

**VIRTUAL SIGN ANIMATED PEDAGOGICAL AGENT TO  
SUPPORT COMPUTER EDUCATION FOR DEAF LEARNERS**

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entitled

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ABSTRACT

A Virtual Sign Animated Pedagogic Agent (VSAPA) is a software tool designed to support a computer-based learning environment for Deaf and Hard of Hearing (D/HH) students. The topic "webcam communication" was used as a demonstrative case study. The usability of the VSAPA learning environment was evaluated on D/HH students in comparison with those of static VSAPA picture and video interface. The results revealed that the VSAPA learning environment facilitated task performance in terms of ability and time to complete the tasks. The results showed significant interface effect on user task performance between the VSAPA and static picture in time spent for doing exercises, but not in time spent for going through the content at their own pace. However, the percentage of participants completing the exercises without error (effectiveness) was slightly higher in the VSAPA group. D/HH students' performance in doing exercise is significantly higher in the VSAPA group when compared to the static. Upon comparing the effect of interface between VSAPA and video, the mean task time was higher in the video group both in studying the context and doing exercises. However, the ability to do exercise of D/HH students in both groups seemed to be similar. Rating of participants' satisfaction by using the system usability scale showed the highest rate in VSAPA interface, followed by video and static picture. To explore the use of the VSAPA learning environment, a multimedia course on Information and Computer Technology (ICT) was implemented to forty D/HH students that were randomly divided into three experimental groups and one control group. The first group received ICT learning via the VSAPA learning environment. The second group was exposed to the same ICT content via a Hearing Teacher via Sign Language Interpreter (HTSLI). The third group studied by themselves using Text-Assisted (TA) instruction. The control group received none of the above interventions. The results showed that students exposed to the VSAPA learning environment had higher percentage gain in the post-test when compared to those in the HTSLI and TA groups. The D/HH students also had high positive attitudes toward the VSAPA learning environment. This study suggests that incorporating a Virtual Sign Animated Pedagogical Agent into a multimedia learning environment can enhance D/HH students' learning.

KEY WORDS: SIGN ANIMATED PEDAGOGIC AGENT/ DEAF AND HARD OF  
HEARING / COMPUTER-BASED LEARNING / USABILITY TEST

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ผู้สอนด้วยภาษามือเสมือนเพื่อช่วยการเรียนรู้คอมพิวเตอร์สำหรับคนพิการทางการได้ยิน

VIRTUAL SIGN ANIMATED PEDAGOGICAL AGENT TO SUPPORT COMPUTER EDUCATION FOR DEAF LEARNERS

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#### บทคัดย่อ

ผู้สอนด้วยภาษามือเสมือน (VSAPA) เป็นเครื่องมือที่พัฒนาขึ้นด้วยโปรแกรมคอมพิวเตอร์เพื่อทำหน้าที่สอนหรือแนะนำการเรียนการสอนในสภาพแวดล้อมของบทเรียนคอมพิวเตอร์ที่พัฒนาขึ้นสำหรับนักศึกษาที่มีความพิการทางการได้ยิน โดยใช้บทเรียนคอมพิวเตอร์เรื่อง “การสื่อสารผ่านทางกล้อง webcam” เป็นกรณีศึกษา และทำการทดสอบการใช้งาน VSAPA ในบทเรียนแบบสื่อผสม โดยการเปรียบเทียบลักษณะการใช้บทเรียนคอมพิวเตอร์ระหว่างกลุ่มที่ใช้ VSAPA กลุ่มที่ใช้ รูปภาพ VSAPA (STATIC VSAPA) และกลุ่มที่ใช้วีดิทัศน์ภาษามือ (VIDEO) ในการสื่อสารกับผู้เรียนที่มีความพิการทางการได้ยิน ผลการทดสอบพบว่าเวลาที่ใช้ในการทำแบบฝึกหัดของบทเรียนระหว่างกลุ่มผู้ใช้ VSAPA และกลุ่มผู้ใช้ STATIC มีความแตกต่างกันอย่างมีนัยสำคัญ แต่เวลาที่ใช้ในการศึกษาบทเรียนไม่มีความแตกต่างกันอย่างมีนัยสำคัญ แต่อย่างไรก็ตามผู้เข้าร่วมการทดสอบสามารถทำแบบฝึกหัดโดยไม่มีข้อผิดพลาดทางโปรแกรมมีจำนวนสูงกว่าในกลุ่มของ VSAPA ดังนั้นความสามารถในการทำแบบฝึกหัดของนักศึกษาที่เรียนด้วย VSAPA มีมากกว่านักศึกษาที่เรียนด้วยรูปภาพหนึ่งของ VSAPA เมื่อเปรียบเทียบผลการใช้บทเรียนระหว่างกลุ่มที่เรียนด้วย VSAPA และกลุ่มที่เรียนด้วย VIDEO พบว่ากลุ่มที่เรียนด้วย VIDEO ใช้เวลามากกว่ากลุ่มที่เรียนด้วย VSAPA ทั้งการเรียนรู้อบบทเรียนและการทำแบบฝึกหัด แต่อย่างไรก็ตามความสามารถในการทำแบบฝึกหัดของนักศึกษาทั้งสองกลุ่มสามารถทำแบบฝึกหัดได้ผลพอกกัน สำหรับการวัดผลความพึงพอใจในการใช้บทเรียนทั้งสามรูปแบบพบว่านักศึกษามีระดับความพึงพอใจในการใช้ VSAPA สูงที่สุด รองลงมาคือรูปแบบบทเรียนที่มี VIDEO และรูปแบบบทเรียนแบบ STATIC ตามลำดับ

การทดลองเพื่อประเมินผลสัมฤทธิ์ทางการเรียน โดยการสุ่มตัวอย่างนักศึกษาพิการทางการได้ยินจำนวนสี่สิบคน แบ่งออกเป็นสี่กลุ่มละสิบคน ได้แก่ กลุ่มที่ 1 คือกลุ่ม VSAPA ซึ่งเรียนจากผู้สอนด้วยภาษามือเสมือน กลุ่มที่ 2 คือกลุ่ม HTSLI ซึ่งเรียนจากผู้สอนที่เป็นคนจริงผ่านทางล่ามภาษามือ กลุ่มที่สามคือกลุ่ม TA ที่ผู้เรียนต้องเรียนด้วยตนเองผ่านทางตัวอักษรหรือข้อความ และกลุ่มที่ 4 ซึ่งเป็นกลุ่มควบคุมซึ่งไม่ได้รับทั้งสื่อการสอนและผู้สอนใดๆ ผลการทดสอบพบว่านักศึกษาที่เรียนด้วย VSAPA สามารถทำแบบทดสอบหลังเรียนได้เปอร์เซ็นต์ที่สูงกว่าเมื่อเทียบกับกลุ่ม HTSLI และกลุ่ม TA นอกจากนี้นักศึกษายังมีทัศนคติที่ดีต่อการการเรียนรู้ด้วย VSAPA ซึ่งผลการวิจัยนี้แสดงให้เห็นว่าผู้สอนด้วยภาษามือเสมือน (VSAPA) สามารถใช้เป็นเครื่องมือในการเรียนการสอนแบบสื่อผสมเพื่อเพิ่มพูนการเรียนรู้เทคโนโลยีคอมพิวเตอร์ได้

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## **CHAPTER I**

### **INTRODUCTION**

Teaching a student who is deaf or hard of hearing has taught with a wide variety of modalities depending on his or her individual needs, the area of the home town in which he or she lives, the school's capacity, and the student's individual abilities. These modalities of approach to teaching include the oral, sign language, or total communication. One of the most pressing concerns regarding the education of Deaf and Hard of Hearing (D/HH) student is their lack of academic success as measured by literacy rates. The sign language approach includes the use of sign language, manually coded. The total communication approach is a combination of oral language and sign language. Sign Language is a visual - gestural language, i.e., it is perceived visually and produced by body movements. This language is based on the idea that for D/HH persons, sight is the most useful tool for communicating and receiving information. As a symbol of distinct culture, Thai Sign Language (ThSL) is a distinct language with its own grammar and vocabulary (Suwanarat, 1991). ThSL uses hand shape, position, body movements, gestures, facial expressions, and other visual cues to form its words. For people who use ThSL as the first or preferred language, Thai becomes a second language, and they have difficulty in reading, writing, understanding and expressing ideas in conventional grammar. These difficulties result from the complications of working between two languages in two different modes (Hear to Help, 2003-2004).

Teaching D/HH students is challenging in most countries. In traditional class instruction, D/HH college students typically learn with the assistance of sign language interpreters (Long & Beil, 2005). Each student has his/her own specific needs and may or may not require support from others with a similar type of hearing loss. Understanding the characteristics of students who are deaf or hard of hearing, as well as the communities in which they live, is an important step toward developing effective instruction and appropriate assessment for these students (Thurlow, 2009). In Thailand, some D/HH persons have difficulties in commanding the Thai language and

need explicit instructions to replace the spoken and help in the written language. This is due to the communication method they used at primary schools and/or facilities. The lack of opportunity to learn new words and broaden their vocabulary is another concern. One of the major problems for D/HH students is learning science and technology. They have difficulty understanding and using specific terminology because the technical language is often English, which might be a third language for them. In addition, the students are taught the content by supporting staff (an interpreter, note-taker, or lip-speaker) that are unlikely to be specialists and have difficulty in understanding the terminology themselves. Most of the information is provided in the written form, which is very difficult for many deaf people to follow. The average reading level for D/HH students at the time of their high school graduation remains at the fourth grade level (Singleton et al., 2004; Wilbur, 2000). The only practical way to make information more accessible to D/HH is to provide the information in a sign language. However, there is still no accepted standard writing system for sign languages, the only way to store and represent sign language is in the form of image sequences.

Despite advances in computer technology, the present teaching-learning for D/HH students both in school and college still rely on the conventional sign language interpreter. In the traditional classroom, all communications are triangulated through the interpreter and fingerspelling - a form of manually coded communication. This is a slow method, about 40 percent as fast as the normal speaking rate (Turkington & Sussman, 2004). Furthermore, fingerspelling is frequently a primary source of errors in the interpretation process, even from professional sign language interpreters (Seal, 2004). The Educational Interpreter Performance Assessment (EIPA) indicates that a level-four interpreter (out of five levels) is only able to interpret approximately 80% of the information accurately (Schick, Williams & Kupermintz, 2006). One of the most important skills for successful interpreters is the ability to understand the information they are seeing or hearing, decide what the message means and how to translate the information into another language (Patrie, 2000). Sign language interpreting is thus an essential supporting service for many deaf students, but until recently little was known about how well deaf students learned via interpreting (Harrington, 2000; Lang, 2002). Jacobs (1977) demonstrated that deaf

college students who depended on sign language interpreting learned significantly less from classroom instruction than hearing peers. Thus, it is important that teachers understand the characteristics of natural sign languages that make them effective as visual-gestural languages for communication. Educators are urged to think visually in order to help maximize opportunities for deaf students to use their visual learning skills in developing Information and Communication Technology (ICT) skills, and their general academic, social, and personal development.

The rapid advance in technology has offered the opportunities for using video, text, graphics, and communication for Deaf education (Akhtar, 2003). However, the subject matter of ICT is technical and abstract and the D/HH students especially those in Thailand often have difficulties with technical vocabulary and problem solving. There is still no ready Thai Sign Language (ThSL) for common ICT terms. To help D/HH employment disparity, in a field with a continuing demand for qualified ICT workers, educators must find a more effective way such as using the animated pedagogic agents to teach D/HH students the necessary skills and knowledge required for subsequent information technology career success.

Pedagogical agents have recently been considered as social learning models that possess the ability to display life-like character for supporting the process of learning (Baylor & Plant, 2005; Craig, Driscoll, & Gholson, 2004). They have also been designed to facilitate learning in a computer-mediated learning environment (Johnson, Rickel, & Lester, 2000; Atkinson, 2002). In a multimedia learning environment, where a pedagogical agent is implemented, the learning contents are delivered through the verbalized instructional messages spoken by the agent as well as the multiple presentations on screen such as graphics, texts, sounds, and animations. Several research works reported that the pedagogical agent helps increase learners' score and has positive effects on learner's attitude toward learning and performance (Baylor, 2000; Baylor, 2002a; 2002b; Baylor & Ryu, 2003; Moreno, Mayer, Spires, & Lester, 2001). Some examples of pedagogical agents in computer learning are Steve (Johnson & Rickel, 1998), Auto Tutor (Graesser, Moreno, & Marineau, 2003) and Cosmo (Lester, Converse, Stone, Kahler, & Barlow, 1997), who have the ability to provide explanation and feedback as well as monitor students performing tasks by delivering modalities with speech, text and gesture. Although several pedagogical

agents have proved to be successful in teaching Information Technology (IT) among the hearing population (Lewis, 2003), whether such an instructional paradigm could address the specific issues and deliver comparable learning experiences to D/HH students still remains to be investigated.

Although video sign language has been used to facilitate D/HH (Fang, 2002), it has several drawbacks. Recording a video of sufficient sign quality is expensive and time consuming, and videos are difficult to correct or revise. There is also a problem of the bandwidth required for downloading from the Internet. Most importantly, the videos are signer dependent and inherently two-dimensional. Visual perception of sign language video needs more regions sufficient spatial and temporal resolution to capture the detailed movements of the signer. Perception of motion (Virsu, Rovamo, Laurenen, & Nasenen, 1982) and detailed spatial vision of the face region was found to be important for comprehending of sign language (Muir & Richardson, 2005). Moreover, the platform would be updated through the script authoring process.

Advances in computer technology have lead to the creation of a Virtual Sign Animated Pedagogical Agent (VSAPA) which is a virtual human-like computer interface character that inhabits a computer-based learning environment. VSAPA provides D/HH students with pedagogical assistance such as presenting explanation, directing attention and giving advice on learning strategies via sign language (Saksiri, 2006). This study explored the effectiveness of the VSAPA in ICT learning environment on D/HH college students' achievement in principles of computer and communication system.

Recent research efforts have aimed to incorporate 3D animations of signers or sign avatars for various applications: using avatars in educational settings, in sign language recognition and translation. Related research investigates the possibility of machine translation of text into (animated) sign language. Sign animations have a number of advantages over static pictures, photos, or videos of human signers (Liesbeth, 2002). They show signs more completely than pictures and photos, because information of sign dynamics is included. A number of 3D animations technologies allow the user to view the sign from every perspective as well, so that hand location and shapes are clearly visible. For example, Vsign (Vsign, 2003) created

3D animated avatars that perform sign language motions together with a player. VisiCast (Visicast, 2003) developed a 3D model of a signing person to accompany subtitles and teletext information on digital television. Vcom3D (2007-2008) is currently developing leading edge software to teach reading to the deaf. Recently Adamo-Villani (2005) developed instructional materials with embedded digital signing avatars for K-3 mathematics curriculum for deaf students and their teachers and parents. Furthermore, Huenerfauth (2008) developed a classifier predicate 3D sign language generator consisting of a movement root and a classifier handshape that can be incorporated into English as American Sign Language translation.

The signing avatar technology has been used extensively to produce interactive multimedia for deaf children. For example, Mathsigner<sup>TM</sup> - a 3D animated American Sign Language (ASL) is an interactive software package designed to teach K-6 math concepts, signs, and corresponding English terminology to deaf children (Adamo-Villani, 2005). SMILE<sup>TM</sup> is an immersive virtual learning environment in which D/HH children ages 5 – 10 employed in learning Science, Technology, Engineering, and Mathematics (STEM) concepts and ASL terminology (Adamo-Villani & Wright, 2007).

In computer-based learning environment, animated pedagogical agents are believed to enhance the learning, especially in the affective and motivational aspects of learning experiences (Atkinson, 2002). For example, STEVE was designed to interact with students in networked virtual environments (Johnson et al., 2000). ADELE was designed to run on a desktop platform with conventional interfaces to integrate with web-based learning material and runs in the student's web browser (Johnson, 1998). Cosmo (Lester et al., 1997) is a 3D character that occupies the Internet Advisor, a learning environment for the domain of Internet packet routing. None of these agents, however, is accessible to D/HH learners because these learning environments are controlled by voice synthesis and the content is text-based.

The development of sign animated interface agents provide a new way of D/HH student interaction by applying features of face-to-face human communication to human-computer interaction. These agents have a range of functions depending on the environment they inhabited: (a) they can provide a learner with opportunistic instructions through which they can respond and adapt dynamically to a surrounding

environment including a learner (Moreno et al., 2001): (b) they can demonstrate how to perform a task (Sampson et al., 2002): (c) they can focus a learner's attention on certain elements or aspects of instructional systems using gestures, locomotion, or gaze (Atkinson, 2002): and (d) they can provide nonverbal as well as verbal feedback on learners' actions.

A number of instructional benefits of animated pedagogical agents have been claimed and studied although no one agent has provided all of the benefits to date (Johnson et al., 2000). These animated pedagogical agents may have a positive impact on learners' motivation and perceived experience of interaction with the system. They may direct learners' attention to the system or tasks through the use of motion, gesture, and facial expression, and thus improving learning outcomes by providing learners with contextualized advice.

This study aimed at constructing a Virtual Sign Animated Pedagogical Agent (VSAPA) to be used as an instructional tool to communicate with D/HH students via Thai Sign Language (ThSL). The VSAPA was developed to effectively convey sign language in combination with facial expression. The VSAPA was based on avatar technology for 3D sign representation of computer content, and innovative pedagogical strategies. The usability of the VSAPA in teaching a webcam communication to D/HH students was evaluated, in comparison with those of video and a static VSAPA picture. This study explored the effectiveness of the VSAPA in ICT learning environment on D/HH college students' achievement in principles of computer and communication system. The effects of VSAPA will be compared with other two different delivery methods i.e. a Hearing Teacher with Sign Language Interpreter (HTSLI) and Text Assisted (TA) instruction.

## **1.1 Significance of the Study**

D/HH people face challenges in the workplace because of their dependence on visual communication in environments that typically use aural/oral communication to convey important information. These challenges have led to the under-representation of D/HH people in the workforce. Learning computer and

information technology in the self-control environment will increase the opportunities of D/HH students to acquire knowledge and skills in IT. This will also increase their opportunities in studying on other subjects such as sciences, mathematics and engineering. Working in the area of IT requires less communication with others and thus reduces a main barrier of D/HH students. Nowadays, there are many D/HH persons who are good at technology. The only barrier in learning and acquiring more skills is the lack of appropriate teaching media and technology.

From a social equity perspective, the quality of computer instruction for D/HH students needs to be improved. This is because quality of computer instruction tangibly affects a graduating D/HH student's prospects within the Information Technology (IT) industry. IT is a field that offers highly rewarding career opportunities to qualify and competitive D/HH graduates. Based on recent data from the National Science Foundation (NSF, 2004), people with disabilities constitute only 7.3% of the workforce categorized as computer and mathematical occupations, as compared to 8.9% of the general American workforce that is disabled. Although in Thailand have no exactly these records. It is obvious that there are few D/HH workers in the Information Technology (IT) industry. To help close this representative employment disparity, in a field with a continuing demand for qualified workers, educators must find more effective ways to teach D/HH students the necessary skills and knowledge required for subsequent information technology career success. VSAPA learning environment, the study set out to explore, might indeed be an effective pedagogical tool in leveling the playing field for the target learners.

A study on the effects of VSAPA implemented in multimedia based instruction in postsecondary computer education is important for several reasons. Firstly, understanding the effects of VSAPA in computer education, in general, is important for selecting and designing effective tools. Educators should select instructional tools that are conducive to the learning environment and audience. Secondly, understanding attitudes of D/HH college students (who are not computer inclined) toward computer could assist attracting under-represented groups to the discipline. Because attitudes influence learning, instructional designers should design and develop tools that can positively change one's attitude about learning and "majoring" in computer.

## 1.2 Definition of Terms

The following are key definitions that are used throughout this study.

*Deaf* - Those individuals whose hearing loss is extreme - 90 decibels or greater. Even with the use of hearing aids or other forms of amplification, for people who are deaf the primary means of developing language and communication is through the visual channel (Hardman, Drew, & Egan, 1999). This term refers to individuals for whom audition is not the primary mode of communication and who have lost their hearing prior to acquiring a spoken language (prelingually deaf). Some authors make a distinction between "deaf" and "Deaf," the former relating to an audio logical definition and the later to a cultural definition (Neidle, 2000).

The uppercase D in Deaf is frequently used to reflect the view that being Deaf is a cultural and linguistic phenomenon rather than a medical anomaly. In this dissertation, the researcher utilize the capitalized form in application to both Deaf and hard of hearing people with the understanding that not all individuals consider themselves culturally or linguistically Deaf. The capital D is used to reflect the view that as in other cultural groups, the Deaf culture is rich and diverse that includes Deaf and hard of hearing people from all walks of life. Perhaps more importantly, the being Deaf is more relevant to language and communication rather than medical issues.

*Hard of Hearing* - Those individuals whose audition is deficient but remains somewhat functional. Individuals who are hard of hearing have enough residual hearing that, with the use of a hearing aid, are able to process human speech auditory.

*Deaf and Hard of Hearing student (D/HH)* - In this study a deaf student refers to a student whose hearing impairment is so severe as to require placement within a special education program. These students exhibit a wide range of hearing loss and communication characteristics. The hearing loss of these students ranged from moderately severe to profound. These students were all deaf adolescents.

*Educational Interpreting* - The educational interpreter is responsible for providing interpreting and other support services to deaf and hard of hearing students in the school or college. The primary function is to facilitate communication among deaf and hard of hearing students and their hearing peers, the classroom teacher, and other personnel in the institution. Interpreters relay information to deaf students using

some form of sign language or English sign system (Stuckless et al., 1989; Marschark et al., 2002; Stedt, 1992).

*Direct Communication Environment* - When a teacher and other deaf children use sign language directly with each other without going through a third party (an interpreter). The deaf student receives all information directly and has full access to all of the communication occurring in his or her classroom (Quigley & Kretschmer, 1982).

*Mainstreaming* - The placement of deaf students in regular school classrooms which can include attending some special classes or being fully mainstreamed. The term "mainstream" is preferred in the field of deaf education, and is used much more frequently than are the terms "inclusion" and "integration." There are a number of different ways for deaf students to be mainstreamed. Some of the options are: 1) complete inclusion in general education classes without any support; 2) complete inclusion in regular classes with some support services; 3) partial inclusion in regular classes with a portion of the time spent in a resource room where the deaf child may receive individualized instruction provided by a deaf educator; 4) co-teaching team that includes a general educator and deaf educator; 5) reverse mainstreaming with a small number of hearing students enrolled in the deaf students' classes; 6) self contained classes where deaf students attend a few academic-related general education classes; 7) self-contained classes where deaf students attend a few nonacademic general education classes; and 8) education in self-contained classes on a full-time basis (Quigley & Kretschmer, 1982; Marschark, 1997).

