DEVELOPING A COMPUTER AIDED LEARNING TOOL FOR TEACHING CONSTRUCTION ENGINEERING DECISION MAKING

Dr. Ahmed Sherif[1] and Hosnachah Mekkawi[2]

ABSTRACT

A large number of computer applications are being developed to make the learning experience more efficient, flexible, yet at the same time enjoyable. Computer-Aided Learning (CAL) tools could offer a better learning environment for construction engineering students. They provide an excellent opportunity to apply and test the management skills that they learned in classrooms, but never had a chance to implement in reality.

This paper reports on the first stage of a research that aims at the development of an interactive Computer-Aided Learning tool for teaching construction engineering decision making. The paper examines the factors that are essential for the successful implementation of this tool and analyzes similar available packages with respect to these characteristics.

First, the learning needs and the skills that are essential for the successful education of construction engineers are introduced. Different learning moods, educational methods and corresponding student behavior are overviewed. CAL, its applications, principles, advantages and disadvantages are discussed. The factors that are essential for the successful development of CAL tools are investigated. Available CAL tools that target construction engineering education are analyzed. Features of the new CAL tool are presented in the conclusion.

KEY WORDS

Education, construction engineering, building, decision-making, computer-aided learning.

INTRODUCTION

Engineering is one of the most important fields in modern technology. A great care should be given to engineering education, which is a critical factor contributing to the success of future engineers. Engineering education should not be limited to providing solid technical background and basic "fundamental skills" such as the logical thought process and computer literacy. It should extend to other "soft skills" (Hissey 2002). These are necessary for the harsh competition in today's workplace, where engineers need added skills and a wider scope of knowledge. With the speedy development in all the fields, engineers must be engaged in a self-learning lifelong process in order to remain in touch with latest research and technology.

[1] Associate Professor, Construction Engrg. Dept., The American University in Cairo, 113 Kasr El Aini Street, Cairo 11511, Egypt, Phone +20 2/7975337, FAX +20 2/5787361, asherif@aucegypt.edu

[2] Technical Coordination Engineer, Dar Al-Handasah Consultants (Shair and Partners), 15 Amr Street, Cairo 11511, Egypt, Phone +20 2/3449680, FAX +20 2/3461170, hosnachah.mekkawi@dargroup.com

Engineers also need to be creative, not only to develop new ideas and innovations, but also to come up with solutions for the new problems that arise from technological advancement.

The education of construction engineers is specifically related to acquiring the management skills that are utilized throughout the lifecycle of any given project. These management skills include directing the flow of work, adhering to commitments and deadlines, dealing with unexpected conditions, coordinating between participants, etc., as construction engineers should be able to work cooperatively with others, and have good communication and presentation skills (Arthur et al. 2002). Practice of the operational and management concepts before getting into the real world is fundamental to the success of these engineers. This is achieved through internships, which are usually limited in scope and restricted in time. Educational tools could prove very useful in this area. They could simulate real life situations in the safety of the classroom environment.

This paper reports on the first stage of a research that aims at the development of an interactive Computer-Aided Learning (CAL) tool for teaching construction engineering decision making. The paper examines the factors that are essential for the successful implementation of this CAL tool and analyzes similar available packages with respect to these characteristics. It concludes by introducing the main features of the new CAL tool.

METHODS OF LEARNING AND TEACHING

In order to integrate the “Fundamental” and “Soft” skills into the engineering curriculum, it is important to examine the educational methods and to understand more about the learning process, student behavior and retention. According to Wilson and Spears (2003), there are several modes for acquiring information. The first mode is the passive "Transmission" of knowledge through traditional lectures. Although this mode is the easiest and most frequently applied, it does not enhance students' analytical and interpersonal skills. A more effective mode of learning is "Acquisition" which is a conscious choice to learn. The material acquired in this case is based on the learner’s initiative. Another mode of learning is "Accretion," which is the gradual unaware acquisition of information. This method usually applies to habits and social rules. Finally, the new information deducted and inspired by one’s mind during reflection, interaction, creative expression is the "Emergence" mode of learning. It is based on one’s ability to analyze, create and innovate. This mode requires opportunity, time and space to reflect and come up with new ideas and conclusions.

The educational methods can generally be divided into two main categories, the “instructor-centered” approach and the “learner-centered” one. In the instructor-centered approach, teachers play the major role in controlling and directing the learning process. On the other hand, in the learner-centered approach, teachers facilitate the learning process for students who have different learning styles. The approach focuses on the student and the development of his self-learning skills, while adapting to individual differences between different students. It is variable and interactive, as the information is acquired by the student himself through exploration and discovery.

