ: Prentice-Hall, Inc.

Joy, E. & Garcia, F. (2000). Measuring learning effectiveness: A new look at no-significant-difference findings. JALN, vol. 4(1), pp. 33-39.

Kadiyala, M. & Crynes, B. (1998). Where's the proof? A review of literature on effectiveness of information technology in education. Proceedings of Frontiers in Education 1998, Tempe, Arizona (Nov. 4-7, 1998), vol.1 pp. 33-37.

Kleiman, G.  (2000). Myths and realities about technology in k-12 schools. *Leadership and the New Technologies (LNT) Perspectives* (online journal), issue 14 April-June, 2000.
Available: http://www.edtechleaders.org/documents/myths.pdf

Kolb, D. (1984). Experiential learning: Experience as the source of learning and development. Englewood Cliffs, NJ: Prentice-Hall.

Kovalik, S. & Olsen, K. (2004).  Exceeding expectations: A user's guide to implementing brain research in the classroom, third book (the translated version).  Dammam, KSA: Dar Alkitab.

Kulik, J. (1994). Meta-analytic studies of findings on computer-based instruction. In Baker, E. L. & O'Neil, H. F. Jr. (eds.), Technology assessment in education and training. (pp. 9-33). Hillsdale, NJ: Lawrence Erlbaum.

Kulik, J. (2003). Effects of using instructional technology in elementary and secondary schools: What controlled evaluation studies say. Arlington, Virginia: SRI International.

Kulik, C., Kulik, J. & Shwalb, B. (1986). The effectiveness of computer-based adult education: A meta-analysis. Journal of Educational Computing Research, vol. 2(2), pp. 235-252.

Kulik, J., Kulik, C. & Bangert-Drowns, R. (1985). Effectiveness of computer-based education in elementary schools. Computers in Human Behavior, vol. 1(1), pp. 59-74.

Kulik, J., Bangert, R. & Williams, G. (1983). Effects of computer-based teaching on secondary school students. Journal of Educational Psychology, vol. 75(1), pp.19-26.

Soe, K., Koki, S. & Chang, J. (2000).  Effect of computer-assisted instruction (CAI) on reading achievement: A meta-analysis. Pacific Resources for Education and Learning, Honolulu, HI.

Lambert, T., Kirby, K. & Dunn, J. (1997).  Clinical education and the computer:  A proposed model for computer-aided learning in the medical curriculum. Australasian Psychiatry, no. 1, pp. 19-21.

Lane, E. (1990). <u>Animation in physics teaching.</u> Paper Presented at Conference on Computer in Physics Instruction. Raleigh, NC, USA.

Liao, Y. (2004). <u>CAI/CAL and students' achievement in Taiwan: A meta-analysis.</u> Paper presented at National Educational Computing Conference. New Orleans, LA.

Lin, S., Liu, E. & Yuan, S. (2001). Web-based peer assessment: feedback for students with various thinking-styles. <u>Journal of Computer Assisted Learning, vol. 17,</u> no. 4, pp. 420-432(0). Blackwell Publishing.

Loong, D. (2003). An overview of IT development in the Asia-Pacific region. In Tan Seng Chee and Angela F. L. Wong (ed.), <u>Teaching and learning with technology: An Asia-Pacific perspective.</u> Singapore: Prentice-Hall.

Lowe, J. (2001). Computer-based education: Is it a panacea? <u>Journal of Research on Technology in Education, vol. 34(2),</u> pp. 163-171.

Luckin, R. & du Boulay, B. (1999) Ecolab: the development and evaluation of a Vygotskian design framework. <u>International Journal of Artificial Intelligence in Education, vol.10,</u> no. 2., pp. 198-220.

Malak, H. (1995). <u>The effect of learning with computers on achievement of tenth grade students in chemistry.</u> Unpublished Master thesis submitted to the Graduate Faculty of AlYarmook University, Erbid, Jordan.

Marzano, R. (1992). <u>A different kind of classroom: Teaching with dimensions of learning.</u> Alexandria, VA: Association for Supervision and Curriculum Development.

Mayer, R. (2001). <u>Multimedia Learning.</u> Cambridge University Press.

Nachmias, R. & Shany, N. (2002). Learning in virtual courses and its relationship to thinking styles. <u>Journal of Educational Computing Research, vol. 27,</u> no. 3, pp. 315-329.

O'Shea, T. & Self, J. (1983). <u>Learning and teaching with computers – Artificial intelligence in education.</u> Sussex: The Harvester.

Paivio, A. (1971). <u>Imagery and verbal processes.</u> New York: Holt, Rinehart, and Winston.

Parr, J. (2006). <u>A review of the literature on computer-assisted learning, particularly integrated learning systems, and outcomes with respect to literacy and numeracy.</u> ISBN:0-477-05196-0, Ministry of Education, Auckland, New Zealand.

Passerini, K. (2000). <u>A comparative analysis of performance and behavioral outcomes in different modes of technology-based learning.</u> Unpublished Dissertation, George Washington University, Washington D.C.

Penuel, W., Means, B. & Simkins, M. (2000). The multimedia challenge. <u>Educational Leadership,</u> no. 2, pp. 34-38.

Perkins, D., Schwartz, J., West, M. & Wiske, M. eds. (1995). <u>Software goes to school.</u> New York, NY: Oxford University Press.

Piaget, J. (1967). <u>Six psychological studies.</u> London: Random House.

Piaget, J. & Inhelder, B. (1969). <u>The psychology of the child.</u> NY: Basic Books.

Piaget, J. (1970). Piaget's theory. In Mussen, P. (ed.), <u>Carmichael's Manual of Child Psychology.</u> NY: John Wiley.

Pressley, M. & Woloshyn, V. (1995). <u>Cognitive strategy instruction that really improves children's academic performance,</u> (2nd ed.). Saline, MI: McNaughton & Gunn.

Price, S. (1989). <u>Using CAI to improve participation and achievement in science research projects in middle school science.</u> Unpublished M.S. Practicum Paper, Nova University.

Qiyun, W. & Sum, C. (2003). Designing hypermedia learning environments. In Tan Seng Chee, T. & Wong, A. (eds.). <u>Teaching and learning with technology: An Asia-Pacific perspective.</u> Singapore: Prentice-Hall.

Reeves, T. (1998). The impact of media and technology in schools: A research report prepared for The Bertelsmann Foundation.

Renzulli, J. (1997). <u>The Schoolwide enrichment model.</u> Mansfield Center, CT: Creative Learning Press.

Renzulli, J. & Dai, D. (2001). In Sternberg, Robert J. (eds.). <u>Abilities, interests, and styles as aptitudes for learning: A person-situation interaction perspective.</u> Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.

Riding, R. & Rayner, S. (1998). <u>Cognitive styles and learning strategies: understanding style differences in learning and behavior.</u> Great Britain: The Cromwell Press Ltd.

Riding, R. & Grimley, M. (1999). Cognitive style, gender, and learning from multimedia materials in eleven years old children. <u>British Journal of Educational Technology, vol. 30(1),</u> pp. 43-57.

Rieber, L. & Kini, A. (1991). Theoretical foundations of instructional applications of computer generated animated visuals. <u>Journal of Computer-based Instruction, vol. 18(3),</u> pp. 83-88.

Rieber, L. (1994). <u>Computers, graphics, & learning.</u> Dubuque, Iowa: WCB Brown & Benchmark Publishers.

Roblyer, M., Castire, W. & King, F. (1988). <u>Assessing the impact of computer-based instruction: A review of recent research.</u> NY: The Haworth Press.

Roschelle, J., Pea, R., Hoadley, C., Gordin, D. & Means, B. (2000). Changing how and what children learn in school with computer-based technology. <u>Children and Computer Technology, vol. 10(2),</u> pp. 76–101.

Ross, J. & Schulz, R. (1999). Can computer-aided instruction accommodate all learners equally? <u>British Journal of Educational Technology, vol. 30,</u> no. 1, pp. 5-24.

Rowland, P. (1988). <u>The effect of mode of CAI and individual learning differences on the understanding of concept relationships.</u> Paper presented at the Annual Meeting of the International Association for Computing in Education, New Orleans, LA.

Rowry, E. (1994). The effects of computer-controlled interactive videodiscs in teaching high school chemistry. <u>Dissertation Abstracts International, 55/07-A.</u>

Rushby, N. (1997). Quality criteria for multimedia association for learning. Technology Journal, vol. 5(2), pp.18-30.

Ryan, A. (1991). Meta-analysis of achievement effects in microcomputer applications in elementary schools. Educational Administration Quarterly, vol. 27(2), pp.161-184.

Simkins, M. & Cole, K. (2002). Increasing students learning through multimedia projects. ASCD, VA.

Soyibo, K. & Hudson, A. (2000). Effects of computer-assisted instruction (CAI) on eleventh graders' attitudes to biology and CAI and understanding of reproduction in plants and animals, Volume 18, Number 2, 191-199 / November 1, 2000.

Song, C. (2002). Literature review for hypermedia study from an individual learning differences perspectives. British Journal of Educational Technology, vol. 33, no. 4, pp. 435-447.

Stanton, N. & Baber, C. (1992). An investigation of styles and strategies in self-directed learning. Journal of Educational Multimedia and Hypermedia, vol. 1(2), pp.147-167.

Steinberg, E. (1991). Teaching computer to teach. New Jersey: Lawrence ErlBaum Associates.

Stern, R. & Repa, J. (2000). A study of the efficacy of computerized skill building for adolescents: Reducing aggression and increasing pro-social behavior.

Sternberg, R. (1997). Thinking styles. Cambridge University Press. Cambridge, UK.

Sternberg, R. (2001a). Thinking styles. In Arthur L. Costa (ed.) Developing Minds: A Resource Book for Teaching Thinking, (3rd ed.),pp. 197-201. Alexandria, VA: Association for Supervision and Curriculum Development.

Sternberg, R. & Grigorenko, E. (1995). Styles of thinking in the school. European Journal for High Ability, vol. 6, pp. 201-219.

Sternberg, R. & Grigorenko, E. (1997). Are cognitive styles still in style? American Psychologist, vol. 52, no. 7, pp.700-712.

Sternberg, R. (1994). Allowing for thinking styles. <u>Educational Leadership</u>, pp. 36-40.

Sternberg, R. & Zhang, L. (eds.) (2001b). <u>Perspectives on thinking, learning, and cognitive styles.</u> Mahwah, NJ: Lawrence Erlbaum Associates.

Summerville, L. (1985). <u>The relationship between computer assisted instruction and achievement levels and learning rates of secondary students in first year chemistry.</u> Dissertation Abstracts International, vol. 46, P. 3, P. 603-A.

Triantafillou, E., Demetriadis, S. & Pombortsis, A. (2003). The design and the formative evaluation of an adaptive educational system based on cognitive styles. <u>Computers & Education, vol. 41,</u> pp. 87–103.

Tseng, H. (1999). Computer-assisted instruction in the math family. <u>Masters Abstracts International, vol. 37 (5),</u> 1303. (UMI No. 1394146).

Underwood, J. & Underwood, G. (1990). <u>Computers and learning – helping children acquire thinking skills.</u> UK: Blackwell Publishers.

Vygotsky, L. (1986). <u>Thought and language.</u> MIT Press, Cambridge, MA.

Vygotsky, L. (1978). <u>Mind in society: The development of higher psychology processes.</u> Cambridge MA: Harvard University Press.

Wainwright, C. (1985). <u>The effectiveness of a computer-assisted instruction package in supplementing teaching of selected concepts in high school chemistry: writing formulas and balancing chemical equations.</u> Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (58th, French Lick Springs, IN).

Whitworth, S. & Berson, M. (2003). Computer technology in the social studies: An examination of the effectiveness literature (1996-2001). <u>Contemporary Issues in Technology and Teacher Education, vol. 2(4),</u> pp. 472-509.

Williams, M. (1997). Learner-control and instructional technologies. In D. H. Jonassen (ed.), <u>Handbook of Research for Educational Communication and Technology</u> (pp. 957-983). New York: Macmillan.

Williamson, V. & Abraham, M. (1995). The effects of computer animation on the particulate mental models of college chemistry students. Journal of Research in Science Teaching, vol. 32, pp. 521-534.

Winser, B. & Cheung, W. (1996). The quality of software for computer-based literacy learning. RELC Journal, vol. 27(2), pp. 83-100.

Wise, K. (1986). The impact of microcomputer simulation on the achievement and attitudes of high school. Physical. Science Education, vol. 76, no. 3, pp. 237.

Wood, E., Woloshyn, V. & Willoughby, T. (1995). Cognitive strategy instruction for middle and high schools. Dexter, MI: Thomson-Shore Inc.

Yaakub, M. (1989). Meta-Analysis of the effectiveness of computer-assisted instruction in technical education and training. Unpublished doctoral dissertation submitted to the faculty of the Virginia Polytechnic Institute and State University. Blacksburg, Virginia.

Yalcinalp, S. (1995). Effectiveness of using computer – Assisted supplementary instruction for teaching the mole concept. Journal of Research in Science Teaching, vol. 32(10), pp.1083-1095.

Zhang, L. & Sternberg, R. (1998). Thinking styles, abilities and academic achievement among Hong Kong University students. Hong Kong Educational Revenue Association, pp. 41-62.

Zhang, L. & Sachs, J. (1997). Assessing thinking styles in the theory of self-government. A Hong Kong Validity Study. Psychological Reports, vol.81, pp.928.

**Questionnaire Results and Analysis (PHASE 2)**

Q1 I was motivated and confident to complete all the tasks and activities in the program

| items | | | Don't agree | Neutral | Agree | Highly agree | Mean | N | Std. Deviation |
|---|---|---|---|---|---|---|---|---|---|
| experimental | I was motivated and confident to complete all the tasks and activities in the program. | Freq. | 2 | 1 | 11 | 14 | 3.32 | 28 | .863 |
| | | % | 7.1 | 3.6 | 39.3 | 50 | | | |
| control | | Freq. | 2 | 7 | 3 | 1 | 2.23 | 13 | .832 |
| | | % | 15.4 | 53.8 | 23.1 | 7.7 | | | |
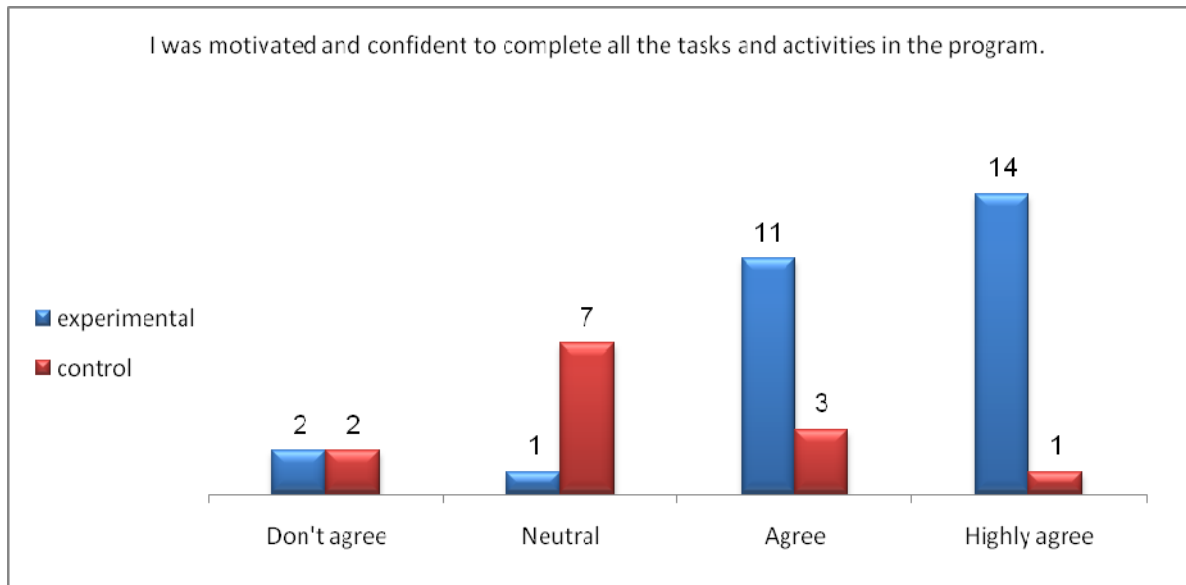


I was motivated and confident to complete all the tasks and activities in the program.
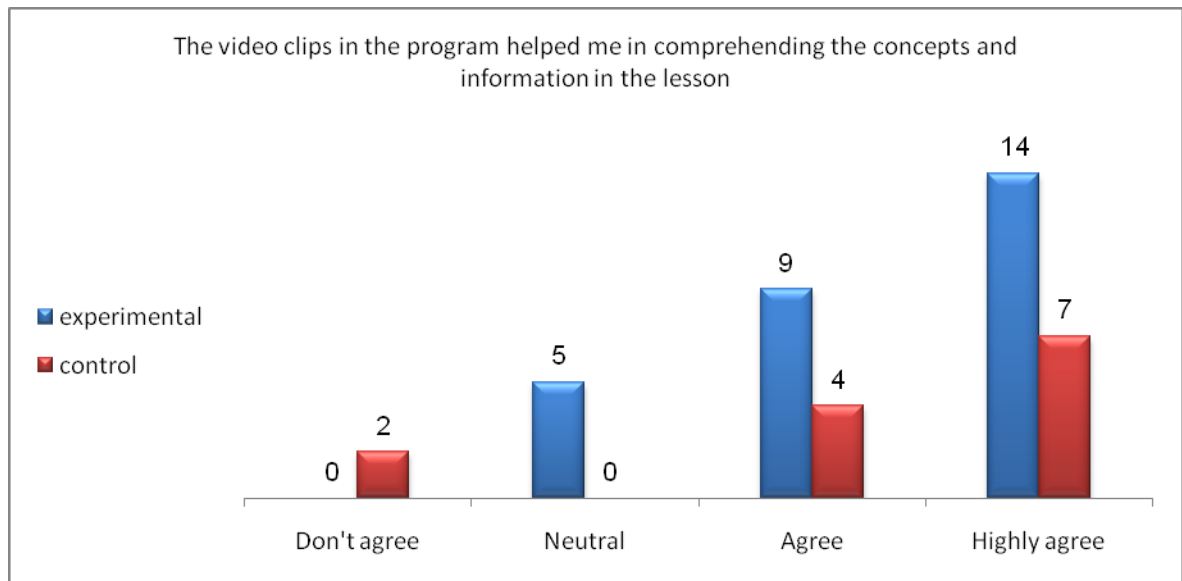
Q2 The program enabled me to relate previous knowledge to the new knowledge in the lessons.

| items | | | Don't agree | Neutral | Agree | Highly agree | Mean | N | Std. Deviation |
|---|---|---|---|---|---|---|---|---|---|
| experimental | The program enabled me to relate previous knowledge to the new knowledge in the lessons. | Freq. | 1 | 5 | 16 | 6 | 2.96 | 28 | .744 |
| | | % | 3.6 | 17.9 | 57.1 | 21.4 | | | |
| control | | Freq. | 1 | 2 | 5 | 5 | 3.08 | 13 | .954 |
| | | % | 7.7 | 15.4 | 38.5 | 38.5 | | | |



The program enabled me to relate previous knowledge to the new knowledge in the lessons.
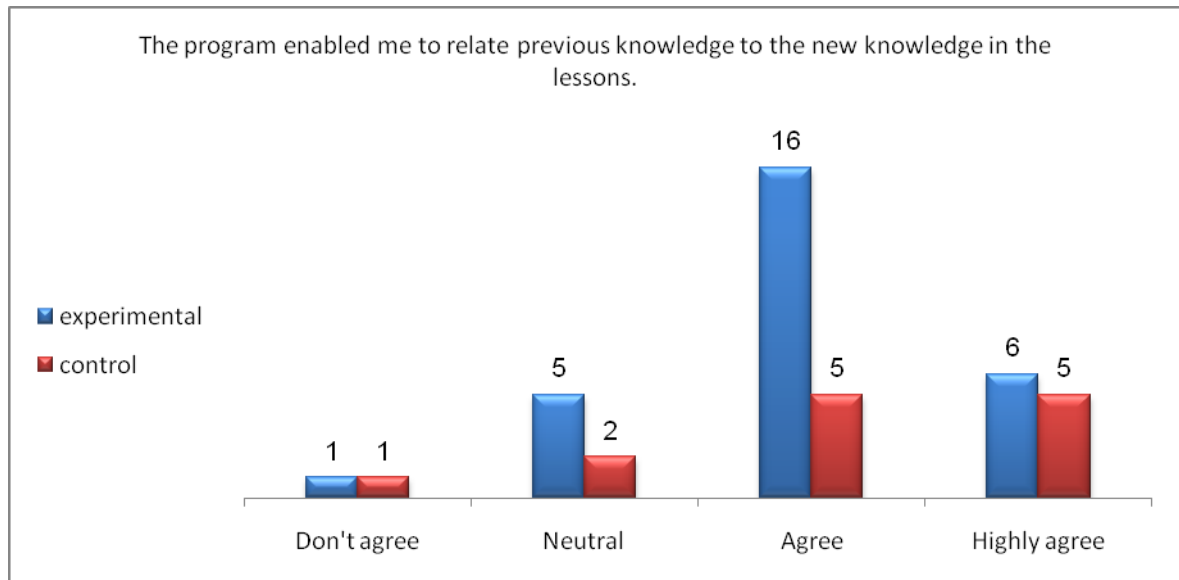
Q3   The video clips in the program helped me in comprehending the concepts and information in the lesson.