*Virtual Sign Animated Pedagogical Agent (VSAPA)*. An animated pedagogical agent may be defined as a human-like, computerized character that appears on the computer screen during instruction whose purpose is to facilitate learning by using sign language to communicate with learners.

*Thai Sign Language (ThSL)*. ThSL is a visual-gestural language used as a primary means of communication by a very large portion of the deaf population in Thailand. ThSL has a unique grammar and syntax. It is unrelated to Thai, although reflecting its influences. ThSL also uses fingerspelling (the manual alphabet in Thai and American) to spell out words including proper names and technical terms.

*Fingerspelling.* Using hand shapes and positions to manually produce the 26 letters of the written alphabet. Manual alphabets, found throughout the world, are not a natural language but invented by educators and derived from a written language. Fingerspelling can either be used by itself or together with a sign language to spell out proper names or technical words.

*Manually Coded English (MCE)* consists of a system of codes that were created for use in educational environments. These codes borrow lexical signs from American Sign Language (ASL) and put them into English word order (Rachel Ann Heenan, 2006).

*Self-paced Learning* – The self-paced learning is a learning environment in which the learner proceeds through a linear or non-linear computer-generated lesson at his or her own pace and without the presence of a human teacher.

*Total Communication (TC)* is a philosophy of communication. TC includes the use of sign language, invented signs, speech, body language, lip-reading, amplification, reading, writing, mime, and pictures (Denton, 1972).

### **1.3 Research Questions**

This experiment was designed to address three research questions. Specifically, they are as follows:

- 1.3.1 What is the effectiveness and efficiency of VSAPA?
- 1.3.2 What is the satisfaction of D/HH users on VSAPA?
- 1.3.3 Does VSAPA support D/HH persons in learning computer?

### **1.4 Summary**

D/HH students who primarily depend upon visual sensory inputs to process information during computer education class lectures have negatively affected student learning delivered through traditional instructor-centered. With a growing emphasis on learning electronically, research is needed to examine whether technology-based learning is fully accessible to deaf learners and whether VSAPA can be an effective pedagogical tool in leveling the playing field for the deaf population.

The study was proposed and carried out to fulfill real needs and to explore opportunities to do so. It aimed to design, develop, implement and evaluate a delivery system that would VSAPA learning environment to enhance D/HH college student learning of computer content. The design of the new system would account for environmental variables and be tailored to D/HH computer education majors and other students who study computer subject as a degree requirement. “Webcam Communication” was selected to implement and evaluate the system prototype during the spring 2008 semester. A multiple-case study methodology was chosen to collect, analyze, and report on the data.

The organization of this dissertation is as follows: Chapter 2 provides the background in and basic knowledge of the Human Computer Interaction (HCI), the biomechanics and modeling of the human body, and sign avatar. Chapter 3 is concerned with the methodology of development of VSAPA model and development of VSAPA learning system. A VSAPA evaluation and the effects of a VSAPA on Information and Communications Technology (ICT) learning will also be shown in this chapter. Chapter 4 gives the result of the proposed VSAPA learning system. Chapter 5 discusses the design and development of the VSAPA learning system. Finally, the conclusions and further work will be provided in Chapter 6.

## **CHAPTER II**

### **LITERATURE REVIEW**

This chapter consists of a review of relevant literature, which is divided into four main sections. The first section reviews research involving deaf education, animated pedagogical agents and their implementation into multimedia-based learning environments. The second section highlights social agency theory, which suggests that computer programs containing animated pedagogical agents can increase learner enjoyment of the instructional program and positively influence learning. The third section is dedicated to presenting research on cognitive load theory and methods in which this theory can inform instructional design. Finally, the fourth section emphasizes the development of a virtual sign language pedagogical agent which is closely related to the advancement of computer technologies and their applications in the studies of sign languages: modeling of the human body, design of virtual gestures, construction of virtual gesture sessions, and conversion of the sessions into virtual signings in a particular sign language. All of these topics can be logically correlated within the scope of human-computer interaction.

#### **2.1 Deaf and Hard of Hearing Education**

Since D/HH persons perceive information through their visual sensory, most D/HH students would gain more information through direct communication than interpreted educational setting, however, there is little sign language interpreter who has skill in the specific discipline such as Mathematics, Computer or Science. Moreover, teaching through interpreter making the information loss from the translation due to the misunderstanding or concept ignorance of interpreter. While the problems also emerge from instructor who may not have experience teaching D/HH students causing the misperception of D/HH persons when using the same teaching tools as hearing peer students. Learning evaluation aspect is also one point to concern.

Educational interpreting has become one of the most important issues in educating deaf students today, students who are deaf or hard of hearing and use sign language as their primary mode of communication would access to sign language interpreting in educational setting. As mainstream academic placement has become the primary means of educating D/HH students, a serious shortage of qualified sign language interpreters has developed. More and more mainstreamed deaf children now depend on educational sign language interpreters (Marschark et al., 2002). In fact, most interpreters work in school and college environments (Stedt, 1992). Professionals in the field of deaf education claim that deaf and hard of hearing students receive an equal opportunity to education just like their hearing peers through sign language interpreters. Successful interpreters have many skills and one of those skills is the ability to understand the concept they are seeing or hearing, decide what the message means and how to translate the information into another language (Patrie, 2000)

As in mainstream schools, most children at college own a mobile phone: the freedom and spontaneity of text messaging has an obvious appeal for deaf children. Many of them also have video phones at home, which enable them to communicate using sign language.

To facilitate uniformity in use and enhance the access to any sign language for improving literacy of the deaf, ICT as a communication medium and learning instrument such as

a) The use of text messages (SMS messages) and e-mailing has opened up a new door for deaf people. This gives deaf people or the hearing impaired a new way of communicating.

b) The interactive whiteboard can be used as a teaching tool for demonstrating what to do because students can see what is happening without listening to the instruction.

c) Instructions can be written with the demonstration.

d) Allowing the interaction without listening or speaking.

Despite the expansion of Deaf people communication technology usage, little is published about how they use electronic communication in their walk of lives and the implication on their concepts of identity and community. Australia is an ideal research base because there is a widespread of technology usage. From the

international study, for example, the Australian Association of the Deaf acquired the wide range information of deaf people by mail. The results showed that Short Message Service (SMS), telephone typewriters (TTY), voice/TTY relay services, fax, and email were used regularly. Deaf users arbitrarily select their communication tools upon many reasons: SMS for social and personal interaction, TTY for longer communication (using the relay service in case of no TTY service), fax for business and social contact and computer as the personal and business email as well as Web browsing, chat room, word processing, games and study.

Nowadays, The D/HH education around the world has been using ICT as a tool supporting the communication, for example, using interactive smart boards to explain, demonstrate and share their work. ICT is opening up new avenues of communication for many deaf children. It is widely agreed that the most effective forms of ICT to use with deaf children are highly visual rather than reliant on the written word or sound. The student can use digital camera capturing work for self-assessment and as subjects for discussion as well as to learn ICT skills. However, the situation in Thailand still dragged behind with lacking of both hardware and software for D/HH learning resource. Many of Thai D/HH students are fluent in using Internet information while digital cameras and video cameras are also invaluable visual tools for learning.

## **2.2 Animated Pedagogical Agent**

The recent introduction of animated pedagogical agents-as mechanisms for instructional delivery-has provided computer-based learning environments with a means of incorporating motivational and life-like characters to aid in the knowledge and skill acquisition of users. An animated pedagogical agent is a computerized, life-like tutor that resides in a multimedia learning environment whose purpose is to assist learning. With its humanistic communication capabilities, an animated agent is able to direct learners' attention to the appropriate element of a problem-solving task using gestures, gaze, and locomotion. Moreover, multimedia learning environments incorporating animated pedagogical agents offer key features that traditional tutoring

programs seem to lack. In particular, animated agents enrich and broaden the communicative relationship between learners and computers as well as provide computers with motivational and affective instructional features that actively engage students (Johnson, Rickel & Lester, 2000). Additionally, simply having an animated agent present in a multimedia learning environment can positively influence the learner's perceptions of their educational experience (Lester, Converse, Kahler, Barlow, Stone & Bhogal, 1997). The combination of an interesting animated agent and a well-structured learning environment optimizes a learner's active engagement with the task and increases the probability of future interactions with the instructional program (Johnson et al., 2000). The available empirical research suggests that animated pedagogical agents nested within multimedia learning environments serve to enhance the learner's ability to transfer knowledge from one situation to another as well as to increase his or her enjoyment of the experience working with the learning tutorial (Atkinson, 2002; Johnson et al., 2000; Mayer, Sobko & Mautone, 2003).

Lester, Converse, Stone, Kahler and Barlow (1997) contributed one of the earliest empirical investigations to the animated pedagogical agent literature by designing a computer-based learning environment that incorporated interactive animated pedagogical agents that provided instruction on botanical anatomy and physiology. Specifically, Lester and colleagues sought to determine if animated agents possessing multiple levels of advice and modalities enhanced students' problem-solving abilities. Learners participated in Design-A-Plant - a learning environment in which they were expected to design eight plants that could thrive in four different environments, each with varying environmental conditions. Located within the learning environment was Herman the Bug, an animated pedagogical agent who provided varying levels of guidance and advice depending on condition - to learners during the lessons. One hundred middle school students were assigned to one of five conditions in which the advice of the animated agent ranged from no advice at all to only principle based verbal advice to the maximum amount of advice needed to assist students during problem-solving. Once students finished their session with the learning environment, they completed a posttest to assess their knowledge of botanical anatomy and physiology. Overall, the findings suggested that animated pedagogical agents positively influenced students' problem-solving performance with their greatest

impact being on complex problems. Further, animated agents who possess multiple levels of advice in combination with multiple modalities produce a more positive impact on problem-solving ability than do agents who are minimally expressive and produce no advice at all. Thus, the study by Lester et al. offers substantial advice for multimedia instructional designers, that are, incorporating fully expressive and life like animated agents into computer-based learning environments increases motivation as well as promotes problem-solving and deep levels of cognitive processing.

Using the *Design-A-Plant* learning environment created by Lester et al., (1997) Moreno, Mayer, Spires and Lester (2001) conducted a series of experiments regarding the presence or absence of an animated agent in conjunction with the delivery of instructions through speech or on screen text. Across five experiments, learners were asked to work with *Design-A-Plant*, an environment that required the learners to create plants that could flourish under specified environmental conditions. In the initial experiment, undergraduate college students received instruction via Herman the Bug whereas 24 students received the same verbal and visual instruction - in the form of on-screen text without the agent. Students spent between 24 and 28 minutes completing the tutorial on botanical anatomy, which involved the design of eight plants. Findings indicated the students guided by the agent scored statistically significantly higher on complex transfer problems than did the group who were provided text-based instructions and did not have the assistance of the agent. Moreover, participants in the agent group reported an increased interest in the material and anticipation to continue interactions with the program. Subsequently, Moreno et al. successfully replicated the findings of the first study with 7th grade students. Students in the agent condition significantly outperformed students in the textual/no agent condition on transfer tests as well as rated their experience with the tutorial as being more enjoyable. Results from additional investigations supported the usage of an animated pedagogical agent in conjunction with verbally narrated instructions as a tool for optimizing learning. This research suggests that bringing together verbal and visual modalities of instruction with humanlike features increases the propensity that deeper learning can occur through the mediation of a surrogate instructor.

Craig, Gholson and Driscoll (2002) investigated a computer-based learning environment wherein an animated pedagogical agent provided lessons on

lightning formation. Specifically, Craig et al. (2002) examined the efficacy of the agent's physical properties (i.e., agent-only, agent with gesture, no agent) and the picture displays (i.e., static, sudden onset, animation) presented on screen during instructional segments. In particular, the researchers wanted to determine if the display of an animated agent caused learners to focus their attention solely on the agent and not on the relevant pictorial information (split-attention effect). The animated agent (a male character) was positioned behind a podium so that only the top half of his body was present. Further, the animated agents supplied verbal content explanations in combination with simultaneous visual displays of lightning formation - the no agent condition also supplied narrations of the instruction. One hundred thirty five undergraduate participants were equally placed into one of nine conditions wherein instruction -lasting 180 seconds - was offered with or without an agent and with three varied forms of pictorial features. When coupled with any of the pictorial exhibits, the presence or absence of the animated agent during the computer-based tutorial did not produce any statistically significant differences. The findings did not indicate a split attention effect when the animated agent was on the screen along with the pictorial information.

Craig et al. (2002) conducted a subsequent experiment involving animated agents in order to test the redundancy effect. The redundancy effect posits that the presentation of redundant information may be detrimental to the learner's performance. The animated agent provided verbal instructions (agent spoken-only), textual instructions (agent printed-only) or concurrent verbal and textual instructions (agent spoken plus printed) regarding lightning formation. Seventy-one participants interacted with the lightning tutorial, which lasted 180 seconds. Participants in the agent spoken-only condition outscored their peers in both the agent printed-only condition and agent spoken plus printed condition on tests of matching and retention. The findings supported the redundancy effect in that the verbal explanations combined with identical textual instructions interfered with the learner's performance on the matching tests. Results from the Craig et al. study highlight pertinent implications for instructional designers: (a) instructions orally delivered by animated agents appear to be superior to textually presented instructions, which is consistent with previous research (e.g., Mayer, 1997; Mayer et al., 2003) and because of this superiority (b) an

emerging need exists to include animated agents into learning environments to orally provide instructions as opposed to conventional text-based instructions.

Atkinson and his colleagues (2001) extended the empirical research to a multimedia-based instructional program that contained a computer-designed animated agent that presented instructions on proportional reasoning word problems. The animated agent provided instructions on mathematical worked examples with a human voice or a computer-generated voice in addition to exhibiting gestures and visual cues. Moreover, the animated pedagogical agent displayed verbal (instructional elaborations) and nonverbal behaviors (gestures, gaze and movement) that directed the learner's attention to the appropriate element of the worked example. Fifty college students were randomly assigned in equal proportions to the human voice condition or the computer voice condition. Participants spent 35 to 40 minutes working in a computer-based learning environment wherein they studied worked examples on proportional reasoning. Once the participants maneuvered through sequential steps of the instructional worked examples, they completed four near transfer problems (structurally resembled the worked examples), four far transfer problems (structurally distinct from the worked examples), and a speaker survey form. Findings indicate that participants in the human voice group statistically outperformed participants in the computer voice group on near and far transfer measures. Furthermore, participants who received instructions through the human voice rated the animated agent more positively than did the participants in the machine voice group. Therefore, the presence of an animated agent with particular humanlike characteristics prompts a social conversation with the participant amidst academically oriented instructions through a multimedia-based environment. Presumably, the learner attends closely to the instructional material and learns more deeply (Atkinson et al., 2001; Lester, Stone & Stelling, 1999; Mayer et al., 2003).

Recently, Atkinson (2002) examined animated agents and their ability to serve as computerized tutors in order to highlight specific features of a multimedia-based learning environment. Specifically, Atkinson examined whether the delivery method of instructional elaborations (aurally or textual) in conjunction with the presence or absence of an animated pedagogical agent (Peedy the parrot) had an effect on learning outcome measures. During the instructional component of the study, 50

college students were exposed to a computer-based learning environment (35 to 40 minute duration) that contained a series of worked examples regarding proportional reasoning word problems. Depending on their condition, learners were guided through the instructional tutorial with an agent (voice-plus-agent, text-plus-agent), without an agent (voice-only, text-only) or without an agent or instructional elaborations (control). Upon completion of the mathematics tutorial, learners were administered tests of near and far transfer. Findings indicated that the participants who were exposed to the agent in combination with narrated instructions significantly outperformed control participants who were not exposed to an animated agent on both near and far transfer tests. Additionally, the participants who received instructions verbally outperformed their counterparts who received textual instructions on near transfer items. Participants in the voice conditions indicated that the worked examples were less difficult than did participants in the textual and control conditions. Subsequently, Atkinson attempted to replicate the initial study by placing students in mixed (voice-plus-agent) or single (voice-only, text-only) modality conditions to receive instructional elaborations regarding mathematics word problems. Seventy-five college students, equally assigned to three conditions, interacted with the computer-based tutorial on proportional reasoning for approximately 35 to 40 minutes. Again, students receiving instructions verbally from an agent significantly outscored their peers in the textual condition on near transfer, and outscored both the voice-only and text-only conditions in terms of far transfer performance. These findings concur with the presumption that aurally (mixed modality) delivered instructions support deeper learning than text-based descriptions (Mayer, 1997; Mayer et al., 2003). An interactive environment between a learner and an animated agent with the capacity to narrate explanations facilitates deeper levels of learning.

To date, research on animated pedagogical agents has yielded favorable results in support of incorporating animated agents into multimedia learning environments. However, little research has been conducted that examines the degree of animation that an agent must possess in order to be effective. In light of this void, Baylor and Ryu (2003) investigated student perceptions of agents who were either static or animated. Seventy-five preservice teachers participated in a computer-based learning environment that presented a case study in which students had to design an

instructional plan to teach supply and demand. Participants were assigned to work in one of three versions of the program: (a) fully animated agent condition, which employed gestures, (b) static agent condition using only a static image, or (c) no-image condition which only provided textual instructions. Across each condition, students received identical amounts of guidance, verbal instructions and textual instructions that appeared in a text bubble, which corresponded to the verbal explanations. The animated agent guided learners through the learning environment, provided examples and advisements that promoted the learner's understanding of the assignment. The experimental sessions required students to participate for approximately 90 minutes. Following exposure to the learning environment, learners were administered measures that assessed their perception of the agent - specifically, how engaging, person-like, credible and instructor-like was the agent. Performance measures were also collected which evaluated the learner's accuracy and performance during the learning environment. Results indicated students in the fully animated condition found the agent to be more engaging and more instructor-like than their peers in both the static agent condition and the no-image condition. Further, students exposed to the fully animated condition indicated that the agent was more person-like than students in the static agent condition. Students rated the agent in the fully animated and static conditions more credible than students in the no-image condition. Finally, no statistically significant differences among conditions were found in terms of performance during the learning environment.

Learners in the Baylor and Ryu (2003) study indicated that an agent possessing the most human like characteristics was more engaging, person-like, credible and instructor-like. Therefore, designers of animated agents should develop believable, life-like agents that are fully expressive as opposed to relying on stationary images of agents. Although the fully animated agent appeared superior in terms of student perceptions, it did not produce a greater level of performance relative to the additional two conditions. In order for animated agents to be optimally effective surrogate tutors, they must create social relationships with learners and promote deeper levels of understanding and learning.

Although the value of allowing animated agents to verbally guide learners through learning programs appears salient, the physical attributes and personality of

the agents must be considered in order to ensure their optimal impact on learning. According to Johnson, et al. (2000) in order for agents to be optimally beneficial in their environment they must be life-like and believable. Animated agents that possess human like characteristics afford learners more enjoyable and engaging interactions and ultimately a more fulfilling learning experience. Further, agents should display humanistic behaviors because computer-like behaviors present an obvious discrepancy from life-like characteristics and could interfere with the learner's attention to the content. Life-like animated agents simulate face-to-face interactions between computers and learners. Upon the learner's establishment of a humanistic connection with a computer based environment, the residential animated agent can demonstrate learning tasks, guide the learner through tutorials, provide emotive verbal and nonverbal feedback and direct the learner's attention to the most important aspects of the instruction using gaze, gesture and locomotion.

As substantiated with the previous review of literature, adding an animated pedagogical agent into a learning environment to provide academic lessons in a variety of domains has yielded favorable performance and learning results. Further, research has suggested in order for agents to be maximally effective, they should be life-like, emotive, engaging characters. However, animated agent research has yet to examine the level of humanistic attributes that are necessary for an agent to possess to remain effective in terms of learning performance. Discovering the degree of life-like characteristics needed by agents has practical implications for instructional designers and future research. Specifically, if an animated agent that displays little humanistic traits is equivocal to a fully expressive agent, the programming efforts of designers can be reduced while still offering effective instructional devices. Identifying the effective animated agent will enable future researchers to tease out which physical properties allow the agent to foster learning (i.e., voice, movement, tactics to direct learner attention such as gesture and gaze). Therefore, the current study sought to answer the previous question by manipulating the humanistic properties of three versions of an animated agent to determine which agent aids in the creation of an environment most conducive to learning.

### 2.3 Social Agency Theory

One theoretical framework for considering the effectiveness and utility of fostering simulated human-to-human connections in multimedia learning environments is social agency theory (Mayer et al., 2003; Moreno, Mayer, Spires, & Lester, 2001). According to this theory, multimedia learning environments can be designed to encourage learners to operate under the assumption that their relationship with the computer is a “social” one, in which the conventions of human-to-human communication apply as described by Reeves and Naas (1996). Essentially, the theory posits that the use of verbal and visual social cues in computer-based environments can foster the development of a partnership by encouraging learners to consider their interaction with the computer to be similar to what they would expect from a human-to-human conversation. For instance, the environment might rely on verbal social cues, such as a standard accented voice, or visual social cues, such as an animated agent that utilizes dynamic non-verbal signals (e.g., gaze, gesture, facial expressions), to encourage learners to approach this situation as if they are engaged in a human-to-human conversation.

Once this social partnership is established, learners can rely on several basic human-to-human social rules that guide their interaction with the multimedia learning environment (Mayer, et al., 2003). According to Grice (1975), these social rules include the *cooperation principle* and its four associated maxims. Specifically, Grice proposed that in human-to-human conversations, an individual listening to another person speaking will assume that he or she is making a concerted effort to make sense by being informative, accurate, relevant, and concise. Thus, the assumption of social agency theory is that learners will assume that the speaker in the multimedia learning environment-like a typical human speaker-is attempting to make sense.

According to social agency theory, priming the social interaction schema will cause the learner to try to understand and deeply process the computer's instructional message concerning academic subject matter. Mayer (1999, 2001) has posited that the cognitive processes that learners employ in order to understand an instructional message include: (a) selection of relevant information, (b) organization of patterns of information, and (c) the integration of prior knowledge with newly

presented information. The ability to process information with deep levels of understanding--that is, to engage in *sense making processes*--will affect whether the learner is able to transfer what was learned to related problem-solving endeavors.