A different categorization of the educational methods includes the following five approaches (Saskatchewan Education 1991): "Direct Instruction," such as traditional lectures, questioning, demonstrations, etc., which suits the transfer of basic knowledge. "Indirect Instruction" includes inquiry, induction, problem solving, decision-making, and discovery. In

"Interactive Instruction," learning is achieved through discussions and sharing of opinions. This approach stimulates students, and enhances their argumentation and convincing skills. "Experiential Learning" which is an activity oriented approach that is based on students' induction, reasoning and deductions while conducting an experiment. It emphasizes the learning process rather than the output. This method could be very beneficial to students, but has resource, time and safety limitations. "Independent Study" enhances students' initiative and ability to learn on their own.

The direct instruction approach corresponds to the "Transmission" mode of learning. It could be considered an instructor-centered approach. On the other hand, the other approaches fall into the category of student-centered learning. They mostly correspond to the "Acquisition" and "Emergence" modes of learning, as students participate in getting the information and are capable of generating their own thoughts. They also involve some degree of "Accretion," since certain information will be transferred unconsciously to the student along the learning process.

COMPUTER-AIDED-LEARNING

Computer-Aided-Learning (CAL) could be successfully used in integrating the learning methods identified above in a unified system. In mid 1980s and early 1990s, CAL was described vaguely as "the use of technology in teaching" or as a set of programs designed to replace the traditional lectures (Oliver 2001). CAL is now defined as "an integrated approach for teaching a subject, in which a learning technology forms a part, and which only comes about after reassessment of the current teaching methods" (Oliver 2001). The term "aided" implies that the computer is not the only tool used in the learning process. CAL became a part of an integrated learning approach. There are many terms associated with CAL like Computer-Aided-Assessment and Visualization, Multimedia and Virtual Reality. These are all used to facilitate the understanding and experiential learning of users.

CAL could be applied through different techniques: the most commonly used applications are the tutorials, demonstrations and presentations. These are used to introduce new information and act as a review tool. More interactive forms of CAL include the "Drill and Practice" format usually applied when mastering a new information or skill is needed. It is used as a second step after the material has already been introduced. There is also the "Problem Solving" technique, capitalizing on the reasoning and analytical skills of students (Rist and Hewer 1996). Another interactive application of CAL is the "Games" format, which provides a motivating learning environment, taking advantage of the competitive interests of learners. The "Strategy" types of games seem to be more suited to CAL implementation, as they require some degree of logic and reasoning before taking action.

CHARACTERISTICS OF EFFECTIVE CAL TOOLS:

CAL tools could offer a better learning environment for construction engineering students. They provide an excellent opportunity to apply and test the management skills that they learned in classrooms, but never had a chance to implement in reality. They could promote group work in an environment where students learn how to cooperate and communicate with other team members. Furthermore, CAL could be more cost-effective than giving additional

classes or increasing class time or decreasing the number of students per class. It could also reduce operational costs. The cost of organizing field trips or acquiring expensive equipment could be significantly reduced by the use of CAL (Mason 1997).

However, applying the latest innovations in CAL might not always be successful. The structure of the tool, the message it delivers to students, as well as the degree to which it responds to the students' needs are among the factors that determine the success of the software. The main characteristics of an effective CAL tool could be summarized as follows:

1. Present Real-life situations: The project(s) selected for CAL implementation should be as realistic as possible by having some degree of complexity that provides a beneficial learning experience and a challenge to students. Yet, they should still be simple enough to be contained within a computer simulation that is accessible through widely available regular desktop computers (Al-Jibouri et al. 2001). The speed of today's computers improves simulation capabilities and enhances interactivity with the system (Gibbons et al. 1998).
2. Self-learning: CAL should ensure a degree of self-dependency during the learning process by creating a "learner-centered" system. The responsibility of understanding should be transferred from the instructor to students in order to create a feeling of urgency to acquire data. Acquiring the correct information, in this case, develops their sense of satisfaction and increases their self-esteem and need for further development (Issa et al. 1999). Moreover, CAL should allow students to set the pace of learning, thus giving time and chance for the "Emergence" mode of learning (Cooper 2003).
3. Non-Linearity and Interactivity: The flow of the CAL tool should be based on students' actions. Interactivity with the system could be provided at different levels. The first level is the stimulation of students' senses as they hear and see a simulation. The second level requires a small input from students in order to advance the learning process. This input ensures that students are alert and tests their comprehension. In the following level, students control the sequence of learning, which makes a significant difference from traditional sequenced lectures. In the highest level, students select the content of the material to be learned. Selection of the most suitable level of interaction depends on the given material, target student group and the degree of guidance required (Issa et al. 1999).
4. Degree of Guidance: Together with non-linearity, there should always be a degree of guidance concerning the branching of the program. This ensures that students will not greatly deviate from the correct path or feel lost within different branches.
5. Uncertainty and Novelty: Integrating uncertainty in CAL projects makes them realistic and teaches students how to respond to the unexpected occurrences in real life situations. Uncertainty could also be used to provide novelty by varying the nature of projects in different runs. This adds a challenging non-repetitive aspect to the game and overcomes one of the defects of CAL, which is the onset of boredom after few runs. The challenge is to provide different parameters at every run, so that it can be re-played differently by the student.

