Universität Erfurt

Dissertation

Influence of Comics Characters as Pedagogical Agents in a Multimedia Learning Environment of Calculus for Thai Students

zur Erlangung des akademischen Grades

einer Doktors der Philosophie (Dr. phil.)

Erziehungswissenschaftliche Fakultät

Aphinan Jitjaroen

Dekan: Prof. Dr. Manfred Eckert

Gutachter: 1. Prof. Dr. Helmut Niegemann (Universität Erfurt)
2. Prof. Dr. Bärbel Kracke (Universität Erfurt)
3. Prof. Dr. Thomas Köhler (Technische Universität Dresden)

eingereicht: 13.01.2009

Datum der Promotion: 19.02.2009

urn:nbn:de:gbv:547-200900256

Zusammenfassung

Die Arbeit soll den Einfluss von Pädagogischen Agenten in Form von Manga-Comicfiguren auf den Lernprozess bei der Vermittlung von Algebra/Funktionen („calculus“) untersuchen.

Dazu werden zunächst theoretische Grundlagen zu den Themen „Pädagogische Agenten“, multimedisles Lernen, Lernmotivation und Instruktionsdesign dargestellt und Hypothesen für die empirischen Studien aufgestellt.

In einer ersten Studie (Vorstudie) wurden die Präferenzen von Studierenden für bestimmte Merkmale von Manga-Comicfiguren als Pädagogische Agenten erfragt („niedlich“ vs. „reputierlich“ bzgl. Des Aussehens und mit „ruhiger“ vs. „lustiger“ Stimme). Die verwendete Figur ist in Asien sehr populär.

In Studie 2 wurden Lerneffekte und Präferenzen „pro“ order „contra“ die beiden Versionen der Manga-Pädagogischen Agenten erfasst und mittels t-Test verglichen. Wie schon in der Dissertation von Domagk (2008) zeigten sich keine Lerneffekte.

Da bei Domagk einige Ergebnesse den Einfluss der Stimme des Pädagogischen Agenten nahe legten, wurden in einer dritten Studie die beiden Figurtypen („Newton“ und „Conan“) mit Jeweils „Ruhiger“ und „lustiger“ Stimme kombiniert und die vier Bedingungen mittels ANOVA verglichen; zur Berücksichtigung der Präferenzen wurde eine MANOVA gerechnet.

In einer vierten Studie wurde der Einfluss der bevorzugten Mangafigur mit einem menschlichen Video-Agenten verglichen. Hier zeigten sich Unterschiede derart, dass die Studenten mit den Manga-Figuren etwas bessere Lernergebnisse aufwiesen, inbesondere schwächere Studenten (mit geringerem Vorwissen) schienen von der bevorzugten Mangafigur leicht zu profitieren.

Die Arbeit bestätigt insgesamt die Ergebnisse von Domagk: Die Verwendung von Pädagogischen Agenten hat generell keine durchschlagenden Ergebnisse für den Lernerfolg, offensichtlich wird das Lernen aber auch nicht behindert. Der Einsatz von Pädagogischen Agenten in Form von Comicfiguren verspricht bestenfalls unter bestimmten Bedingungen (Studienanfänger) leichte Vorteile, denen der finanzielle Aufwand bei der Entwicklung der Figuren gegenüber steht.

Abstract

The purpose of this research was to examine the influence of Japanese comics characters (manga) as pedagogical agents and the effect of prior knowledge on students' learning and perception in calculus multimedia. Initially, 56 undergraduate calculus students were asked for their preferences, with 84% of them preferring to have animated manga agents integrated. These students then studied calculus multimedia with and without manga. The results were compared by "Student's t-test". It was revealed that the use of manga did not enhance knowledge, despite their use being rated by the students as satisfying. Secondly, two manga character types ("cute" and "prestigious"), and two narration voice styles ("calm" and "amused") were investigated. 89 undergraduate students were randomly assigned to classes in one of the four conditions. The results were analysed by ANOVA, it showed no effects of manga characteristics and voice style on learning, while preferences were analysed by MANOVA, which indicated (significance as hypothesized) that the amused voice style was prominent. The combined factors of cute with an amused voice, and prestigious with a calm voice, were the most distinguished. Finally, a cute manga agent was compared with a human video agent. The results from 121 students were analysed by ANOVA, showing that they learned better when using the comics character. Overall, the students with more prior educational knowledge learned better regardless of the agent type.