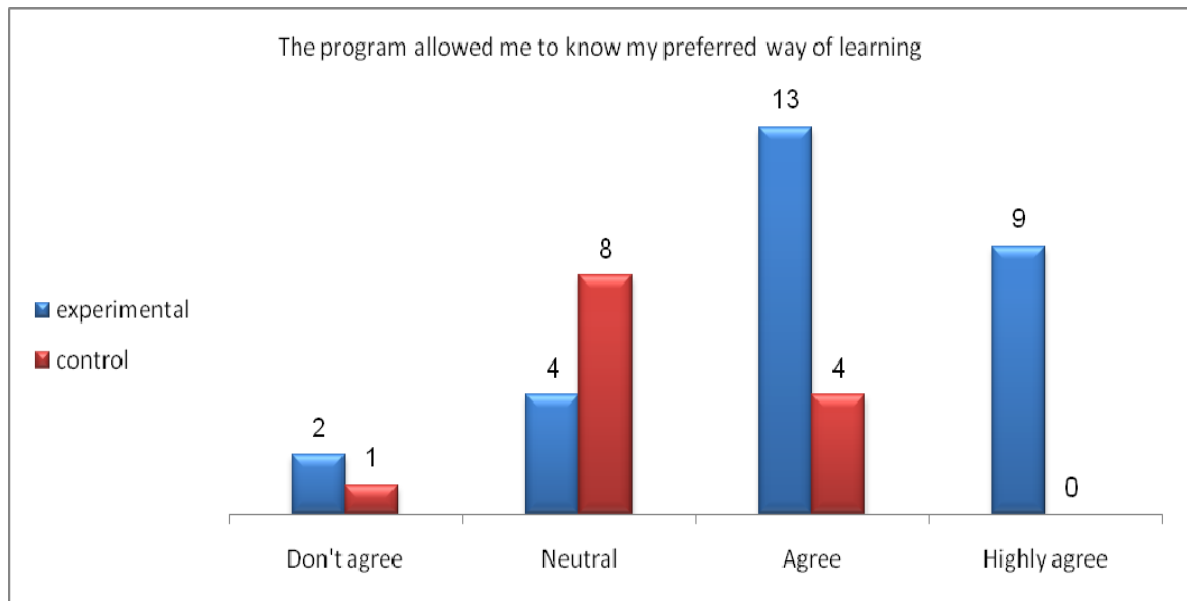| items | | | Don't agree | Neutral | Agree | Highly agree | Mean | N | Std. Deviation |
|---|---|---|---|---|---|---|---|---|---|
| experimental | The video clips in the program helped me in comprehending the concepts and information in the lesson.. | Freq. | 0 | 5 | 9 | 14 | 3.32 | 28 | .772 |
| | | % | 0 | 17.9 | 32.1 | 50 | | | |
| control | | Freq. | 2 | 0 | 4 | 7 | 3.23 | 13 | 1.092 |
| | | % | 15.4 | 0 | 30.8 | 53.8 | | | |

Q4 The program provided various activities that deepened and extended my knowledge related to the lessons.

| items | | | Don't agree | Neutral | Agree | Highly agree | Mean | N | Std. Deviation |
|---|---|---|---|---|---|---|---|---|---|
| experimental | The program provided various activities that deepened and extended my knowledge related to the lessons... | Freq. | 0 | 6 | 15 | 7 | 2.93 | 29 | .884 |
| | | % | 0 | 21.4 | 53.5 | 25 | | | |
| control | | Freq. | 0 | 3 | 1 | 9 | 3.46 | 13 | .877 |
| | | % | 0 | 23.1 | 7.7 | 69.2 | | | |



The program provided various activities that deepened and extended my knowledge related to the lessons
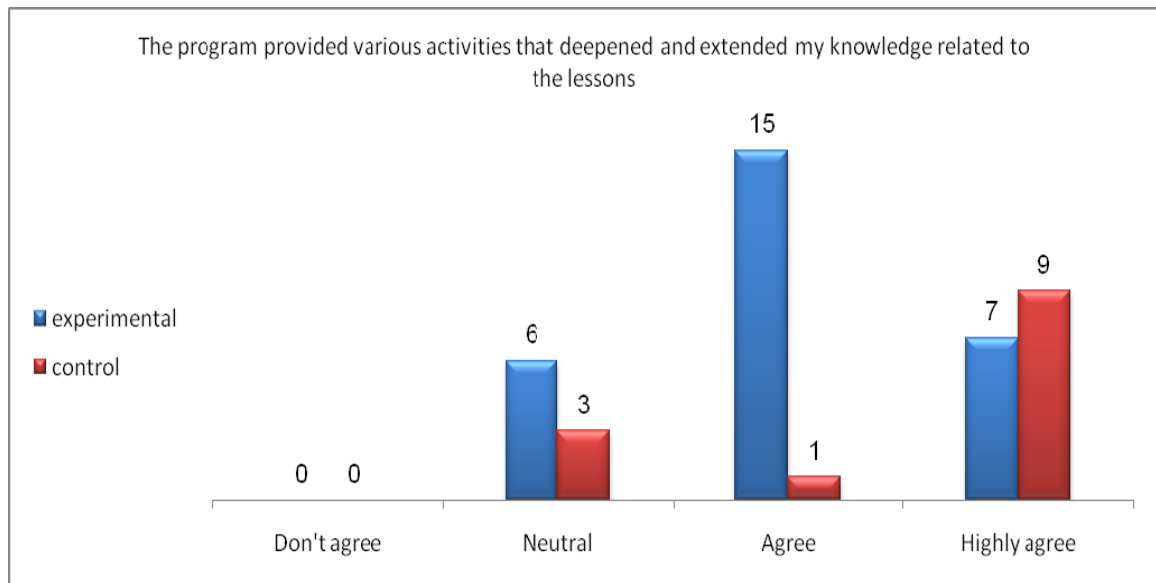
Q5 The program allowed me to know my preferred way of learning.

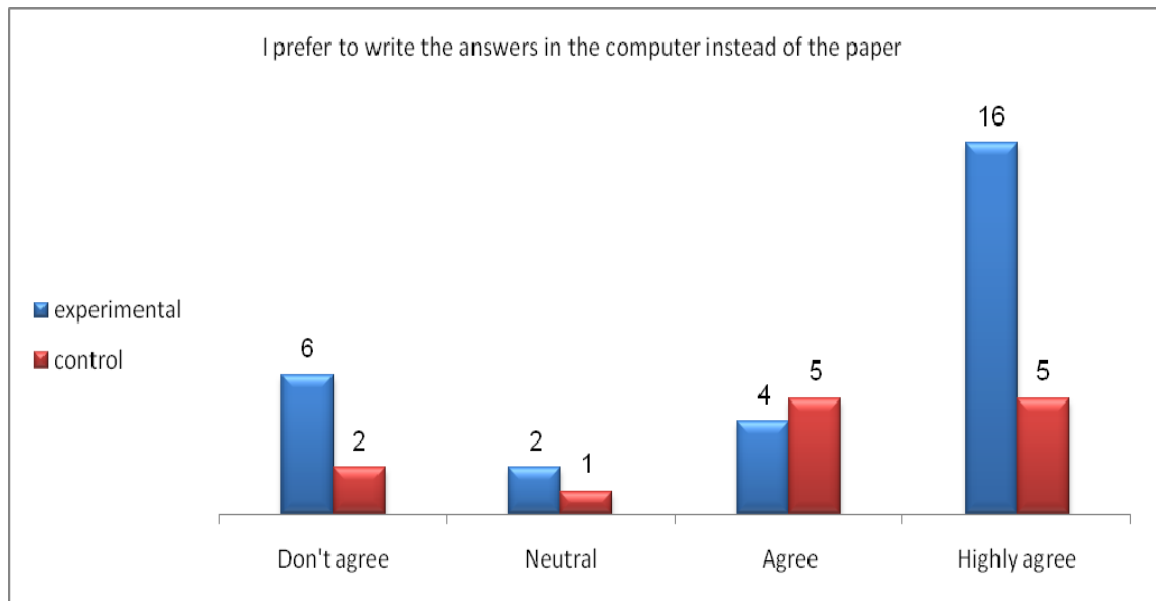| items | | | Don't agree | Neutral | Agree | Highly agree | Mean | N | Std. Deviation |
|---|---|---|---|---|---|---|---|---|---|
| experimental | The program allowed me to know my preferred way of learning.... | Freq. | 2 | 4 | 13 | 9 | 3.04 | 28 | .881 |
| | | % | 7.1 | 14.3 | 46.4 | 32.1 | | | |
| control | | Freq. | 1 | 8 | 4 | 0 | 2.23 | 13 | .599 |
| | | % | 7.7 | 61.5 | 30.8 | 0 | | | |

Q6:The program was enough for me to understand the lessons.

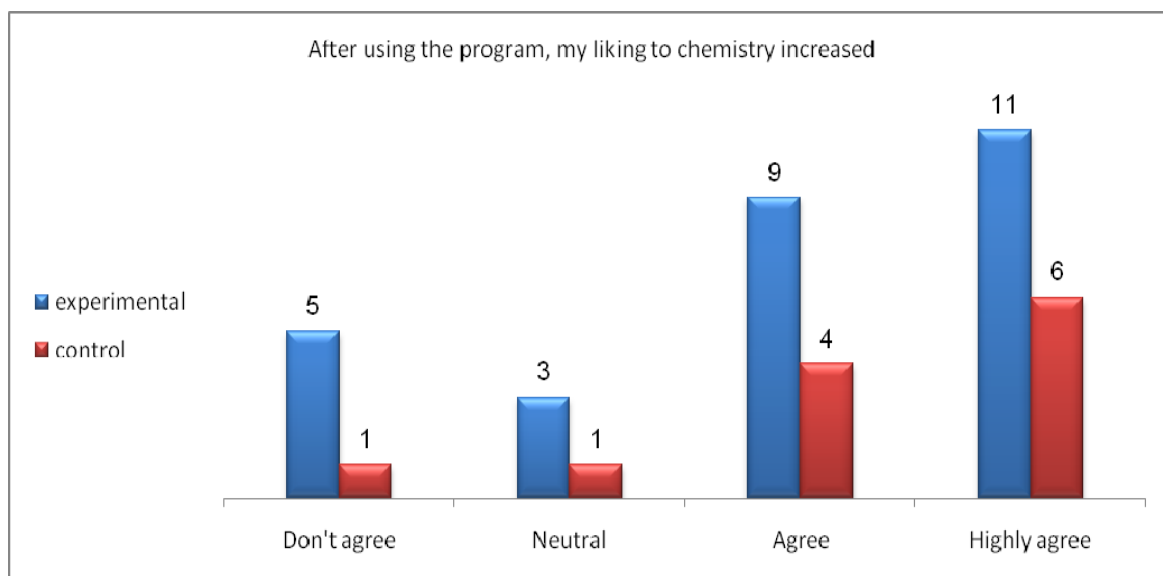| items | | | Don't agree | Neutral | Agree | Highly agree | Mean | N | Std. Deviation |
|---|---|---|---|---|---|---|---|---|---|
| experimental | The program was enough for me to understand the lessons.... | Freq. | 3 | 6 | 13 | 6 | 2.79 | 28 | .917 |
| | | % | 10.3 | 20.7 | 44.8 | 20.7 | | | |
| control | | Freq. | 1 | 1 | 2 | 9 | 3.46 | 13 | .967 |
| | | % | 7.7 | 7.7 | 15.4 | 69.2 | | | |



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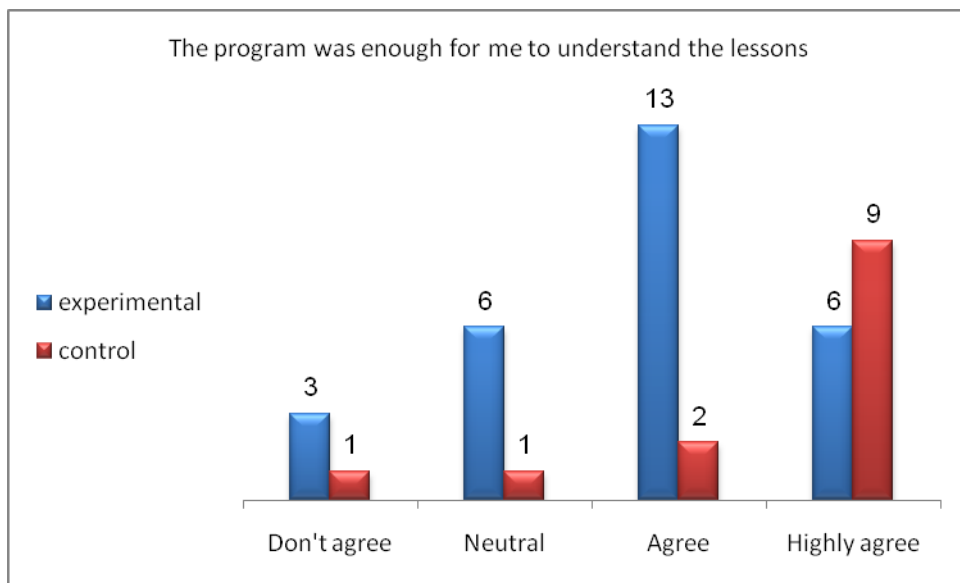
Q7: I prefer to write the answers in the computer instead of the paper

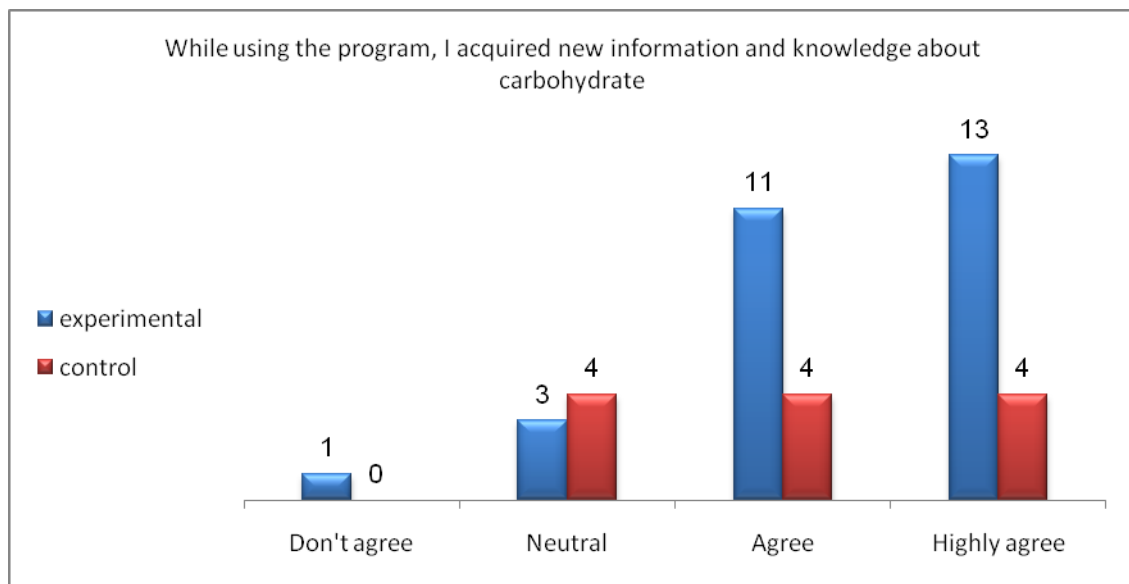| items | | | Don't agree | Neutral | Agree | Highly agree | Mean | N | Std. Deviation |
|---|---|---|---|---|---|---|---|---|---|
| experimental | The program was enough for me to understand the lessons.... | Freq. | 6 | 2 | 4 | 16 | 2.97 | 28 | 1.245 |
| | | % | 21.4 | 7.1 | 14.3 | 57.1 | | | |
| control | | Freq. | 2 | 1 | 5 | 5 | 3.00 | 13 | 1.080 |
| | | % | 15.4 | 7.7 | 38.5 | 38.5 | | | |



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Q8: After using the program, my liking to chemistry increased.

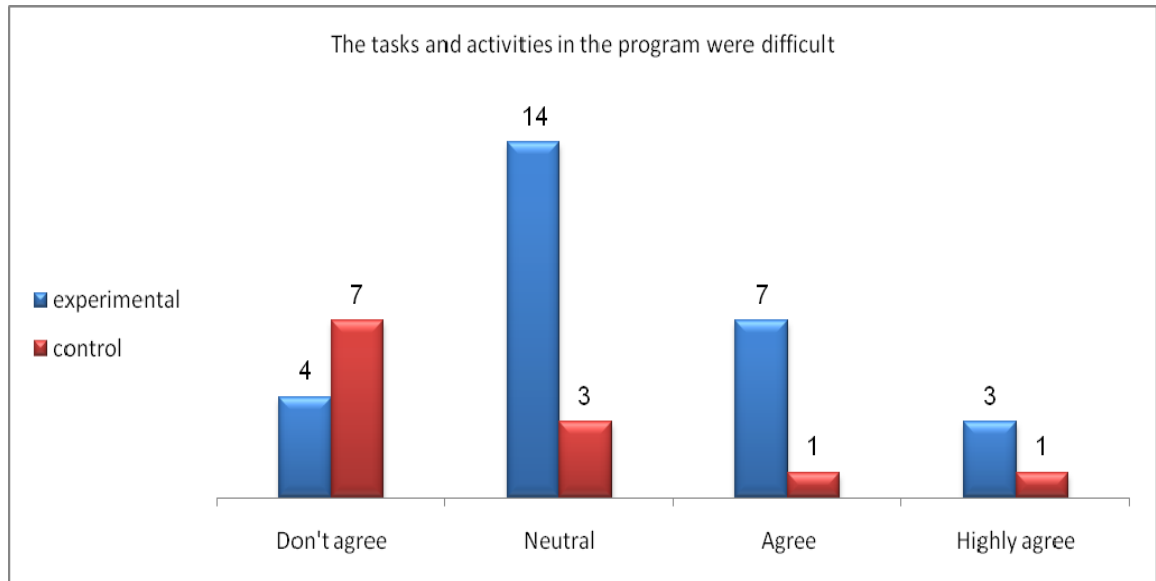| items | | | Don't agree | Neutral | Agree | Highly agree | Mean | N | Std. Deviation |
|---|---|---|---|---|---|---|---|---|---|
| experimental | After using the program, my liking to chemistry increased | Freq. | 5 | 3 | 9 | 11 | 2.93 | 28 | 1.120 |
| | | % | 17.9 | 10.7 | 32.1 | 39.3 | | | |
| control | | Freq. | 1 | 1 | 4 | 6 | 3.25 | 12 | .965 |
| | | % | 8.3 | 8.3 | 33.3 | 50.0 | | | |

Q9: While using the program, I acquired new information and knowledge about carbohydrate

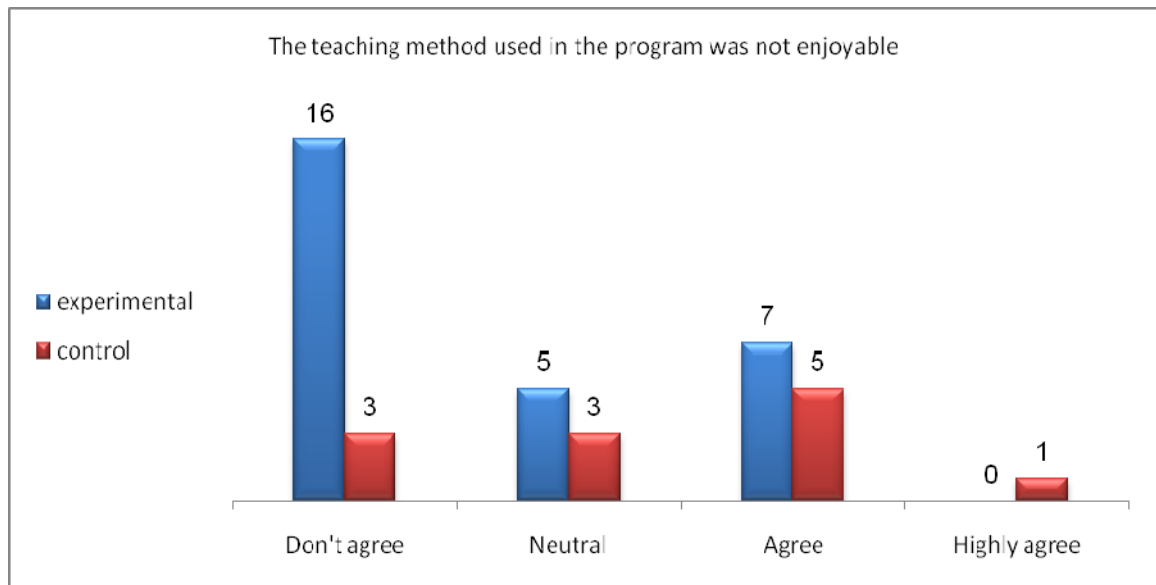| items | | | Don't agree | Neutral | Agree | Highly agree | Mean | N | Std. Deviation |
|---|---|---|---|---|---|---|---|---|---|
| experimental | While using the program, I acquired new information and knowledge about carbohydrate | Freq. | 1 | 3 | 11 | 13 | 3.29 | 28 | .810 |
| | | % | 3.6 | 10.7 | 39.3 | 46.4 | | | |
| control | | Freq. | 0 | 4 | 4 | 4 | 3.00 | 12 | .853 |
| | | % | 0 | 33.3 | 33.3 | 33.3 | | | |



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Q10: The tasks and activities in the program were difficult