6. Assessment of User's Performance: Computers could easily, and automatically, keep a record of students' actions (Gibbons et al. 1998). This should be used to provide students with feedback in the form of assessment scores during, and at the end, of sessions. The record would also help teachers in evaluating students' performance.
7. Interface: The CAL tool should provide an attractive, user-friendly interface that utilizes efficient visualization techniques. On the other hand, extensive and inappropriate use of visual aids may lead to ambiguity. An important aspect of the interface is dual coding of information. People remember 20% of what they hear, 50% of what they see, and 70% of what they see and hear (Issa et al. 1999). Dual coding means strengthening the given information by using more than one medium. This enhances the recalling process. CAL should also exploit the speed and timing capabilities by showing actions in fast, slow or frozen motions (Gibbons et al. 1998).
8. Creativity: The interactive learning medium, the stress relief, together with the enjoyment provided by CAL should be utilized to stimulate students' creativity.
9. Enjoyment: Today's students are used to games and other entertaining computer packages. CAL applications should be attractive enough to rise to the expectations of these students by providing interesting forms of learning.
10. Safe Learning Environment: Safety includes both the physical and moral meanings. The computer provides a virtual, non-threatening simulated environment, where students can investigate activities, which may otherwise be difficult or unsafe to practice (Mason 1997). An example is construction site activities.

Implementation of CAL should also consider some of its limitations. Some students might not be at ease with the excessive use of technology. CAL tools might become ambiguous or overloaded, thus hindering the learning process (Mason 1997). Some learners might become disoriented because non-linear nature of CAL that lacks a system of cues or maps that could enable them to navigate easily, i.e. "discourse cues" (Gygi 1990). In addition, CAL applications will never be able to duplicate real-life fully, no matter how good they are. Many parameters are usually omitted for practical reasons. Thus, CAL tools should resemble reality as much as possible, while focusing on core activities. This could be considered an advantage because it allows students to concentrate and comprehend basic principles (Masson 1997). Furthermore, computers should complement the normal methods of teaching, as CAL deprives students of the personal contact and gestures of their instructors (Harasim 1998; Moore 1992; Feenburg 1998). Finally, development of the learning tool and investigation of the technical data could turn out to be costly and time consuming if not planned properly.

CAL PACKAGES FOR CONSTRUCTION ENGINEERING EDUCATION

Several CAL packages were developed for the education of construction engineering students. These tools had different forms, ranging from simple on-screen presentations, to demonstrations and tutorials as well as game formats. Earlier attempts at the development of CAL games for construction were as old as 35 years ago, where "The Construction Management Game" and "Constructo" were developed by Au et al. (1969), and Halpin &

Woodhead (1970) respectively. Since that date, many applications were introduced. Some were developed for teaching mechanics of materials like MD solids (mdsolids.com). Others, like "DEFLECT," aimed at teaching structural design (MacCallum and Hanna 1997). Many other games teach surveying. These include Survey, Isis (Mika 1996) and SurCAL, AshCAL and TrimCAL (Smith & Roberts 1997). The financial aspects of construction were also addressed by some packages like the “Equipment Replacement Game” and "A Simulation Game Aiming at Pricing Construction Contracts in a Competitive Market" (Nassar 2002).

A limited number of CAL games addressed the operational and managerial aspects of construction projects. This paper concentrates on these educational packages. Seven CAL games were selected representing the range of CAL types that are currently available in this area. A unique name was assigned to each game in order to facilitate identification.