Index of Content

Acknowledgements

This research was carried out at Faculty of Education, University of Erfurt, Erfurt, Germany during the year 2003-2008. The fellowship and other financial were support from the Office of the Civil Service Commission, Thailand that is gratefully acknowledged.

I wish to express my gratitude to Prof. Dr. H.M. Niegemann for supervising the academic research and for providing excellent working facilities as a member in his research group. Moreover his valuable knowledge, constructive critics and continuing encouragement were essential during the whole work. I would like to sincere thanks to Prof. Dr. Bärbel Kracke from The University of Erfurt and Prof. Dr. Thomas Köhler from The TU Dresden for his willingness to reviewing of the manuscript.

My special thanks to Ms. Manuela Linde, Director of International Office for friendly facilitation during my whole working at University of Erfurt, and go as well to all staff members of Faculty of Education, like Dr. Steffi Domag for statistical analysis and prior-knowledge aid. Hereby I wish to thank for my long understanding friends and enjoyable friendship to Thomas Gundermann, for setting-up my 5 yrs. office at ZLB137. Ms. Lisa Niegemann for her hard work to be an electronical-editorial this dissertation. My wonder international conference “E-Learn 2008” at Las Vegas was fluently with the supported by Ms. Frauke Kämmerer for poster preparing and production. Zigie and all members of Trackl’s family, Johannes and Stephanie Leder (the first English editor), Elijha Torrico from Texas the final English editor, the persons were helping me from the first till the last days in Erfurt. The pleasant working atmosphere has been very important for me.

I wish to acknowledge my deeply grateful to Dr. Sanchai Patachot for his very important messaged on the human resource development scholarship that I’ve got for 5.5 yrs., Ms. Orathai Buntawong, Mr. Chaiwat Toomdaungkeaw, Ms. Arporn Intachai, friends and students at Lampang and Payap campuses for their effort and help in conducting the calculus e-learning experiment in Thailand. My heartily thanks are extended to my colleagues for their help during my absence from Ragamangala University of Technology Lanna, Lampang.

Finally, I warmly thank my mother, Ms. Banjong Deemarg for inspiring, encouragement and continuous support during my whole life. Furthermore, I wish to thank my entire family. My deep thanks go to my wife; Dr.Wanphen Jitjaroen for Agent Conan narration and my daughter; Similan Jitjaroen for manga’s computer sketching. I profound your love, comprehensive and encouragement, you are most wonderful part of my life.

List of Abbreviations

AI	Artificial Intelligence
Agent	Being endowed with movement to give the impression of being alive.
Animated pedagogical agent	On-screen character who communicate with learners by providing feed back, guidance, and encouragement
Anime	Manga animation
ANOVA	Analysis of variance
Anthropomorphic	Having the appearance and/or traits of humans.
Deictic gesture	An animated pedagogical agent use of hand gestures and locomotion to direct students' attention to visual stimuli on the computer screen.
Lifelike	Giving the illusion of being animated or alive.
Manga	Manga is a Japanese word referring to comics and printed cartoons.
MANOVA	Multivariate analysis of variance
Modalities	Each one of the sensory processing channels of information, such as the visual, auditory, or hectic modalities.
PAs	Pedagogical agents
Software agent	A computer-enacted character that acts on behalf of a user to carry out a particular task.
Social cues	Aspects of multimedia instructional messages that encourage the learner to view the tutor as a social partner, such as conversational style and human voice.