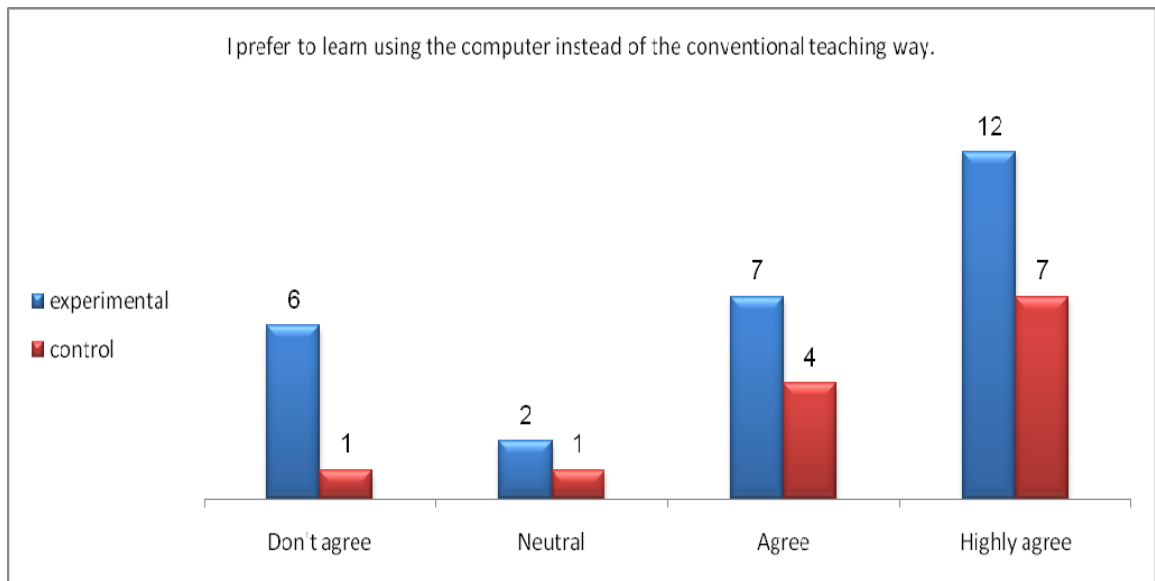| items | | | Don't agree | Neutral | Agree | Highly agree | Mean | N | Std. Deviation |
|---|---|---|---|---|---|---|---|---|---|
| experimental | The tasks and activities in the program were difficult | Freq. | 4 | 14 | 7 | 3 | 2.32 | 28 | .863 |
| | | % | 14.3 | 50.0 | 25.0 | 10.7 | | | |
| control | | Freq. | 7 | 3 | 1 | 1 | 1.67 | 12 | .985 |
| | | % | 58.3 | 25.0 | 8.3 | 8.3 | | | |

Q11: The teaching method used in the program was not enjoyable

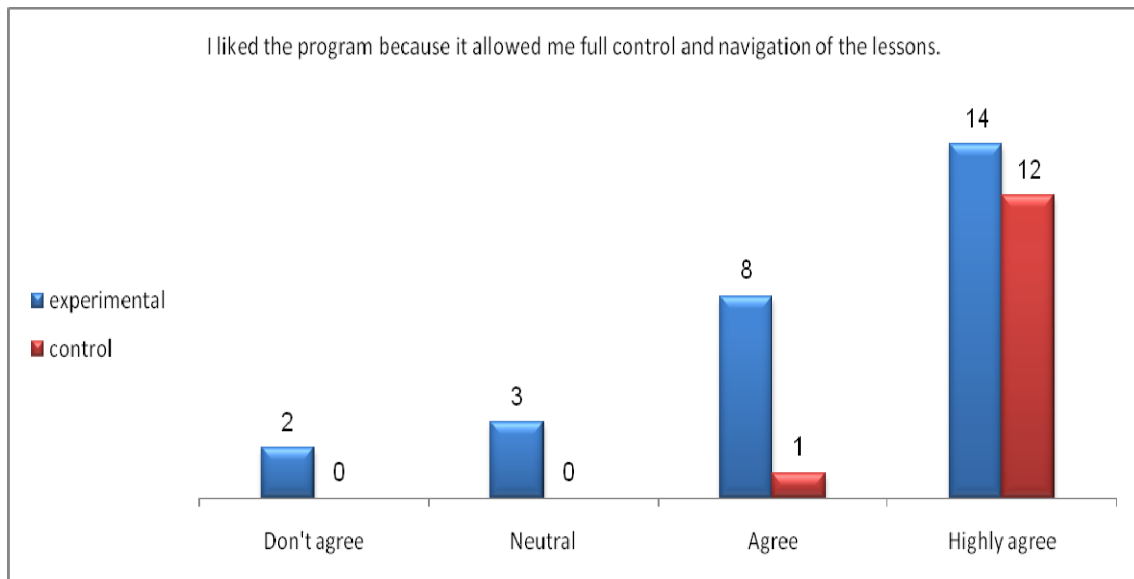| items | | | Don't agree | Neutral | Agree | Highly agree | Mean | N | Std. Deviation |
|---|---|---|---|---|---|---|---|---|---|
| experimental | The teaching method used in the program was not enjoyable | Freq. | 16 | 5 | 7 | 0 | 1.68 | 28 | .863 |
| | | % | 57.1 | 17.9 | 25.0 | 0 | | | |
| control | | Freq. | 3 | 3 | 5 | 1 | 2.33 | 12 | .985 |
| | | % | 25.0 | 25.0 | 41.7 | 8.3 | | | |

Q12: I prefer to learn using the computer instead of the conventional teaching way.

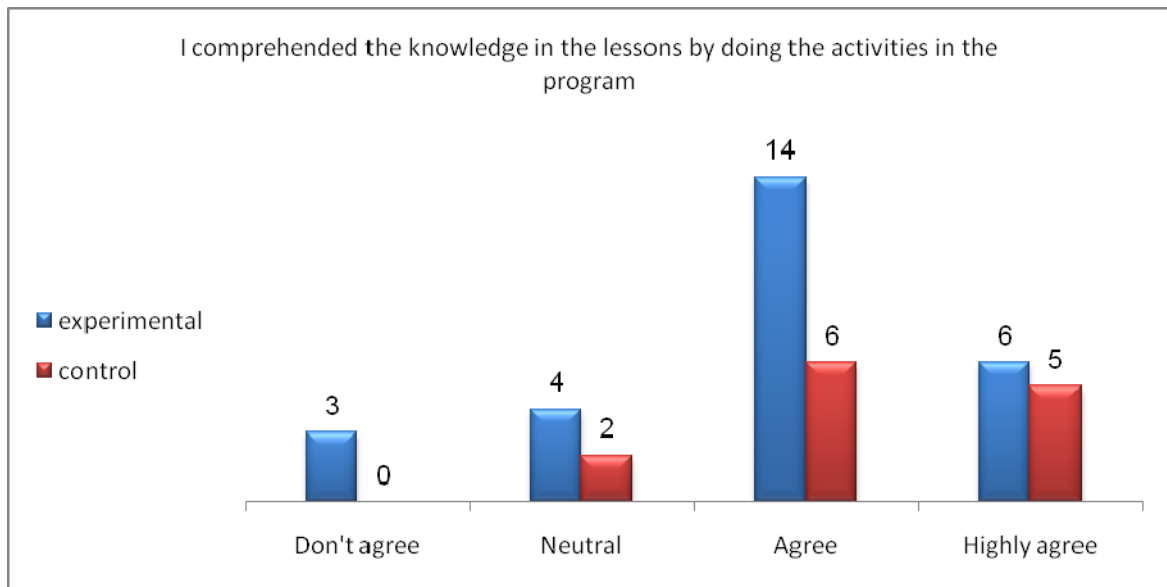| items | | | Don't agree | Neutral | Agree | Highly agree | Mean | N | Std. Deviation |
|---|---|---|---|---|---|---|---|---|---|
| experimental | The teaching method used in the program was not enjoyable | Freq. | 6 | 2 | 7 | 12 | 2.93 | 27 | 1.207 |
| | | % | 22.2 | 7.4 | 25.9 | 44.4 | | | |
| control | | Freq. | 1 | 1 | 4 | 7 | 3.31 | 13 | .947 |
| | | % | 7.7 | 7.7 | 30.8 | 53.8 | | | |

Q13: I liked the program because it allowed me full control and navigation of the lessons.

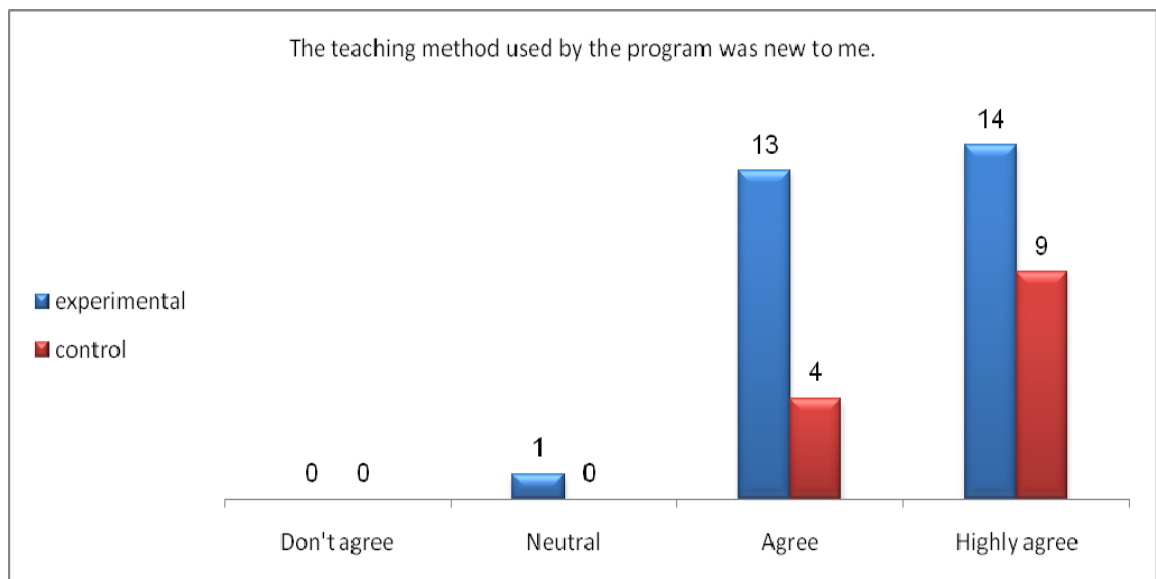| items | | | Don't agree | Neutral | Agree | Highly agree | Mean | N | Std. Deviation |
|---|---|---|---|---|---|---|---|---|---|
| experimental | I liked the program because it allowed me full control and navigation of the lessons | Freq. | 2 | 3 | 8 | 14 | 3.26 | 27 | .944 |
| | | % | 7.4 | 11.1 | 29.6 | 51.9 | | | |
| control | | Freq. | 0 | 0 | 1 | 12 | 3.92 | 13 | .277 |
| | | % | 0 | 0 | 7.7 | 92.3 | | | |

Q14: I comprehended the knowledge in the lessons by doing the activities in the program

| items | | | Don't agree | Neutral | Agree | Highly agree | Mean | N | Std. Deviation |
|---|---|---|---|---|---|---|---|---|---|
| experimental | I comprehended the knowledge in the lessons by doing the activities in the program | Freq. | 3 | 4 | 14 | 6 | 2.85 | 27 | .907 |
| | | % | 11.1 | 14.8 | 51.9 | 22.2 | | | |
| control | | Freq. | 0 | 2 | 6 | 5 | 3.23 | 13 | .725 |
| | | % | 0 | 15.4 | 46.2 | 38.5 | | | |

I comprehended the knowledge in the lessons by doing the activities in the program
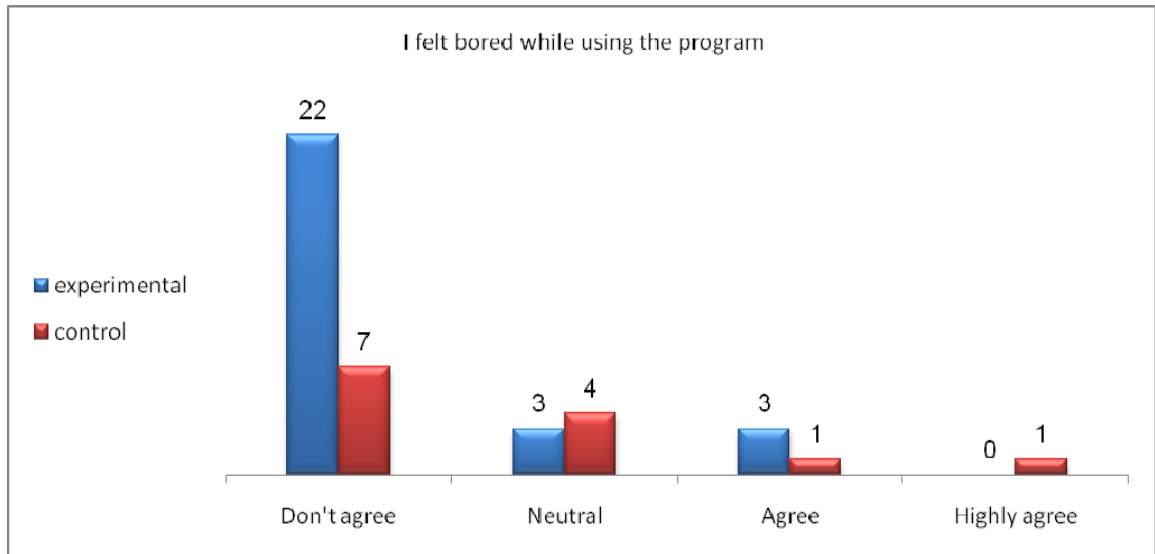
Q15: The teaching method used by the program was new to me.

| items | | | Don't agree | Neutral | Agree | Highly agree | Mean | N | Std. Deviation |
|---|---|---|---|---|---|---|---|---|---|
| experimental | The teaching method used by the program was new to me | Freq. | 0 | 1 | 13 | 14 | 3.46 | 28 | .576 |
| | | % | 0 | 3.6 | 46.4 | 50.0 | | | |
| control | | Freq. | 0 | 0 | 4 | 9 | 3.69 | 13 | .480 |
| | | % | 0 | 0 | 30.8 | 69.2 | | | |



The teaching method used by the program was new to me.

Q16: I felt bored while using the program.

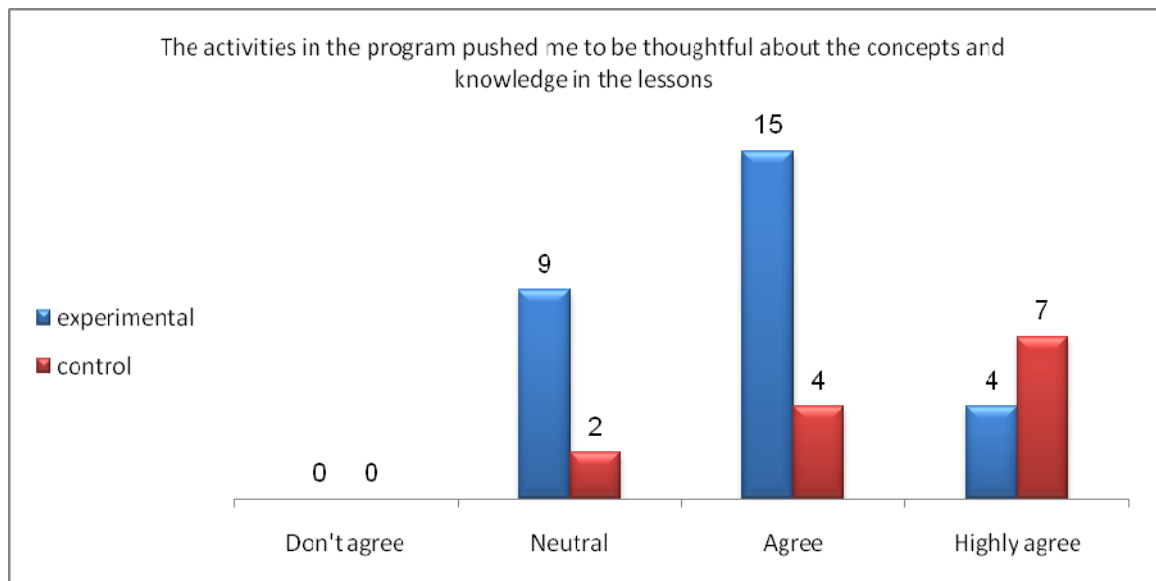| items | | | Don't agree | Neutral | Agree | Highly agree | Mean | N | Std. Deviation |
|---|---|---|---|---|---|---|---|---|---|
| experimental | I felt bored while using the program | Freq. | 22 | 3 | 3 | 0 | 1.32 | 28 | .670 |
| | | % | 78.6 | 10.7 | 10.7 | 0 | | | |
| control | | Freq. | 7 | 4 | 1 | 1 | 1.69 | 13 | .947 |
| | | % | 53.8 | 30.8 | 7.7 | 7.7 | | | |



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Q17: The program always showed me when and why I was right or wrong after answering any question

| items | | | Don't agree | Neutral | Agree | Highly agree | Mean | N | Std. Deviation |
|---|---|---|---|---|---|---|---|---|---|
| experimental | The program always showed me when and why I was right or wrong after answering any question | Freq. | 3 | 1 | 15 | 8 | 3.04 | 27 | .898 |
| | | % | 11.1 | 3.7 | 55.6 | 29.6 | | | |
| control | | Freq. | 0 | 1 | 7 | 5 | 3.31 | 13 | .630 |
| | | % | 0 | 7.7 | 53.8 | 38.5 | | | |
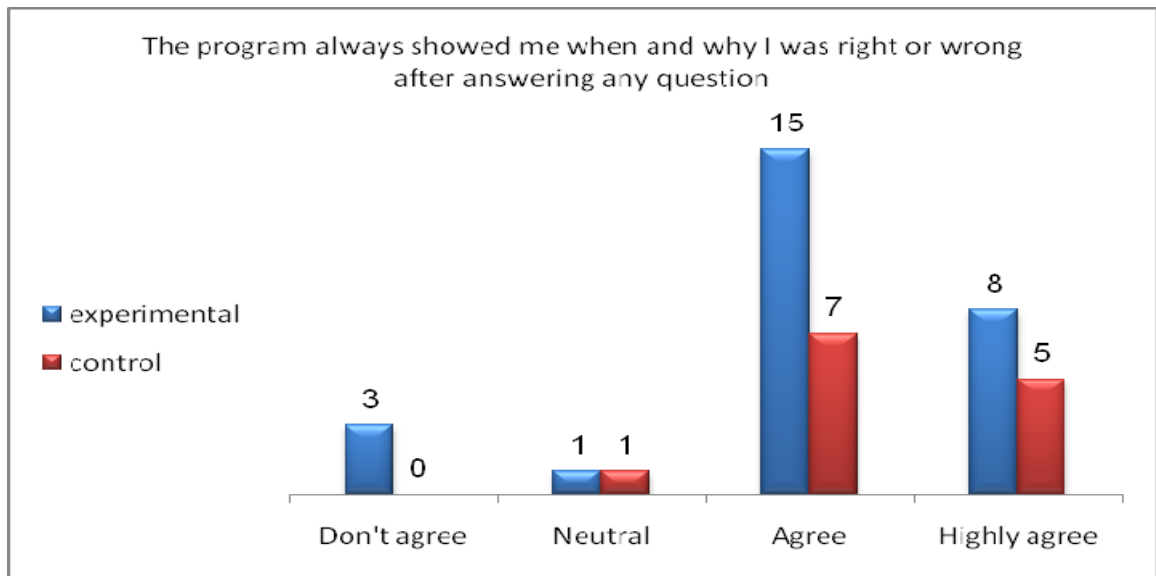


The program always showed me when and why I was right or wrong after answering any question

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Q18: The activities in the program pushed me to be thoughtful about the concepts and knowledge in the lessons

| items | | | Don't agree | Neutral | Agree | Highly agree | Mean | N | Std. Deviation |
|---|---|---|---|---|---|---|---|---|---|
| experimental | The activities in the program pushed me to be thoughtful about the concepts and knowledge in the lessons | Freq. | 0 | 9 | 15 | 4 | 2.82 | 28 | .670 |
| | | % | 0 | 32.1 | 53.6 | 14.3 | | | |
| control | | Freq. | 0 | 2 | 4 | 7 | 3.38 | 13 | .768 |
| | | % | 0 | 15.4 | 30.8 | 53.8 | | | |