1. The Hong Kong Game was developed by the Department of Real Estate at Hong Kong University. It teaches planning of on-site construction activities. A task is presented to students, together with alternative methods and activities. Students are required to make a sequenced list of selected activities and method statements, describing the rational for their selection (Marsh & Rowlinson 1999).

2. Contract & Construct (C&C) models contract management. It teaches trade-offs between cost, quality, time and safety, as well as decision-making and people-management. The program simulates the construction of a chemical plant, where students act as project managers aiming at the successful completion of their projects. In the first stage, students select contractors. In the second stage, construction activities advance automatically. Unexpected events and problems occur, challenging students to select appropriate decisions. (Martin 2000).

3. VIRCON (VIRtual CONstruction) teaches the basics of construction planning. The game is played by groups of students (contractors) biding for a given project. The VIRCON system -provided online- is used for project planning, scheduling, cost estimation, and documentation activities. Pre-bid reports are submitted to a “Board of Review” which selects the winning team. (Jaafari et al. 2001)

4. The Building Industry Game (B.I.G.) aims at the development of students' ability to analyze situations, gather data, and make strategic decisions while balancing time, cost and quality. B.I.G. is played by groups of students (contractors) submitting bids for given projects. To increase the challenge, the game generates an additional computer contractor X who also bids. Players start with the same financial position which changes during the game due to overhead costs, bidding expenses, and lack of work. B.I.G. produces dynamic balance sheets, which add profit and subtract costs and losses (Johnston et al. 2003).

5. The Management Game teaches project planning and control. It models the construction of a rock and clay fill dam. Students act as the contractor’s project manager who is responsible for the performance of earthworks. They report to the head office (the umpire), who can vary game parameters such as weather, site layout and other random events in order to give different levels of difficulty. Overheads and liquidated damages are accounted for (Al-Jibouri et al.2001).

6. COMMITTED links between the technical and management studies through presentation of the tendering stage. The first stage of the game involves tender preparation by students. The second stage handles project implementation, which includes selecting subcontractors and solving technical issues, while monitoring cost. The game also covers ethical issues and claims. (Hornibrook 1996)
7. Superbid aims at teaching the different factors that should be considered during the bidding process. Students, assuming the role of a general contractor, submit bids for program generated projects. Financial transactions such as loans and deposits can be made (Abu Rizk 1992).

ANALYSIS OF SELECTED CAL PACKAGES

Now, it is important to investigate the above games in relation to the main characteristics of an effective CAL tool, which were identified before. The analysis is based on the information published about these games in the references cited above.

1. Present real-life situations: Most of the applications present rather realistic projects. These were designed for game purposes, having variables controlled by instructors, as in the case of C&C, BIG, the Management Game, COMMITTED and SuperBid. A real-life project is even used as a case study in one of the applications (VIRCON). Some other applications concentrate on specific construction activities such as piling as in the case of Hong Kong Game. These activities are also realistic in nature.
2. Self-learning: All the games promote self-learning, because of their open-ended game format. They allow students to practice and learn various management concepts on their own. Some of these applications, such as the Hong Kong and the Management games, provide help tools allowing self-study of technical information.
3. Non-linearity and Interactivity: The studied packages offer a limited degree of non-linearity. The game structure or role-playing assumed by these games implied that students are the ones making decisions in regards to selection of their paths. However, the programs do not present enough path options for selection by students. Some games offer interactivity with other applications, such as the Hong Kong Game, which gives access to a note pad that enables students to write method statements while remaining within the game mode.
4. Degree of Guidance: One of the games providing a notable degree of guidance is The Hong Kong Game. It includes a corrective feedback mechanism that allows students to modify their answers accordingly. It also offers a theoretical overview in the form of diagrams and illustrations describing the activities that are not familiar to students. In addition, the optimum solution is also offered at a late stage of the program. Other forms of guidance are provided by some of the applications, such as the Management Game, through assistance screens or right-clicking on relevant screen parts.
5. Uncertainty and Novelty: The occurrence of unexpected events is common in many games. For example, the second stage of C&C application focuses on uncertainty and unexpected events. In both B.I.G. and the Management Game, the administrator

controls several variables such as weather and material cost during the game. In the B.I.G. he may also generate change orders during work. However, the majority of these games are limited in terms of novelty. They do not provide means for changing game parameters during different runs. This could be overcome by altering the unexpected events in each case.