Additionally, the social agency theory seeks to determine the conditions under which learners interpret their interaction with a computer-based learning environment. Specifically, do learners perceive their computer experiences as an instance of social communication or information delivery? The difference between the two descriptions of human-computer interactions affects the learner's schema activation, levels of cognitive processing, and the quality of learning that takes place. Learners may perceive an interaction as social if they are able to receive the social cues necessary to form a simulated human-to-human conversation with the computer--cues that we posit are provided by friendly on-screen agents who speak in a human voice. Perceiving the computer as a social partner encourages the learner to engage in a sense making process that increases the probability of positive transfer (Mayer et al., 2003).

In contrast, a learner may identify a computer interaction as being a case of *information delivery* (Mayer et al., 2003). In this instance, the computer may incorporate weak social cues--perhaps by utilizing a computer-synthesized voice--that fail to foster an authentic social partnership with the learner. As a result, the learner does not rely on his or her sense-making processes, as in a case of social conversation, but merely attempts to learn by memorization. Due to the learners' inadequate cognitive processing (i.e., poor selection of information and ineffective organizational and integration strategies), their performance on subsequent tests of transfer will suffer.

In a typical educational setting, a social exchange--including verbal and nonverbal interaction--can naturally occur between a teacher and learner in conjunction with the presentation of academic material. However, when a learner is engaged in a computer-based learning episode, the opportunity for a social exchange between the learner and the learning environment is often times nonexistent (Mayer et al., 2003). Recently, Moreno et al (2001) have proposed a solution to this problem by incorporating animated pedagogical agents into multimedia learning environments in an effort to foster the development of a social relationship between learners and

computers. According to the social agency theory, the combination of a multimedia learning environment and an animated agent elicits verbal and visual social cues that create virtual relationships between agents and learners as substitutes for authentic human-to-human interactions that possess the social properties employed in a human conversation. Moreover, animated agents assume the role of a human teacher giving instruction and feedback as the learner acquires and processes new information. Social agency theory stipulates that the life-like characteristics and behaviors of an animated agent prompt the social engagement of the learner, thus allowing the learner to form a simulated human bond with the agent.

In sum, research on social agency theory suggests that the integration of an animated agent into a learning environment is better able to promote social agency than environments absent of an agent. According to social agency theory, learners will establish a social relationship with the computer when social cues are elicited during the computer program. Therefore, learners may perceive an animated agent that provides the greatest amount of visual and verbal social cues as being more social and subsequently these learners may experience higher performance marks than learners exposed to less expressive agents. In order to investigate this issue, the present study assessed the level of social agency for three varying forms of animated agents by administering a social agency survey to learners.

## **2.4 Cognitive Load Theory**

Cognitive load may be defined as “a multidimensional construct representing the load that performing a particular task imposes on the learner's cognitive system” (Paas, Tuovinen, Tabbers, & Van Gerven, 2003, p. 64). The cognitive load construct contains two dimensions: (a) a dimension responsible for the interaction between learner and task characteristics, and (b) an assessment dimension consisting of mental load, mental effort and performance. Mental load refers to the burden placed on learners due to instructional parameters whereas mental effort is the amount of working memory resources that are dedicated to an instructional activity. Further, performance consists of learner achievements (i.e., accuracy of learner responses) accomplished during instructional sessions (Paas, 1992; Paas et al., 2003).

A chief concern of cognitive load theory (Sweller, 1988) is “the development of instructional methods that efficiently use people's limited cognitive processing capacity to stimulate their ability to apply acquired knowledge and skills to new situations (i.e., transfer)” (Paas et al., 2003). Specifically, cognitive load theory provides guidelines that aid in instructional design endeavors. Moreover, cognitive load theory is based on the assumption that a cognitive architecture exists that contains a limited working memory and a presumably unlimited long-term memory. This theory examines how restrictions placed on working memory during learning activities can aid in the creation of effectively designed instruction (Renkl & Atkinson, 2003). Working memory is responsible for storing information that is being actively processed, such as problem solving activities; however, working memory has a very limited storage capacity. In fact, previous research has suggested that working memory can hold relatively few chunks of information at one time (Miller, 1956). Accordingly, cognitive load theory strongly suggests that instruction be designed in a manner that minimizes the presentation of information that is not directly relevant to learning so that the working memory does not become overloaded. Preventing working memory from becoming overloaded may increase the probability of information being successfully transferred from working memory into long-term memory. Because actively processing information during learning trials occurs in working memory, it is necessary to highlight the different types of cognitive load included in cognitive load theory that may impose restrictions on the working memory.

In sum, cognitive load theory can assist instructional designers by providing guidelines for the development of instructional materials that exploit the capacity of working memory as opposed to overloading such. However, to analyze the amount of cognitive load imposed by specific instruction, cognitive load must be directly assessed. Previous research involving cognitive load tends to assume the degree of induced cognitive load based on performance scores instead of relying on direct measurements of the construct. Recognizing the need to directly assess the amount of cognitive load placed on learners in multimedia learning environments, the present study assessed the amount in which learners' perceive cognitive load during

the presentation of worked examples and practice problems included in the computer-based tutorial.

Furthermore, the current experiment employed a direct, subjective measure of cognitive load adopted from Paas and Van Merriënboer (1993) that assesses task difficulty. In particular, learner ratings of perceived task difficulty were collected throughout the instructional phase of the experiment. Using task difficulty to quantify cognitive load is a reliable technique, in fact "a direct link exists between cognitive load and the difficulty of the learning materials, because this difficulty is a direct result of the intrinsic and extraneous load of the materials" (Brunken et al., 2003). Moreover, employing methods that assess task difficulty as an indicator of cognitive load have been heavily relied upon in this line of research (see Kalyuga, Chandler, & Sweller, 1998, 2000; Kalyuga et al., 2001; Paas & Van Merriënboer, 1993, 1994; Van Gerven, Paas, Van Merriënboer, & Schmidt, 2002).

## **2.5 Human Computer Interaction**

Human Computer Interaction/Interface (HCI), is about designing computer systems that support people so that they can carry out their activities productively and safely; or Human Computer Interaction (HCI) is, put simply, the study of people, computer technology and the ways these influence each other. The study in HCI is to determine how researcher can make this computer technology more usable by people; and Human Computer Interaction (HCI) is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them. From the above definition, four important ideas stand out: people, computing systems, interaction, and usability.

The term people here refers to an individual D/HH student working together to learn a multimedia learning system with VSAPA, human video sign recorded or static VSAPA. Many people think of a user-centered interface when considering HCI. The term human computer interface instead of user interfaces because the domains of the user and the user population have been changing rapidly. Computing systems differ from traditional computers. Computing systems include

computer vision, computer graphics, image processing, operating system, and informatics. Usability is concerned with a system's simplicity to learn and its efficiency and effectiveness to use. Researchers evaluate the usability of a system they have developed by implementing and testing the design. Finally, interaction or interface is the key word in HCI. Thomas & Hewett (2006) describe HCI as an interdisciplinary area with emphasis on the joint performance of tasks by humans and machines, and the structure of communication between human and machines. For example, in the domain of computer science, the interaction takes the form of application design and engineering of human interfaces, in psychology, that of application of theories of cognitive processes and the empirical analysis of user behavior, in sociology and anthropology, that of interactions between technology, work, and organization, and in industrial design, that of interactive products.

## **2.6 Human Modeling**

The human body is too complex an organic structure to be described clearly in one section. In the research areas of HCI and computer graphics related to the studies of the human body, the emphasis is on how to apply the biomechanical features of the body to model a virtual human and to simulate the body movements. The skeletal structure of the human body is often used to describe the body motion. In human body modeling and animation simulation, there are two basic approaches: (1) record the motion by using motion capture systems and then modify or retarget such a motion to create individuality, and (2) create computational models that are controlled by a few parameters. The first step in modeling the human body and simulating of its movements is to describe the body joints mathematically, specifically, the joint locations, motion centers and axes, and the relationships among the joints.

## **2.7 Sign Avatar**

Sign avatar is a virtual human or cartoon that can serve as a working platform for sign language users. The principles of constructive learning are especially

relevant to the education of D/HH students. The technology has advanced to the point where software programs are available to create them from text (Jemni & Elghoul, 2007), voice (IBM's "SiSi" ("SayitSignit")), live signing (Morrissey, 2008), and sign-writing systems such as HamNoSys (Hanke, 2002). Signing avatars have been created in many sign languages.

Avatars have also been used to interpret television news and other programs, to teach sign language (Royal National Institute for the Deaf, 2008; Jemni & Elghoul, 2007), for sign language research (Nelson, 2009), on internet social and information sites (Elliott, Glauert, Kennaway, Marshall & Safar, 2008; Kennaway, Glauert & Switserlood, 2007), to facilitate better communication between deaf and hearing people (Glauert, Elliott, Cox, Tryggvason & Sheard, 2006) and are increasingly being used for teaching school subjects to deaf children (Vesel, 2005; Adamo-Villani, Doublestein & Martin, 2005).

## **2.8 Usability Test**

Usability, a key concept of human-computer interface, is concerned with making computer systems easy to learn and easy to use through a user-centered design process. Poorly designed computer-based interactive multimedia system can be extremely annoying to users. Referring to any software product, from the users' point of view the user interface is the most important component, since it is what the users see and work with when using a product. A good design of the user interface results when designers understand people as well as technology. The designers must understand who will be the users of their products, their personal characteristics, their physical capabilities, their goals and the tasks they need to accomplish, the circumstances under which they work.

A product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use. Effectiveness is defined as the accuracy and the completeness with which specified users achieve specified goals in particular environments. Efficiency refers to the resources expended in relation to the accuracy and completeness of goals achieved. Satisfaction is defined as the comfort and the acceptability of the system for its users and other people

affected by its use. Usability is therefore intended as a high level goal of system design. The overall standard ISO 9241 contains guidance on user interfaces design, and provides requirements and recommendations which can be used during the design and evaluation of user interfaces (ISO 9241, 1998).

## **2.9 Summary**

Although the researches have indicated that the animated pedagogical agents are the effective instructional components in computer-based learning environments, it still needed to investigate the environments in which agents significantly contribute to learning. Cognitive load theory suggests that an animated agent with little expression placed in a simple learning environment will create an environment in which learning is optimally fostered. However, social agency theory suggests that a fully expressive animated agent will positively influence learning due to its large provision of social cues. Further, a need exists to assess the cognitive load of multimedia learning environments that include animated agents in combination with worked examples. In particular, the type of cognitive load (i.e., intrinsic, extraneous and germane) that is imposed on learners during their interaction with animated agents and worked examples during computer-based tutorials needs to be assessed to determine which aspects of the student's interaction with the program (i.e., complexity of the material, superfluous instruction) are overloading. Measuring cognitive load relative to varying forms of expressive on-screen agents and worked example complexity is needed to directly assess and determine the existing level of cognitive load rather than assuming an amount of imposed cognitive load due to the complexity of the domain and/or problem-solving performance. Empirical investigations are warranted to determine if a performance gap exists when learners are exposed to the worked examples with varying degrees of complexity and if the worked examples are interceded by the presence of an animated agent.

## **CHAPTER III**

### **METHODOLOGY**

In a scenario of accessibility to computer education, which also incorporates user-system interaction by means of signing into ThSL, the current work addresses to the population of D/HH Thai students of postsecondary level, aiming at developing a platform with animated signing in ThSL by a virtual human tutor or avatar . The development of a sign language interfacing system is closely related to the advancement of computer technologies and their applications in the studies of sign languages: modeling of the human body, design of virtual gestures, construction of virtual gesture sessions, and conversion of the sessions into virtual signings in a particular sign language. All of these topics can be logically correlated within the scope of human-computer interaction. In this chapter, some of the recent work related with the proposed sign language interfacing system will be introduced: modeling of the human body, development of VSAPA model, development of VSAPA learning system and design and evaluation of a VSAPA.

### **3.1 Modeling of the human body**

In the research areas of Human Computer Interaction (HCI) and computer graphics related to the studies of the human body, the emphasis is on how to apply the biomechanical features of the body to model a virtual human and to simulate the body movements. In this section, the skeletal structure of the human body is used to describe the body motion. The first step in modeling the human body and simulating of its movements is to describe the body joints mathematically, specifically, the joint locations, motion centers and axes, and the relationships among the joints.

There are three basic steps in multilevel deformation modeling creating a rigid body for the skeleton, modeling muscle design and deformation, and generating skin. The first step considers the basic structure modeling: the definition of the joints,

their positions and orientations, and the geometric model that describes the body hierarchy. Next, muscles are attached to bones across joints and work like springs along action lines which have a fixed endpoint and a movable endpoint.

## **3.2 Development of VSAPA model**

VSAPA model was developed using an iterative, user-centered design approach (Norman, 1986). Construction of the VSAPA model comprised two main stages: the modeling stage and the animation stage.

### **3.2.1 Modeling Stage**

In the modeling stage, the VSAPA was given specific controls to make animating facial expression and hand-shape signs easier (more intuitive). The modeling processes included editing object surface or material properties (e.g., color, luminosity, diffusing, and shading components), adding textures, and adjusting macro muscles and other features. Objects were fitted within a skeleton, a central framework of an object with the capability of affecting the shape or movements of that object. The shaped model supported the process of animation: the movement of the skeleton automatically affected the corresponding portions of the model.

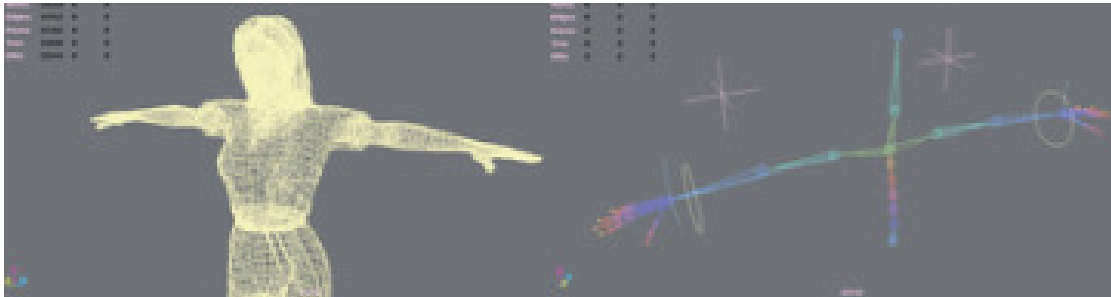
#### **3.2.1.1 Head Modeling**

A virtual head model was created by deforming the prototype 3D mesh and texture with overlaid texture elements from the 3D software library. The head model was connected to the body parts and animated to produce a variety of facial expressions.

#### **3.2.1.2 Body Modeling**

The completed head model was imported to the 3D computer graphics software to fit the body to the neck. This was done by placing the body below the head model and editing the body mesh to create a matching counterpart to the neck cutoff contour. The biped skeleton was created by fitting the biped inside the mesh and subordinating both neck and body to the same control (Figure 1). The same spine

object of the biped skeleton was used to synchronize the movements between neck and body.



**Figure 1. Composition of the VSAPA Model**

### **3.2.2 Animation Stage**

The VSAPA was composed of two main animation components: face and hand animation. In this study, the skeletal animation technique was used. It involved construction of a series of 'bones', and each bone had a 3D transformation (position, scale, and orientation) and an optional parent bone. The series of bones therefore formed a hierarchy. Animation was performed to change bone transformation over time, under the influence of an animation controller for hand and facial expression.

#### **3.2.2.1 Facial Expression**

The head model (with embedded muscles and bones, facial macro-muscle libraries, and facial animation sequences from the 3D library) was imported into 3D computer graphics software. These files stored all data needed to animate the head model mesh. The 3D computer graphics skeletal animation was saved and used as a reference upon authoring facial animation in the library. The model played facial animations synchronized with a skeletal animation. In animation mode, the animation library was used to place and tune the expression along the timeline and added to the body parts. In this process, Thai Sign Language (ThSL) video clips were used as a reference for animating. Examples of the results are shown in Figure 2.

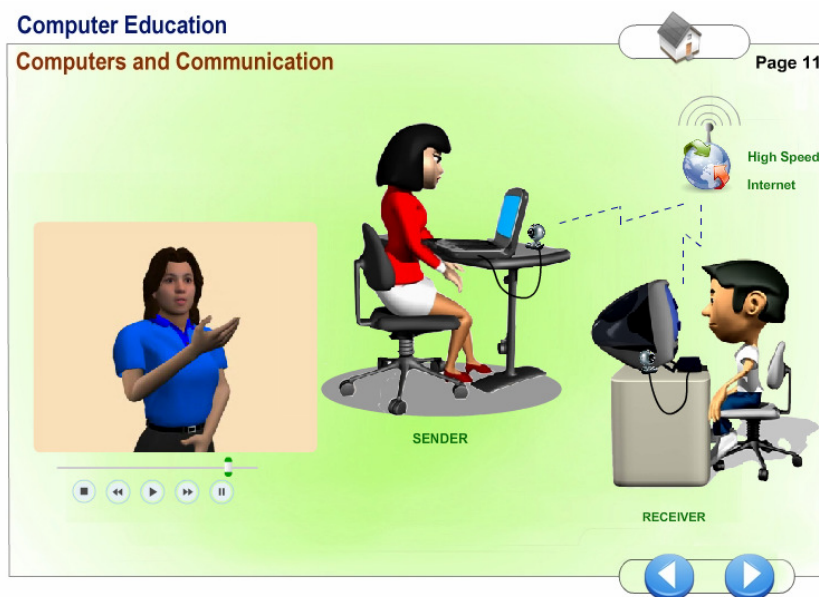
#### **3.2.2.2 Hand Animation**

Hand animation is the most complex algorithm. The head model with facial expression and the upper body were first imported back into the 3D

computer graphics environment using the import-export plug-in. To perform hand-sign animation, the angles of many parts of the human body were controlled including those of the shoulder, elbow, wrist, fingers, and knuckle joints. Hand animating was accomplished using the key frames, where animation for a parameter was defined by specifying its exact value at a given number of time. Computer interpolation was used to determine the values between the key frames. Animations on facial expression and hand movement were combined and run on 3D software. The screen showed facial expression and animation of hands and related body parts. The whole scene was then rendered and exported to an avi file. The completed VSAPA is illustrated in Figure 3.



**Figure 2. The Animation Stages of the VSAPA**



**Figure 3. The screenshot of VSAPA which includes the sign language**

### **3.3 Development of VSAPA Learning System**

The VSAPA was used to design a learning environment for a “Webcam communication” course for D/HH college students. The development of the VSAPA learning environment, by using action script programming of Macromedia Flash™ MX (2004), focused on three components: VSAPA, pedagogical strategies, and the learning interface.

#### **3.3.1 VSAPA**

The VSAPA acted as a learning companion to D/HH students. In the computer domain, the VSAPA taught the concepts of “webcam communication” and provided advice and questions to the students as they learned how to communicate with sign language through the Internet or offline learning. VSAPA explained the basic hardware and software components, and how to set up the communication system.

The VSAPA model was capable of signing toward the content on the screen and directed its gaze toward the students. In addition, the signs and facial expressions responded to student action: puzzlement for error and pleasure for completed task.

#### **3.3.2 Pedagogical Strategies**

The VSAPA learning environment was developed as a computer-based instructional system that specified the teaching strategies and course content. The instructional strategy covered various aspects of sequencing and organizing the content, including specifying the learning activities and delivering the content and activities. Our strategy was to build a user-friendly system that made learning easy, and to use animation as the main visual carrier of information. The contents were developed based on a 3D learning environment and human-like animated agents. The VSAPA coordinated with the students to carry out tasks on “Webcam communication”. This included text, sign language with the agent, animations, and adjunct questions. To effectively present these materials to D/HH learners, the content was developed using a series of items. Each item contained a short text screen, a corresponding animation explicating the passage of text, and a ThSL version of the

text. Curriculum scripts were used to organize the topics and contents of the tutorial dialog. These scripts included tutor-posed questions, didactic descriptions, sample exercises, animations, figures, and texts. The scripts for computer literacy included three subtopics: hardware, software, and system demonstration.

D/HH learners typically first read the text screen, then viewed the ThSL agent, and then watched the media animations. After completing the activities, the learners were expected to be able to select and apply technologies to the assigned tasks.

### **3.3.3 Learning Interface**

The user interface acted as a front end to the VSAPA learning system and permitted the student to interact with the learning environment. In this study, face-to-face interaction with the animated agents provided a new metaphor for human-computer interaction based on a sign language dialogue as shown in Figure 3. The media (text, picture, animation) and the VSAPA were combined either sequentially or simultaneously on the same screen. In cases when the agent and media appeared simultaneously, the VSAPA scene design should be in a bubble or box. Two functions needed by the D/HH learners were the abilities to use a fast-forward and fast-backward option while searching for information in the learning system. A map of the entire system was also used to indicate changes in the scenes. Figure 3 displays some screenshots of the VSAPA learning environment.

### **3.3.4 Validation of the VSAPA learning system**

The effectiveness of the VSAPA learning system depended on the correctness of the VSAPA presentation. ThSL must be used correctly by the agent model, with correct syntax, vocabulary, and facial expression. The VSAPA presenter was validated by three professional ThSL educators: two deaf persons and one hard of hearing person with hearing aids. In addition, the learning interface was validated by an expert in computer science.

### **3.3.5 Learning Materials**

The computer lesson “Computers and Communication” using the case study “Webcam Communication” consisted of the following parts; Lesson, Workshop Test and Evaluation Form

3.3.5.1 Lesson: the description of sign language communication via Internet which has the main factors; Sender, Receiver and Hardware and Software communication such as webcam, computer, webcam driver, high speed Internet and msn program. The lesson consisted of content, introduction with the question “How to communicate the sign language via Internet?” The lesson would show the concept of hardware and software installation, explain the definition of “sender” and “receiver”, introduce hardware and software; computers, webcam and webcam driver including the driver working process explanation. After finishing the hardware and software installation, the instructor would urge student using the question “Is the system ready to use now?” While students can interact to the system by clicking an answer. If the answer is correct, student would receive the compliment, on the other hand, if the answer is wrong, student would gain more explanation about the system completeness. When finishing the program installation, the program would simulate the system process and practice the self learning system.