169

Q19: The program helped me correct some misconceptions

| items | | | Don't agree | Neutral | Agree | Highly agree | Mean | N | Std. Deviation |
|---|---|---|---|---|---|---|---|---|---|
| experimental | The program helped me correct some misconceptions | Freq. | 3 | 7 | 11 | 7 | 2.79 | 28 | .957 |
| | | % | 10.7 | 25.0 | 39.3 | 25.0 | | | |
| control | | Freq. | 0 | 2 | 7 | 4 | 3.15 | 13 | .689 |
| | | % | 0 | 15.4 | 53.8 | 30.8 | | | |
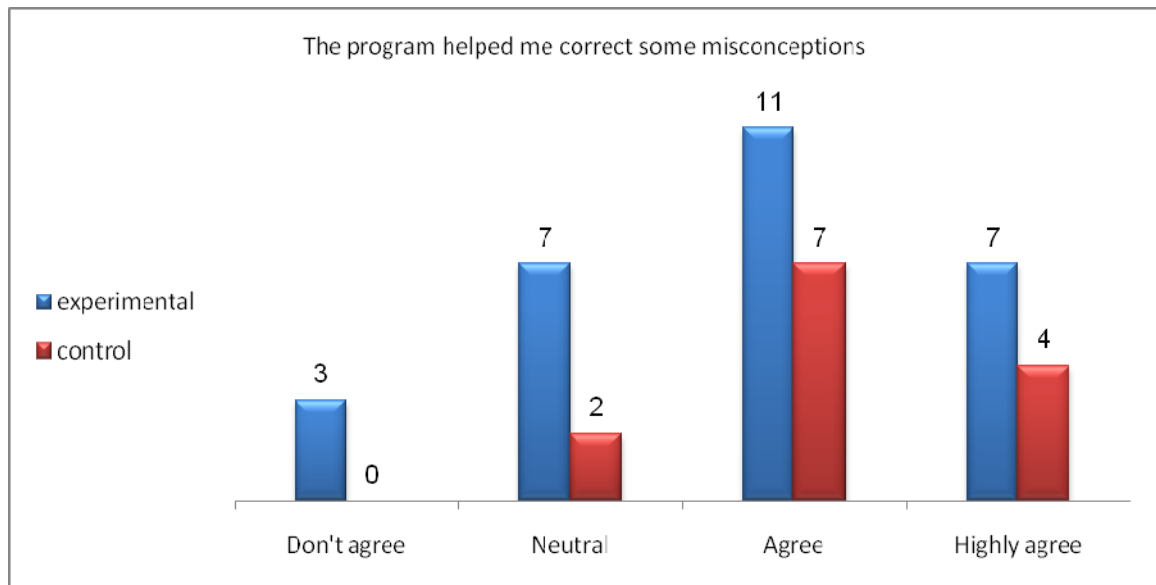
Q20: I could not answer all the activities in the program

| items | | | Don't agree | Neutral | Agree | Highly agree | Mean | N | Std. Deviation |
|---|---|---|---|---|---|---|---|---|---|
| experimental | I could not answer all the activities in the program | Freq. | 10 | 7 | 8 | 3 | 2.14 | 28 | 1.044 |
| | | % | 35.7 | 25.0 | 28.6 | 10.7 | | | |
| control | | Freq. | 4 | 6 | 3 | 0 | 1.92 | 13 | .760 |
| | | % | 30.8 | 46.2 | 23.1 | 0 | | | |
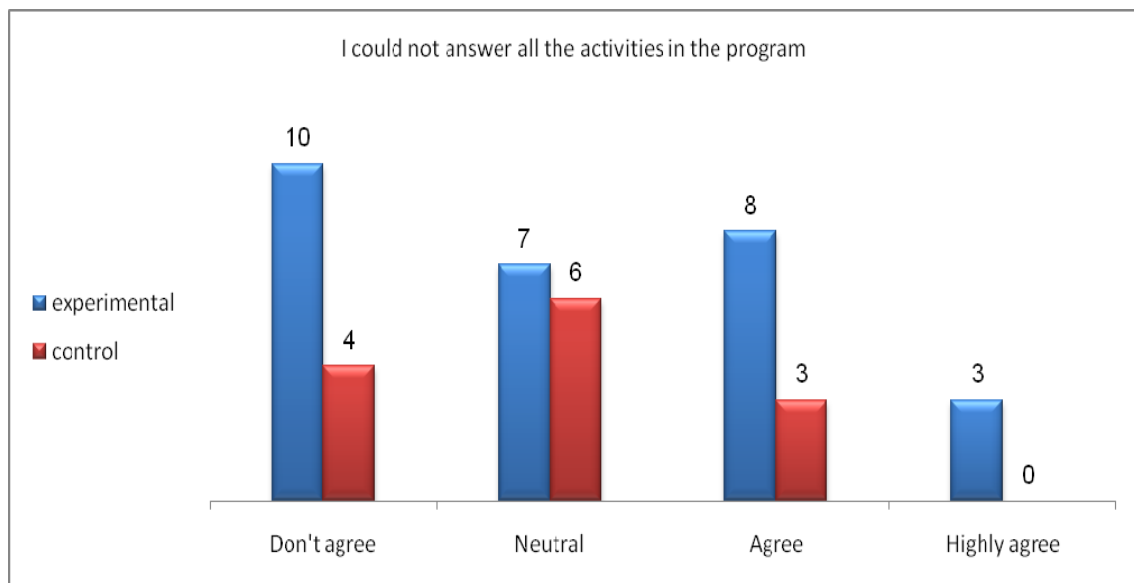
Q21: The program cannot replace the teacher

| items | | | Don't agree | Neutral | Agree | Highly agree | Mean | N | Std. Deviation |
|---|---|---|---|---|---|---|---|---|---|
| experimental | The program cannot replace the teacher | Freq. | 1 | 5 | 4 | 18 | 3.39 | 28 | .916 |
| | | % | 3.6 | 17.9 | 14.3 | 64.3 | | | |
| control | | Freq. | 3 | 1 | 4 | 5 | 2.85 | 13 | 1.214 |
| | | % | 23.1 | 7.7 | 30.8 | 38.5 | | | |



The program cannot replace the teacher
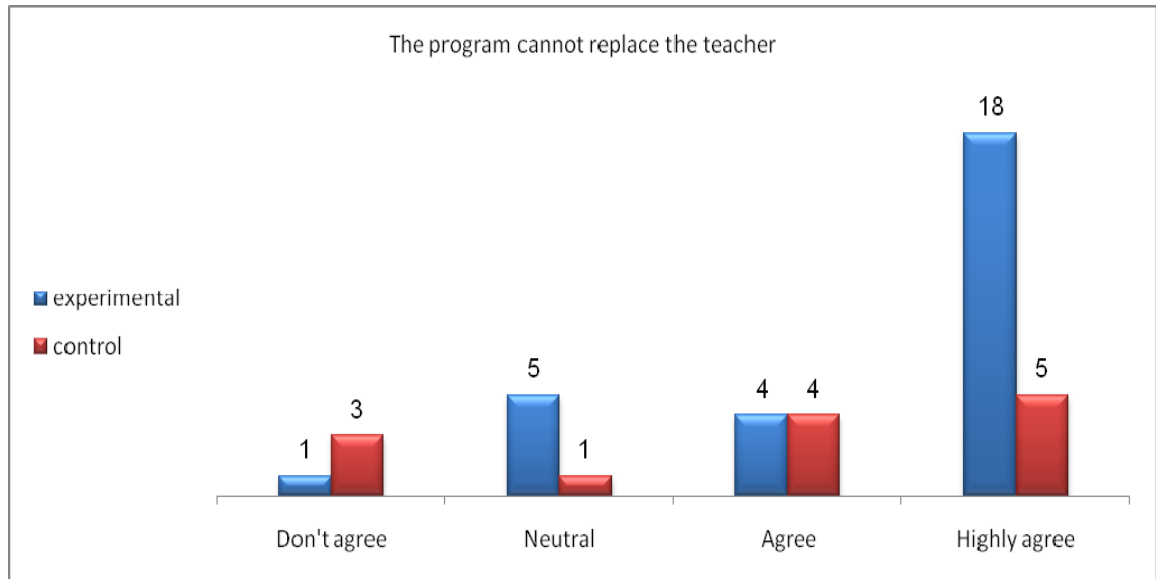
Q22: The activities in the program were inappropriate.

| items | | | Don't agree | Neutral | Agree | Highly agree | Mean | N | Std. Deviation |
|---|---|---|---|---|---|---|---|---|---|
| experimental | The activities in the program were inappropriate | Freq. | 19 | 4 | 4 | 0 | 1.44 | 27 | .751 |
| | | % | 70.4 | 14.8 | 14.8 | 0 | | | |
| control | | Freq. | 9 | 3 | 1 | 0 | 1.38 | 13 | .650 |
| | | % | 69.2 | 23.1 | 7.7 | 0 | | | |



173
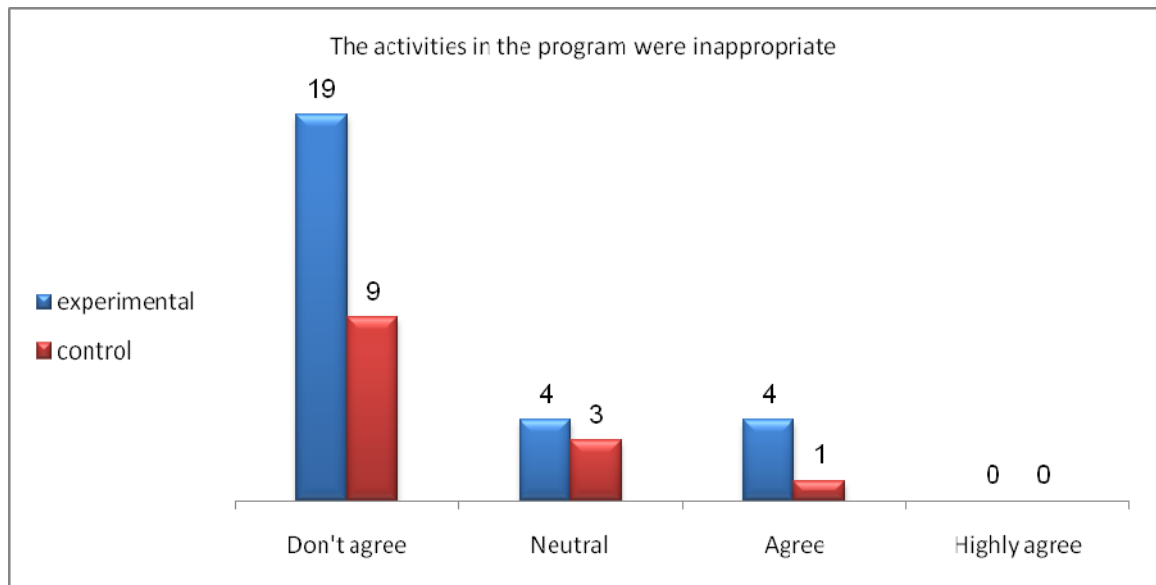
Q23: The program was easy to use.

| items | | | Don't agree | Neutral | Agree | Highly agree | Mean | N | Std. Deviation |
|---|---|---|---|---|---|---|---|---|---|
| experimental | The program was easy to use | Freq. | 1 | 3 | 7 | 17 | 3.43 | 28 | .836 |
| | | % | 3.6 | 10.7 | 25.0 | 60.7 | | | |
| control | | Freq. | 0 | 0 | 4 | 9 | 3.69 | 13 | .480 |
| | | % | 0 | 0 | 30.8 | 69.2 | | | |



The program was easy to use
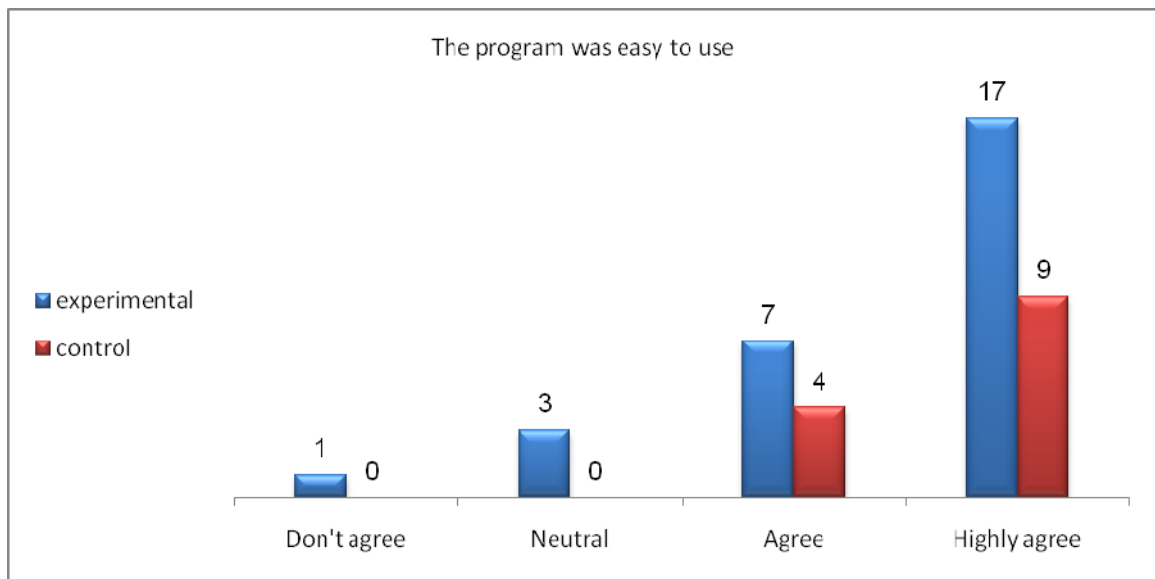
Q24 The program provided the learning material in an easy way

| items | | | Don't agree | Neutral | Agree | Highly agree | Mean | N | Std. Deviation |
|---|---|---|---|---|---|---|---|---|---|
| experimental | The program provided the learning material in an easy way | Freq. | 1 | 3 | 11 | 13 | 3.29 | 28 | .810 |
| | | % | 3.6 | 10.7 | 39.3 | 46.4 | | | |
| control | | Freq. | 0 | 1 | 6 | 6 | 3.38 | 13 | .650 |
| | | % | 0 | 7.7 | 46.2 | 46.2 | | | |



The program provided the learning material in an easy way
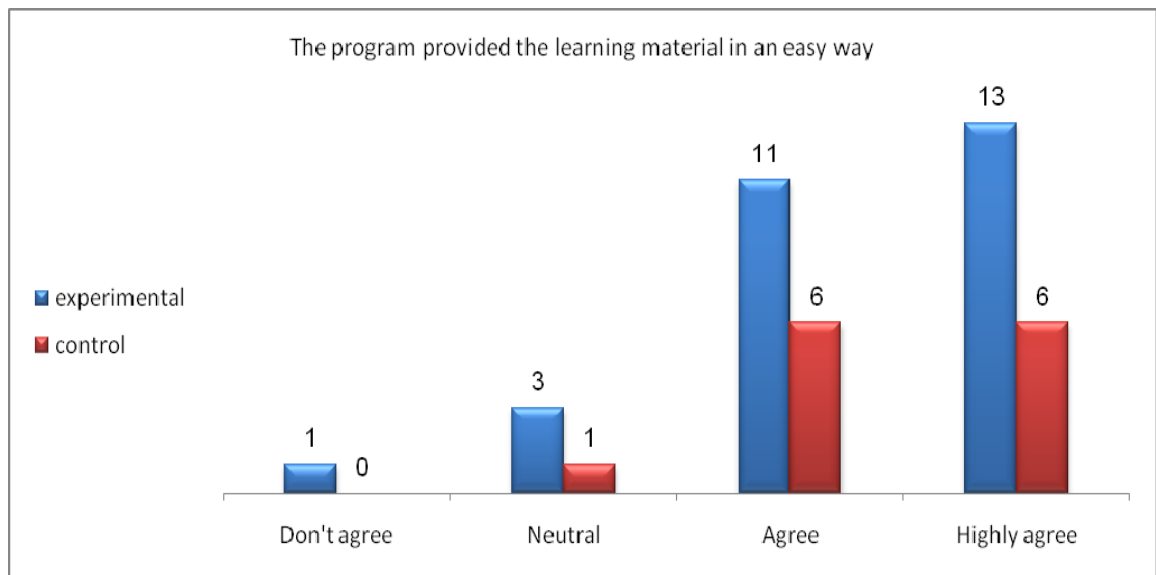
Q25: The activities in each lesson helped me understand the knowledge in the lesson.

| items | | | Don't agree | Neutral | Agree | Highly agree | Mean | N | Std. Deviation |
|---|---|---|---|---|---|---|---|---|---|
| experimental | The activities in each lesson helped me understand the knowledge in the lesson. | Freq. | 2 | 6 | 13 | 6 | 2.85 | 27 | .864 |
| | | % | 7.4 | 22.2 | 48.1 | 22.2 | | | |
| control | | Freq. | 0 | 3 | 5 | 5 | 3.15 | 13 | .801 |
| | | % | 0 | 23.1 | 38.5 | 38.5 | | | |



The activities in each lesson helped me understand the knowledge in the lesson.
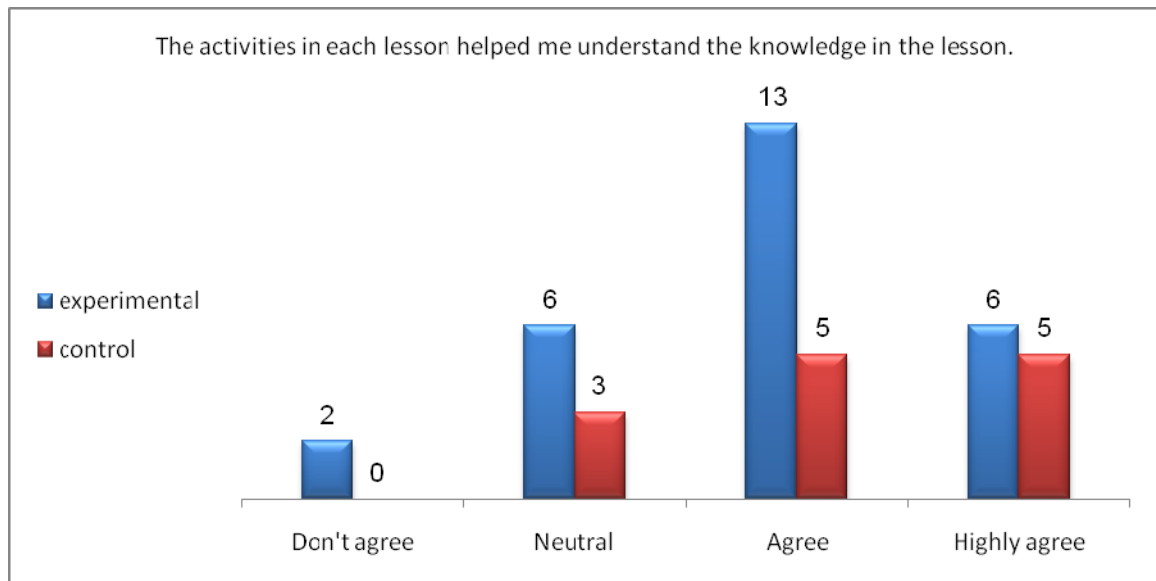
## DETAILS OF CAT (PHASE 1)
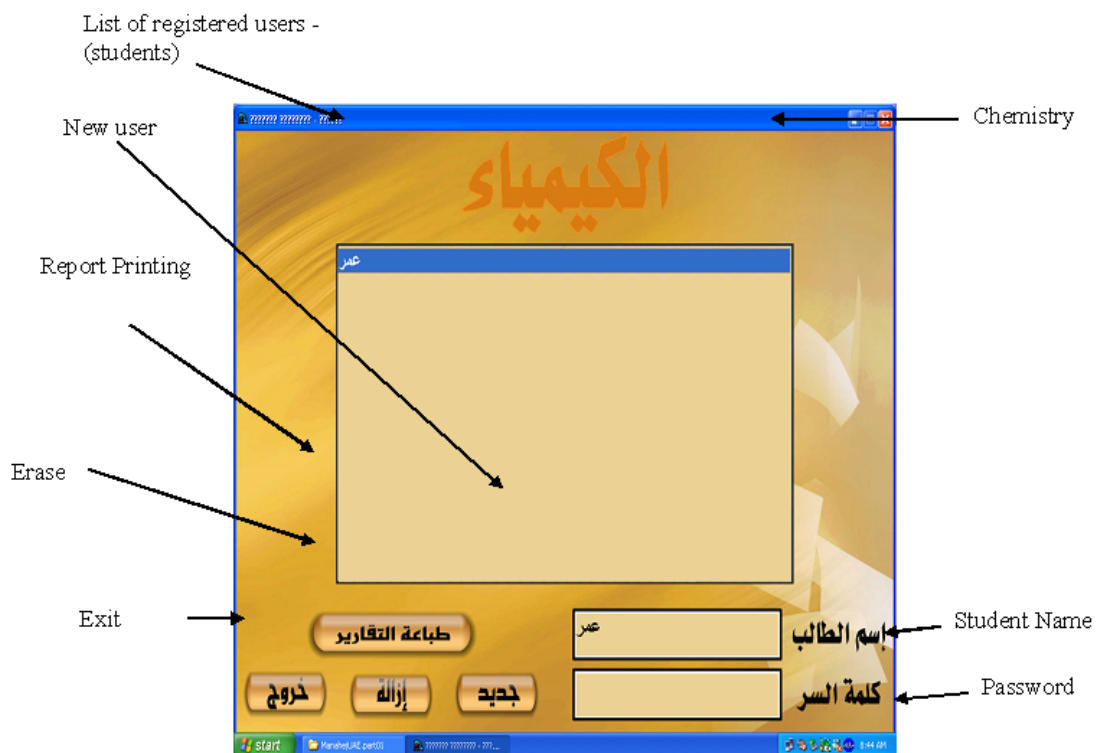


This is the first screen that the student comes to upon starting the CAT program.  This screen gives the student the ability to enter his name and create his own password to keep his own personal records.  Upon saving his name and password, it will be stored so that next time he comes into the CAT program his name will be listed in the box in the middle of the screen.  The student will choose his name and the program will put him back where he left off.

177
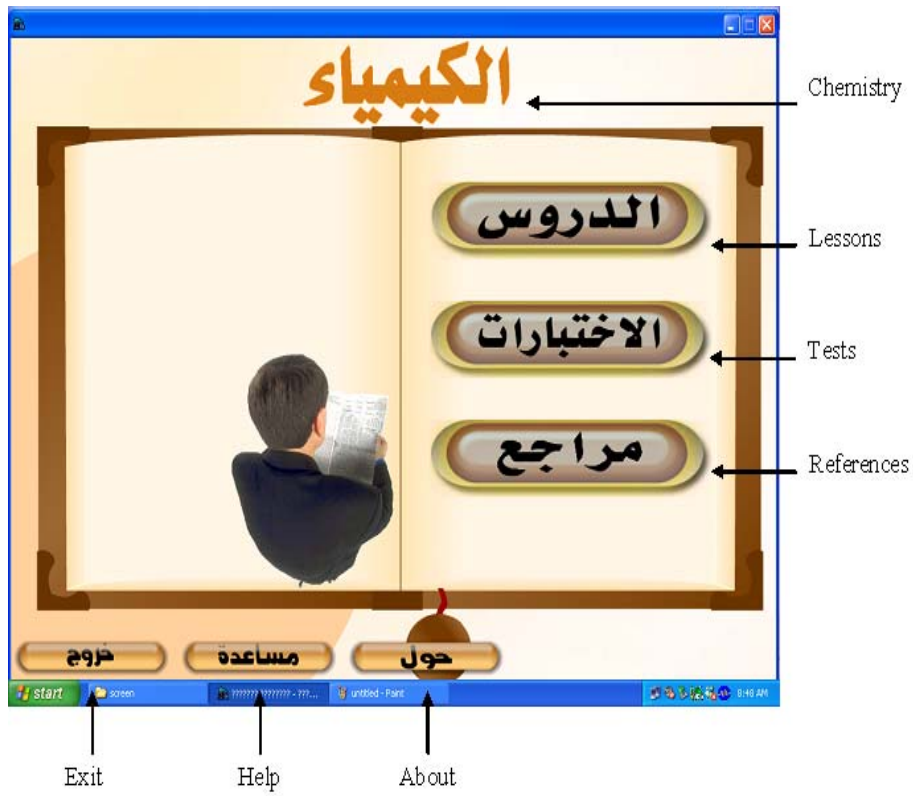
Once the student has created his account, he will come to this screen where he can start taking lessons or take tests or look at references. He is also able to exit the program, and seek help.