6. Assessment of User's Performance: Counters are used by some applications to assess performance. The C&C game includes different counters for cost, time, quality, morale and safety. These change according to students' decisions. Superbid defines the winner as the player having the highest return on investment. B.I.G. uses financial results, such as profit, as means for assessment. Reports are also used for assessment. These could take the form of financial data as in Vircon, where groups submit their bid costs and durations. They could also take the form of work programs and financial plans, which are submitted before and at the end of the game in the Management Game. A simpler approach is adopted by Committed and the Hong Kong Game, where students describe and comment on their performance in a final report.
7. Interface: All the games provide simple user-friendly interfaces. Most games use consecutive windows and forms with navigation buttons, as in the case of C&C. They may also depend on pressing parts of the screen as in the case of the Management Game. The same is for the first module of VIRCON, which provides a user-friendly interface for data entry and analysis, and a databank for each project. The user builds these by filling required edit-boxes. Some games limit their interface to forms, tables and reports such as B.I.G., where no graphical illustration of activities is used. While other games utilize the dual coding of information by including explanatory diagrams and video clips, as in the case of the Hong Kong Game and the Management Game. This is expanded in VIRCON, which includes a "Schedule Simulator" that illustrates the duration of the activities in a 3D presentation, and 3D "Walk-Through" tool.
8. Creativity: The level of student creativity promoted by these games is closely related to the amount of non-linearity and guidance offered. It also relates to uncertainty provisions. These vary between the different games as discussed before.
9. Enjoyment: According to the authors, most of the games provide a joyful non-traditional learning experience.
10. Safe learning environment: All the games provide a kind of safe learning environment. VIRCON's 3D walkthrough and the videos of the construction operations presented by the Hong Kong Game and the Management Game expose students to the on-site techniques while remaining in the safety of their classrooms.

CONCLUSION

CAL tools could offer a better learning environment for construction engineering students. They provide an excellent opportunity to apply and test the management skills that they learned in classrooms, but never had a chance to implement in reality. An effective CAL tool should present real-life situations, promote self-learning, provide non-linearity and

interactivity, while maintaining a suitable degree of guidance. It should allow for uncertainty and novelty. It should also be able to effectively assess user's performance and to offer a user-friendly interface. In addition, effective CAL should promote creativity, enjoyment, and provide a safe learning environment. Analysis of the available CAL game packages revealed the areas of their strength and the areas that require some improvement.

A new CAL package is currently under development. It builds on experience obtained from previously developed packages, while achieving the characteristics discussed in this paper. The new CAL package focuses on improving students' decision-making skills in the aspects related to the excavation and foundation phases of building construction. Like the investigated games, the new software is a combination of "Role-Playing" and "Strategy" game formats. It covers excavation related activities, namely excavation equipment, dewatering and soil support methods, together with other important concepts such as mobilization, surveying, safety, overtime shifts and reporting. Students would act as construction managers. They are allowed to make mistakes and given options for rectification. The flow of the game is non-linear, as it depends on students' actions. Different alternatives are offered to students for dewatering, soil support and excavation, with corresponding steps and quality actions. If the methods selected are not correct, students will be faced with unexpected problems that must be solved. Ignoring important steps such as soil investigation or safety precautions will also cause consequent problems. In order to achieve a high score, students should watch three given counters: Cost, Time and Quality. Cost and time should be watched against the contract budget and duration. The Quality counter, however, changes according to student decisions and the selection of available quality procedures. To ensure that students will not make random decisions, some tricky unnecessary options or activities are offered. Selecting these increases the cost and time, and decreases the quality counter. The program keeps a record of students' actions. This record is used to give students feedback and evaluation of their performance at the end of the game. Guidance will be available in the form of corrective messages, charged consultancy and help buttons linking to help files. The interface is simple and user-friendly. Information concerning different processes is presented separately in the form of associated help files. In order to allow for novelty, the instructor is allowed -in a separate application- to design different projects by varying parameters such as type of soil, site area, type of support, etc.

REFERENCES

Abou Rizk, S. (1992). "A Stochastic Bidding Game for Construction Management." *Second Canadian Conference on Computing and Civil Engineering*, CSCE, Ottawa, Ontario.

Al-Jibouri, H. Saad and Micheal J. Maudesley, (2001). "Design and Experience with a Computer Game for Teaching Construction Project Planning and Control". *Engineering Construction and Architectural Management*: 8 5/6, p.418-427.

Au, T., Bostleman R. L. and Parti E. (1969), "Construction Management Game – Deterministic Model", *ASCE Journal of Construction Division,* Vol. 95, pp. 25-38

Contract and Construct - User Guide. Contract and Construct Homepage. (www.Contract-and-Construct.com last cited 18 February 2006)

Cooper, O. Elisabeth (Winter 2003) "Competing with Computer Games Revolutionizing Engineering Education". *Quest.* Volume 6, issue 1.