Appendix Index

Preface

Learning supported by technology can be an efficient way to foster successful learning, but often the cognitive overload prevents better results (Niegemann, 2006). Therefore, during the last twenty years, a theory of cognitive load in multimedia learning has been developed (Mayer, 2005). The theory states that reducing cognitive load enhances learning as well as transferring performance (Baylor, 2002). Three important aspects of this theory are: dual-channel assumption, limited-capacity assumption, and active processing assumption (Mayer and Moreno, 2003). The theory has helped clarify how to obtain better results from supported learning with multimedia. Another aspect of this theory refers to possible advantages of learning with animated pedagogical agents. Johnson (1994) describes a pedagogical agent as an autonomous agent that supports human learning by interacting with students in the context of interactive learning environments. The research on animated pedagogical agents is viewed as a very positive attempt to introduce more pedagogical support and motivational elements into multi-media instruction (Clark, 2005).

The goal of this dissertation is twofold:

To investigate the acceptance of pedagogical agents by students and teachers.

To examine how the classroom performance of calculus students is affected by the use of pedagogical agents, specifically comics characters, in calculus multimedia.

In order to adequately investigate the use of the pedagogical agent, the researcher will also address the following questions:

Do pedagogical agents enhance or hinder learning?

What characteristics cause the pedagogical agents to be effective?

Part I Theoretical Foundation

This part will discuss the theoretical framework and background necessary to understanding the use of pedagogical agents in multimedia learning. A broad overview of information will be introduced in this part: 1 Instructional design theories, 2 Learning environments, 3 Educational multimedia, 4 Theoretical framework of multimedia learning with pedagogical agents. 5 Pedagogical Agents characteristics, and 6 Overview of manga.

1 Instructional Design

In 1962 Robert Glaser synthesized the work of previous researchers and introduced the principle of instructional design, providing a model which links learner analysis to the design and development of instruction. Various explanations for instructional design, (one definition of it being the science of creating detailed specifications for the development, implementation, evaluation, and maintenance of situations that facilitate the learning of both large and small units of subject) matter at all levels of complexity (Berger and Kam, 2004). A general instructional design is also known as ADDIE (Analysis, Design, Development, Implementation, and Evaluation), is used as an instructional design technique methodology (Tab. 1).

Tab. 1: ADDIE steps to create learning media (Seels and Glasgow, 1998)

Phase	Task	Output
Analysis	Needs analysis Task analysis Instructional analysis Learner analysis	Problem statement Behavioural task statements Learner prerequisite Knowledge
Design	What are the objectives?	Measurable objectives
Development	Draft materials	Storyboard Exercises
Implementation	Is the client ready to take responsibilities for the course?	Implementation guides Progress tracking systems Procedures for monitoring Resource consumption
Evaluation	Have we solved the problem?	Recommendations for change Project report

Although a variety of systematic instructional design process have been described (e.g., Dick and Carey, 1996, Gagné, Briggs and Wager, 1992, Kemp, Morrison, and Ross, 1998) all descriptions include the core elements of analysis, design, development, implementation, and evaluation (ADDIE) in order to ensure congruence among goals, strategies, and evaluation, and the effectiveness of the resulting instruction. Fig. 1 represents one way to depict the relationship among these core elements.