The Sixth Group in the Periodic Table (Oxygen Group)

المجموعة السادسة
(مجموعة الأكسجين)

Beginning of lesson

بداية الدرس

Stop lesson

إيقاف

Start lesson

إعادة

Previous

السابق

Next

التالي

Forward & Backward

Screen 1 out of 27

مشهد 1 من 27

Exit

رجوع

خارطة التفكير

المنظم البياني

الجدول الدوري

خصائص المجموعة السادسة

Thinking Map

Graphic Organizer

Periodic Table

Properties of the Sixth Group

The first screen the student sees is the title screen of the lesson he is going to take. He has an array of buttons to help him through the lessons. These buttons show up on every screen throughout the lesson. The first button will take the student immediately to the beginning of the lesson to redo or review the lesson if he so wishes. The 'stop' button will stop the audio speaker from explaining while the 'start' button will restart it. The 'previous' and 'next' buttons will take the student to the previous or the next lesson. In the lesson, the student also has the ability to go back and forward one screen at a time by using the arrow keys. The student can quit the lesson at any time by pressing 'exit'. At the bottom of the screen, he can view the properties of the Oxygen group, as well as the Periodic table by clicking on those buttons. Furthermore, he can view the graphic organizer and the thinking map of the thinking skill/process infused in this particular lesson.

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This is the introduction to the compare and contrast thinking skill which is infused in this lesson. This introduction explains the importance and usefulness of performing the compare and contrast skillfully. It confirms the benefits of its skillful use. It also explains how this thinking skill helps the student in acquiring and comprehending the knowledge in these lessons. The student has the option to preview a demonstration of the thinking skill and how to use the graphic organizer and the thinking map.



This screen activates student's prior experience with the compare and contrast thinking skill. What are some of the things in your life you can compare between?

Screens 13 -15: This is the main activity of the lesson which is called thinking actively, where it interweaves the explicit thinking skill with the content. The student is guided through the thinking activity step by step by using the graphic organizer and the thinking map. In the last step, the student is asked to give his conclusion after making the comparison. The activity is comparing the Oxygen element with other elements in the Sixth group. The student will fill the graphic organizer with the needed information to complete the comparison activity. The student has the option to view a proposed conclusion.

Video clips to further demonstrate some of the Oxygen's properties.



Screens 25-27: This is the applying thinking part of the lesson which helps the student transfer the thinking skill to other situations and contexts. It provides a variety of exercises in which the skill is required. This gives the student a chance to practice the skill independently. The applying thinking part allows the student to take

over his task himself as well as deepen his understanding of the content, and at the same time internalize the thinking process.



Based on the student's observation, he is asked to come up with a conclusion about Oxygen's bond with non-metallic elements.

Finally, he is asked to compare between oxygen's bonding with metallic and non-metallic elements using the compare graphic organizer.

Screens 16-17: This is the applying thinking part of the lesson which helps the student transfer the thinking skill. It provides a variety of exercises in which the skill is required. This gives the student a chance to practice the skill independently. The applying thinking part allows the student to take over his task himself as well as deepen his understanding of the content, and at the same time internalize the thinking process.
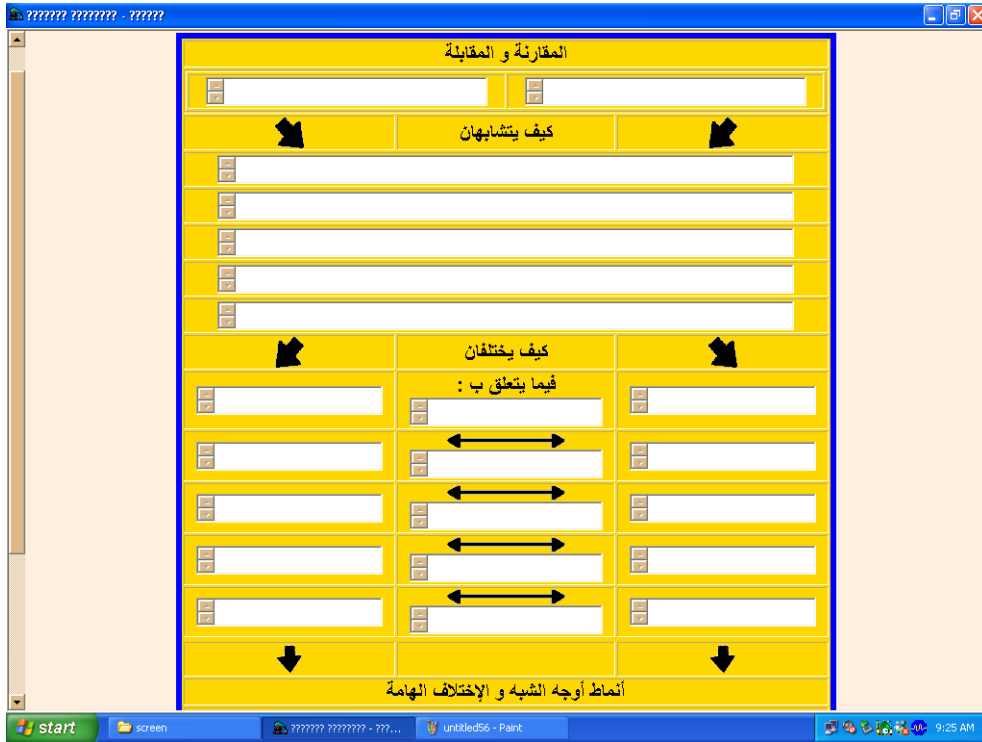
Compare & Contrast Graphic Organizer
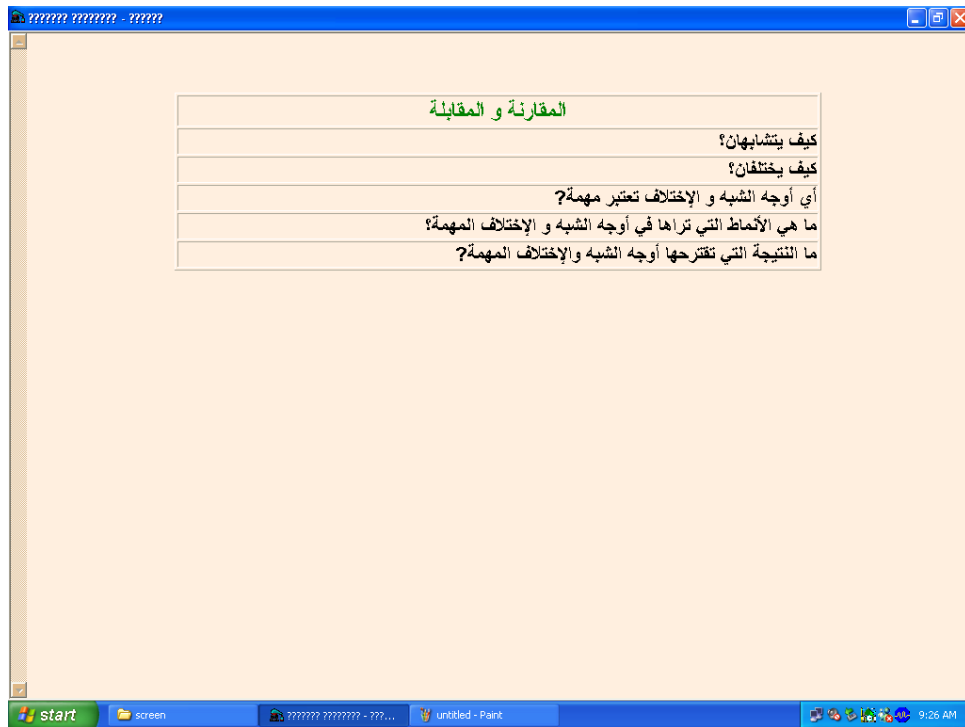


Compare & Contrast Thinking Map

A questionnaire

 to evaluate the effectiveness of CAT

Dear student,

We are striving to provide excellent educational services to help you and all students in your education.  Currently, we are developing computer software to contribute to the enhancement of the teaching and learning process.

We seek your cooperation to carefully read the items of this questionnaire regarding the computer program which you used in learning the chemistry unit about the sixth group, and answer the items honestly and objectively.  Your answers will help us in our work in developing an effective learning environment using the computer.  The information gathered in this questionnaire will only be used for the purposes of research and will be confidential.

No need to write your name.  The time limit is thirty minutes.
We appreciate your cooperation.

Omar Ahmed
The researcher

Put a check mark in front of each item under the appropriate rating:

| St No. | Items | Highly agree | Agree | Neutral | Don't agree |
|--------|-------|--------------|-------|---------|-------------|
| | | **Ratings** | | | |
| 1 | I was motivated and confident to complete all the tasks and activities in the program. | | | | |
| 2 | The program enabled me to relate previous knowledge to the new knowledge in the lesson. | | | | |
| 3 | The video clips in the program helped me in comprehending some of the concepts and information in the lesson. | | | | |
| 4 | The program provided various activities that deepened and extended my knowledge. | | | | |
| 5 | The program allowed me to reflect on my way of thinking. | | | | |
| 6 | The program aroused in me the need to adopt important habits like persistence, determination and perseverance that will help me to succeed in my education. | | | | |
| 7 | The program allowed me to cooperate, discuss and think with my peer which helped me to understand the lesson. | | | | |
| 8 | After using the program, my liking to chemistry increased. | | | | |
| 9 | While using the program, I acquired new information and knowledge about Oxygen and the sixth group. | | | | |
| 10 | The tasks and activities in the program were too difficult that I could not complete them. | | | | |
| 11 | The program gave me the opportunity to write and record my thoughts. | | | | |
| 12 | There is no way to get help in the program. | | | | |
| 13 | The program allowed me full control and navigation of the lesson. | | | | |
| 14 | The program use of the compare and contrast thinking skill helped me comprehended the lesson. | | | | |
| 15 | The teaching method used by the program was new to me. | | | | |
| 16 | I felt bored while using the program. | | | | |
| 17 | The program always showed me when and why I was right or wrong after answering any question. | | | | |
| 18 | The program was easy to use. | | | | |
| 19 | The program helped me correct some | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | misconceptions. | | | | | |
| 20 | whenever I needed help the program provided it. | | | | | |
| 21 | The program pushed me to be thoughtful in learning the knowledge in the lessons. | | | | | |
| 22 | I was in need of the teacher during using the program. | | | | | |

Do you like to add any other comments?

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Do you have any suggestions to enhance the program?

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**INVENTORY**

Read each of the following statements, and then rate yourself on a 1-7 scale, where each rating corresponds to how well a statement describes you : 1=Not at all satisfactory; 2=not satisfactory; 3=nearly suitable; 4=somewhat suitable; 5=suitable; 6=very suitable; and 7=perfect.

1- When making decisions, I tend to rely on my own ideas and ways of doing things.

2- When discussing and writing down ideas, I follow formal rules of presentation.

3- When discussing or writing down ideas, I like criticizing others' ways of doing things.

4- I am careful to use the proper method to solve my problem.

5- When faced with opposing ideas, I like to decide which is the right way to do something.

6- When faced with a problem, I use my own ideas and strategies to solve it.

7- I like to check and rate opposing points of view or conflicting ideas.

8- I like to play with my ideas and see how far they go.

9- I like projects that have a clear structure and a set plan and goal.

10- I like problems where I can try my own way of solving them.

11- Before starting a task or project, I check to see what method or procedure should be used.

12- I like projects where I can study and rate different views and ideas.

13- I like situations in which my role or the way I participate is clearly defined.

14- I prefer tasks or problems where I can grade the design or methods of others.

15- When working on a task, I like to start with my own ideas.

16- When making a decision, I like to compare the opposing points of view.

17- Before starting a task, I like to figure out for myself how I will do my work.

18- I like to figure out how to solve a problem following certain rules.

19- I feel happier about a job when I can decide for myself what and how to do

it.

20-    I enjoy working on things that I can do by following directions.

21-    I like situations where I can compare and rate different ways of doing things.

22-    I like to follow definite rules or directions when solving or doing a task.

23-    I enjoy work that involves analyzing, grading, or comparing things

24-    I like situations where I can use my own ideas and ways of doing things.

A questionnaire

 To Evaluate the Effectiveness of CAT
in learning the carbohydrate lessons

Dear student,

We seek your cooperation to carefully read the items of this questionnaire regarding the computer program which you used in learning the chemistry unit about the carbohydrates, and answer the items honestly and objectively.  Your answers will help us in our work in developing an effective learning environment using the computer.

The information gathered in this questionnaire will only be used for the purposes of research and will be confidential.
No need to write your name.  The time limit is thirty minutes.

We appreciate your cooperation.

Omar Ahmed
The researcher

Put a check mark in front of each item under the appropriate rating:

| St No. | Items | Highly agree | Agree | Neutral | Don't agree |
|---|---|---|---|---|---|
| 1 | I was motivated and confident to complete all the tasks and activities in the program. | | | | |
| 2 | The program enabled me to relate previous knowledge to the new knowledge in the lessons. | | | | |
| 3 | The video clips in the program helped me in comprehending the concepts and information in the lesson. | | | | |
| 4 | The program provided various activities that deepened and extended my knowledge related to the lessons. | | | | |
| 5 | The program allowed me to know my preferred way of learning. | | | | |
| 6 | The program was enough for me to understand the lessons. | | | | |
| 7 | I prefer to write the answers in the computer instead of the paper. | | | | |
| 8 | After using the program, my liking to chemistry increased. | | | | |
| 9 | While using the program, I acquired new information and knowledge about carbohydrate. | | | | |
| 10 | The tasks and activities in the program were difficult. | | | | |
| 11 | The teaching method used in the program was not enjoyable. | | | | |
| 12 | I prefer to learn using the computer instead of the conventional teaching way. | | | | |
| 13 | I liked the program because it allowed me full control and navigation of the lessons. | | | | |
| 14 | I comprehended the knowledge in the lessons by doing the activities in the program. | | | | |
| 15 | The teaching method used by the program was new to me. | | | | |
| 16 | I felt bored while using the program. | | | | |
| 17 | The program always showed me when and why I was right or wrong after answering any question. | | | | |
| 18 | The activities in the program pushed me to be thoughtful about the concepts and knowledge in the lessons. | | | | |

| | | | | | |
|---|---|---|---|---|---|
| 19 | The program helped me correct some misconceptions. | | | | |
| 20 | I could not answer all the activities in the program. | | | | |
| 21 | The program cannot replace the teacher. | | | | |
| 22 | The activities in the program were inappropriate. | | | | |
| 23 | The program was easy to use. | | | | |
| 24 | The program provided the learning material in an easy way. | | | | |
| 25 | The activities in each lesson helped me understand the knowledge in the lesson. | | | | |

What are your comments about the program?

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..............................................................................................................................

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Do you have any suggestions to enhance the program?

..............................................................................................................................

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# APPENDIX VI
## ACHIEVEMENT TEST

Abu Dhabi Educational Zone

Khaleefa Bin Zayed Secondary School

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Achievement Test for Grade 12 Students

Bio-Chemistry, Carbohydrates


-------------------------------------------------


Data:

Student's Name:

Group:


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Test Instructions:

1. Answer all the questions.
2. Start with reading the question carefully so that you understand it.
3. Identify the elements of the answer in your mind before writing them on the answer sheet.
4. Write the answer on the question paper in the specified area according to the instructions of each question.

**Answer all the following questions.**

**Question One: Put (    ) in front of the true statement and (      ) in front of the false statement. Correct the false statement.**

1- Glucose is one of the components of nucleic acids.                                    (    )


2- Some monosaccharide's contain five carbon atoms (pentose) and six carbon acids (hexose).                                                                                          (    )


3- Lactose molecule dissolves into water to glucose molecule and fructose molecule.
                                                                                                          (    )


4- Sucrose is a reduction agent in the Alkaline medium.                          (    )



5- To distinguish starch, it can be mixed with iodine solution and gives blue colour.
                                                                                                          (    )

**Question Two: Choose the correct answer and circle it.**

1- Glucose is known as _____ sugar.

a- cane          b- dairy          c- malt          d- grapes


2- Sugar that decomposes in water into glucose and fructose is _____

a- maltose          b- sucrose          c- ribose          d- galactose


3- The general molecular formula for all monosaccharides is _____

a- $CnH_2nO_n$

b- $C_{12}H_{22}O_{11}$

c- $(C_6H_{10}O_5)n$

d- $C_5H_{10}O_5$


4- Sugar that is found in the milk of mammals is _____

a- lactose          b- sucrose          c- ribose          d- galactose

**Question Three: Complete the following sentences.**

1- Carbohydrates are _____

2- Monosaccharides (hexose) differ from each other in that

-

-

3- Maltose and sucrose are examples of _____saccharides.

4- Starch is different from cellulose in characteristics because they are different in
_____

5- Lactose results from the condensation of _____


**Question Four: Answer only three questions of the following.**

1- How do you experimentally distinguish a carbohydrate?

2- Write down the chemical formula which expresses the formulation of maltose molecule from the condensation of two glucose molecules. (ring formula)

3- Explain the difference between oligosaccharides carbohydrates and polysaccharides carbohydrates.

4- Explain the difference between amylase and amylopectin?

5- Write the structural formula for the fructose and the ribose (open chain).

# BIOCHEMISTRY INTRODUCTION

Biochemistry is considered one of the main domains in chemistry. It refers to the field concerned with studying the chemical reactions which take place in bodies of living things in addition to the compounds formed by them.

For the chemist, biochemistry is the lenses through which he looks at the interactions which happen inside the living cell, and on which the life of the living thing depends. Thus, the living cell is considered the plant of bio-compounds. The reactions which occur in the living cell exceeds those which take place in the hugest factory on earth. In this program, we will consider carbohydrates as an example of a common bio-compound. Upon completion of this unit, you are expected to:

- identify chemical elements which compose some biochemical compounds, their structural units and their active groups.
- classify these compounds according to their water dissolution.
- write the structural formulae to the units composing these compounds.
- conclude the significant chemical and physical characteristics.
- distinguish some compounds by practical experiments.
- identify the significance of these compounds in industry and in the lives of living things.

**First: Carbohydrates**

You learned in biology that green plants do the photosynthesis process to produce carbohydrate substance as the following equation shows:

sunlight

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

chlorophyll          carbohydrate substance
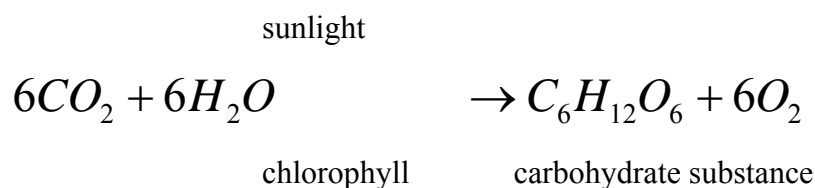
The equation above shows that carbohydrates molecule consists of the following elements: carbon, hydrogen and oxygen. The percentage of hydrogen to oxygen is similar to that of their percentage in water (1:2).

Now notice the following formulae and identify the active groups in each of them:
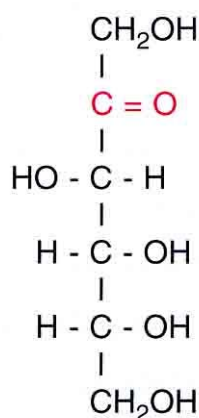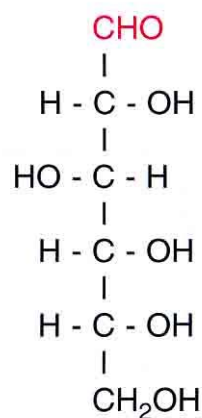


fructose                          glucose

You will find that both contain hydroxyl groups (-OH), one group of Aldehyde carbonyl (-CHO) in glucose and ketone group ( C=O) in fructose.

As you know, starch belongs to carbohydrates which dissolve in water into glucose units. Accordingly, carbohydrates are defined as aldehydes or ketones with multi hydroxyls or that gives these substances upon dissolution in water.

Based on water dissolution, carbohydrates are divided into

1- monosaccharides
2- oligosaccharides

3- polysaccharides

## Monosaccharides

This is the simplest type of carbohydrates because it does not dissolve in water into simpler compounds. Its general formula is ($C_nH_{2n}O_n$) where (n) indicates the number of carbon atoms which range between 3-6.