3.3.5.2 Workshop Test consisted of 2 parts;

Part 1: Listing Hardware/Software. This workshop is about the listing of hardware/software used in the webcam communication system. It consisted of six questions. The exercise used in this part is the hardware selecting in accordance with its usage. The workshop feature is in the interactive form as shown in the Figure 4 and 5 respectively.



Figure 4. The screenshot of workshop 1 explanation



Figure 5. The screenshot of workshop 1 activation

Part 2: Activating Communication System. This workshop is about the webcam communication system connection for testing the understand of hardware and software selection and system installing simulation. If D/HH student can complete the workshop, the program would activate to show the system work process. Activities in this part are the questions reply five items as shown in the Figure 6 and 7 respectively.



Figure 6. The screenshot of workshop 2 explanation



Figure 7. The screenshot of workshop 2 activation

3.3.5.3 Evaluation Form: evaluating the overall lesson usage, in each lesson would consist of 5 levels opinions; highly disagree...highly agree as shown in the Figure 8.



Figure 8. The screenshot of evaluation form

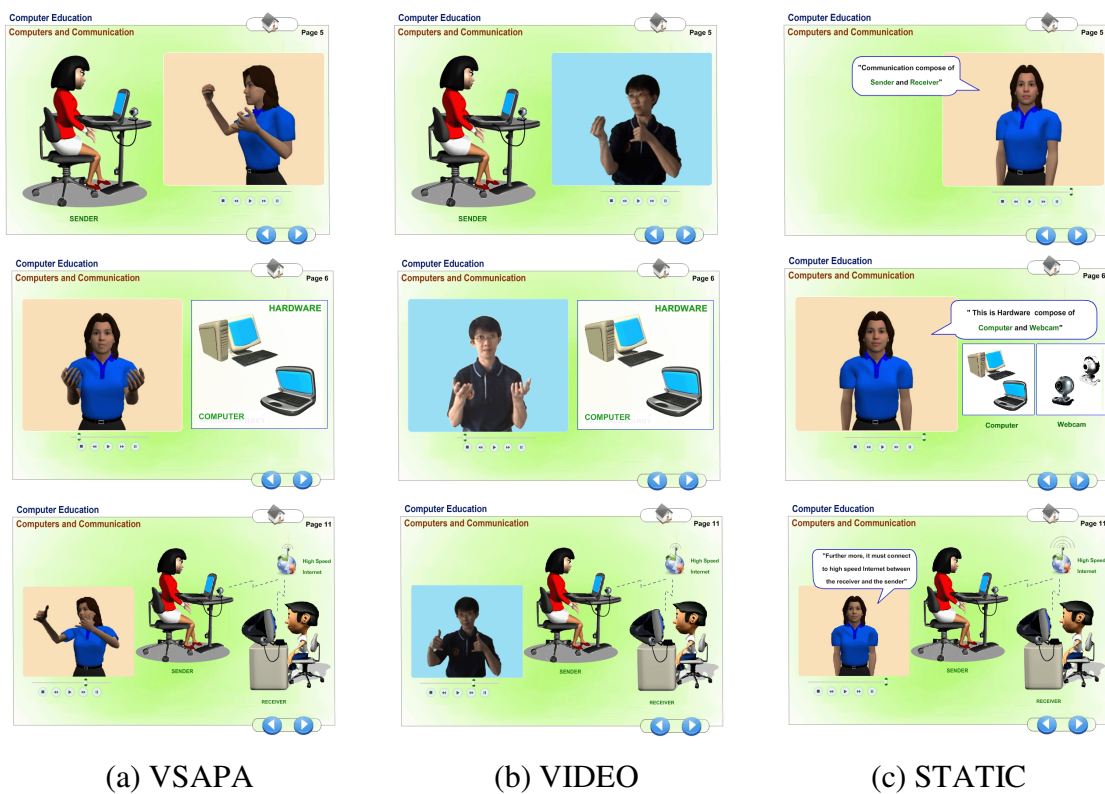
### 3.4 Design and evaluation of a VSAPA

#### 3.4.1 Participants

Selecting and recruiting participants involves identifying and describing the relevant skills and knowledge of the person (s) who will be users of a software product. A total of forty-five D/HH undergraduate student volunteers from Ratchasuda College, Mahidol University, Thailand, were involved in the testing. Thirty-seven of the participants were deaf (12 males and 25 females), and eight of the participants were hard of hearing (4 males and 4 females). In addition, the participants represented a broad demographic range: twenty-nine females and sixteen males who were 21 to 35 years old. They were all using ThSL as their first language. These participants had basic computer experience, including knowledge of Microsoft Windows, keyboarding skills, and the ability to access and navigate the learning media screen. In this study, the participants with no VSAPA learning experience were selected to ensure that prior learning skills would not skew their reactions.

### 3.4.2 Study Design

The D/HH students were randomly divided into three groups of 15 persons each. The three groups were asked to study “webcam communication” by using three different interfaces, but with the same learning materials. The first group (VSAPA) received the newly developed VSAPA learning environment. The second group was asked to watch a video of similar instructional material; the real ThSL-teacher was used in the video instead of the VSAPA. The third group received a text-based learning condition, which was a static picture of VSAPA (no sign language) as shown in Figure 9.



**Figure 9. Some screenshot of the (a) VSAPA, (b) VIDEO and (c) STATIC learning environment**

This study was designed to compare the effectiveness of VSAPA interactive learning with those of video-based and static picture expository learning. Further, it aimed to investigate the effects of different interface structures on

simulation-based interactive learning. The experiment included three treatment conditions. In the first conditions, the students learned the principles of webcam communication through interacting with a VSAPA. In the video and static conditions, the students received the same detailed step-by-step instructions as the VSAPA group, except there is video sign sequence and static picture instead of the VSAPA.

The computer simulation used for interactive learning was adapted from the content in computer course. Three tasks were used to tap into the usability of the user interface. These tasks were typical of learners' interaction with the learning environment. Task-1(theory) was related to the learning materials. Task-2 (exercise) was related to exercise about hardware and software icon recognition, and Task-3 (exercise) dealt with information search to activate the webcam communication system via the Internet. In this study, all students in each group performed the test individually and interacted with the interface using mouse and keyboard. The order in which the students performed the activities was the same for all interfaces and all subjects. They were asked to perform a cognitive walkthrough the following three tasks.

Task 1 (Studying the content): The D/HH students were asked to use the VSAPA learning environment to study the principles of "webcam communication".

Task 2: (Exercise on listing hardware/software): The D/HH students were asked to list the basic hardware and software used in the webcam communication.

The students selected the hardware/software from the provided lists and dragged the listed hardware/software to the appropriate field to match the hardware/software description.

Task 3 (Exercise on activating communication system): The students were asked to implement the "webcam communication" by dragging the right icon to the right place.

The students selected the software from the provided list and dragged the listed software to the appropriate box to activate the webcam communication. The students were allowed to ask questions before performing the tasks to ensure understanding of the tasks.

The computers used for all students were Pentium-based PC using a Windows operating system and with at least 8 MB of free memory. The PC used in the

study had a standard configuration, with a mouse and a color monitor at 1024X768 resolutions. The operating system was Windows XP. Time on each task was measured from the time the participant began the Task-1 to the time he/she signaled completion. The total time is approximately one hour for the groups. These sessions were conducted by three of the investigators, two experienced educational interpreters at the postsecondary level, each with more than 5-year professional experience and one experienced educational computer technology.

On arrival, the students were informed that the materials would be on webcam communication. They were also told that this task did not measure their abilities but aimed at determining whether they would meet the needs of users. The students were also informed that their interaction would be recorded. After signing the consent form, the students were then given instructions for conducting the three tasks and for rating the questionnaire after completing the task. They were asked to communicate with the researcher (by sign signal) after completion of each task. The researcher reset the state of the computer before each task and provided instructions for the next task. They were told that no external assistance would be provided. However, some small hints on technical problems could be provided upon request.

Each student worked alone without any interruption and was observed through a one-way mirror. As the students carried out each task, they were encouraged to “think aloud” and sign their thoughts. The whole testing session was videotaped, and two D/HH data collectors, who were familiar with the VSAPA learning environment, observed and took notes of students’ performance.

### **3.4.3 Performance Test**

#### **3.4.3.1 Usability Test**

The enhanced learner control in the VSAPA learning environment required that the system has been carefully designed to provide appropriate usability measurements. The test investigated whether a learning system had adequate usability. The measures should focus on the end results as defined in ISO 9241 Part 11 (ISO 9241, 1998):

Effectiveness: “accuracy and completeness.” Error free completion of tasks can be measured only by taking the context of use of the system.

The number of errors incurred during the performance of each task in individual students from each group was measured.

Efficiency: “resources expended.” How quick a user can perform tasks?..

The task completion time was measured in individual students from the three groups.

Satisfaction: “positive attitudes toward the use of the learning system.” Satisfaction is a success factor for the learning system; it’s essential for maintaining workforce motivation.

The System Usability Scale (SUS) developed by John Brooke (Brooke, 1996) was used to measure participants’ satisfaction with the learning environment. The efficiency and effectiveness of the three different interfaces were recorded during task performance. At the end of the session, all students were asked to complete a subjective rating scale on SUS. The SUS is a reliable questionnaire consisting of 10 items with a score range of 0-100 (Kraig, 2006). It is correlated (0.8588) with the 50-item SUMI questionnaire (Holyer, 1993). Each item was rated on a 5-point Likert scale ranging from “Strongly Disagree” to “Strongly Agree”. The SUS was administered to the students after completing all the tasks.

#### 3.4.3.2 Agent Persona Instrument

In addition, the students were asked whether they perceived the VSAPA as helpful for learning, human-like, credible, and engaging. The Agent Persona Instrument (API) (Baylor & Ryu, 2003) was used. There were five to ten items per factor, and each item was scored on a 5-point Likert scale with 1 indicating “strongly disagree” and 5 indicating “strongly agree.” In this study, the instruments were adapted to a video with sign language for practical use with D/HH students.

#### 3.4.3.3 Interview

Five students from each group were randomly selected for a 10-minute semi-structured interview. The interview data were conducted in a “webcam communication” context in order to gain the ‘inside’ perspectives of D/HH students who had just completed the learning system. The questions are related to the

D/HH students' likes and dislikes about the given learning experience, and whether they had any suggestion to improve the interface design instruction.

Each student was interviewed separately by the researcher and the sign language interpreter in-person in the classroom and was assured that the responses would be confidential. The interviews transcribing a video-recorded in sign language were interpreted, and transcribed into Thai. A cross-case analysis was conducted to analyze the interviews in order to present common perspectives of the students and to provide results in a more organized way.

#### 3.4.3.4 Data Collection and Analysis

The ease of use of the VSAPA learning environment by students with hearing disabilities was examined in comparison with those of video and static text-based environment. The standard usability testing protocols as stated in the session performance task were used in all three groups. The investigators examined how the users self-identified with the system and whether the features were provided and explained in such a way as to benefit a wide range of D/HH students.

The three tasks were then analyzed for effectiveness (the percentage of students who completed each task correctly) and efficiency (mean time taken to complete each task) and satisfaction (mean system usability score in using the learning system) and data of the experiments were analyzed statistically by using the SPSS (Statistical Package for the Social Sciences version 12).

The statistical analyses included descriptive statistics of the data revealing frequency, mean task time, and standard deviation. Analysis of variance (ANOVAs) was also used to determine significant differences between groups.

### **3.5 Effects of a Virtual Sign Animated Pedagogical Agent on ICT learning**

#### **3.5.1 Participants**

A total of forty D/HH student volunteers from the Bachelor of Arts Programme in Deaf Studies at Ratchasuda College, Mahidol University, Thailand

were involved in the study. Consent for participants was obtained according to Mahidol University Institution Review Boards (MU-IRB) policy for the use of human subjects in research. All participants met the following criteria: (a) use of ThSL as the primary means of communication (b) pre-lingual hearing-impaired, with a loss of 70 dB or greater. Thirty-seven of the D/HH students were deaf, and three were hard of hearing. The D/HH students (19 males and 21 females) had an average of two years experience using educational interpreters prior to coming to the college. All of them used ThSL communication mode during the interview session. They have the right to withdraw from the study at any point without penalty.

### **3.5.2 Instructional Materials (VSAPA)**

The instructional materials with the Virtual Sign Animated Pedagogical Agent (VSAPA) aimed to introduce the principles of “Computer and Communication” to the D/HH students. The topics covered were fundamental principles of communication (e.g. sender, receiver), hardware devices (e.g., computer, terminal, and Webcam), basic software (e.g., Webcam Driver, MSN) and connection media (e.g., high speed Internet). The D/HH students were allowed to progress through the multimedia lessons at their own pace by using a control panel with reverse, back, play, fast forward and exit buttons. The lessons have covered the image and animation sequences on implementation of the computer and communication system. Some screenshots of the VSAPA learning environment interface shown in Figure 10 were designed to facilitate the learning of D/HH students. They can click backward or forward the page links to access the learning activities designed for each topic. D/HH students are also able to modify the animation speed of VSAPA actions by using a slider. The VSAPA also displays ThSL, facial expressions and gestures, to pinpoint important aspects of the instruction on the computer screen.

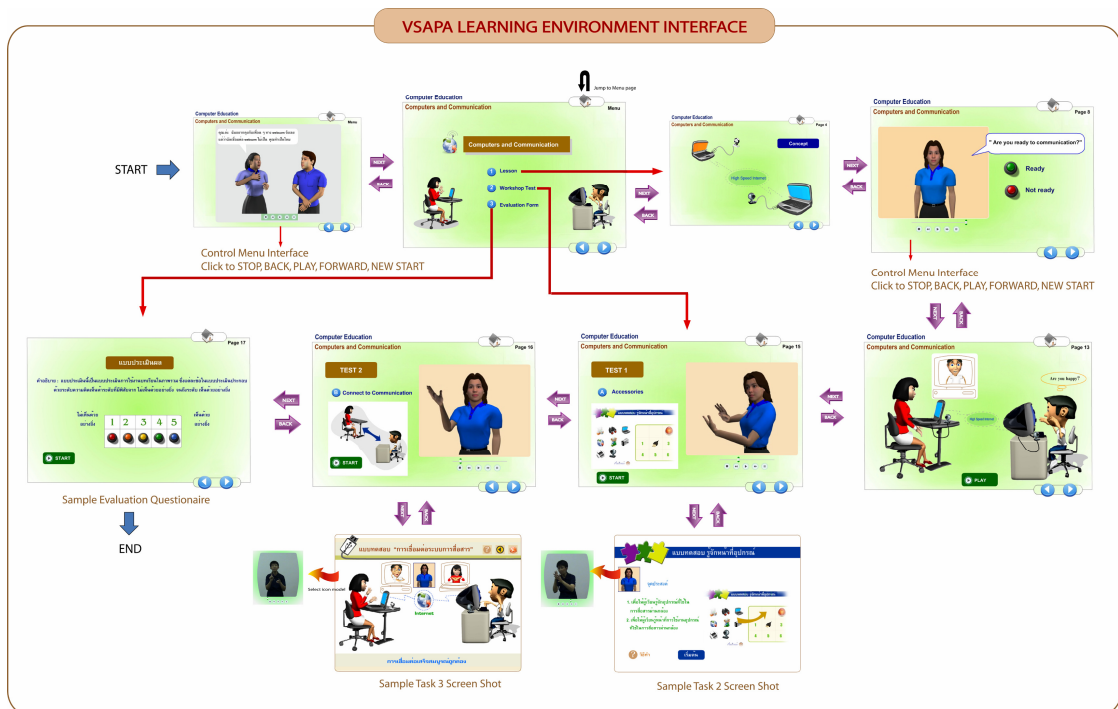


Figure 10. Some screenshot of the VSAPA learning environment

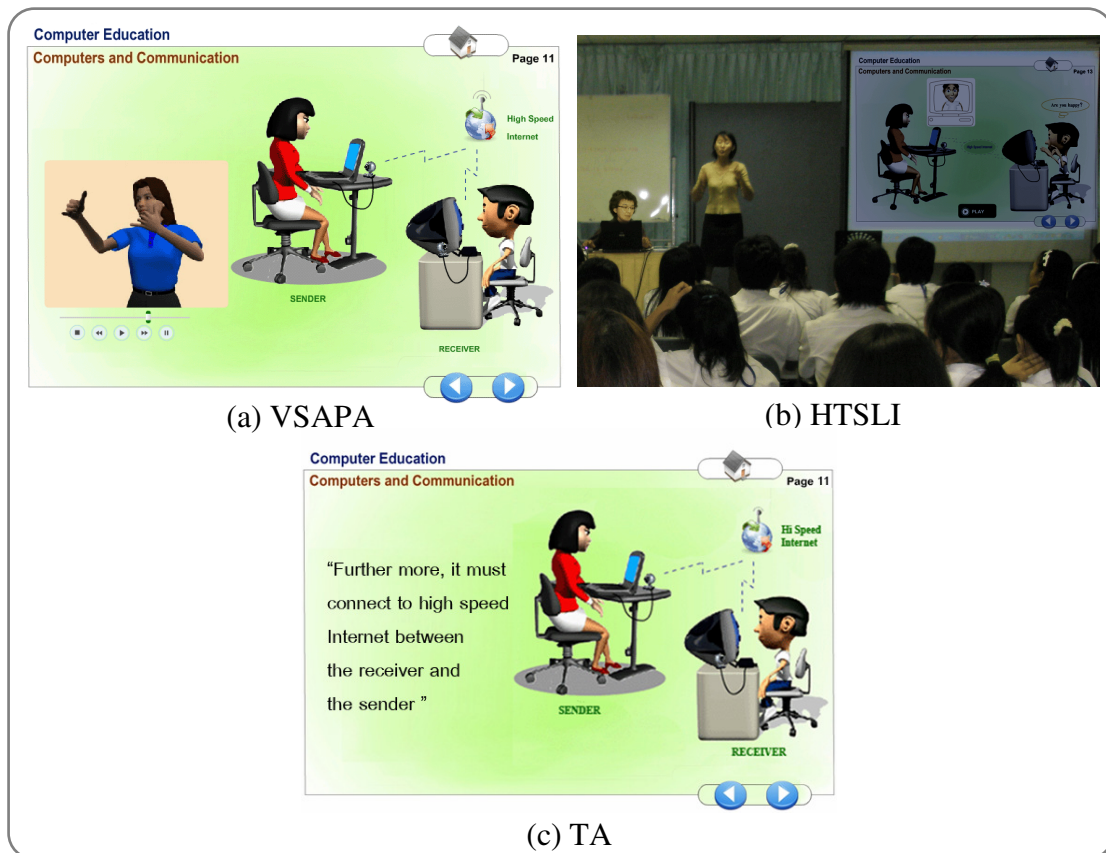


Figure 11. Some screenshot of the (a) VSAPA, (b) HTSLI and (c) TA learning environment

### **3.5.3 Study Design**

Ten D/HH students were randomly assigned to each of the four groups: (a) VSAPA (learning ICT in a VSAPA learning environment), (b) HTSLI (learning ICT via a hearing teacher with a sign language interpreter), (c) TA (learning by using text only) and (d) Control group (no treatment). The three experimental groups as shown in Figure 11 were given the same contents according to the objectives of the unit “computer and communication”. The text and images used for the learning media were the same for all of treatment groups. The time allocated for each group was one hour. All the four groups were given pre-test prior to the intervention. There was no significant difference in prior knowledge among the four groups.

The D/HH students were informed that the major purpose of this ICT-based learning was to enhance their ICT comprehension skills, and their tasks included: (a) learn and understand the instructional material as measured by the abilities to perform exercises on hardware and software; and (b) answer the questions (post-test) after completing the learning activity. Comprehension was emphasized as the main purpose of the study. During the intervention, the participants were required to meet with the researcher at the designated computer lab to be informed about the learning system. The researcher can help the participants with technical and procedural problems, if necessary.

The learning activities were conducted by the researcher and three of the experienced educational interpreters at the postsecondary level. Interpreting and transliteration were clearly described and demonstrated in order to ensure that D/HH students fully understand the three different interventions. Then each group of the students indicated their own preferences for the classroom of choice. The students were told that the learning material would be of the ICT nature. The D/HH students in the VSAPA and TA groups studied at their own pace without the help of the interpreter.

### **3.5.4 Data Collection and Analysis**

The instrument for assessment was composed of pre/post-test, open-ended questions and interviews. Pre-test and post-test questions, and one open-ended multi-topic question for attitude test were validated by four experts in computer and

communication technique and one expert in deaf studies. A pilot study was conducted to investigate feasibility of using VSAPA on the target group. The pre/post-test questions comprised two parts. Part 1 assessed the learner's ability to recall the basic hardware and software in the computer and communication system. It was composed of six multiple-choice questions with four alternative answers. Part 2 assessed the learner's ability to comprehend the basic principles of computer and communication in implementing the system. It consisted of five multiple-choice questions with four alternative answers. The maximum attainable scores on the Part 1 and Part 2 questions are six and five respectively.

The attitudinal open-ended multi-topic question was designed to measure the participants' attitudes toward the learning experience and was administered with the post-test at the end of the intervention.

The semi-structured interviews were conducted by the sign language interpreter. It aimed to obtain student's opinions about the learning environment. Twenty D/HH students were randomly selected from each of the three experimental groups for a 15 minute semi-structured interview. Questions relating to the pedagogical agent were given to members of the VSAPA group only, while questions about traditional learning were directed at the HTSLI and TA groups. The questions are related to the students' likes and dislikes about the learning experience, the influence of the ICT on their motivation and their suggestions for improving the instruction. Each student was interviewed face-to-face but separately by the researcher and the sign language interpreter in the classroom and was assured that the responses would be confidential. The sign language interpreted interviews were videotaped throughout for accuracy, and the interviews were transcribed into Thai. A cross-case analysis was conducted to analyze the interviews to present common perspectives of the students and to provide results in a more organized way.

The pre-test and post-test results for the control and experimental groups were collected and analyzed by using descriptive and inferential statistics. Data analysis was conducted in Minitab (2007) using t-tests to determine the significant difference between the pre-test and post-test of each group. An ANOVA test was used to compare the differences of the mean pre-test and post-test scores in these intervention groups.

## **CHAPTER IV**

### **RESULTS**

This chapter presents the results on investigation of the effects of VSAPA interface which is embedded in a computer-based learning system in terms of mean task time and mean task scores. The attitude of D/HH students on the use of VSAPA was given. The interview results from users of three different types of interface will be shown in this chapter. Additionally, the effect of VSAPA learning environment on D/HH students' knowledge on computer and communication and reports the attitudes of D/HH students toward the learning environment was also presented.