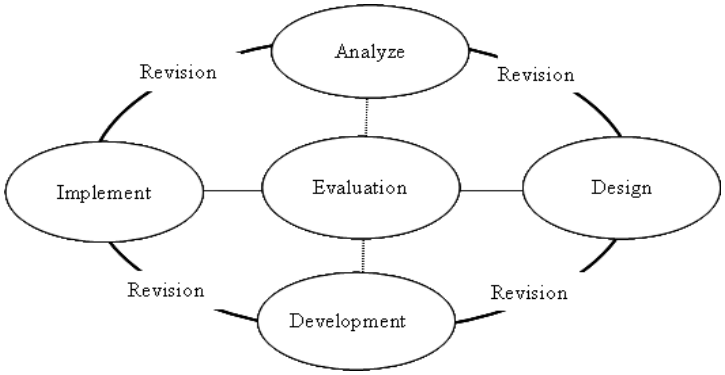


Fig. 1: Importance of Instructional design

Based on the Gustafson & Branch (2002) definition of instructional design (ID), although there have been advances in learning theory in recent years, the technology of development and delivery systems, the training, skill and sophistication of instructional designers, and the unifying variables contained in most of the original ID models remain the same. These unifying variables are as follows: the instructional design is a systematic process usually conducted by a team of professional and involves analysis of the performance problem as well as the design, development, implementation, and evaluation of an instructional solution to the given problem. Moreover, instructional design is an empirical process that is learner-centred and goal-oriented, geared towards providing a reliable and valid measurement of the skills and knowledge that the learners will be required to demonstrate in the real world.

While instructional design is well accepted in business, industry, government, and the military, there is a growing use of instructional design process in colleges at the scholastic level and schools, especially as they become more involved in distance learning programs that require high quality instruction without the benefit of live instructors. Proprietary schools and companies providing occupational skills or certification in technical areas are also increasingly looking to instructional design as a means of ensuring both the effectiveness and relevance of their services. Instructional design, as currently practice, has much to offer for now and in the future, but it does not meet all the needs for enhancing human performance in a complex and ever-changing world.

1.1 Dick and Carey's Instructional Design Model

ADDIE illustrates the conceptual components of instructional design; however, the need remains to indicate how to apply the instructional design process. Instructional design models serve this purpose by describing how to conduct the various steps that comprise the instructional design process. One of the most popular and influential instructional design models was created by Dick and Carey (1996) depicted in Fig. 2.

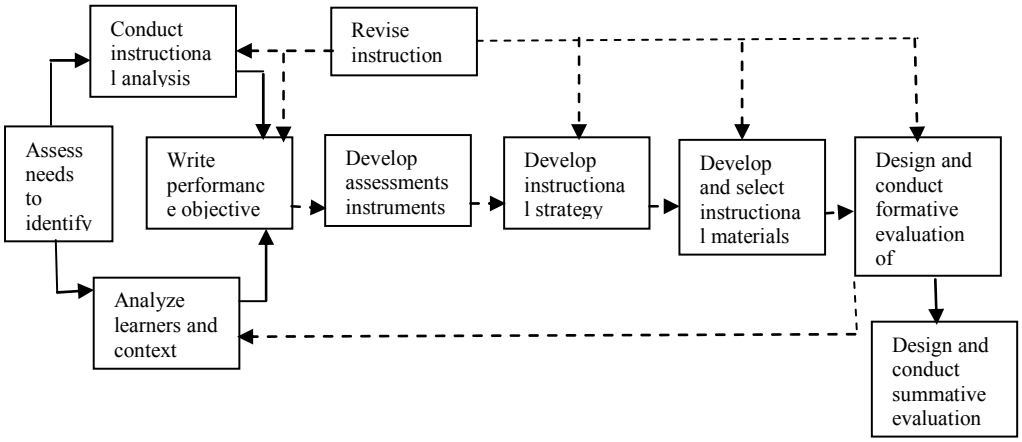


Fig. 2: Dick and Carey's instructional design model

1.2 Decision Oriented Instructional Design Model

Bridges across instructional design ideals and multimedia learning producers were established, known as instructional design assistant (ID Assistant), by Niegemann (2006). Due to this, many multimedia learning developers were not familiar with utilizing instructional design theories and models. This is rather true in non-English speaking countries, where instructional design is not yet an established academic discipline. Multimedia learning products produced by graphics computer specialists often miss the instructional target. Thus, instructional design assistant (ID Assistant) was developed as a prototype in order to help instructional designers attain their goal. The principle of the ID-Assistant is based on a decision-based model of instructional design, which tries to integrate the relevant features of known ID models. This system aims to assist developers in designing multimedia-learning environments which meet the most important requirements of the instructional design theory see Fig. 3.