The most common monosaccharides in nature are those which contain five carbon atoms (pentose) and six carbon atoms (hexose). Table 3-1 shows some examples on them.

| (6) atoms | | (5) atoms | | Number of carbon atoms in a molecule |
|---|---|---|---|---|
| Ketone | Aldehyde | Ketone | Aldehyde | **Type of Carbonyl Group** |
| $CH_2OH$<br><br>C=O<br><br>HO-C-H<br><br>H-C-OH<br><br>H-C-OH<br><br>$CH_2OH$ | H-C=O<br><br>H-C-OH<br><br>HO-C-H<br><br>H-C-OH<br><br>H-C-OH<br><br>$CH_2OH$ | $CH_2OH$<br><br>C=O<br><br>H-C-OH<br><br>H-C-OH<br><br>$CH_2OH$ | H-C=O<br><br>H-C-OH<br><br>H-C-OH<br><br>H-C-OH<br><br>$CH_2OH$ | **The formula of the monosaccharide** |
| Ketohexose | Aldohexose | Ketopentose | Aldopentose | **Name of Saccharide Group** |
| Fructose | Glucose | Ribulose | Ribose | **Name of Saccharide** |

It is noticed from the table that *Aldopentose* means a compound that contains an aldehyde group *aldo* and the syllable *pent* which means *five carbon atoms*. The syllable *ose* means *sugar* in Greece.

Pentoses exist in living things' cells; Ribose and deoxyribose are parts of RNA and DNA (Figure 3-1). Some hexoses like glucose exist in the blood and the human being depends on it for energy. Its percentage in the blood of the healthy human body is 80-120 milligrams per 100 milliliters of blood. Fruits and honey also contain some monosaccharides. Glucose is called grapes sugar.

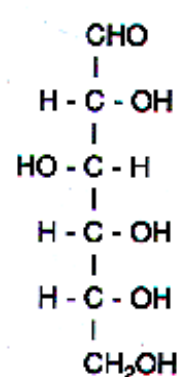**The Structural Formula of Monosaccharides:**

Check the structural formulae for the following monosaccharides:
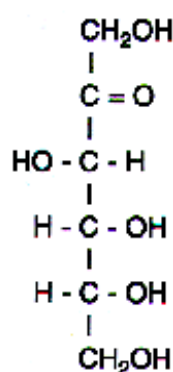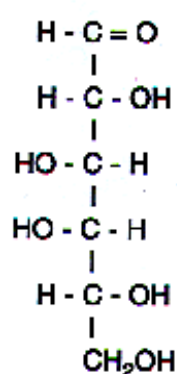


|                 |                 |                |
|:---------------:|:---------------:|:--------------:|
| $CH_2OH$        | $H-C=O$         | $CHO$          |
| $C=O$           | $H-C-OH$        | $H-C-OH$       |
| $HO-C-H$        | $HO-C-H$        | $HO-C-H$       |
| $H-C-OH$        | $HO-C-H$        | $H-C-OH$       |
| $H-C-OH$        | $H-C-OH$        | $H-C-OH$       |
| $CH_2OH$        | $CH_2OH$        | $CH_2OH$       |
| fructose        | galactose       | glucose        |

Notice that all of them have the molecular formula ($C_6H_{12}O_6$) which is distinctive to all monosaccharides (hexoses), but they are different in the following ways:

A- The type of the carbonyl group (aldehyde) or (ketone)

B- The distribution of hydroxyl groups around the carbon atom.

These differences result in saccharides variety.

We can also notice that the previous formulae of monosaccharides have open carbonic chain; however, it has been proven that all saccharides take a cyclic form in their solid state.

How does this happen?

With regard to glucose, the cycle results when an aldehyde group is bonded with a hydroxyl group on the carbon atom number 5 forming a hexagonal cycle which contains an oxygen atom.



Glucose,
open form

Glucose,
cyclic form
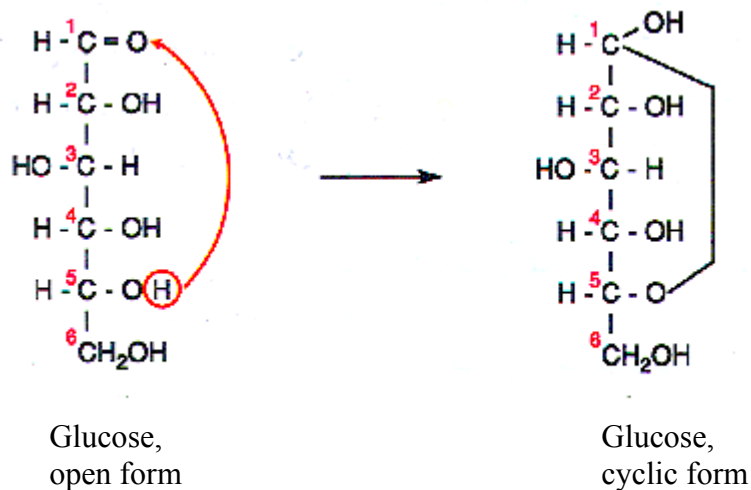
The formation of the
cyclic form of glucose

Concerning fructose, a ketone group is bonded with a hydroxyl group on the carbon atom before the last forming a pentagonal cycle. The following two formulae clarify the cyclic forms of glucose and fructose.



fructose

glucose
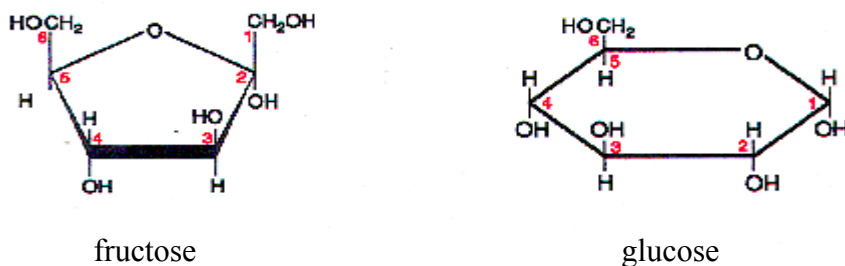
It can be written in the following simple form:

fructose                                    glucose
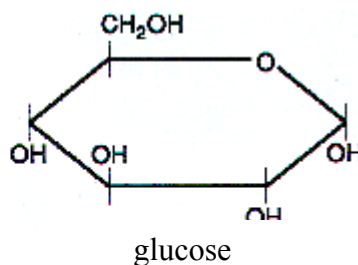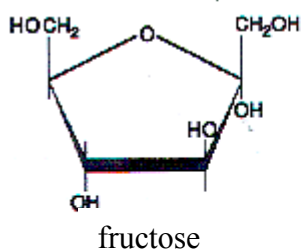
**Characteristics of Monosaccharides:**

**Physical Characteristics:**

- Crystallized sweet substances, the sweetest of which is fructose which is found in big amounts in honey.
- They can easily dissolve in water to form hydrogen bonds between hydroxyl groups in the saccharide molecule and water molecules. These saccharides do not dissolve in organic solvents.
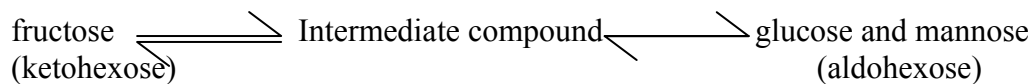
**Chemical Characteristics:**

You studied that carbonyl group can be oxidized into carboxyl group, and that it can be reduced into primary or secondary alcohol. So, monosaccharides are considered oxidization and reduction agents.

- Monosaccharides behave as oxidization agents in their reaction with sodium, and saccharide is reduced into sorbitol alcohol.

What is the structural formula of sorbitol alcohol?

- They also behave as reduction agents, and they are oxidized. The outcome of the reaction depends on saccharide's type and the power of the oxidizing agent. Benedict's solvent and Tolin's solvent are two examples of oxidizing agents used to find monosaccharides.

Both glucose and fructose reduce Benedict's solvent. Glucose reduction to Benedict's solvent is because the molecule contains an aldehyde group. But how does fructose reduce Benedict's solvent although it does not have an aldehyde group? This reduction is due to the occurrence of internal transformations in the molecule in the alkaline medium, which results in the existence of a mixture of balanced monosaccharide molecules, some of which contain aldehyde groups that are responsible for the reduction process.

fructose $\xrightarrow{\hspace{2cm}}$ Intermediate compound $\xrightarrow{\hspace{2cm}}$ glucose and mannose
(ketohexose)                                                        (aldohexose)

Such transformations occur in living things' fibers, where hexoses transform from one saccharide to another in order for the living thing to get benefit from it as a source of energy.

## Oligosaccharides

They are saccharides whose water dissolution of each molecule results in (2-10) molecules of monosaccharides, and they are classified into disaccharides and trisaccharides and so on depending on the number of monosaccharides resulting from water dissolution. We will study disaccharides here.

## Disaccharides

The following figure shows the relationship between disaccharides and monosaccharides.
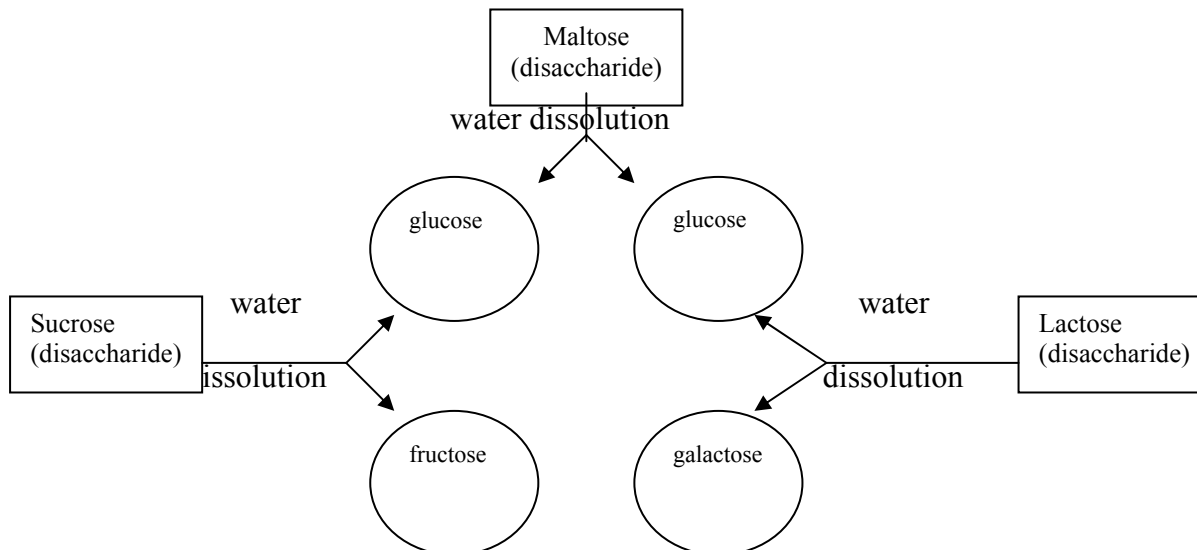


The figure shows that maltose, lactose and sucrose are examples of disaccharides. They dissolve in water, and molecules of monosaccharides result from each molecule. The general molecule formula of disaccharides is ($C_{12}H_{22}O_{11}$)

$$C_{12}H_{22}O_{11} + H_2O \underset{\text{condensation}}{\overset{\text{water dissolution}}{\rightleftharpoons}} 2C_6H_{12}O_6$$
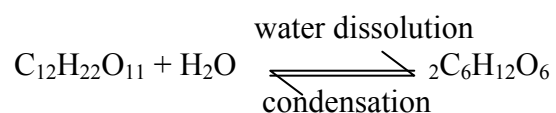
**Maltose**

The following equation shows the relation between glucose and maltose:

$$2C_6H_{12}O_6 \xrightarrow[\text{water dissolution}]{\text{condensation}} C_{12}H_{22}O_{11} + H_2O$$
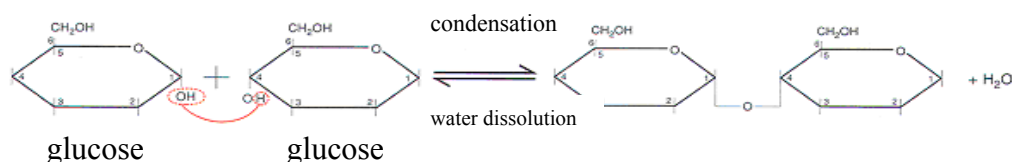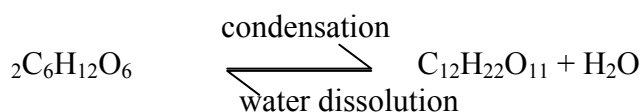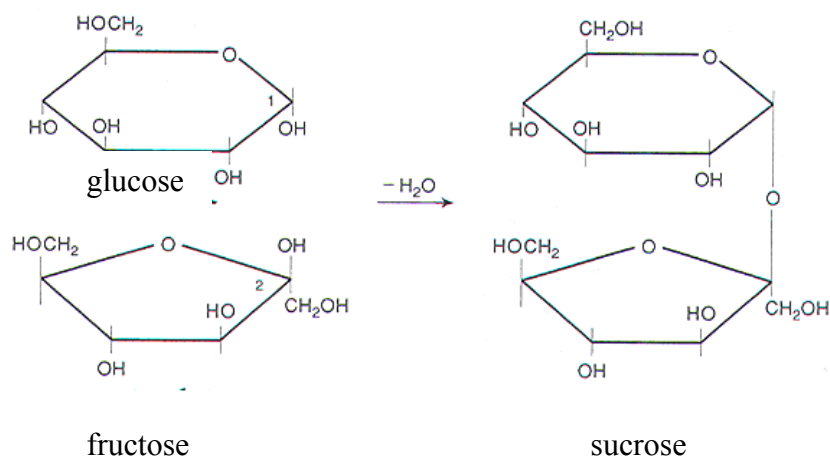


glucose              glucose

We notice from this equation that maltose molecule results from the condensation of two glucose molecules with the bond of carbon atom number (1) from glucose molecule, carbon atom number (4) from another molecule and losing one water molecule. Water dissolution, on the other hand, is the opposite of dissolution, and it occurs with the presence of mineral acids like concentrated hydrochloric acid or enzymes. Maltose is found in barley seeds during its initial growing and when starch dissolves in water.

---

What is the last and the pre-last outcome of starch digestion?

---

**Sucrose (cane sugar):**

It is the sugar we use for food. It is concentrated in sugar cane and beet, which are two sources to get sugar from industry. You can notice in the equation that sucrose molecule results from the condensation of glucose molecule and fructose molecule where carbon atom number (1) from glucose is bonded with carbon atom number (2) from fructose and losing one water molecule.

glucose

fructose

sucrose

$-H_2O$

We conclude from this activity that maltose reduces Benedict's solvent because it contains aldehyde group which is not bonded with glucose molecules. Sucrose, however, does not reduce Benedict's solvent because the glucose aldehyde group (carbon atom 1) is bonded with fructose carbonyl group (Carmon atom 2) to form the bond between the two molecules.

**Lactose**

Lactose is one of the main components of mothers' milk, and it is called dairy sugar because it can be found in the dairy of all mammals. It is less sweet than cane sugar, and it has less ability to dissolve in water. Lactose molecule results from the condensation of glucose molecule and galactose molecule. The bond in lactose molecule is similar to that of maltose's (bond 1-4)



galactose

glucose
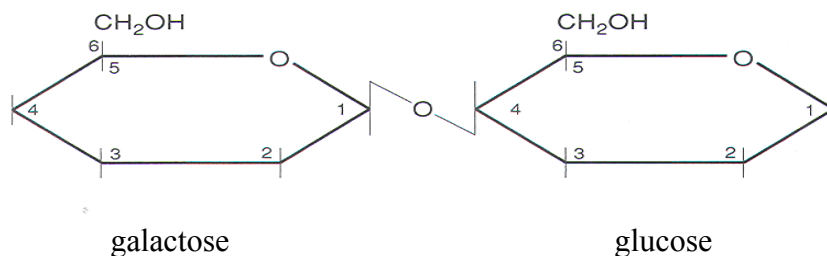
| Does lactose reduce Benedict's solvent? Why? |
| --- |

**Characteristics of lactose in mothers' milk:**

- It does not produce gases in the child's bowel.
- It helps in the growth of some kinds of useful bacteria in the child's bowel like Vitamin B.
- Natural aperient for the child.
- Not so sweet so the child can take a big amount of mother's milk.

Mother's milk also contains vitamins and natural antibiotics. Its structure changes to suit the child's age.

Why is natural suck better than artificial one?

**Polysaccharides:**

Starch and cellulose are polysaccharide carbohydrates. Their main source is plants. The molecule of each results from the condensation of thousands of glucose molecules. The general formula for each is $n(C_6H_{10}O_5)$.

**Starch**:

Starch is composed of amylose (20%) and amylopectin (80%). Both result from the condensation of glucose units. The difference between the two lies in the shape of the chain which forms the molecule: amylose's chain is straight while amylopectin's chain is branchy.

Amylose



Amylopectin
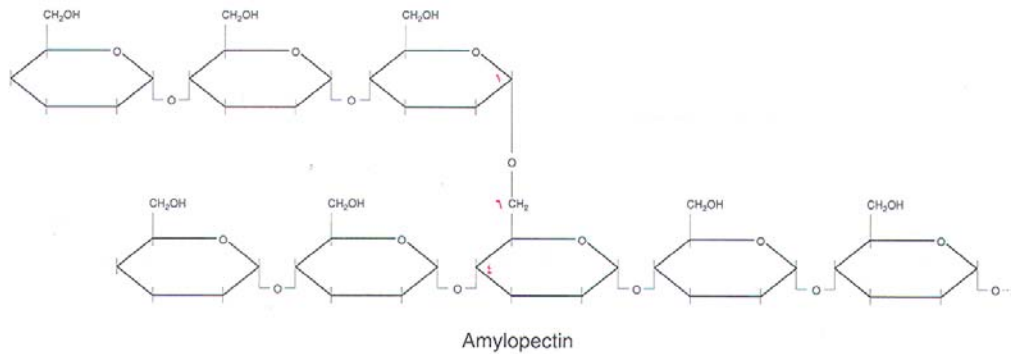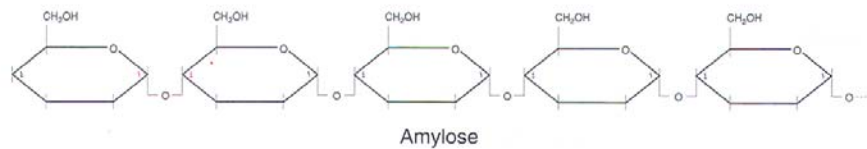
**Starch's Existence and its Significance:**

Starch exists as small white seeds in most plants. It is stored in many seeds like wheat, corn, rice, and others. Plants use starch while growing. It is also the main food of many peoples because bread and bakery are made of it (figure 3-4).
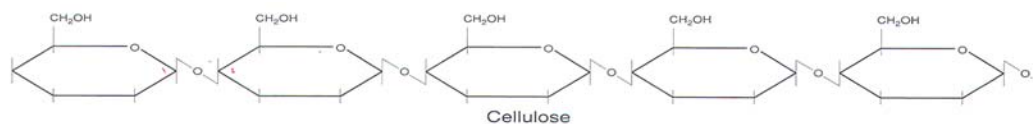
**Starch Characteristics:**

- Only around 20% dissolves in cold water. In hot water, its small seeds swell and its walls explode producing gelatinous shiny liquid which changes into a sticky material when it cools down.
- With Iodine solution, starch gives blue colour.

What results from starch's water dissolution?

**Cellulose**:

It is one of the primary components of plant cells. It consists of parallel chains that have no branches. Its units are from glucose, and the chains are bonded with hydrogen bonds forming packs (figure 3-6).

Cellulose

Cellulose is a white, solid substance which neither dissolves in water, nor in other organic solvents. Although starch and cellulose consist of glucose units, their characteristics are different due to their dissimilarity in bonds with glucose units. Unlike starch, cellulose does not dissolve easily in water, but when it is heated with Sulfur acid under pressure, it dissolves into glucose.

Cellulose is one of the most common polysaccharides. It composes more than 50% of carbon compounds in nature. Cotton is considered an example of pure cellulose. Cellulose also constitutes 4-%-53% from wood's mass, which is why wood is considered a very important material in the paper industry.

**Importance of Carbohydrates:**

Carbohydrates have big value in our lives: starch and saccharides are the main sources which supply humans with energy. Cellulose is considered the main source of omnivorous animals. The following industries are based on carbohydrates:

1- Bread and sweets.
2- Paper industry which depends on cellulose found in trees.
3- Textile industry, whether textiles which depend on natural fibers like cotton and linen or textiles which depend on artificial fibers like artificial silk which is prepared by cellulose acetate, a primary substance which results from treating a mixture of cellulose and concentrated sulfur acid with acetic acid.
4- Cellulose is used in preparing overlays used in the desalinization of sea water douching and anti-douching.

**LESSONS CONTENT**

The four lessons in

What do you know about oligosaccharide carbohydrates?

We learn the following from the video:

1- Oligosaccharide carbohydrates:

a- definition

b- classification

2- Disaccharides:

a- their general molecular formula

b- the outcome of its dissolution in water

c- how they form by condensation

d- examples

e- their relation to monosaccharides

Now click on Video 7 button.

After watching Video 7, what learning outcomes have you acquired about oligosaccharide carbohydrates and disaccharides?

You can replay the video anytime to make sure that you have learnt the previous outcomes.

phase 2 were about Carbohydrates.

Sequence of the lessons for the control group (style 4) is as follows:

 Lesson 1: Style 4 (Control Group)

What do you know about?

-   biochemistry
-   photosynthesis
-   carbohydrates

Video 1

We will learn the following from Video 1:

1- Biochemistry:

a- definition

b- the most common bio-compounds

c- Their importance for living things

2- Carbohydrates:

a- their source

b- elements that compose them and their percentages.

c- their structural formulae

d- definition

Now click on Video 1 button.

After watching Video 1, what learning outcomes have you acquired about biochemistry and carbohydrates?

You can replay the video anytime to make sure that you have learnt the previous outcomes.

What do you know about:
- types of carbohydrates?
- monosaccharides?

We will learn the following from Video 2:

1- Types of carbohydrates.

2- Monosaccharides:

a- where the name comes from.

b- their general molecular formula.

c- their types and the general molecular formula of each type.

d- the most common types:

i. structural formula.

ii. different forms.

iii. examples.

iv. name explanation

v. presence.

vi. importance.