Feenburg, A. (1998) “The written world”, in : R. Mason & A. Kaye (Eds.) *Mindwave: communication, computers and distant education*. Oxford: Pergamon Press.

Gibbons, Andrew S., and Fairweather, Peter G. (1998). *Computer-Based Instruction: Design and Development*. New Jersey: Educational Technology Publications.

Gygi, K. (1990) “Recognizing the Symptoms of Hypertext ... and What to do about it” in B. Laurel (Ed) *The Art of Human-Computer Interface Design*, Reading: Addision-Wesley.

Halpin, D., Woodhead, R., W., (1973) *Constructo - A Heuristic Game for Construction Management*, University of Illinois Press, Champaign, Illinois.

Harasim, L. (1989) 'Online education: a new domain', in: R. Mason & A. Kaye (Eds.) *Mindwave: communication, computers and distant education*. Oxford: Pergamon Press.

Hissey, Ted W. (2000). “Enhanced Skills for Engineers”. *Proceedings of the Institute of Electrical and Electronics Engineers (IEEE)*, Vol. 88, No. 8, p. 1367-1370.

Hornibrook, F.J. (1996) “Further Development of the Construction Management Game (COMMITED)”. *Proceedings of 1996 IEEE International Conference on Multi-Media Engineering Education*: p.71-76.

Issa, A.R. Raja, Robert F. Cox and Clifford F. Killingsworth (1999) “Impact Of Multimedia-Based Instruction on Learning and Retention”. *Journal of Computing in Civil Engineering*: 281-290.

Jaafari, Ali, Manivong, K. Kitsana and Chaaya, M. (2001). “Vircon: Interactive System for Teaching Construction Management.” *Journal of Construction Engineering and Management:* p66-75.

Johnston, Hal, Him Borland and Kevin Craig. (2003). Building Industry Game (B.I.G) A Computer Simulation for Construction Management. *Proceedings of the 39th Annual Conference* The Associated Schools of Construction (ASC), Clemson University - Clemson, South Carolina, pp 79-90. (available at http://www.asceditor.usm.edu/archives/2003/Johnston03.htm)

MacCallum C, Hanna, R (1997). “DEFLECT: A Computer Aided Learning Package for Teaching Structural Design”, *HABITAT*, Issue 3.

Marsh, Jonathon and Steve Rowlinson (Winter 99). “CAL in Construction: Attitudes to Learning”. *HABITAT*, Issue 8: p5-7.

Martin, A. (2000/1 8). “A Simulation Engine for Custom Project Management Education”. *International Journal of Project Management*, 18, 201-213.

Masson, Alan. (July 97). “The Use of Simulations in Education”. *HABITAT*, Issue 4.

MDSolids Homepage <www.mdsolids.com>

Mika, Steven (June 96). “Information System”. *HABITAT*, Issue 2.

Moore, M. G. (1992) ‘Distance education theory’, *American Journal of Distance Education*, 5, 3, 1-6.

Nassar, Khaled, (2002). “Pricing Construction Contracts in a Competitive Market: A Simulation Game”. *ASC Proceedings of the 38th Annual Conference*: April 11-13, 47-54.

Oliver, Andrew (2001) *“What is Computer Aided Learning (CAL)?”*. University of Hertfordshire. LTDU Learning and Information Services <http://www.herts.ac.uk/ltdu/learning/whatiscal.pdf >

Rist, Roger and Hewer, Sue. Chapter 2: What is Learning Technology? - Some Definitions in the book “*Implementing Learning Technology*” edited Stoner, G. (available at http://www.icbl.hw.ac.uk/ltdi/implementing-it/what-def.htm) Heriot-Watt University, 1996.

Smith, J, Martin and Bethin W. Roberts (July 1997). “Teaching Engineering Surveying Through Computer Aide Learning”. *Habitat*, Issue 4.

Saskatchewan Education (1991, last modified 6 September 2000). *Instructional Approaches – A Framework for Professional Practice.* Saskatchewan Education, USA. URL: (available at http://www.sasked.gov.sk.ca/docs/policy/approach/index.html)

Wilson, Leslie, and Spears, Andrea (1997, last updated 3/05). “*Types of Learning*”. (http://www.uwsp.edu/education/lwilson/learning/typesofl.htm last cited 18 February 2006)