#### **4.1 Effects of the interfaces on mean task time and mean task scores**

The D/HH students in each group were given the same three tasks with different interfaces, namely, VSAPA, video and static one. For the first task, each student was asked to study the concept of webcam communication at his/her own pace. The knowledge gained from the first task was then used in performing exercises in the second and the third tasks on listing hardware/software and activating the communication system, respectively. The results in Table 1 show a significant difference in the mean task time in each task for all the three interfaces. Results from one-way ANOVA for the relationships between groups (Table 2) show no significant difference in time used for studying the content between the VSAPA and static group. However, the video group spent significantly longer time for studying content than those in the VSAPA and static group. The time spent for exercises on listing the hardware/software as well as activating the communication system in the VSAPA group was significantly less than those of the static and video groups (Table 1).

**Table 1 Mean task times of the VSAPA, VIDEO and STATIC groups**

Task	VSAPA		VIDEO		STATIC (control)		df	F	Sig.
	Mean	SD	Mean	SD	Mean	SD			
Studying the Content	25.56	2.98	28.33	4.44	24.80	2.02	2	4.745	.014*
Listing Hardware/Software	7.40	1.13	17.47	2.18	12.73	2.13	2	107.414	.000*
Activating Communication System	8.40	1.07	11.40	2.45	12.53	2.85	2	13.464	.000*
Total	41.36	5.18	57.20	9.07	50.06	7.00			

\*Significant at the .05 level

**Table 2 Comparison of mean task times between the three types of interface**

Task	df	F	Sig.
<b>Studying the Content</b>	2	4.745	.014*
VSAPA vs VIDEO			.027*
VSAPA vs STATIC			.529
VIDEO vs STATIC			.005*
<b>Listing Hardware/Software</b>	2	107.414	.000*
VSAPA vs VIDEO			.000*
VSAPA vs STATIC			.000*
VIDEO vs STATIC			.000*
<b>Activating Communication System</b>	2	13.464	.000*
VSAPA vs VIDEO			.001*
VSAPA vs STATIC			.000*
VIDEO vs STATIC			.176

\*Significant at the .05 level

The results in Table 3 show the mean scores for the two exercises on listing hardware/software and activating the communication system. There was significant difference in the mean test scores on both exercises among the three groups. The results of the one way ANOVA analysis (Table 4) show that the mean test scores of the VSAPA group and video group were higher than those of the static group in both exercises. However, there was no significant difference in the mean test scores between the VSAPA group and video group. The static group received less mean test scores when compared to those of the VSAPA and video groups.

**Table 3 Mean scores of the knowledge test for the VSAPA, VIDEO and STATIC groups**

Task	VSAPA		VIDEO		STATIC (control)		df	F	Sig.
	Mean	SD	Mean	SD	Mean	SD			
Listing Hardware/Software	4.20	1.01	3.73	1.16	2.13	0.99	2	15.725	.000*
Activating Communication System	3.86	0.99	3.13	0.83	2.13	1.13	2	11.576	.000*

*\*Significant at the .05 level*

**Table 4 Comparison of the mean test scores of knowledge test between the three types of interface**

Task	df	F	Sig.
<b>Listing Hardware/Software</b>	<b>2</b>	<b>15.725</b>	<b>.000*</b>
VSAPA vs VIDEO			<b>.234</b>
VSAPA vs STATIC			<b>.000*</b>
VIDEO vs STATIC			<b>.000*</b>
<b>Activating Communication System</b>	<b>2</b>	<b>11.576</b>	<b>.000*</b>
VSAPA vs VIDEO			<b>.049</b>
VSAPA vs STATIC			<b>.000*</b>
VIDEO vs STATIC			<b>.008*</b>

*\*Significant at the .05 level*

## 4.2 Effects of the system designed interfaces on the task error

The percentage error of each interface was measured in each task by observing the interface design defects in each group. The number of participants who experienced error in each task in each group was counted and calculated as percentage error by dividing with the total number of participants in each group (15). As shown in Table 5 there was no system error in the first task where the students were only go through the webcam communication concept page by page. However, in the second task on listing hardware and software where the students had to choose the hardware or software items that matched the questions. There were two participants in the VSAPA group and one each in the video and static groups made a task error. In activating the communication system by dragging the right icon to the right place, one participant in each type of the interface made a task error. The overall results suggest that VSAPA are as good as the other two interfaces in designing the content of learning material, however, designing the interface for exercises still have some problems.

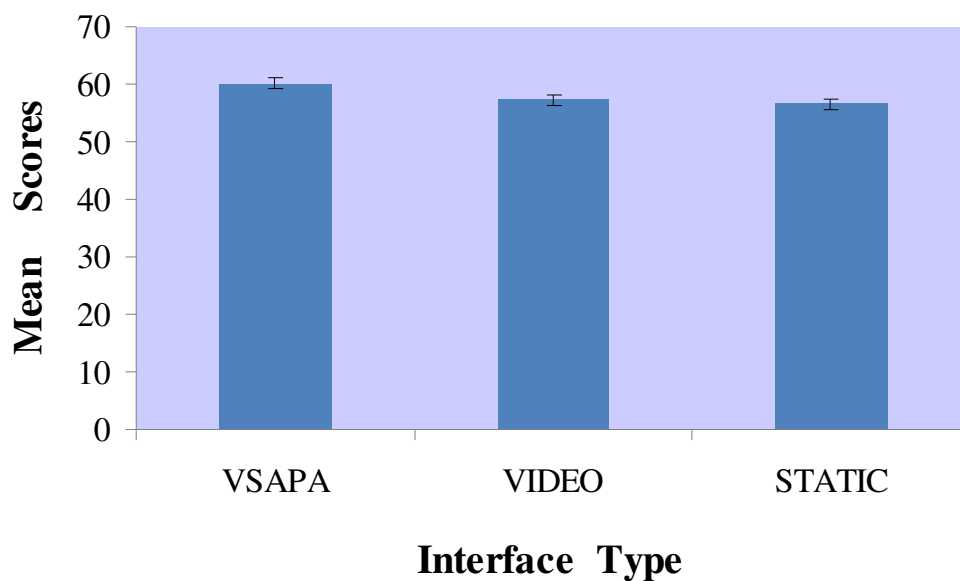
**Table 5 Number and percentage of task errors in the three types of interface**

Task	VSAPA		VIDEO		STATIC (control)	
	Number	%	Number	%	Number	%
Studying the Content	0	0.0	0	0.0	0	0.0
Listing Hardware/Software	2	13.3	1	6.6	1	6.6
Activating Communication System	1	6.6	1	6.6	1	6.6

## 4.3 Attitude of D/HH students on the use of VSAPA

The satisfaction of D/HH students on the use of VSAPA compared to those of video and static interface was measured by using the System Usability Scale (SUS). The SUS is a simple, ten-item questionnaire giving a global view of subjective

assessments of usability. SUS is a Likert scale on a 5 point scale ranging from “strongly agree” to “strongly disagree”. SUS yields a single number representing a composite measure of the overall usability of the system being studied. However, the scores for individual items are not meaningful on their own. SUS scores have a range of 0 to 100. The results in Figure 12 show that mean SUS score of the VSAPA group was significantly higher than those of the video and static groups.

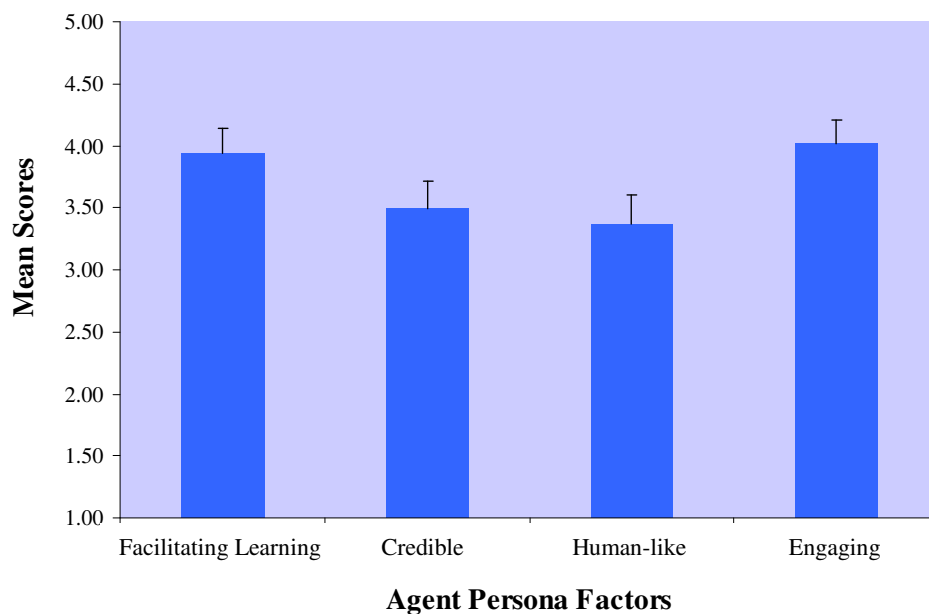


**Figure 12. Mean SUS scores from VSAPA, VIDEO and STATIC groups**

In addition to the SUS scale, the D/HH students in the VSAPA group were given a questionnaire on Agent Persona Instrument (API) (Baylor & Ryu, 2003) which measured perception of the students on four attributes: facilitating learning, credible, human-like and engaging. Key factors for VSAPA to be perceived as facilitating learning consists of 10 items that are related to how well the VSAPA helps the D/HH student through the learning process, e.g., by promoting reflection and learning support. For credible factor which consists of 5 questions related to the credibility and believability of the VSAPA and its advice for helping the learner understand the learning content. There are 5 items address the VSAPA’s behavior and emotional expression in terms of its naturalness and personality as human-like. The last factor is

engaging; it consists of 5 questions that related to how entertaining and enjoyable it was for the learner to work with the VSAPA.

The results in Figure 13 show the mean scores from students' rating of a 5-point Likert scale, ranging from strongly disagree (1) to strongly agree (5). The high scores were on engaging ( $4 \pm 0.89$ ) and facilitating learning ( $3.9 \pm 0.84$ ). Lower score were observed on credible ( $3.5 \pm 0.83$ ) and human-like ( $3.4 \pm 1.04$ ); however, they were still in the acceptable range.



**Figure 13. Mean scores of Agent Persona Evaluation of the VSAPA group**

#### **4.4 Interview results from users of three different types of interface.**

The interview questions for the three groups of D/HH students concerned their experiences in using the given interfaces in terms of information presentation, visual perception, hands-on practice and comprehension of knowledge.

The D/HH students in the VSAPA group felt that the VSAPA was very useful in enhancing their learning as shown in the following excerpts:

*“The VSAPA is an excellent and extremely efficient tool that suits my learning style, “I am able to focus more easily.” “Visual tools provided in the learning media are very informative and demonstrative.”*

*“I like the way it’s interactive. Virtual, 3D visual images make computer-based presentation more realistic”, “It is much easier for me to receive accurate information through interaction with computer making it more helpful than watching a finger-spelled lecture.”*

*“Learning from a computer screen with VSAPA is much easier than following “fingerspelling lectures.”*

*“Fingerspelling used to express technical terms is very hard to decode”. Real images for computer parts make the information very concrete, which enhances my comprehension and arouses my curiosity”*

*“It is useful but it should be improved by having more expressive faces and more natural sign language.”*

Although the video group found the video useful in supporting their understanding, they complained that the video took too much time as follows:

*“Sometimes, I did not understand a word so I watched the video more than one time to try to figure it out.”*

*“I think it takes more time to see the video because whenever I know the content or some technical term, I feel I have to wait for the video sequence.”*

*“Sometimes I had some problem about the video loading, it take time and difficult to see.” “However, the video can explain more clearly and I can control it by my own pace.”*

The static group seemed to have problems understanding due to lack of reading skills. The following are excerpts from the static group:

*“I like the picture and the exercise format. I try to do them, but I had to give up sometimes, because I could not understand how to do them correctly.”*

*“I think the static pictures are easy to use, but I could not understand the content clearly. There were many technical terms. I didn’t like to read the sentence.”*

*“I like to learn the computer learning unit having the sign language that incorporates multimedia such as 3D animation or lesson like a game simulation.”*

Interviewing results from the VSAPA group for their opinions on the design of VSAPA courseware and tools showed that the D/HH students have positive attitude toward the design of VSAPA and seemed to have no problem with language or technique. The following are excerpts from the students:

*“Since I have never used other software like a VSAPA, I have no basis to make a comparison. However, I had no problem in accessing the program or completing the workshops. The language used in the program was very understandable.”*

*“As a hard of hearing student, this was the best way for me. I don’t know ThSL fluently so this self- paced learning together with the tools makes it easier for me to understand. The subtitles for activities are helpful in explaining what I need to do.”*

*“The design of the VSAPA courseware is wonderful and the instructions are clear. The Thai is simple. There are many pictures that help explain concepts and technical terms.”*

#### **4.5 Effects of VSAPA learning environment on D/HH students’ knowledge on computer and communication**

Tables 6 and 7 show the mean scores of pre-test and post-test for workshop 1: Listing Hardware/Software and workshop 2: Activating Communication System questions for the VSAPA, HTSLI, TA and CONTROL groups. The results from one way ANOVA revealed that there was no significant difference among the four groups in both pre-test of workshop 1 question (sum of squares: 1.00; df: 3; mean square: 0.333; F: 0.36, p: 0.783) and pre-test of workshop 2 question (sum of squares: 1.875; df: 3; mean square: 0.625; F: 0.90, p: 0.452). The post-test scores of the two experimental groups, VSAPA and HTSLI, were significantly higher than those of the pre-test, both in workshop 1 (Table 6) and workshop 2 (Table 7). In the TA group, the post-test scores were slightly less than those of the pre-test in both workshop 1 and workshop 2. There was no significant difference between mean scores of the pre-test and post-test in control group who received no treatment.

The post-test scores of workshop 1 question in VSAPA, HTSLI, TA and CONTROL groups ranged from 3 to 5, 2 to 5, 0 to 2 and 0 to 2 (Table 6) respectively. No student received 100% on post-test scores. All students in the VSAPA group scored over 50% in the post-test in workshop 1. In the post-test scores for workshop 2, five and four students got 100% on post-test scores in the VSAPA and HTSLI

groups respectively. Ten students scored over 50% on post-test in VSAPA and HTSLI instruction groups, while only six students scored over 50% on post-test in TA group.

**Table 6 T-test assessment for pre-test and post-test of listing hardware/software questions**

Instruction	Pre-test			Post-test			Sig.
	Min	Max	Mean(S.D.)	Min	Max	Mean(S.D.)	
VSAPA	1	3	1.8(0.78)	3	5	4.2(0.92)	0.001*
HTSLI	0	3	1.9(0.99)	2	5	3.4(0.97)	0.001*
TA	0	3	1.7(1.06)	0	2	1.3(0.67)	0.024*
CONTROL	0	3	1.5(1.08)	0	2	1.3(0.82)	0.780

\*Significant difference at  $p < 0.05$

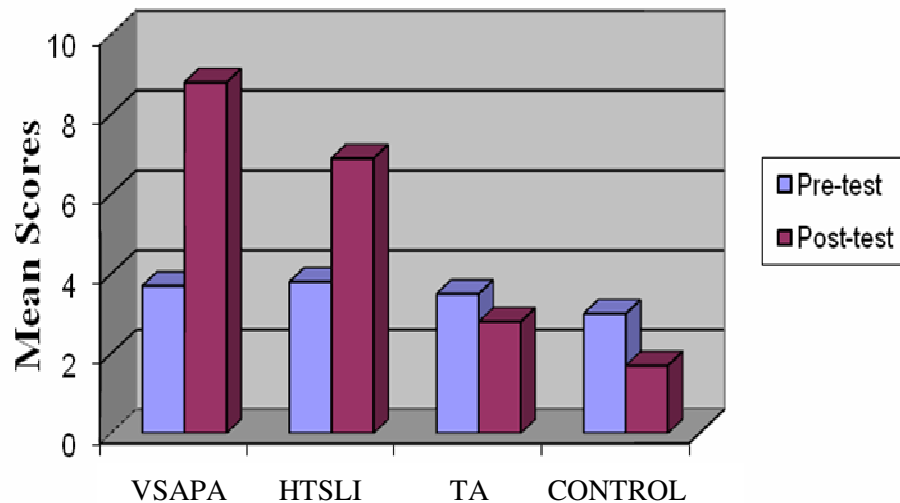
**Table 7 T-test assessment for pre-test and post-test of activating communication system questions**

Instruction	Pre-test			Post-test			Sig.
	Min	Max	Mean(S.D.)	Min	Max	Mean(S.D.)	
VSAPA	1	3	1.9(0.73)	3	5	4.1(0.87)	0.000*
HTSLI	0	3	1.9(0.99)	3	4	3.5(0.52)	0.001*
TA	1	3	1.8(0.63)	0	3	1.5(0.85)	0.002*
CONTROL	0	3	1.5(0.85)	0	2	1.4(0.84)	0.413

\*Significant difference at  $p < 0.05$

The results in Figure 14 show the mean scores of the sum of workshop 1 and workshop 2 questions for pre-test and post-test. The D/HH students seemed to gain more knowledge in webcam communication through the VSAPA learning environment than those of the HTSLI group. However, the results in Figure 14 showed that knowledge gained for workshop 1 and workshop 2 were slightly different. The results from analysis of variance suggested a statistically significant difference in the post-test mean scores of workshop 1 (sum of squares: 61.00; df: 3; mean square: 20.33;  $F(3) = 25.59$ ,  $p = 0.000$ ) and workshop 2, (sum of squares: 41.40; df: 3; ms:

13.80;  $F(3) = 27.30$ ;  $p: 0.000$ ) between the three experimental conditions and a control group. These results implied that knowledge acquisition in the three learning environments was significantly different across all of the tests.



**Figure 14. Pre-test and post-test mean scores (sum of workshop 1 and workshop 2 questions) of the VSAPA, HTSLI, TA and CONTROL groups**

The results in Table 8 show the relationship by analysis of covariance of post-test scores in workshop 1: Listing Hardware/Software questions for the three different interventions. The results revealed a statistically significant difference in the post-test scores between the VSAPA group and TA group (0.00), and between the HTSLI group and TA group (0.00). However, there is no statistically significant difference between the VSAPA and HTSLI groups (0.074).

The results in Table 9 show the relationship by analysis of covariance of post-test scores in workshop 2: Activating Communication System questions for the three different interventions. The results revealed a statistically significant difference in the post-test scores between the VSAPA group and TA group (0.00), and between the HTSLI group and TA group (0.00). However, there is no statistically significant difference between the VSAPA and HTSLI groups (0.08).

This study detected differences in measurement outcomes from D/HH participant responses to an experimental and a control measure. In the case of the experimental measure, differences were found in the instructional setting of the treatment effect between groups.

**Table 8 Analysis of variance for D/HH students’ post-test scores for listing hardware/software questions of the three experimental groups and control group**

<b>One-way ANOVA: Score versus Method</b>					
<b>Group I</b>	<b>Group II</b>	<b>SS</b>	<b>MS</b>	<b>F</b>	<b>Sig.</b>
VSAPA	HTSLI	3.200	3.200	3.60	0.074
	TA	42.050	42.050	64.69	0.000*
	CONTROL	42.050	42.050	55.25	0.000*
HTSLI	TA	22.050	22.050	31.75	0.000*
	CONTROL	22.050	22.050	27.37	0.000*
TA	CONTROL	7.200	7.200	14.73	0.001*

*\*Significant difference at  $p < 0.05$*

**Table 9 Analysis of variance for D/HH students' post-test scores for activating communication system questions of the three experimental groups and control group**

One-way ANOVA: Score versus Method					
Group I	Group II	SS	MS	F	Sig.
VSAPA	HTSLI	1.800	1.800	3.45	0.080
	TA	11.250	11.250	21.77	0.000*
	CONTROL	36.450	36.450	49.33	0.000*
HTSLI	TA	4.050	4.050	14.88	0.000*
	CONTROL	22.050	22.050	44.60	0.000*
TA	CONTROL	7.200	7.200	14.73	0.000*

\*Significant difference at  $p < 0.05$

#### 4.6 Attitudes of D/HH students toward the learning environment

Regarding attitude of D/HH students toward the learning environment, the students were interviewed on their experiences in using VSAPA, HTSLI or TA for learning the ICT content. The students were asked to describe them in terms of information presentation, visual perception, hands-on practice in the learning environment and the resulting comprehension of ICT knowledge.

The D/HH students in the VSAPA group felt that the VSAPA learning environment in terms of information presentation was very useful and enhanced their learning as shown in the following excerpts, some of which may be inarticulate and incoherent because these were all hand-signed.