Now click on Video 2 button.

After watching Video 2, what learning outcomes have you acquired about types of carbohydrates and monosaccharides?

You can replay the video anytime to make sure that you have learnt the previous outcomes.

What can you see in picture 1?

**Lesson 2: Style 4 (Control Group)**

Video 3

What do you know about hexoses?

We learn the following from Video 3:

1. hexoses.

a. molecular formula.

b. examples.

c. structural formula.

d. distribution of hydroxyl groups in them.

e. causes of their diversity.

f. their ring forms in their solid state.

Now click on Video 3 button.

After watching Video 3, what learning outcomes have you acquired about hexoses?

You can replay the video any time to make sure that you have learnt the previous outcomes.

Video 4

What do you know about the physical characteristics of monosaccharides?

We will learn the following from Video 4:

1- Physical characteristics of monosaccharides:
a. their physical state and shape in normal degrees.
b. their taste.
c. why they melt easily in water while they do not melt in other organic solvents.

Now click on Video 4 button.
After watching Video 4, what learning outcomes have you acquired about physical characteristics of monosaccharides?
You can replay the video any time to make sure that you have learnt the previous outcomes.

Video 5

What do you know about the chemical characteristics of monosaccharides?

We learn the following from Video 5:

1- the chemical characteristics of monosaccharides.
a- their behaviour as oxidization agents:
   i. Sorbitol alcohol
     1. its formation
     2. its structural formula
     3. its uses
b- their behaviour as reduction agents:

i. factors that control the oxidization outcomes.

Now click on Video 5 button.

After watching Video 5, what learning outcomes have you acquired about the chemical characteristics of monosaccharides?
You can replay the video any time to make sure that you have learnt the previous outcomes.

Video 6

What do you know about
- the reduction of aldehyde and ketone to Benedict solvent?
- Sugar transformations in our bodies?

We learn the following from Video 6:

1- the explanation of the reduction of aldehyde and ketone to Benedict solvent and examples.
2- the significance of sugar transformation in our bodies.

Now click on Video 6 button.

After watching Video 6, what learning outcomes have you acquired about the reduction characteristic of aldehyde and ketone?
You can replay the video any time to make sure that you have learnt the previous outcomes.

Lesson 3: Style 4 (Control Group)
Video 7

What do you know about oligosaccharide carbohydrates?

We learn the following from the video 7:

1- Oligosaccharide carbohydrates:

a- definition

b- classification

2- Disaccharides:

a- their general molecular formula

b- the outcome of its dissolution in water

c- how they form by condensation

d- examples

e- their relation to monosaccharides

Now click on Video 7 button.

After watching Video 7, what learning outcomes have you acquired about oligosaccharide carbohydrates and disaccharides?

You can replay the video anytime to make sure that you have learnt the previous outcomes.

Video 8

What do you know about maltose?

We learn the following from Video 8:

1- maltose

a- its water dissolution

b- the outcome of its water dissolution

c- how it forms by condensation

d- explanation for its reduction of Benedict solvent

e- presence

Now click on Video 8 button.

After watching Video 8, what learning outcomes have you acquired about maltose? You can replay the video anytime to make sure that you have learnt the previous outcomes.

Video 9

What do you know about sucrose?

We will learn the following from Video 9:

1- Sucrose:
a. how it dissolves in water
b. the outcome of its dissolution in water
c. how it is produced by condensation
d. the explanation of why it does not reduce Benedict solvent
e. where it gets its name from
f. presence

Now click on Video 9 button.

After watching Video 9, what learning outcomes have you acquired about sucrose? You can replay the video anytime to make sure that you have learnt the previous outcomes.

Video 10

What do you know about lactose?

We will learn the following from Video 10:

1- lactose:

a. how it dissolves in water

b. the outcome of its dissolution in water

c. how it is produced by condensation

d. the explanation of its reduction to Benedict's solvent

e. where it gets its name from

f. presence

g. The significance of its existence in mother's milk

Now click on Video 10 button.

After watching Video 10, what learning outcomes have you acquired about lactose? You can replay the video anytime to make sure that you have learnt the previous outcomes.

Lesson 4: Style 4 (Control Group)

Video 11

What do you know about polysaccharide carbohydrates?

We learn the following from Video 11:

1- polysaccharide carbohydrates:

a. definition

b. general molecular formula

c. examples

d. starch:

  i. formation

  ii. components

  iii. presence

Now click on Video 11 button.

After watching Video 11, what learning outcomes have you acquired about polysaccharide carbohydrates?

You can replay the video anytime to make sure that you have learnt the previous outcomes.

Video 12

What do you know about starch?

We will learn the following from Video 12:

1- Starch:

a. characteristics

b. how to detect it

c. the outcome of its water dissolution

d. importance

Now click on Video 12 button.

After watching Video 12, what learning outcomes have you acquired about polysaccharide carbohydrates?

You can replay the video anytime to make sure that you have learnt the previous outcomes.

Video 13

What do you know about cellulose?

We will learn the following from Video 13:

1- cellulose:

a. its formation

b. why and how it is different from starch

c. presence in nature and wood

d. characteristics

e. its dissolution in water and organic solvents

f. the outcome of its dissolution

Now click on Video 13 key.

After watching Video 13, what learning outcomes have you acquired about cellulose? You can replay the video anytime to make sure that you have learnt the previous outcomes.

Video 14

What do you know about the importance of cellulose?

We learn the following from Video 14:

1- the importance of cellulose and its uses
a. why, unlike humans, animals can digest it

Now click on Video 14 key.

After watching Video 14, what learning outcomes have you acquired about cellulose importance?

You can replay the video anytime to make sure that you have learnt the previous outcomes.

Lessons sequence for the experimental group:

Lesson1: Legislative

What do you know about:

- biochemistry
- photosynthesis

- carbohydrates

Video 1

We will learn the following from Video 1:

1- Biochemistry:

a- definition

b- the most common bio-compounds

c- Their importance for living things


2- Carbohydrates:

a- their source

b- elements that compose them and their percentages.

c- their structural formulae

d- definition


Now click on Video 1 button.


After watching Video 1, what learning outcomes have you acquired about biochemistry and carbohydrates?

You can replay the video anytime to make sure that you have learnt the previous outcomes.


Activities:

- define carbohydrates in your own way.

- develop a method that will simplify recalling the molecular formula of the carbohydrate substance which has resulted from the photosynthesis process.


What do you know about:

- types of carbohydrates?
- monosaccharides?


Video 2

We will learn the following from Video 2:

1- Types of carbohydrates.

2- Monosaccharides:

a- where the name comes from.

b- their general molecular formula.

c- their types and the general molecular formula of each type.

d- the most common types:

i. structural formula.

ii. different forms.

iii. examples.

iv. name explanation

v. presence.

vi. importance.

Now click on Video 2 button.

After watching Video 2, what learning outcomes have you acquired about types of carbohydrates and monosaccharides?
You can replay the video anytime to make sure that you have learnt the previous outcomes.

 - Imagine that you are a monosaccharide with six atoms, and that you want to introduce yourself. Write a letter to chemistry scientists introducing yourself to them.
- Aldopentose and ketopentose wrote a letter to introduce themselves toe ach other. What would the letters possibly contain?

Lesson 2: Legislative

Video 3
What do you know about hexoses?

We learn the following from Video 3:

1. hexoses.
a. molecular formula.
b. examples.

c. structural formula.

d. distribution of hydroxyl groups in them.

e. causes of their diversity.

f. their ring forms in their solid state.

Now click on Video 3 button.

After watching Video 3, what learning outcomes have you acquired about hexoses? You can replay the video any time to make sure that you have learnt the previous outcomes.

Activity:

(You can work on this activity alone or with your friend).

1. Write an academic article showing the difference in structural formulae of monosaccharides.

2. Design a three-dimensional shape showing the solid state of glucose and fructose.

Video 4

What do you know about the physical characteristics of monosaccharides?

We will learn the following from Video 4:

1- Physical characteristics of monosaccharides:

a. their physical state and shape in normal degrees.

b. their taste.

c. why they melt easily in water while they do not melt in other organic solvents.

Now click on Video 4 button.

After watching Video 4, what learning outcomes have you acquired about physical characteristics of monosaccharides?

You can replay the video any time to make sure that you have learnt the previous outcomes.

Activity:

(You can work on this activity alone or with your friend).

If you were a newspaper editor and a chemist, write a press interview in which you ask and answer yourself about the physical characteristics of monosaccharides.

Example:

Question: What is the shape of a monosaccharide?

Answer: It takes the form of crystalline solids.

Continue the press interview.

Video 5

What do you know about the chemical characteristics of monosaccharides?

We learn the following from Video 5:

1- the chemical characteristics of monosaccharides.

a- their behaviour as oxidization agents:

    i. Sorbitol alcohol

      1. its formation

      2. its structural formula

      3. its uses

b- their behaviour as reduction agents:

    i. factors that control the oxidization outcomes.

Now click on Video 5 button.

After watching Video 5, what learning outcomes have you acquired about the chemical characteristics of monosaccharides?

You can replay the video any time to make sure that you have learnt the previous outcomes.

Activity:

(You can work on this activity alone or with your friend).

If you were a newspaper editor and a chemist, write a press interview in which you ask and answer yourself about the monosaccharides being oxidization and reduction agents at the same time.

Video 6

What do you know about

- the reduction of aldehyde and ketone to Benedict solvent?
- Sugar transformations in our bodies?

We learn the following from Video 6:

1- the explanation of the reduction of aldehyde and ketone to Benedict solvent and examples.

2- the significance of sugar transformation in our bodies.

Now click on Video 6 button.

After watching Video 6, what learning outcomes have you acquired about the reduction characteristic of aldehyde and ketone?

You can replay the video any time to make sure that you have learnt the previous outcomes.

Activity:

(You can work on this activity alone or with your friend).

Provide a report about an experiment that you conducted to show fructose's reduction to Benedict solvent although it is a ketone.

In order to get the Nobel Prize, connect this discovery to interactions that take place in our bodies.

Lesson3: Legislative

Video 7

 What do you know about oligosaccharide carbohydrates?

We learn the following from the video 7:

1- Oligosaccharide carbohydrates:
a- definition
b- classification

2- Disaccharides:
a- their general molecular formula
b- the outcome of its dissolution in water
c- how they form by condensation
d- examples
e- their relation to monosaccharides

Now click on Video 7 button.

After watching Video 7, what learning outcomes have you acquired about oligosaccharide carbohydrates and disaccharides?
You can replay the video anytime to make sure that you have learnt the previous outcomes.

Activity:
(You can work on this activity alone or with a friend).

1- Imagine that you are a disaccharide. Introduce yourself.
2- Design an outline to show the outcomes of water dissolution for sucrose, maltose, and lactose.

Video 8

What do you know about maltose?

We learn the following from Video 8:

1- maltose

a- its water dissolution

b- the outcome of its water dissolution

c- how it forms by condensation

d- explanation for its reduction of Benedict solvent

e- presence

Now click on Video 8 button.

After watching Video 8, what learning outcomes have you acquired about maltose? You can replay the video anytime to make sure that you have learnt the previous outcomes.

Activity:
(You can work on this activity alone or with a friend).

1- Write a scientific story about a journey made by maltose until its dissolution producing Glucose. Provide an accurate scientific description of the dissolution process.

2- Design a proper way to get students understand how two glucose molecules condense to produce maltose.

Video 9

What do you know about sucrose?

We will learn the following from Video 9:

1- Sucrose:

a. how it dissolves in water

b. the outcome of its dissolution in water

c. how it is produced by condensation

d. the explanation of why it does not reduce Benedict solvent

e. where it gets its name from

f. presence

Now click on Video 9 button.

After watching Video 9, what learning outcomes have you acquired about sucrose? You can replay the video anytime to make sure that you have learnt the previous outcomes.

Activity:

(You can work on this activity alone or with a friend).

1- what will happen if sucrose solution is heated with concentrated hydrochloric acid, and the outcome is detected by Benedict's solvent?

2- Imagine that you are sucrose and speak about how you are produced in detail.

Video 10

What do you know about lactose?

We will learn the following from Video 10:

1- lactose:

a. how it dissolves in water

b. the outcome of its dissolution in water

c. how it is produced by condensation

d. the explanation of its reduction to Benedict's solvent

e. where it gets its name from

f. presence

g. The significance of its existence in mother's milk

Now click on Video 10 button.

After watching Video 10, what learning outcomes have you acquired about lactose? You can replay the video anytime to make sure that you have learnt the previous outcomes.

Activity:
(You can work on this activity alone or with a friend).

1- Imagine a debate between lactose and maltose in which each one of them speaks about its self. Write down the debate.
Example:
Lactose: I am the product of the condensation of a glucose molecule and a galactose molecule.
Maltose: But I am the product of the condensation of ….

Continue the debate.

Lesson4: Legislative

Video 11

What do you know about polysaccharide carbohydrates?

We learn the following from Video 11:

1- polysaccharide carbohydrates:
a. definition
b. general molecular formula
c. examples
d. starch:

i. formation

ii. components

iii. presence

Now click on Video 11 button.

After watching Video 11, what learning outcomes have you acquired about polysaccharide carbohydrates?
You can replay the video anytime to make sure that you have learnt the previous outcomes.

Activity:
(You can work on this activity alone or with a friend).

1- Design a method which enables people to differentiate between polysaccharide carbohydrates and oligosaccharide carbohydrates.

Video 12
What do you know about starch?

We will learn the following from Video 12:
1- Starch:
a. characteristics
b. how to detect it
c. the outcome of its water dissolution
d. importance

Now click on Video 12 button.

After watching Video 12, what learning outcomes have you acquired about polysaccharide carbohydrates?
You can replay the video anytime to make sure that you have learnt the previous outcomes.

Activity:

(You can work on this activity alone or with a friend).


1- Innovate an alternative method to detect starch.

2- Generate alternatives and possibilities for uses of starch.


Video 13


What do you know about cellulose?


We will learn the following from Video 13:

1- cellulose:

a. its formation

b. why and how it is different from starch

c. presence in nature and wood

d. characteristics

e. its dissolution in water and organic solvents

f. the outcome of its dissolution


Now click on Video 13 key.


After watching Video 13, what learning outcomes have you acquired about cellulose?
You can replay the video anytime to make sure that you have learnt the previous outcomes.


Activity:

(You can work on this activity alone or with a friend).

1- You are cellulose, and you would like to apply for a job. Write down your CV.

Example:

Name: cellulose

Presence: …….

Continue the CV mentioning what you know about cellulose.

2- You have put magic glasses through which you can see molecular structures. You are examining a piece of cotton. What can you see in cotton's molecular structures? Describe what you can see.

Video 14

What do you know about the importance of cellulose?

We learn the following from Video 14:

1- the importance of cellulose and its uses
a. why, unlike humans, animals can digest it

Now click on Video 14 key.

After watching Video 14, what learning outcomes have you acquired about cellulose importance?
You can replay the video anytime to make sure that you have learnt the previous outcomes.

Activity:
(You can work on this activity alone or with a friend).

1- Write a letter to municipality chief telling him how to get benefits from cellulose.

Lesson 1: executive

What do you know about:

- biochemistry
- photosynthesis
- carbohydrates

Video1
We will learn the following from Video 1:

1- Biochemistry:

a- definition

b- the most common bio-compounds

c- Their importance for living things


2- Carbohydrates:

a- their source

b- elements that compose them and their percentages.

c- their structural formulae

d- definition


Now click on Video 1 button.


After watching Video 1, what learning outcomes have you acquired about biochemistry and carbohydrates?

You can replay the video anytime to make sure that you have learnt the previous outcomes.


Activities:

- define carbohydrates.

- what are the components of carbohydrates?

- describe the photosynthesis process.


What do you know about:

- types of carbohydrates?

- monosaccharides?


We will learn the following from Video 2:

1- Types of carbohydrates.

2- Monosaccharides:

a- where the name comes from.

b- their general molecular formula.

c- their types and the general molecular formula of each type.

d- the most common types:

i. structural formula.

ii. different forms.

iii. examples.

iv. name explanation

v. presence.

vi. importance.

Now click on Video 2 button.

After watching Video 2, what learning outcomes have you acquired about types of carbohydrates and monosaccharides?

You can replay the video anytime to make sure that you have learnt the previous outcomes.

Activities:

- What are the types of carbohydrates?

- Explain the meanings of the following words: ketohexose, aldohexose and ketopentose.

- Explain the benefit of ribose in the human body.

 Lesson 2: executive

Video 3

What do you know about hexoses?

We learn the following from Video 3:

1. hexoses.

a. molecular formula.

b. examples.

c. structural formula.

d. distribution of hydroxyl groups in them.

e. causes of their diversity.

f. their ring forms in their solid state.

Now click on Video31 button.

After watching Video 3, what learning outcomes have you acquired about hexoses? You can replay the video any time to make sure that you have learnt the previous outcomes.

Activity:
(You can work on this activity alone or with your friend).

1. What is the percentage of glucose in the blood of the healthy human? What is its importance to human beings?
2. Describe the structural formulae of glucose, galactose and fructose.
3. Summarize the reasons of saccharides' diversity.
4. How do the ring shapes of glucose and fructose form?

Video 4

What do you know about the physical characteristics of monosaccharides?

We will learn the following from Video 4:

1- Physical characteristics of monosaccharides:
a. their physical state and shape in normal degrees.
b. their taste.
c. why they melt easily in water while they do not melt in other organic solvents.

Now click on Video 4 button.
After watching Video 4, what learning outcomes have you acquired about physical characteristics of monosaccharides?
You can replay the video any time to make sure that you have learnt the previous outcomes.

Activity:

(You can work on this activity alone or with your friend).

1- What are the physical characteristics of monosaccharides?

2- Which monosaccharides are sweeter?

Video 5

What do you know about the chemical characteristics of monosaccharides?

We learn the following from Video 5:

1- the chemical characteristics of monosaccharides.

a- their behaviour as oxidization agents:

    i. Sorbitol alcohol

      1. its formation

      2. its structural formula

      3. its uses

b- their behaviour as reduction agents:

    i. factors that control the oxidization outcomes.

Now click on Video 5 button.

After watching Video 5, what learning outcomes have you acquired about the chemical characteristics of monosaccharides?

You can replay the video any time to make sure that you have learnt the previous outcomes.

Activity:

(You can work on this activity alone or with your friend).

1- When are monosaccharides oxidization agents and when are they reduction agents?

2- What is the structural formula of sorbitol alcohol?

3- What are the factors pivotal for the product of monosaccharides oxidization?

Video 6

What do you know about

- the reduction of aldehyde and ketone to Benedict solvent?
- Sugar transformations in our bodies?

We learn the following from Video 6:

1- the explanation of the reduction of aldehyde and ketone to Benedict solvent and examples.

2- the significance of sugar transformation in our bodies.

Now click on Video 6 button.

After watching Video 6, what learning outcomes have you acquired about the reduction characteristic of aldehyde and ketone?

You can replay the video any time to make sure that you have learnt the previous outcomes.

Activity:

(You can work on this activity alone or with your friend).

1- What is the role of aldehydes when they interact with Benedict's solvent?

2- How does the reduction process of Benedict's solvent occur when fructose solution is added to it?

Lesson 3: executive

Video 7

Activity:

(You can work on this activity alone or with a friend).

1- What is the outcome of the condensation of two monosaccharide molecules?

2- What results from water dissolution of sucrose, lactose and maltose?

3- What is the general molecular formula of disaccharides?

4- Summarize the process of dissolution and formation of a disaccharide in a general molecular formula.

Video 8

What do you know about maltose?

Video 8
We learn the following from Video 8:

1- maltose
a- its water dissolution
b- the outcome of its water dissolution
c- how it forms by condensation
d- explanation for its reduction of Benedict solvent
e- presence

Now click on Video 8 button.

After watching Video 8, what learning outcomes have you acquired about maltose? You can replay the video anytime to make sure that you have learnt the previous outcomes.

Activity:
(You can work on this activity alone or with a friend).

1- Summarize the relation between glucose and maltose in a formula.

2- Describe the process of the condensation of two glucose molecules to produce a maltose molecule.

3- How does the impact of the presence of a group of unconnected aldehydes in maltose appear on its characteristics?

Video 9

What do you know about sucrose?

We will learn the following from Video 9:

1- Sucrose:

a. how it dissolves in water

b. the outcome of its dissolution in water

c. how it is produced by condensation

d. the explanation of why it does not reduce Benedict solvent

e. where it gets its name from

f. presence

Now click on Video 9 button.

After watching Video 9, what learning outcomes have you acquired about sucrose? You can replay the video anytime to make sure that you have learnt the previous outcomes.

Activity:

(You can work on this activity alone or with a friend).

1- Explain the process of the condensation of glucose molecule and fructose molecule to produce sucrose.

Video 10

What do you know about lactose?

We will learn the following from Video 10:

1- lactose:

a. how it dissolves in water

b. the outcome of its dissolution in water

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c. how it is produced by condensation

d. the explanation of its reduction to Benedict's solvent

e. where it gets its name from

f. presence

g. The significance of its existence in mother's milk

Now click on Video 10 button.

After watching Video 10, what learning outcomes have you acquired about lactose? You can replay the video anytime to make sure that you have learnt the previous outcomes.

Activity:

(You can work on this activity alone or with a friend).

1- How does lactose result?

2- Summarize the importance of lactose in mother's milk.

Lesson 4: executive

Video 11

What do you know about oligosaccharide carbohydrates?

We learn the following from the video:

1- Oligosaccharide carbohydrates:

a- definition

b- classification

2- Disaccharides:

a- their general molecular formula

b- the outcome of its dissolution in water

c- how they form by condensation

d- examples

e- their relation to monosaccharides

Now click on Video 11 button.

After watching Video 11, what learning outcomes have you acquired about oligosaccharide carbohydrates and disaccharides?

You can replay the video anytime to make sure that you have learnt the previous outcomes.

Activity:

(You can work on this activity alone or with a friend).

1- What is the outcome of the condensation of two monosaccharide molecules?

2- What results from water dissolution of sucrose, lactose and maltose?

3- What is the general molecular formula of disaccharides?

4- Summarize the process of dissolution and formation of a disaccharide in a general molecular formula.

Video 12

What do you know about maltose?

We learn the following from Video 12:

1- maltose

a- its water dissolution

b- the outcome of its water dissolution

c- how it forms by condensation

d- explanation for its reduction of Benedict solvent

e- presence

Now click on Video 12 button.

After watching Video 12, what learning outcomes have you acquired about maltose? You can replay the video anytime to make sure that you have learnt the previous outcomes.

Activity:

(You can work on this activity alone or with a friend).

1- Summarize the relation between glucose and maltose in a formula.

2- Describe the process of the condensation of two glucose molecules to produce a maltose molecule.

3- How does the impact of the presence of a group of unconnected aldehydes in maltose appear on its characteristics?

Video 13

What do you know about sucrose?

We will learn the following from Video 13:

1- Sucrose:
a. how it dissolves in water
b. the outcome of its dissolution in water
c. how it is produced by condensation
d. the explanation of why it does not reduce Benedict solvent
e. where it gets its name from
f. presence

Now click on Video 13 button.

After watching Video 13, what learning outcomes have you acquired about sucrose?

You can replay the video anytime to make sure that you have learnt the previous outcomes.

Activity:

(You can work on this activity alone or with a friend).

1- Explain the process of the condensation of glucose molecule and fructose molecule to produce sucrose.

Video 14

What do you know about lactose?

We will learn the following from Video 14:

1- lactose:
a. how it dissolves in water
b. the outcome of its dissolution in water
c. how it is produced by condensation
d. the explanation of its reduction to Benedict's solvent
e. where it gets its name from
f. presence
g. The significance of its existence in mother's milk

Now click on Video 14 button.

After watching Video 14, what learning outcomes have you acquired about lactose? You can replay the video anytime to make sure that you have learnt the previous outcomes.

Activity:

(You can work on this activity alone or with a friend).

1- How does lactose result?

2- Summarize the importance of lactose in mother's milk.

 Lesson 1: Judicial

What do you know about:
- biochemistry
- photosynthesis
- carbohydrates

Video 1

We will learn the following from Video 1:

1- Biochemistry:

a- definition

b- the most common bio-compounds

c- Their importance for living things

2- Carbohydrates:

a- their source

b- elements that compose them and their percentages.

c- their structural formulae

d- definition

Now click on Video 1 key.

After watching Video 1, what learning outcomes have you acquired about biochemistry and carbohydrates?

You can replay the video anytime to make sure that you have learnt the previous outcomes.

Activity

- analyze carbohydrates molecule into its components.

- why is starch considered a carbohydrate?

- why is water dissolution mentioned in defining carbohydrates?

What do you know about:

- types of carbohydrates?
- monosaccharides?

Video 2

We will learn the following from Video 2:

1- Types of carbohydrates.

2- Monosaccharides:

a- where the name comes from.

b- their general molecular formula.

c- their types and the general molecular formula of each type.

d- the most common types:

i. structural formula.

ii. different forms.

iii. examples.

iv. name explanation

v. presence.

vi. importance.

Now click on Video 2 key.

After watching Video 2, what learning outcomes have you acquired about types of carbohydrates and monosaccharides?

You can replay the video anytime to make sure that you have learnt the previous outcomes.

What can you see in picture 1?

Activity

- compare the presence rate of carbohydrates which contain five or six carbon atoms in nature with other monosaccharides, and explain the significance of that.

- why is the group to which fructose belongs called ketohexose?

- compare between ketopentoses and aldohexoses.

Lesson 2: Judicial

Video 3

What do you know about hexoses?

We learn the following from Video 1:

1. hexoses.
a. molecular formula.
b. examples.
c. structural formula.
d. distribution of hydroxyl groups in them.
e. causes of their diversity.
f. their ring forms in their solid state.

Now click on Video 3 key.

After watching Video 3, what learning outcomes have you acquired about hexoses?
You can replay the video any time to make sure that you have learnt the previous outcomes.

Activity:
(You can work on this activity alone or with your friend).

1. Why do humans get diabetes?
2. Although hexoses have one molecular formula, they are multiple and varied. What is the reason behind that?
3- Compare the structural formulae of glucose, galactose and fructose.
How are they similar?
How are they different?
What do you conclude from this comparison?
4- Analyze the process of the formation of the ring shape of hexoses.
5- How is glucose's ring shape different from fructose's ring shape in the solid state?

6- Monosaccharides exist in the form of an open carbonic chain. Present a critique to this statement.

Video 4

What do you know about the physical characteristics of monosaccharides?

We will learn the following from Video 4:

1- Physical characteristics of monosaccharides:
a. their physical state and shape in normal degrees.
b. their taste.
c. why they melt easily in water while they do not melt in other organic solvents.

Now click on Video 4 key.
After watching Video 4, what learning outcomes have you acquired about physical characteristics of monosaccharides?
You can replay the video any time to make sure that you have learnt the previous outcomes.

Activity:
(You can work on this activity alone or with your friend).
1- Why is it easy for monosaccharides to dissolve in water, whereas they do not dissolve in organic solvents.
2- Why is honey so sweet?

Video 5

What do you know about the chemical characteristics of monosaccharides?

We learn the following from Video 5:

1- the chemical characteristics of monosaccharides.

a- their behaviour as oxidization agents:

   i. Sorbitol alcohol

      1. its formation

      2. its structural formula

      3. its uses

b- their behaviour as reduction agents:

   i. factors that control the oxidization outcomes.


Now click on Video 5 key.


After watching Video 5, what learning outcomes have you acquired about the chemical characteristics of monosaccharides?

You can replay the video any time to make sure that you have learnt the previous outcomes.


Activity:

(You can work on this activity alone or with your friend).

1- Although sorbitol alcohol is sweet, it is used by people who have diabetes or who or on diet. What is the reason behind that?

2- What is supposed to be the effect of the monosaccharides reaction with sodium and tolin solution? Why do you think this hypothesis is true?


Video 6

What do you know about

   - the reduction of aldehyde and ketone to Benedict solvent?

   - sugar transformations in our bodies?


We learn the following from Video 6:


1- the explanation of the reduction of aldehyde and ketone to Benedict solvent and examples.

2- the significance of sugar transformation in our bodies.


Now click on Video 6 key.

After watching Video 6, what learning outcomes have you acquired about the reduction characteristic of aldehyde and ketone?

You can replay the video any time to make sure that you have learnt the previous outcomes.

Activity:

(You can work on this activity alone or with your friend).

1- In a lab experiment you found that fructose reduced Benedict's solvent. Submit a report in which you analyze the process.

2- What is the difference between glucose's reduction to Benedict solvent and fructose's reduction to Benedict solvent. What do you conclude about it?

Lesson 3: Judicial

Video 7

What do you know about oligosaccharide carbohydrates?

We learn the following from video 7:

1- Oligosaccharide carbohydrates:

a- definition

b- classification

2- Disaccharides:

a- their general molecular formula

b- the outcome of its dissolution in water

c- how they form by condensation

d- examples

e- their relation to monosaccharides

Now click on Video 7 key.

After watching Video 7, what learning outcomes have you acquired about oligosaccharide carbohydrates and disaccharides?

You can replay the video anytime to make sure that you have learnt the previous outcomes.

Activity:

(You can work on this activity alone or with a friend).

1- Assess the given outline which shows the relation between disaccharides and monosaccharides, and assess its effectiveness in making students understand the relation. Provide the advantages and disadvantages.

2- What is the reason behind the name 'disaccharide'?

Video 8

What do you know about maltose?

We learn the following from Video 8:

1- maltose

a- its water dissolution

b- the outcome of its water dissolution

c- how it forms by condensation

d- explanation for its reduction of Benedict solvent

e- presence

Now click on Video 8 key.

After watching Video 8, what learning outcomes have you acquired about maltose?

You can replay the video anytime to make sure that you have learnt the previous outcomes.

Activity:

(You can work on this activity alone or with a friend).

1- Maltose reduces Benedict solvent. Provide an analysis for that.

2- Compare and contrast between glucose and maltose. Come up with a summary and a conclusion.

Video 9

What do you know about sucrose?

We will learn the following from Video 9:

1- Sucrose:
a. how it dissolves in water
b. the outcome of its dissolution in water
c. how it is produced by condensation
d. the explanation of why it does not reduce Benedict solvent
e. where it gets its name from
f. presence

Now click on Video 9 key.

After watching Video 9, what learning outcomes have you acquired about sucrose? You can replay the video anytime to make sure that you have learnt the previous outcomes.

Activity:
(You can work on this activity alone or with a friend).

1- how are sucrose and maltose different? Provide a useful summary from this comparison.

2- Why doesn't sucrose reduce Benedict solvent?

Video 10

What do you know about lactose?

We will learn the following from Video 10:

1- lactose:

a. how it dissolves in water

b. the outcome of its dissolution in water

c. how it is produced by condensation

d. the explanation of its reduction to Benedict's solvent

e. where it gets its name from

f. presence

g. The significance of its existence in mother's milk

Now click on Video 10 key.

After watching Video 10, what learning outcomes have you acquired about lactose? You can replay the video anytime to make sure that you have learnt the previous outcomes.

Activity:

(You can work on this activity alone or with a friend).

1- What is meant by saying, "the link in lactose molecule is similar to that of the maltose's.' Are their any other similarities between the two? What are they?

2- What pluses does lactose have over glucose?

Lesson 4: Judicial

Video 11

What do you know about polysaccharide carbohydrates?

We learn the following from Video 11:

1- polysaccharide carbohydrates:
a. definition
b. general molecular formula
c. examples
d. starch:
   i. formation
   ii. components
   iii. presence

Now click on Video 11 key.

After watching Video 11, what learning outcomes have you acquired about polysaccharide carbohydrates?
You can replay the video anytime to make sure that you have learnt the previous outcomes.

Activity:
(You can work on this activity alone or with a friend).

1- Use the graphic organizer to compare between polysaccharide carbohydrates and oligosaccharide carbohydrates in all aspects. Provide a summary of the comparison.
2- What are the similarities and differences between amylose and amylopectin?

Video 12

What do you know about starch?

We will learn the following from Video 12:

1- Starch:

a. characteristics

b. how to detect it

c. the outcome of its water dissolution

d. importance

Now click on Video 12 key.

After watching Video 12, what learning outcomes have you acquired about polysaccharide carbohydrates?

You can replay the video anytime to make sure that you have learnt the previous outcomes.

Activity:

(You can work on this activity alone or with a friend).

1- Following is an experiment to differentiate between white bread and toasted bread by detecting starch: It is known that starches, like bread are named thus because they have a high rate of starch, but

is white bread the same as toasted bread?

Is the digestion of both the same?

To answer these questions we conduct the following experiment:

Instruments and materials:

Glass, some water, some Iodine, two pieces of white bread, spoon, knife, microwave, bowl.

Procedures:

1. Fill half of the glass with water.

2. Add a spoonful of Iodine to the water, stir them well, and pour the solution into the bowl.

3. heat a piece of white bread in the microwave till it becomes toasted.

4. Put one piece of white bread and the piece of toasted bread into the Iodine solution.

1- What do you think you are supposed to see now?

2- Why do you think Iodine was used in this experiment?

3- What is your opinion about this method in detecting starch?

Video 13

What do you know about cellulose?

We will learn the following from Video 13

1- cellulose:

a. its formation

b. why and how it is different from starch

c. presence in nature and wood

d. characteristics

e. its dissolution in water and organic solvents

f. the outcome of its dissolution

Now click on Video 13 key.

After watching Video 13, what learning outcomes have you acquired about cellulose? You can replay the video anytime to make sure that you have learnt the previous outcomes.

Activity:

(You can work on this activity alone or with a friend).

1- How is starch different from cellulose? What is the effect of this difference?

Video 14

What do you know about the importance of cellulose?

We learn the following from Video 14:

1- the importance of cellulose and its uses
a. why, unlike humans, animals can digest it

Now click on Video 14 key.

After watching Video 14, what learning outcomes have you acquired about cellulose importance?
You can replay the video anytime to make sure that you have learnt the previous outcomes.

Activity:
(You can work on this activity alone or with a friend).

1- Why is cellulose considered important in our lives?

**TEACHER INTERFACE**



Figure IX-1: Teacher Interface Screen

The teacher opens the Setup Tool by double clicking the setup tool icon; the Main Menu Screen appears.

Under the Main Menu there are three main headings:

1. Lessons
2. Lessons Questions
3. Thinking Style Questions

Under Lessons, you can either add a new lesson or change an existing one.

Lessons Questions allows the teacher to add new questions or edit existing ones.

Thinking Style Questions allows the teacher to add the Sternberg-Wagner Self-Assessment Inventory statements of the three thinking styles (Legislative, Executive and Judicial Styles) or edit existing statements.

1. Lessons Menu

'Add Lesson' SubMenu:

To ensure students are learning in an optimal way a rich environment was made available. The system contains the following data types:

- Rich Graphic to augment ideas

- Flash Animation to clarify ideas

- Video that contains lessons explained by teacher.

- Sound data.

- Normal text to include lessons text and instructions.

The system has got containers for each of the mentioned data types. These containers are dynamically filled with suitable data based on lessons and thinking models. This method allows for ease of data access based on thinking model and allows teachers with no technical background to enter and edit lessons using the teacher interface.

The Screen Content:
When adding a new lesson, the screen consists of the following fields:

1. Title: Title of Lesson.
2. Style: A drop-down menu allowing the teacher to choose one of the three thinking styles – Legislative, Executive and Judicial.
3. Lesson: Allows the entry of lesson text and any instructions.
4. Video: Allows the attachment of five video clips for each lesson.
5. Audio: Allows the attachment of five audio files for each lesson.
6. Image: Allows the attachment of five images for each lesson.
7. Animation: Allows the attachment of five animated clips for each lesson.

Once the teacher has filled in the appropriate information, the 'submit' button enters the information into the database.

'Change Lesson' SubMenu:

When changing an existing lesson, the system allows to select a lesson. The same screen content appears as when adding a new lesson and the user has the ability to make changes and scroll between the different lessons.

2. Lesson Questions

'Add Question' Submenu:

The Screen Content:

When adding new lesson questions, firstly, the system allows the teacher to choose the style and the lesson. The new questions will be associated with the selected style and lesson.

The screen consists of the following fields:

1. Style: A drop-down menu allowing the teacher to choose one of the three thinking styles – Legislative, Executive and Judicial Styles
2. Text Box: Allows the selection of a lesson by highlighting.
3. Select:  Takes the teacher to the second screen that allows entry of questions associated with style and lesson chosen.

Secondly, the system allows entering the questions.

The screen consists of the following fields:

1. Multiple Choice Question:
2. True and False Question:
3. Open-ended Question:

Add question button allows the lesson questions to be submitted to the database which are associated with the selected style and lesson.   These questions will appear in the student interface.

'Change Question' SubMenu:

When changing existing lesson questions, the system allows to choose the style and the lesson. The same screen content appears as when adding new lesson questions and the user has the ability to make changes.

3.  Thinking Style Questions

'Add Questions' SubMenu
The Screen Content:

Thinking Style Questions allows the teacher to add the Sternberg-Wagner Self-Assessment Inventory statements of the three thinking styles (Legislative, Executive and Judicial Styles) or edit existing questions.
Each style contains eight statements. Each statement can be rated by choosing one of the following ratings on a scale of 1-7 where each rating corresponds to how well a statement describes the student:
1=Not at all satisfactory; 2=not satisfactory; 3=nearly suitable; 4=somewhat suitable; 5=suitable; 6=very suitable; and 7=perfect.

'Change Questions' SubMenu

When changing existing Inventory statements, the system shows the stored thinking style statements and allows making changes.

Once the teacher has filled in the appropriate information, the 'submit' button enters the information into the database.
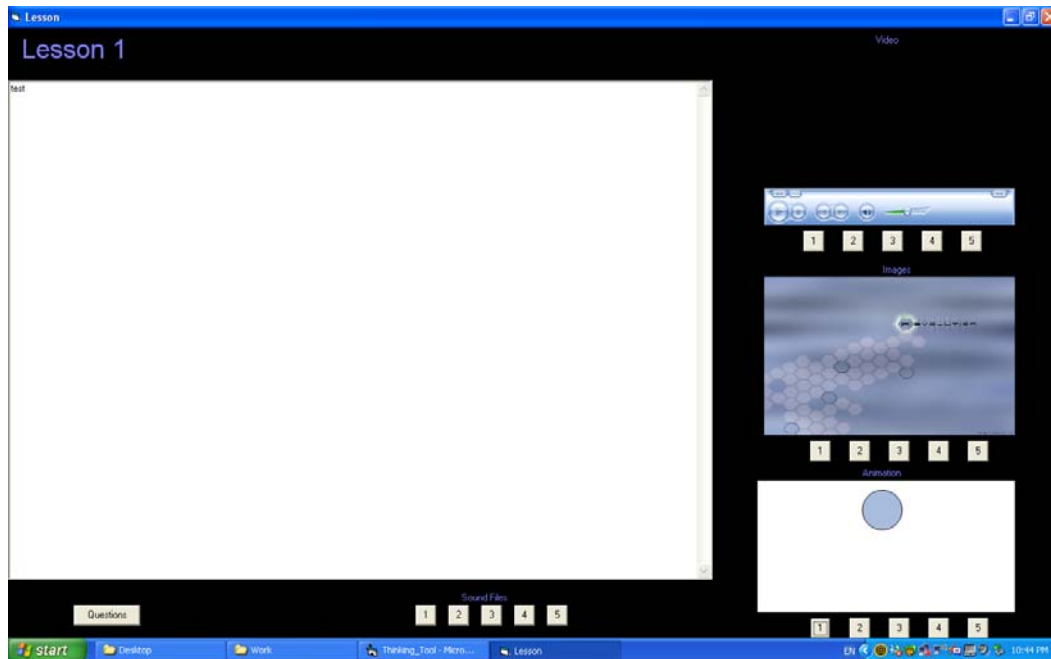
**Student interface**



Figure IX-2: Student Interface Screen

The student opens the Thinking Tool by double clicking on the Thinking Tool icon. The Login interface consists of login name and password fields and three buttons- New User, Style 4, and Login. The 'Style 4' button is only used by the control group. Clicking on the 'Style 4' button takes the students to the lesson index screen and then to the lesson area where they can read the lesson objectives and watch the clips. The two other buttons are used by the students of the experimental group. As an existing user, the student logs into the Thinking Tool through the student interface using login name and password. Then the student clicks the 'Login' button where the system takes him to the 'lesson index' screen and then to the lesson area where he can learn the lesson according to his thinking style.

As a new user, the student clicks the 'New User' button where the system takes him to the 'new user' screen. The screen consists of the following fields:

1. Username: allows to enter username.
2. Password: allows to enter password.
3. Name: allows to enter name.

4. Sternberg-Wagner Self-Assessment Inventory statements: The inventory consists of 24 statements distributed on the three styles: Legislative, Executive, and Judicial. Thus, each style contains eight statements. Each statement can be rated by choosing one of the following ratings on a scale of 1-7 where each rating corresponds to how well a statement describes the student: 1=Not at all satisfactory; 2=not satisfactory; 3=nearly suitable; 4=somewhat suitable; 5=suitable; 6=very suitable; and 7=perfect

5. Register: allows to register after filling in all fields and stores all information in the database

Once the student presses the 'register' button, two message boxes appear. The first shows the score received for each thinking style on the assessment and the second is the 'User Registered Successfully' message.

Once logged in, the system takes the student, according to his thinking style, to view the 'lesson index' screen. Here the student highlights a lesson from the lesson index and presses the 'select' button. Then the system takes the student to the lesson based on his thinking style.

The 'lesson' screen consists of the following fields:
1. Lesson Text: allows user to read the lesson and any instructions.
2. Video: allows to watch the video clips teacher has attached.
3. Audio: allows to listen to the audio clips teacher has attached.
4. Image: allows to see the images teacher has attached.
5. Animation: allows to see the animation clips teacher has attached.
6. Lesson questions: allows to answer lesson questions.

# GLOSSARY OF TERMS

Abu Dhabi Educational Zone: is the educational department which is in charge of education in Abu Dhabi state's schools in the United Arab Emirates.

Achievement: In this study, it is the knowledge, concepts, terms, processes, and skills which the student acquires by undergoing the teaching process using the CAT software. Achievement is measured by the achievement test which the author prepared to serve the purposes of this study.

Biochemistry: is considered one of the main domains in chemistry. It refers to the field concerned with studying the chemical reactions which take place in bodies of living things in addition to the compounds formed by them

CAT: An educational computer program that individualizes the learning experience by offering different tasks and activities which meet the needs of the three thinking styles: Legislative, Judicial, and Executive.

Cognitive Style: An individual's preferred and habitual approach to organizing and representing information.

Computer-Assisted Instruction (CAI): Instruction that is delivered by a computer to teach the student and to direct the activities of the learner toward the acquisition of pre-specified knowledge or skills. The term is used synonymously with such terms as Computer-Based learning (CBL), Computer-Aided Instruction and Computer-Assisted Learning (CAL).

School Wide Optimum Model (SWOM): An integrated model which is based on modern knowledge and learning theories, as well as, several educational frameworks and programs that have had great impact on classroom success worldwide. The aim of this model is raising generations of self life-long, wise, productive, thoughtful learners. SWOM focuses on nurturing the heart, the mind, and the soul.

Thinking Style: A preferred way of thinking and expressing or using one or more abilities.

Zone of Proximal Development (ZPD): is concerned with how best to help learners learn. It is the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or collaboration of more capable peers.