*“The VSAPA learning environment provides the excellent visual information that was accurate, interesting, realistic, informative and demonstrative.”*

*“Fingerspelling was visual, and easy to comprehend.”*

*“Easy to read and work on tasks with the VSAPA feedback, interaction, animation, color, real-life pictures, and decoding finger-spelled terminologies used in ICT signed lecture.”*

*“I know I will get “accurate information” this way “instead of lectures in the class”. It is a “good idea to play with hands-on practice and learn from it instead of doing the real thing”.*

*“I think it is more valuable to practice a lot and to memorize based on my knowledge and application” than just to read from a book and attend a lecture.”*

*“I would prefer to do self-learning paced because it is more interested than having gone to a class to listen to the professor’s lecture.”*

*“I can learn and process information easily if I play and practice with my laptop computer.”*

*I prefer to work in my room with my laptop, “I think learning through doing for computers and communication subject is far more effective than learning through watching signed lectures with frequent use of fingerspelling because I can't manage to pay attention to fingerspelling without my experience of subject.”*

*“Since I have never used other software like this, I have no basis to make a comparison. However, I had no problem accessing this lesson”.*

*“As a hard of hearing learner, this was the best way for me. I don’t know ThSL fluently so this self paced learning along with the tools make it easier for me to understand.”*

*“The Thai text is simple”. There are many pictures that help explain concepts and terminologies.”*

*“The VSAPA “look and feel” and thus enabled D/HH students to learn by doing via repeated practices, and thus stimulated students’ curiosity to discover ICT information.”*

*“I like to learn the ICT from the VSAPA learning environment because I can interact with the lesson by myself.”*

*“Technical terms was easy to comprehend and useful for practicing.”*

*“I could work on tasks with the VSAPA feedback.”*

*“I think it is more valuable to be able to recall hardware, software and how to set up the communication system.”*

*“I don’t know ThSL and fingerspelling fluently enough so this self paced learning together with the VSAPA makes it easier for me to understand.”*

Although the HTSLI group found the HTSLI learning environment useful in supporting their understanding but they complained that the HTSLI learning system took time and depended too much on interpreter’s skills as follows:

*“I was not able to catch the fingerspelling related to computer and communication content: Also the lecture was too long and abstract. I have no idea how computer and communication function and work.”*

*“I can’t recognize the fingerspelling”.*

*“I can’t follow and practice the technical terms from the interpreter.”*

*“I have difficulty paying attention to the signed-lecture course because I didn’t know much about computer so I couldn’t follow all lectures.”*

*“The interpreter signed too fast and hopped from topic to topic.”*

*“I’d prefer to learn with the deaf teacher who could sign.”*

*“I could not practice by myself, only reviewed from video tape.”*

The TA group found that the TA learning environment was difficult and hard to understand as follows:

*“I don’t like to learn with the text because I can’t understand the instruction.”*

*“It is boring.”*

*“I can read the text but I’m confused when I did the exercises.”*

*“I had just clicked from page to page because it has no interesting lesson.”*

*“I don’t know how to do exercises. I don’t like to read text. I am not sure what I had learnt from this lesson.”*

*“I can learn by myself, but I am not sure about my knowledge gain.”*

## **CHAPTER V**

### **DISCUSSION**

#### **5.1 Effects of the learning system designed interfaces**

The results from this study clearly indicated that the newly developed VSAPA had positive effects on D/HH students' achievement and attitude toward the instructional material on webcam communication. This is evidenced from the results on knowledge test of the given tasks and from student interviews. One of the advantages of implementing VSAPA in a computer education interface is VSAPA can effectively engage and motivate D/HH students in their learning. In the VSAPA learning environments, the content is delivered through sign language by the animated pedagogic agents in addition to texts and graphics on the computer screen. This helps stimulate the D/HH learner's interest.

The findings that the D/HH students felt more motivated to learn in the VSAPA environment are supported by the information delivery hypothesis, an implication of Mayer's cognitive theory on multimedia (Mayer et al., 2001): if an animation is designed to be interactive and appropriately simplified, it would be more likely to decrease cognitive load and thus release cognitive resources for better comprehension and learning. Our results coincide with those of Baylor, & Ryu (2003) that animated agents influence attitudes toward learning and thus encourage the latter. The D/HH students from VSAPA group expressed more positive attitude towards the learning and probably resulted in better knowledge gained when compared to the static group.

Although this study was not designed to discover the specific way in which the VSAPA enhances learning, it is interesting to speculate how this may occur. As suggested by Baylor & Ryu (2003), two factors might be responsible for the positive effects of the pedagogical agents in facilitating learning: VSAPA's persona and information delivered by the VSAPA. Regarding the VSAPA persona, the results in this study are in agreement with several other studies (Baylor 2002a, 2002b, Baylor

et al., 2004) that the learner's interests are aroused by the agent persona. The features of VSAPA in this study were designed to give key characteristics of a pedagogical agent's persona which includes its propensity to be engaging, human-like, credible and facilitating learning (Baylor & Ryu, 2003). Thus it is not surprising that the scores of agent persona measures in this study are quite high. Moreover, the interviewing results indicated that the D/HH students did appreciate the visual appearance of the VSAPA in its gender, skin color, age, facial features, body, hairstyle as well as the articulation of the hands (hand signs, gestures) and facial expression.

The VSAPA developed in this study is similar to that of Steve and Adele (Johnson et.al., 2000) and AutorTutor (Graesser et al., 2003) in that it was designed to engage learners and to encourage deeper learning. The engaging persona of VSAPA agents facilitates the tasks for the D/HH students so that they are able to learn with the agent as intended and with an effort to learn how to use it. Credible personas of VSAPA make learners confident in the agent and help them recognize the VSAPA as trustworthy, competent, and consistent in behavior. Finally, human-like personas of VSAPA serve as a pedagogical mentor to effectively represent the content and pedagogy. The persona effect of an animated pedagogical agent is domain specific and can improve human-computer interaction if the agent displays the functional behaviors matching the system's purposes (Dehn & van Mulken, 2000). In addition, the effect of a pedagogical agent on learner interest could also be explained by the theory of social presence (Kehrwald, 2008) which is a subjective quality of the communication medium and can be a function of nonverbal cues (Short, Williams & Christie, 1976). VSAPA with a sign language cues is considered to have high social presence that can lead to promotion of interest in D/HH students.

The positive effect of VSAPA on the achievement of D/HH students was also attributable to the learning material delivered by VSAPA. The multimedia system was designed for effective delivery of content and exercises on webcam communication. Media features such as sign language, facial expression, image, and animation are integrated to support the learning system. Visual communications along with sign language have been recognized as an effective strategy in teaching and learning for D/HH students.

Although there are a number of tools and software to help D/HH persons in the area of linguistics and language processing, e.g., ViSiCAST (Elliott et al., 2000) and TESSA avatar (Elliott et al., 2000), the users must have access to the complicated software and hardware to see the animated-sign content. Other specific translator software to form sign language, i.e., HamNosys symbols (Hanke, 2002), SiGML (Kennaway, 2004), and VCom3D (Vcom3D, 2007-2008), although useful, cannot be used in the VSAPA learning system. These agents are inflexible and require additional equipment and software. Most importantly, these agents lack the facial expressions which are the essential feature of Thai Sign Language that should be incorporated in the software design. The VSAPA learning environment developed in this study is the first software that shows the facial expression of Thai Sign Language and is flexible and easy to use. There is no need to install special hardware or software. The D/HH learners in this study favored VSAPA because the quality of the sign language message delivered by the VSAPA was informative and helpful. The ease of the user interface in the VSAPA also allowed the D/HH students to learn efficiently by themselves without extra help. This is similar to the previous research work on Mathsigner<sup>TM</sup> that helps of D/HH children to learn mathematics via 3D sign language (Adamo-Villani, 2005). Similarly, Vcom3D has been used to support literacy for D/HH students (Vcom3D, 2007-2008).

The results on usability test suggest that the newly designed VSAPA has features adequate for supporting learning of webcam communication of the D/HH students. The learning efficiency of the VSAPA group was superior to that of the other two interfaces, i.e., video and static picture of VSAPA with on-screen text. The results clearly illustrated that not only the time spent for completing the given tasks was less in the VSAPA group, but the knowledge test scores were also higher when compared to those of the static picture of VSAPA. The VSAPA interface is also more efficient than that of the video interface in terms of the time used for task completion although there seems to be no statistical significant difference in the knowledge gained. The study time spent for learning was equal in the VSAPA and static group, but the students seemed not to gain equal information despite the presence of on-screen text. This may be due to problems of the D/HH students in reading the text: they preferred communicating via sign language as evidenced from the interviewing results. The

longer time spent in doing exercise via video compared to that of VSAPA may be due to limitations of the video clip both in quality and performance. The most important region of sign language video image is the face of the signer which is the space for comprehension of sign language (Muir, Richardson & Hamilton, 2005). The participants seemed not to follow the detailed movements of the fingerspelling in a video clip. In addition, there was some loss of quality in the decoded video sequence that have the effect on the perception of quality sign language video content (Richardson, 2003;.Singleton et al., 2004; Wilbur, 2000). This is supported by vision theory, in particular that, D/HH students' perception of sign language is an important factor possibly influencing the process for forming sign sequence by the visual system (Haake, M. & Gulz, A., 2008).

The effectiveness in terms of accuracy and completeness of the VSAPA seemed not to be different from those of the other two interfaces on video and static picture of VSAPA. The task errors as measured in this study occurred when the D/HH students could not complete the drag and drop exercises due to technical problems. There was no error in task 1 where the student just clicked the content knowledge page by page. However, the students had task errors in all three different interfaces in the two exercises which were designed for the drag and drop control, a feature whereby pictures or icons should be dragged to the right places. This technology may be difficult for some D/HH students; the instructor should give adequate instruction on this. It is also difficult for D/HH students to differentiate between the similar icons or pictures; addition of visual affordances such as shading, text and other elements may be helpful. Nevertheless, the percentage error in this study (6.6 and 13.3%) is not overly high and there is no critical error. The completion rate of exercise 1 is 86% for VSAPA and 93% for video and static groups. For exercise 2, the completion rate is 93% for all groups. At the sample size of 15 in this study, the margin of error is about 23% for the completion rate of 50% and 16% for the completion rate of 95% (Sauro & Lewis, 2009). The findings from this study give evidence in favor of using VSAPA as a software agent. The D/HH students are more motivated and achieve better knowledge when the learning includes a personalized interaction with a VSAPA rather than on-screen static picture. Results from both video analysis and interviews agreed with those of the usability tests. The video tape showed that students who were

unfamiliar with the VSAPA learning environment managed to use it fairly easily and that they were able to successfully complete most of the VSAPA tasks. From interviews, all participants in the VSAPA group preferred to have the VSAPA in the learning environment.

It should be considered that the effectiveness and efficiency are also context specific. Thus, it is not easy to definitely conclude which learning interface is more usable than the other. However, the highest System Usability Scale (SUS) in the VSAPA group suggested that the student preferred the VSAPA learning environment. This may be due to the design of VSAPA that covered both social learning theory and instructional design concepts, such as the agent persona (Yanghee & Baylor, 2006). Nevertheless, for better outcomes consideration should be made to ensure that the D/HH students can follow the instruction more closely and process what is being learned more thoroughly. Although assessment of the agent persona for engaging and facilitating learning indicated a good interaction between the knowledge domain of the learning module and the VSAPA's persona, the effective design characteristics should be more comprehensive on interface agents within the learning system. Nevertheless, to increase satisfaction, the appearance of VSAPA should be improved, e.g., facial expression and body shape should be more human-like. Hand animation should also be modified for better fingerspelling.

Although this finding is preliminary it has implications for further studies in matching the agent with the personalities of D/HH learners to build up a good rapport with the latter. More efforts are needed for the designers to create instructorless, self-paced lessons capable of providing greater learning because of the atmosphere of rapport created by the VSAPA. Based on the results of this study, the instructional designer should be cognizant of the fact that sign avatars can strongly influence learners in terms of their motivation, attitudes and learning, even when learners are only watching the avatars signing. Generally, the learners can perceive avatars as offensive, computerized, emotionally overwhelming, respectable, and nice. The learners can thus be emotionally and attitudinally influenced by sign language pedagogical agents.

## **5.2 Effects of VSAPA learning environment on D/HH students' knowledge on computer and communication**

The results in this study also clearly demonstrated that the VSAPA learning unit was as effective as the HTSLI instruction in enhancing D/HH college students' learning about the computer and communication system. Both methods were certainly much more effective than those of the Text-assisted method in which the students studied on-screen text by themselves, without the help of either the VSAPA or interpreters. The results indicated that the VSAPA instruction is an effective pedagogical tool to assist D/HH student learning of ICT content. This is not surprising since several animated agents have been widely adopted for many topics. For example, AutoTutor (Graesser et al., 2003), Cosmo (Lester et al., 1997) and Steve (Johnson et al., 1998) have been shown to enhance computer literacy in students. In addition, students have been shown to gain higher achievements in mathematics and felt more motivated to learn by using the animated agent such as Mathsigner™ (Adamo-Villani, 2005) and SMILE™ (Adamo-Villani & Wright, 2007). Although the results did not show statistically significant difference in the post-test scores between the VSAPA and HTSLI learning environment, the VSAPA instruction seemed to have higher gains than those of the HTSLI instruction. It should be pointed out that the HTSLI instruction has employed the sign language interpreter who has skills in conveying ICT terminologies. However, a significant diversity in sign language modes still exists among deaf individuals (Turkington & Sussman, 2004) and there is no standard signing. This contributes to communication difficulty in a traditional lecture setting. Since there are no ready signs devised to express special ICT terminologies and abstract concepts, thus for want of better thing the fingerspelling has been used throughout signed lectures. Not only this method is a slow instruction delivery (Lang, 2002) but also causes difficulties and errors in visual perception (Seal, 2004). This is supported by the interviewing results that fingerspelling of technical terms in ICT is hard to decode. The students also commented that they had more understanding toward ICT terminologies via VSAPA and they felt more comfortable in the VSAPA learning environment. Moreover, the time spent in studying the same amount of content in the VSAPA group was about half of those of the HTSLI and TA groups. Most importantly, the students in HTSLI instruction voiced that they probably did not

grasp all information from fingerspelling and also felt that the interpreter might not convey the entire lecture content to them.

The results indicated that the VSAPA instruction were significantly much more effective than the TA instruction in supporting D/HH student's learning. This is supported by the interviewing results that the D/HH students had difficulty in reading and understanding text even though it was on screen and had image and interface similar those in VSAPA learning environment. This may be due to low literacy levels, especially in reading, of D/HH students (Williams, 2004). The results thus suggest that for better achievements, D/HH students should be exposed to the learning material by using both sign language and on-screen text. This is in agreement with several other research works that animated agents with sign language help to increase effectiveness in teaching science and mathematics for D/HH students (Adamo-Villani, 2005; Adamo-Villani & Wright, 2007).

The D/HH students had positive attitude toward the VSAPA learning environment, as evidenced from the open-ended multitopic question and interview results that VSAPA helped to engage and motivate them in their ICT learning. This finding coincides with the study of Baylor & Ryu, (2003) that animated agents with verbal audio can encourage and motivate students to learn and therefore influence their attitudes toward learning. Akhtar (2003) has also reported a positive attitude and achievement of D/HH students by incorporating graphics, animation into text for D/HH education.

The D/HH students in this study reflected that VSAPA provided excellent visual information that was accurate compared to that of fingerspelling by inexperienced HTSLI. In addition to the mere interest generated realistic message VSAPA signed lectures were easy to comprehend. Most importantly, the D/HH students felt that the appearance of VSAPA is credible and human-like and thus facilitating their learning by stimulating their curiosity to discover ICT information while reducing anxiety over causing possible damage to the equipment or messing up the system.

The results on comparable achievements in ICT learning in the VSAPA and HTSLI groups suggested that VSAPA can be used in place of HTSLI, especially, in the case of sign language interpreter who lacks of content knowledge in the subjects

(e.g. science, mathematics, and computer). The advantage of VSAPA is that the students may view the new learning method via VSAPA as encouraging, informative and helpful and thus allowing the D/HH students to grasp the subject faster comparing to reading text. Nevertheless, there is also a drawback with VSAPA learning in that it lacks the class/peer discussion that the lecturer provided. Several research works on information delivery through pedagogic agents have suggested that the learners could perceive this computer-mediated learning as a social communication (Kim & Baylor, 2006; Baylor & Plant, 2005; Cathie & Libby & Maureen & Nicola, 2009). It could be possible that the D/HH students might also have social communication during their studying via the VSAPA learning environment.

The outcomes of the D/HH student are not attributable only to the persona effects of VSAPA, but it is also attributable to the learning material delivered by the VSAPA. Understanding the cognitive foundations of learning by D/HH college students and the challenges presented by various educational settings would help educators better able to match instructional methods and supporting services to D/HH students' strengths and needs.

### **5.3 Limitations**

The present study contains several limitations related to the computer-based instruction and measurement. First, the VSAPA avatar presented across all conditions is feminine. Receiving lessons from an agent with a female characteristic may yield different results than receiving instructions from male characteristic. Along these lines, a promising solution is allowing learners to choose the VSAPA agent from whom they prefer in receiving the instructional explanations.

Second, in order to gauge social agency, the present study relies on a subjective measure in which learners rate their social interaction with the animated agent. Relying on this self-report measure to indicate the social relationship between agents and learners may not yield the reliable results that more direct, objective measures may provide. In order to obtain more direct, objective social agency measures, Atkinson, Mayer and Merrill (2001) suggested assessing the facial

expressions and gestures that learners display when interacting with an animated agent during learning tutorials. Additionally, it may be beneficial to employ qualitative research techniques to gauge learners' degree of social agency. For instance, a debriefing session could take place at the end of an experiment wherein learners provide their thoughts on the animated agent included in the learning environment.

Third, the number of posttest questions was rather small, i.e. only six and five questions in workshop 1 and workshop 2 respectively. In a recent two-experiment study examining the efficacy of animated agents in computer-based learning environments, Atkinson (2002) employed a posttest consisting of only six items and indicated that the small number of problems limited the reliability of the measurement. As a result, in a follow up experiment Atkinson modified the posttest to include eight items and reported that using eight items, rather than six, strengthened the reliability of the posttest. Although employing only eight posttest items may decrease the measure's reliability, using a small number of test items still allows the assessment of the target skill to be valid (see Atkinson; Atkinson et al., 2001). Moreover, adding more test items to increase the reliability of the posttest measure may inadvertently introduce unnecessary error in the form of participant fatigue. The posttest is the final segment of the two-hour experimental session and there is concern that participants will lose interest in the task and subsequently their posttest performance will decline.

Fourth, the sample size of study was rather small which may lead to inaccuracy of the data. This is because, at the time the research conducted, there was only education place for the number of D/HH persons at the postsecondary level and it had the highest student number. Thus, there should be research on other groups with a larger sample size and more diverse subject pool, possibly from several different cultures (deaf, hard of hearing, speech or lip reading).

Fifth, the instructional intervention time included in the study was relatively short and with only one subject area on webcam communication. The effects VSAPA on learner's interest in the long-term use should also be studied.

Sixth, the research conducted in the short-term involvement, the long-term use of VSAPA in enhancing learning of D/HH students should also be investigated.

Lastly, the algorithm used in VSAPA was not flexible, this is because VSAPA was conducted objectively on the educational purpose, making it fixed on the sign language for “webcam communication” topic only.

## **5.4 Further Study**

As cited earlier in the limitation, the population group used in this research was only students of Ratchasuda College, Mahidol University. The further studies should be conducted with a larger sample size and diversify subject matter.

The avatar of VSAPA is feminine which might have the psychological effects to the learners; it should have an investigation on this aspect.

The topic “webcam communication” of VSAPA is constrain the facial expression of avatar due to it need not much facial communication while in the other topics may need more facial expression. The further study should develop the software having more facial expression on avatar including add more avatar choices item in many presenters such as male, female or cartoon for children.

The topic conducted in this research was “webcam communication” which was in the computer usage field, so the future work may expand to the other fields such as Mathematics, Science or Foreign language including the overall computer field.

The research used “Script” as a tool for software development which was fixed for one topic because it aimed to solve the sign language interpreter and/or teacher shortage problem on the subject. The research result showed learning through VSAPA assisting and satisfying D/HH learners. To make the continuous development and expand to other fields, there should be the algorithm developing research on the sign language script that was more flexible or using the machine translation for VSAPA.

Since there is an increasing number of educators and schools trying to incorporate multimedia in their existing curriculum and instruction, it would be beneficial to conduct a study on the effects of integrated media systems on various topics.

## **CHAPTER VI**

### **CONCLUSION**

In this study, a user-friendly interface for a virtual sign animated pedagogic agent (VSAPA) was developed to facilitate D/HH students' learning in the topic "webcam communication". The present study was set to find out the relative effects of an animated pedagogical agent, when used in multimedia-based learning programs, compared to a static picture of the VSAPA and video. The results from usability test indicate that VSAPA is more effective than a simpler multimedia system in motivating and improving D/HH students' performance upon receiving the same instruction. When compared students in VSAPA group with those who learned from the hearing teacher via a sign language interpreter (HTSLI), both groups acquired equal level of comprehension, which was superior to students learned by Text-Assisted (TA) instruction. However, the students in VSAPA group seemed to acquire a higher level of motivation toward the learning than those in the HTSLI group. This may be attributed to the characteristics of VSAPA in being engaging, credible, human-like and thus facilitating learning. The clear sign language and pleasant visual appearance are other strong points that may be contributed to positive attitudes toward learning and thus results in improvement in their achievement.

VSAPA has been designed in such a way to facilitate the task for the D/HH students and to make sure that they are able to make use of the agent as intended and with a minimum effort to learn how to use it. The positive results on Agent Persona Instrument suggested that VSAPA enhanced motivation of the D/HH students. The results in this study also suggested an interaction between the knowledge domain of the learning module and VSAPA's persona, as judged by the perception of learners that the VSAPA was engaging and facilitated their learning. Results from video analysis and interviews indicated participants' satisfaction. Nevertheless, for a better result in facilitating the learning outcomes there should be improvement in the animated agent's body shape, facial expression, signing speed, and fluency of

fingerspelling. A limitation of the present study, besides the rather small sample size, is that the communication preferences of deaf and hard of hearing participants have not been addressed. Some of the students may have relied on sign language for communication, while others used speech and lip reading. The results of this study indicate that the VSAPA instructional format offers some appealing advantages for students with hearing loss. Furthermore, it verifies the role of D/HH learners and their knowledge, and provides support that multimedia instruction should take into consideration the learner factor in its design. It also offers some guidance to educators for selecting instructional technology appropriate for their target student population. Results from this study indicate that VSAPA instruction can be beneficial to the D/HH students who are experiencing some difficulties with a subject matter, particularly in learning ICT subjects on which most interpreters lack skills in signing. Moreover, it is important for educators to find a way to make the D/HH students feel more comfortable in the learning environment not only for ICT but in several other topics as well, especially, in science and mathematics. Thus, further investigation is needed to examine the effects of VSAPA in different fields. Based on this study, an effective VSAPA should not only be able to provide a learner with knowledge and skills but also to motivate the D/HH learners.

## **6.1 Implication**

With the advancement of multimedia and information technology, a growing number of instructional programs now embed multimedia elements in their instructional presentations in an attempt for improving their pedagogical effects. One of the multimedia elements discussed currently in the field of instructional technology is sign animated pedagogical agents. It is clear that there exists great enthusiasm on the potential of the VSAPA, in facilitating learning of the D/HH students.

The result in this study had led to the possibility of using VSAPA for improving learning of D/HH students. Nevertheless, many more studies are needed for this technique for the sustainable impact on D/HH students learning issues. In designing the VSAPA, it is important to match the key characteristics of VSAPA with

the personalities of the D/HH students in order to build up a cordiality rapport and understanding between VSAPA and the students.

VSAPA can be applied extensively in every discipline for D/HH student education; moreover, it can be used as the communication tool of sign language. This is because VSAPA conducted as the sign language software for self-paced learning; it can inform desire information to D/HH persons as wish.

The algorithm of VSAPA can be the prototype of software development, especially in Thailand, this is because the lacking of teaching tool for D/HH students. Then, the related teaching D/HH student persons can develop more software for D/HH self-paced learning easier.

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## **APPENDICES**

## APPENDIX A

### HUMAN SUBJECTS APPROVAL DOCUMENT



No. MU 2007-069

Documentary Proof of Ethical Clearance  
The Committee on Human Rights Related to  
Human Experimentation  
Mahidol University, Bangkok

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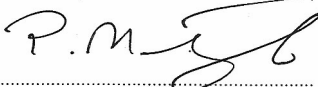
Title of Project: Virtual Sign Animated Pedagogical Agent to Support Computer Education for Deaf Learners  
(Thesis for Ph.D.)

Principle Investigator: Mrs. Benjaporn Saksiri

Name of Institution: Institute for Innovation and Development of Learning Process

Approved by the Committee on Human Rights Related to Human Experimentation

Signature of Chairman: .....  
(Professor Dr. Srisin Khusmith)

Signature of Head of the Institute: .....  
(Professor Dr. Pornchai Matangkasombut)

Date of Approval: ..... 12 APR 2007 .....

Date of Expiration: ..... 11 APR 2010 .....

## **APPENDIX B**

### **INTRODUCTORY LETTER**

[g4737907@student.mahidol.ac.th](mailto:g4737907@student.mahidol.ac.th)

Participant's contact information

**RE: A Virtual Sign Animated Pedagogical Agent To Support Computer Education For Deaf Learners**

Dear (insert the participant's name),

You are invited to participate in a research study to understand the usage of a VSAPA learning environment. There is presently no information available to document the lived experiences of deaf and hard-of hearing technicians' perceptions of VSAPA usage in the workplace; therefore, your responses are very important in understanding the influence of communication technologies.

Your valuable participation will consist of a recorded interview lasting approximately 60-minutes at a mutually agreed upon place. An interpreter will be present for the interview, to assure sign language communications are as efficient and accurate as possible. The taped interview session will not include your name, but will be coded into a schema of technician number, hearing status, date, and gender. After the interview, the transcription will be available upon request.

Thank you in advance for participating in this study. I look forward to scheduling your interview session and learning of your experiences with the VSAPA learning environment.

Sincerely,

Benjaporn Saksiri, Mrs

## **APPENDIX C**

### **INFORMED CONSENT**

MAHIDOL UNIVERSITY  
INFORMED CONSENT: Participant's Form

Project Title: A Virtual Sign Animated Pedagogical Agent To Support Computer Education For Deaf Learners

Dear [insert participant's name], I am a Doctoral Student in the Institute for Innovative Learning at Mahidol University working toward a Doctor of Philosophy in Science and Technology Education Degree. I am conducting research on the learning experiences of deaf and hard-of-hearing learners' use of the VSAPA learning environment.

I would like you to participate in this study of the VSAPA learning environment. It is hoped that this study can be used to help us provide more information about what your experience has been with the VSAPA learning environment in the classroom. This information will help us further understand and assist with providing learning tools for deaf and hard-of-hearing learners.

For this study, you will be asked to:

1. Participate in a recorded interview (video taped) with the researcher, where you will be asked questions about your experiences using the VSAPA learning environment.
2. It is anticipated that your participation will take approximately 60 minutes.
3. A certified interpreter will be provided to assure your contributions are interpreted and recorded as accurately as possible.
4. There is no more than minimal risk to individuals who participate in this research study, and confidentiality will be maintained.
5. If your data is used in a publication, your name or other identifying information will not be used. Instead, you will be given a code number in order to assure confidentiality.
6. Written records will be kept in a secure file to which only the researcher has access.
7. Your participation in this study is voluntary. If you decide not to participate in the study, it will not change your relationship to Ratchasuda College, Mahidol University in any way.
8. You may withdraw from the study at any time, for any reason and without penalty. It is hoped, however, that you will offer your full participation.

Questions about any risk to you because of participation in this study may be addressed to: Researcher, Benjaporn Saksiri, at email addresses

[g4737907@student.mahidol.ac.th](mailto:g4737907@student.mahidol.ac.th)

I have read the Informed Consent Form and agree to participate in the study, A Virtual Sign Animated Pedagogical Agent To Support Computer Education For Deaf Learners, conducted by Benjaporn Saksiri.

I understand that the interview will be recorded with an interpreter present.

I understand that the recording will not have my name on it and will have a code number for identification instead.

I understand that I can withdraw from this study at any time without penalty or prejudice.

I understand that I will receive payment for my participation.

By signing this form I certify that I am 18 years of age, or older.

Your Name \_\_\_\_\_

Your Signature \_\_\_\_\_

Date \_\_\_\_\_

## APPENDIX D

### SYSTEM USABILITY SCALE

*System Usability Scale*

	Strongly disagree				Strongly agree
1. I think that I would like to use this system frequently	1	2	3	4	5
2. I found the system unnecessarily complex	1	2	3	4	5
3. I thought the system was easy to use	1	2	3	4	5
4. I think that I would need the support of a technical person to be able to use this system	1	2	3	4	5
5. I found the various functions in this system were well integrated	1	2	3	4	5
6. I thought there was too much inconsistency in this system	1	2	3	4	5
7. I would imagine that most people would learn to use this system very quickly	1	2	3	4	5
8. I found the system very cumbersome to use	1	2	3	4	5
9. I felt very confident using the system	1	2	3	4	5
10. I needed to learn a lot of things before I could get going with this system	1	2	3	4	5

## APPENDIX E

### AGENT PERSONA INSTRUMENT

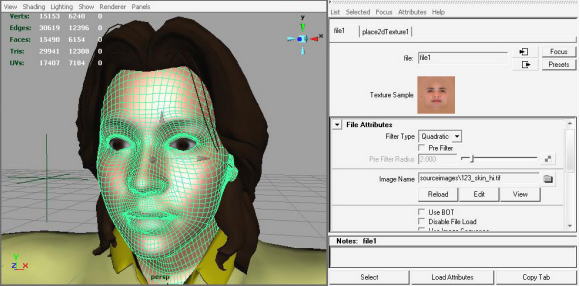

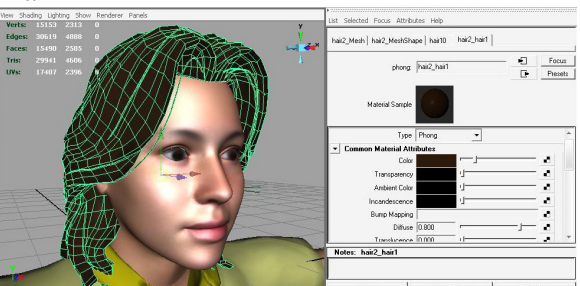

Respond to the following statements indicating the strength of your agreement/disagreement with the statement.					
Item	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
	5	4	3	2	1
<b>Facilitating Learning</b>					
1. The agent led me to think more deeply about the presentation.					
2. The agent made the instruction interesting.					
3. The agent encouraged me to reflect what I was learning.					
4. The agent kept my attention.					
5. The agent presented the material effectively.					
6. The agent helped me to concentrate on the presentation.					
7. The agent focused me on the relevant information.					
8. The agent improved my knowledge of the content.					
9. The agent was interesting.					
10. The agent was enjoyable.					
<b>Credible</b>					
1. The agent was knowledgeable.					
2. The agent was intelligent.					
3. The agent was useful.					
4. The agent was helpful.					
5. The agent was instructor-like.					
<b>Human-like</b>					
1. The agent has a personality					
2. The agent's emotion was natural.					
3. The agent was human-like.					
4. The agent's movement was natural.					
5. The agent showed emotion.					
<b>Engaging</b>					
1. The agent was expressive.					
2. The agent was enthusiastic.					
3. The agent was entertaining.					
4. The agent was motivating.					
5. The agent was friendly.					

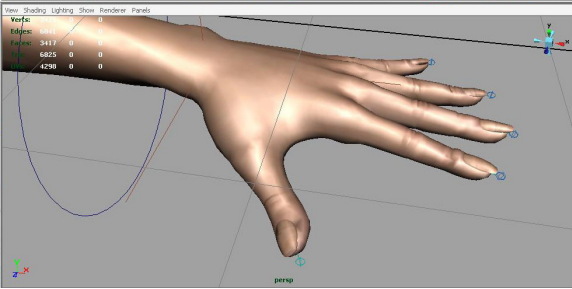
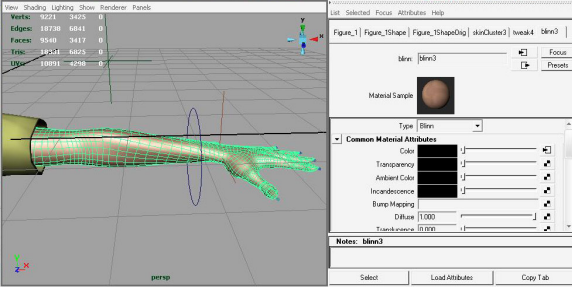
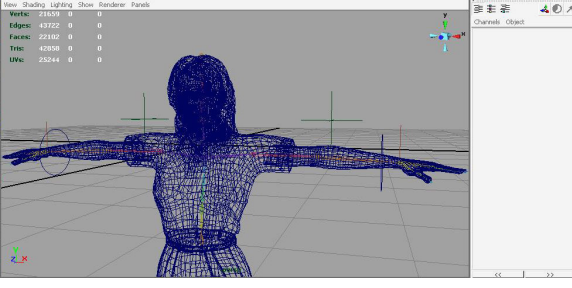
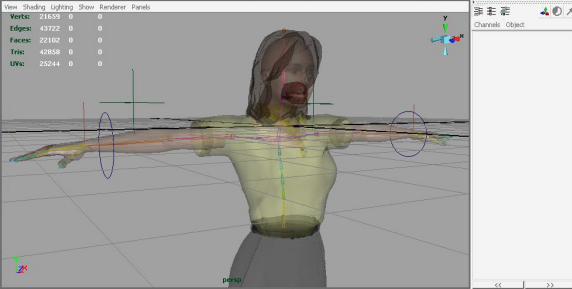
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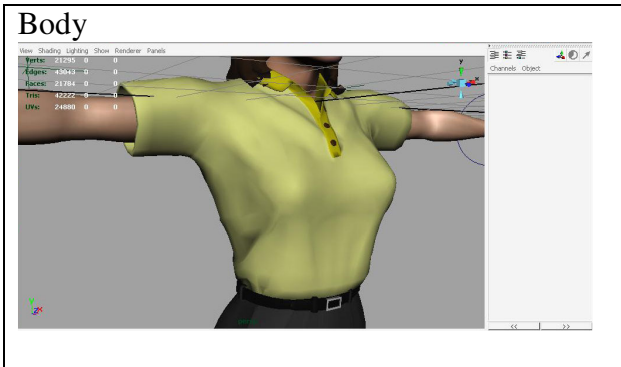
*Journal of Educational Computing Research*, 28(4), 373-395.

## APPENDIX F

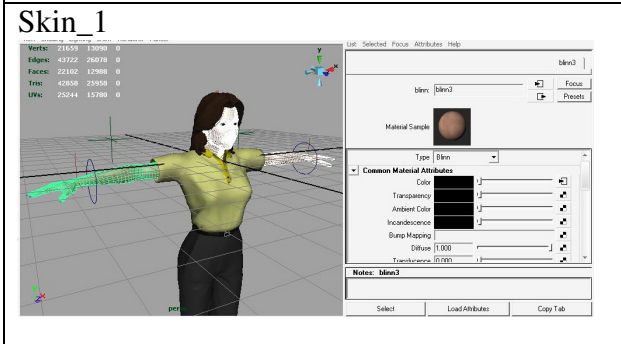
### SCREENSHOT OF VSAPA DESIGN AND DEVELOPMENT

<p><b>Face</b></p> 	<p>The screen displays the design and development of VSAPA's face.</p>
<p><b>Eye</b></p> 	<p>The screen displays the design and development of VSAPA's eyes.</p>
<p><b>Hair</b></p> 	<p>The screen displays the design and development of VSAPA's hair.</p>
<p><b>Head</b></p> 	<p>The screen displays VSAPA's face and head after completely developed.</p>

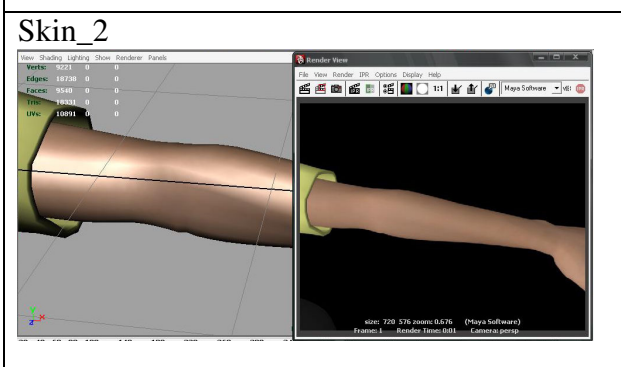
<p><b>Hand_2</b></p> 	<p>The screen displays the design and development of VSAPA's hands.</p>
<p><b>Arm_1</b></p> 	<p>The screen displays the design and development of VSAPA's arms.</p>
<p><b>Bone_1</b></p> 	<p>The screen displays wire frame of VSAPA's upper body.</p>
<p><b>Bone_2</b></p> 	<p>The screen displays texture of VSAPA's upper body.</p>



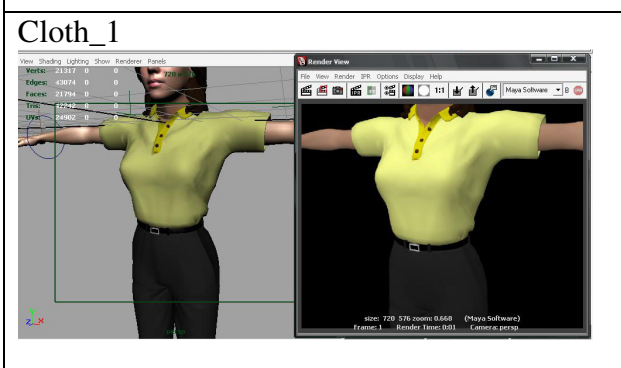
The screen displays VSAPA's body after completely developed



The process of making texture

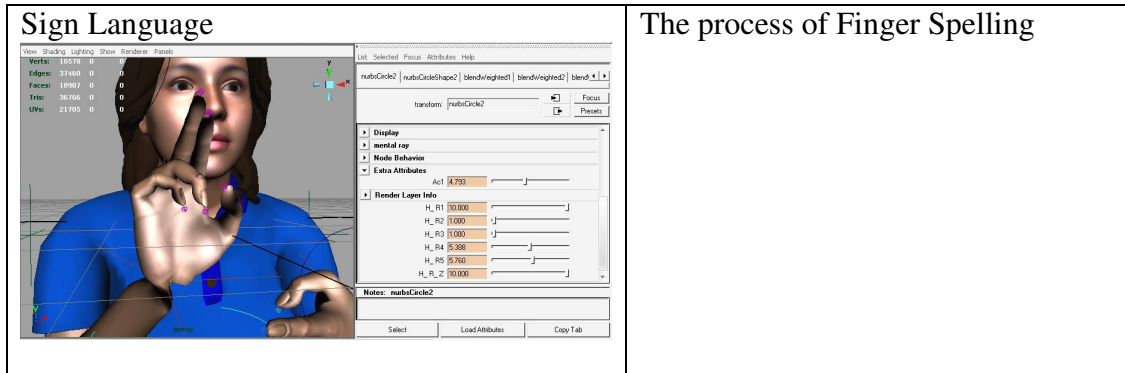


The process of rendering skin color



The process of rendering body and clothes

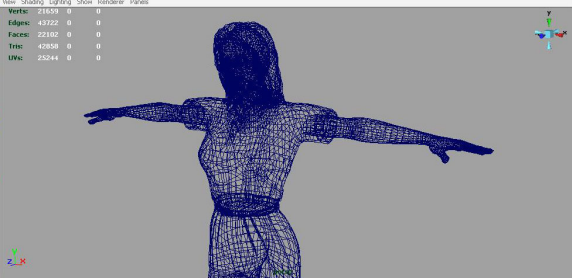
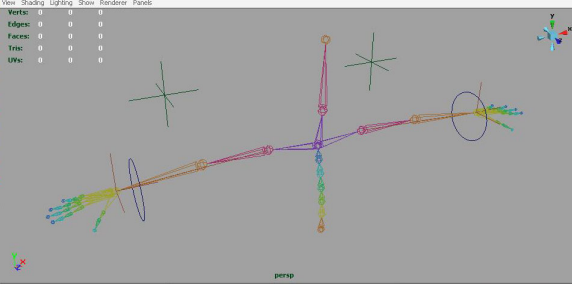
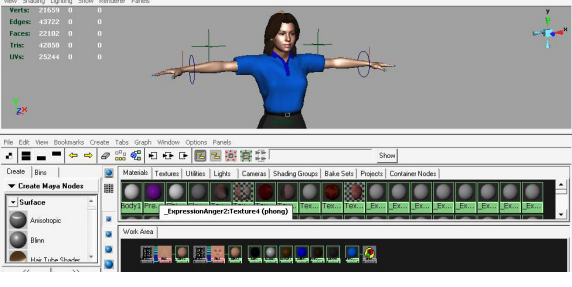
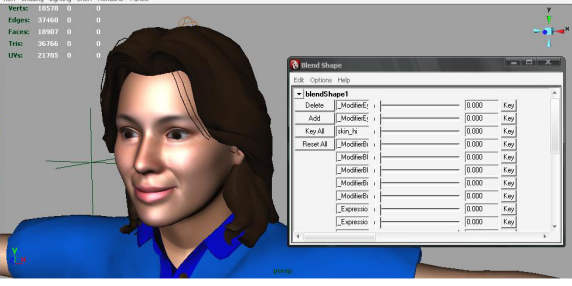
	<p>The process of rendering body and clothes</p>
	<p>The process of Facial Animation</p>
	<p>The process of Hand Animation</p>
	<p>The process of making Sign Language</p>

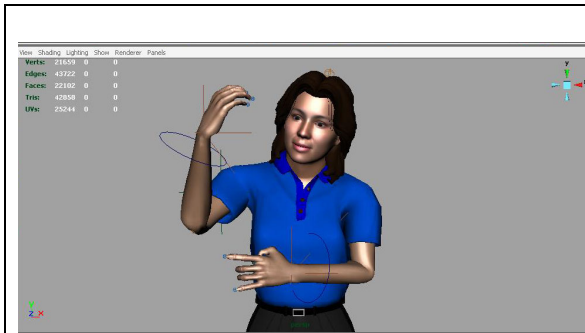


## The process of Finger Spelling

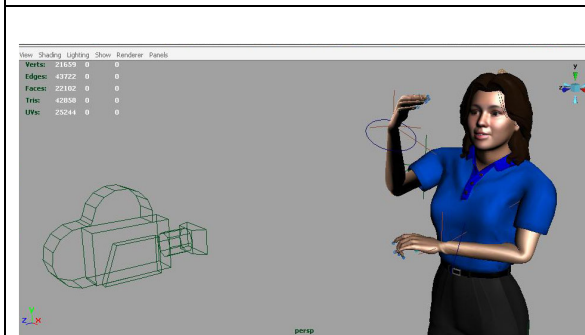
## APPENDIX G

### VSAPA MODELING

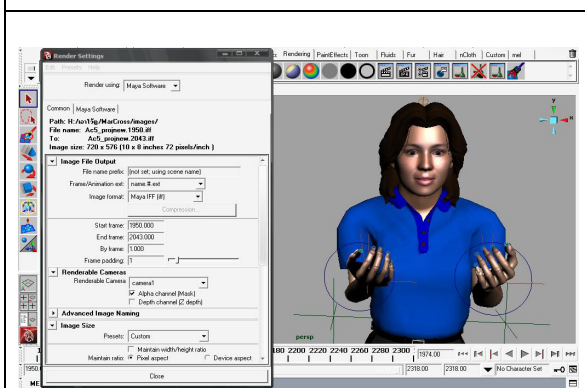
	<p>Step 1: Making the shape of body, head, arms and hands</p>
	<p>Step 2: Connecting joints and bones</p>
	<p>Step 3: Making texture, i.e. skin color, clothes</p>
	<p>Step 4: Making facial expressions</p>



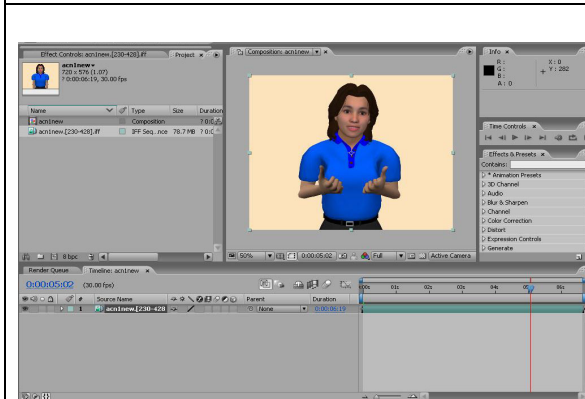
Step 5: The process of making movements with details of each part, i.e. movements of fingers, body, arms



6.1 The process of setting camera under 3D program




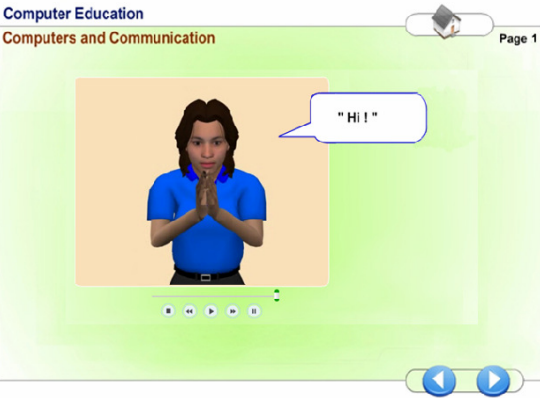

6.2 The process of setting render scale under (using) 3D program



6.3 The rendering process under Compost program

## APPENDIX H

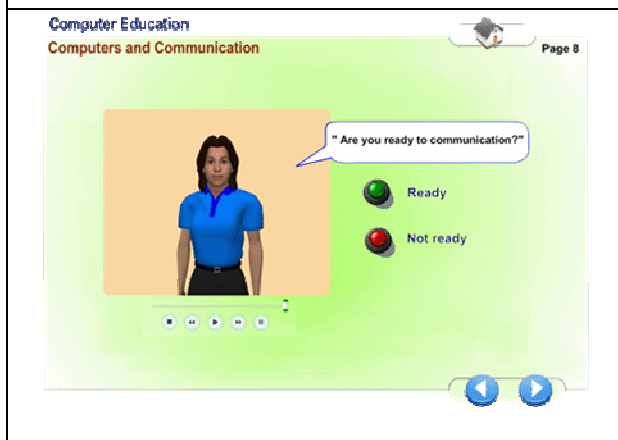
### SCREENSHOT OF VSAPA LEARNING SYSTEM

<p><b>Main Menu</b></p> 	<p>Main Menu</p>
<p><b>Greeting</b></p> 	<p>Greeting</p>
<p><b>Computer Education</b></p> 	<p>Introduction to the Computers and Communication lesson. The topic is “Webcam Communication”.</p>

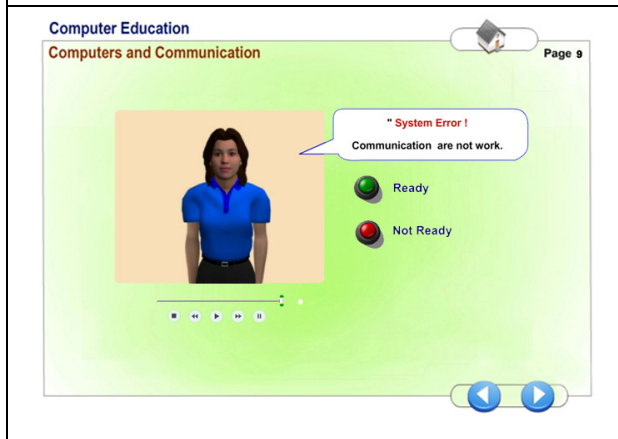
	<p>VSAPA motivate with question:          “Are you know, what is the computers and communication?”</p>
	<p>Lesson on webcam communication.</p>
	<p>Lesson on main components of communication that consists of sender, receiver and high speed Internet.</p>
	<p>VSAPA shows the communication devices: computers and webcams.</p>



VSAPA explains about the webcam driver.



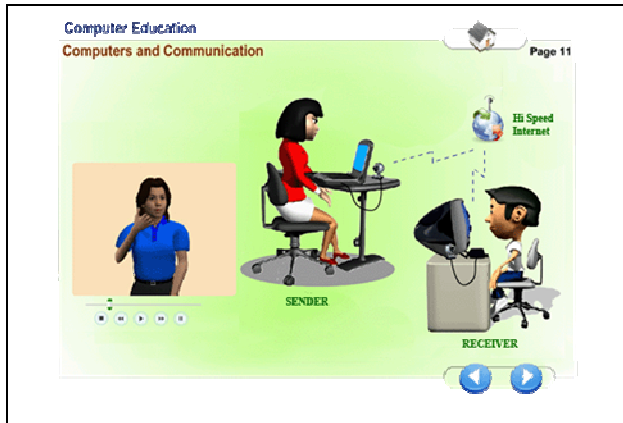
VSAPA asks a question the installations of equipments are ready for webcam communication setting.



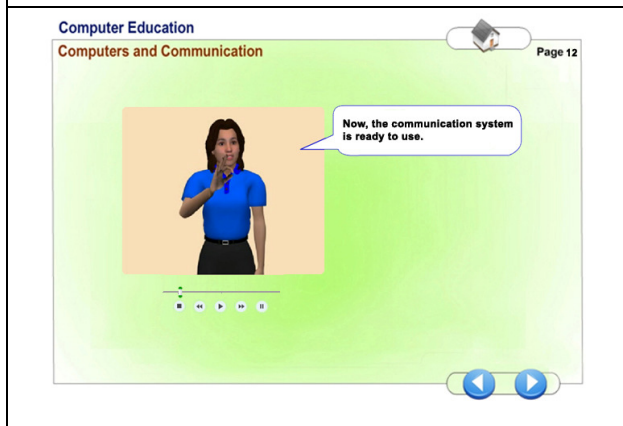
Wrong answer, try again.



Correct, excellent!



VSAPA is explaining about the communication system via Internet after the installation is completed.



VSAPA shows that the communication system is ready to use.



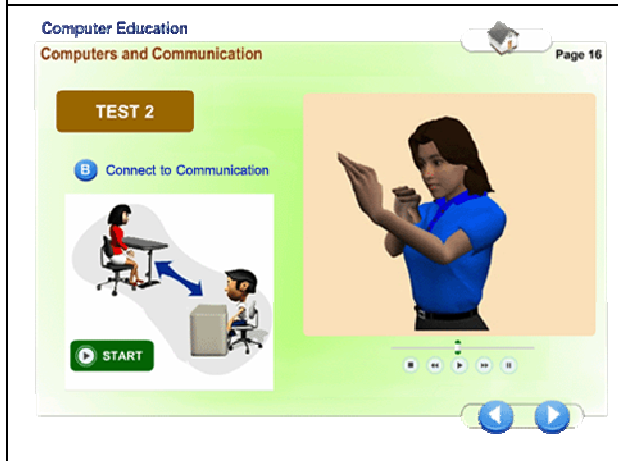
The screen displays the communication between sender and receiver.



The screen displays the communication between sender and receiver.




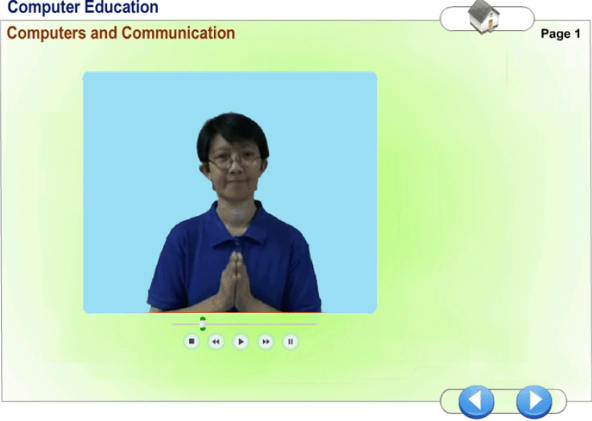
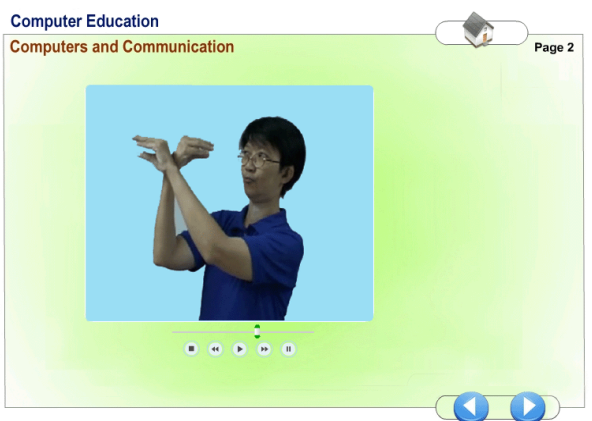
VSAPA is explaining how to do the Test of workshop 1 which is about Hardware and Software, basic components of the communication via internet.  
 Instruction: Matching the items of hardware or software on the left to the correct explanation on the function of that hardware/software in the box on your right hand side. When the answer is correct, the light will blink. When the answer is not correct, there will be no blink.

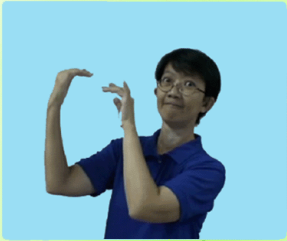

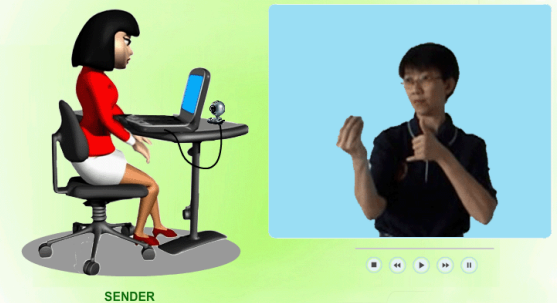






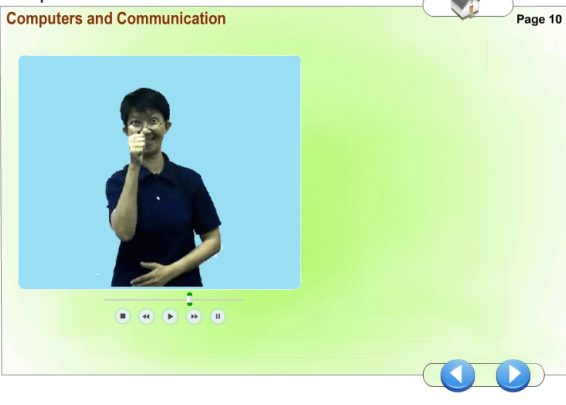
VSAPA is explaining how to do the Test of workshop 2 which is about Computers and Communication implementation.  
 Instruction: Put the given items in the correct positions. After all items are put in the correct positions, the program will be activated. If any item is put in the wrong position, there will be no response from the program.


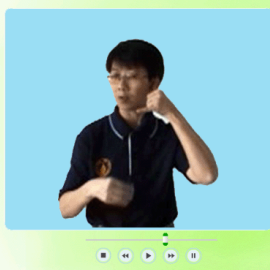
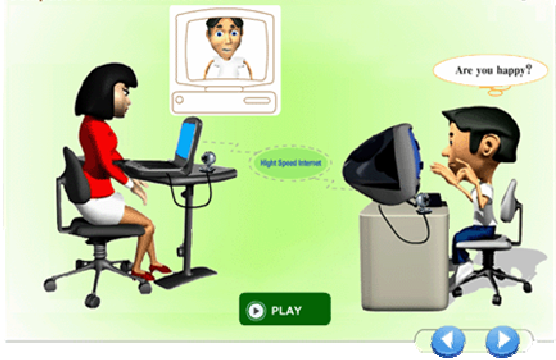

## APPENDIX I



### SCREENSHOT OF VIDEO LEARNING SYSTEM

<p>Main Menu</p> 	<p>Main Menu</p>
<p>Computer Education Computers and Communication</p> 	<p>Greeting</p>
<p>Computer Education Computers and Communication</p> 	<p>Introduction to the Computers and Communication lesson. The topic is “Webcam Communication”.</p>

<p>Computer Education Computers and Communication Page 3</p>  <p>Navigation controls: play, stop, back, forward, volume.</p>	<p>Video signer motivate with question: “Are you know, what is the computers and communication?”</p>
<p>Computer Education Computers and Communication Page 4</p>  <p>Navigation controls: play, stop, back, forward, volume.</p>	<p>Lesson on webcam communication.</p>
<p>Computer Education Computers and Communication Page 5</p>  <p>Navigation controls: play, stop, back, forward, volume.</p>	<p>Lesson on main components of communication that consists of sender, receiver and high speed Internet.</p>
<p>Computer Education Computers and Communication Page 6</p>  <p>Navigation controls: play, stop, back, forward, volume.</p>	<p>Video signer shows the communication devices: computers and webcams.</p>



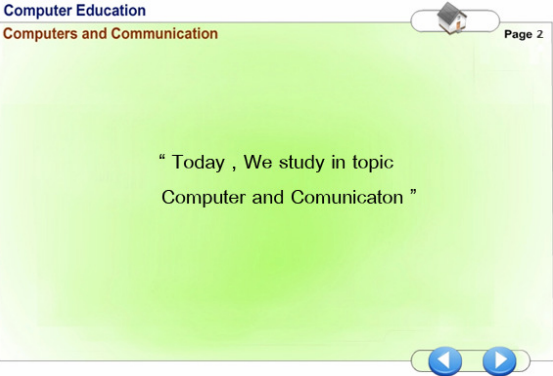
	<p>Video signer explains about the webcam driver.</p>
	<p>Video signer asks a question the installations of equipments are ready for webcam communication setting.</p>
	<p>Wrong answer, try again.</p>
	<p>Correct, excellent!</p>




<p>Computer Education Computers and Communication Page 11</p>  <p>SENDER</p> <p>RECEIVER</p> <p>High Speed Internet</p>	<p>Video signer is explaining about the communication system via Internet after the installation is completed.</p>
<p>Computer Education Computers and Communication Page 12</p> 	<p>Video signer shows that the communication system is ready to use.</p>
<p>Computer Education Computers and Communication Page 13</p>  <p>Are you happy?</p> <p>PLAY</p>	<p>The screen displays the communication between sender and receiver.</p>
<p>Computer Education Computers and Communication Page 14</p>  <p>Yes ... I very happiness.</p> <p>PLAY</p>	<p>The screen displays the communication between sender and receiver.</p>


 <p>The screenshot shows a video player interface. At the top left, it says 'Computer Education' and 'Computers and Communication'. Below that is 'Page 15'. The main content area is titled 'TEST 1' and 'A Accessories'. It features a grid of icons representing various computer accessories and a matching exercise with numbered boxes (1-6). A 'START' button is visible at the bottom left. On the right side of the video frame, a sign language interpreter is visible against a blue background. Video control buttons are at the bottom right.</p>	<p>Video signer is explaining how to do the Test of workshop 1 which is about Hardware and Software, basic components of the communication via internet. Instruction: Matching the items of hardware or software on the left to the correct explanation on the function of that hardware/software in the box on your right hand side. When the answer is correct, the light will blink. When the answer is not correct, there will be no blink.</p>
 <p>The screenshot shows a video player interface. At the top left, it says 'Computer Education' and 'Computers and Communication'. Below that is 'Page 16'. The main content area is titled 'TEST 2' and 'B Connect to Communication'. It features an illustration of two people at a computer workstation with a blue arrow indicating communication. A 'START' button is visible at the bottom left. On the right side of the video frame, a sign language interpreter is visible against a blue background. Video control buttons are at the bottom right.</p>	<p>Video signer is explaining how to do the Test of workshop 2 which is about Computers and Communication implementation. Instruction: Put the given items in the correct positions. After all items are put in the correct positions, the program will be activated. If any item is put in the wrong position, there will be no response from the program.</p>

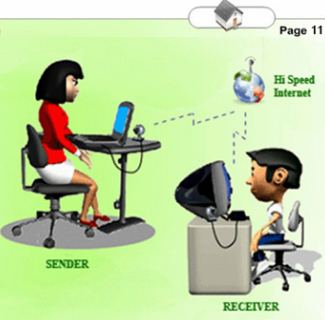
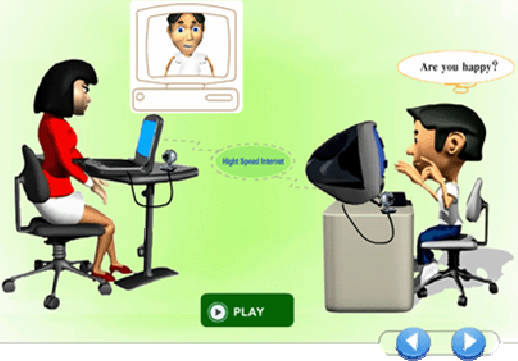
## APPENDIX J



### SCREENSHOT OF TEXT ASSISTED LEARNING SYSTEM

	<p>Main Menu</p>
	<p>Greeting</p>
	<p>Introduction to the Computers and Communication lesson. The topic is "Webcam Communication".</p>

<p>Computer Education Computers and Communication Page 3</p> <p>" Are you know? What is the Computer and Communication? "</p>	<p>The screen displays motivate with question: "Are you know, what is the computers and communication?"</p>
<p>Computer Education Computers and Communication Page 4</p> 	<p>Lesson on webcam communication.</p>
<p>Computer Education Computers and Communication Page 5</p>  <p>" Communication compose of Sender and Receiver "</p>	<p>Lesson on main components of communication that consists of sender, receiver and high speed Internet.</p>
<p>Computer Education Computers and Communication Page 6</p> <p>" This is Hardware compose of Computer and Webcam "</p> 	<p>The screen displays shows the communication devices: computers and webcams</p>

<p>Computer Education Computers and Communication Page 7</p> <p>“ This communication to require <b>Web Camera Driver</b> and <b>MSN Messenger Program</b> ”</p>  <p>Web Camera Driver</p>	<p>The screen displays explains about the webcam driver.</p>
<p>Computer Education Computers and Communication Page 8</p> <p>“ Are you ready to communication? ”</p> <p><input checked="" type="radio"/> Ready <input type="radio"/> Not Ready</p>	<p>The screen displays asks a question the installations of equipments are ready for webcam communication setting.</p>
<p>Computer Education Computers and Communication Page 9</p> <p>“ <b>System Error !</b> Communication are not work ”</p> <p><input checked="" type="radio"/> Ready <input type="radio"/> Not Ready</p>	<p>Wrong answer, try again.</p>
<p>Computer Education Computers and Communication Page 10</p> <p>“ OH ... Yes, you excellent ”</p>	<p>Correct, excellent!</p>

<p>Computer Education Computers and Communication Page 11</p> <p>"Further more, it must connect to high speed Internet between the receiver and the sender "</p> 	<p>The screen displays is explaining about the communication system via Internet after the installation is completed.</p>
<p>Computer Education Computers and Communication Page 12</p> <p>" Communication ready to use and present to next time "</p>	<p>The screen displays shows that the communication system is ready to use.</p>
<p>Computer Education Computers and Communication Page 13</p> 	<p>The screen displays the communication between sender and receiver.</p>
<p>Computer Education Computers and Communication Page 14</p> 	<p>The screen displays the communication between sender and receiver.</p>





	<p>The screen displays is explaining how to do the Test of workshop 1 which is about Hardware and Software, basic components of the communication via internet. Instruction: Matching the items of hardware or software on the left to the correct explanation on the function of that hardware/software in the box on your right hand side. When the answer is correct, the light will blink. When the answer is not correct, there will be no blink.</p>
	<p>The screen displays is explaining how to do the Test of workshop 2 which is about Computers and Communication implementation. Instruction: Put the given items in the correct positions. After all items are put in the correct positions, the program will be activated. If any item is put in the wrong position, there will be no response from the program.</p>

## APPENDIX K





### WORKSHOP 1: LISTING HARDWARE/SOFTWARE

**Instruction : Please select the correct answer**





1. What is Internet connection?

- |    |   |            |    |  |                     |
|----|---|------------|----|--|---------------------|
| a. |  | Computer   | b. |  | Web Camera Driver   |
| c. |  | Web Camera | d. |  | High Speed Internet |





2. What is the software to control the Webcam?

- |    |   |          |    |  |                   |
|----|---|----------|----|--|-------------------|
| a. |  | Camera   | b. |  | Web Camera        |
| c. |  | Computer | d. |  | Web Camera Driver |





3. What is a device which generates images that can be accessed by and displayed on the World Wide Web through a server?

- |    |   |          |    |  |            |
|----|---|----------|----|--|------------|
| a. |  | Printer  | b. |  | Web Camera |
| c. |  | USB Port | d. |  | Binocular  |





4. What is a programmable machine?

- |    |   |                       |    |  |                     |
|----|---|-----------------------|----|--|---------------------|
| a. |  | Printer               | b. |  | Computer            |
| c. |  | MSN Messenger Program | d. |  | High Speed Internet |

5. What is an instant messaging program?

- a.  Computer
- b.  High Speed Internet
- c.  MSN Messenger Program
- d.  Web Camera Driver

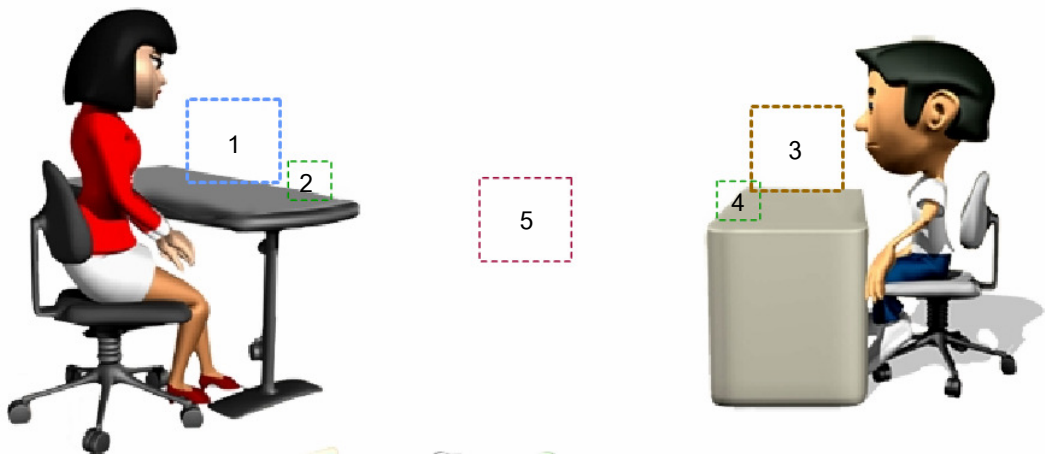
6. Which device is used to connect a webcam to computer?

- a.  Camera
- b.  USB Port
- c.  Web Camera Driver
- d.  High Speed Internet





## APPENDIX L

### WORKSHOP 2: ACTIVATING COMMUNICATION SYSTEM





**Instruction: Please select any device to the right place at the position number 1, 2, 3, 4 and 5 that can activate the communication system**



1. Device at position number 1 is...

- |    |   |           |    |  |                     |
|----|---|-----------|----|--|---------------------|
| a. |  | Computer  | b. |  | High Speed Internet |
| c. |  | Webcamera | d. |  | Web Camera Driver   |

2. Device at position number 2 is...

- |    |   |                       |    |  |                     |
|----|---|-----------------------|----|--|---------------------|
| a. |  | Computer              | b. |  | Webcamera           |
| c. |  | MSN Messenger Program | d. |  | High Speed Internet |

3. Device at position number 3 is...



a. Computer



b. High Speed Internet



c. Webcamera



d. Web Camera Driver

4. Device at position number 4 is...



a. Webcamera



b. Computer



c. MSN Messenger Program



d. High Speed Internet

5. Device at position number 5 is...



a. Messenger Program



b. Web Camera Driver



c. Computer



d. Webcamera

## **BIOGRAPHY**

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<b>PUBLICATION / PRESENTATION</b>	Saksiri, B., & Ruenwongsa, P. (2010). Effects of a Virtual Sign Animated Pedagogical Agent on ICT Learning. The International Journal of Learning, Volume 17.