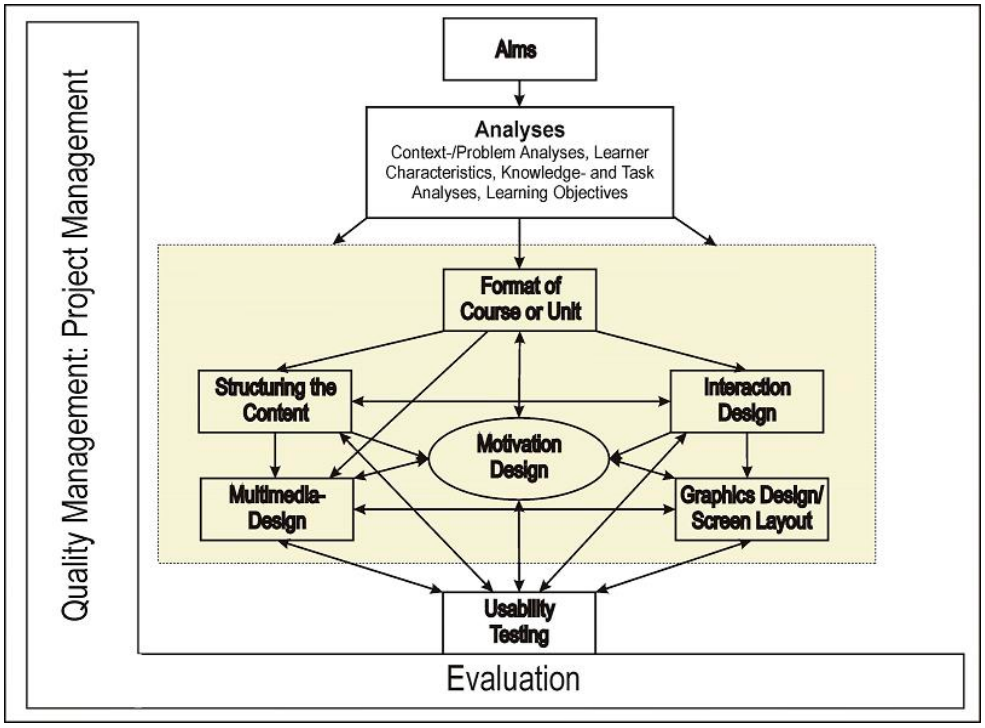


Fig. 3: The DO ID (Decision Oriented Instructional Design) model

The keys of the ID-Assistant have been revealed by Niegemann (2006) as (a) A repository of possible solutions for pedagogical design decisions of different kinds (represented by design patterns). (b) Hints and recommendations for the analysis of the conditions of learning, especially learning characteristics, knowledge analysis, job and task analysis, and the determination of learning objectives. (c) Principles which relate the conditions of learning and given context conditions with alternative solutions. (d) An interface for the human-computer interaction. (e) A "generator" for recommendations regarding instructional design decisions (selection of suitable pedagogical design patterns regarding the given conditions). The core of the system is a repository of instructional design principles represented by pedagogical design patterns the ID assistant should support ID producers to design and develop more efficient multimedia learning environments.

2 Educational Multimedia

Multimedia is the combination of two or more media type into a single coherent message. In practice, however, due to the computer's capability to harness and manipulate diverse media, the term multimedia has become more complex. Nowadays, multimedia usually refers to contemporary software that contains combinations of text, graphics, animation, video, or audio. Multimedia often implies the inclusions of some form of hyper linking. Hyperlinks allow users to determine their own parts or follow personal interests through a lesson rather than a linear path. However, not all multimedia is educational. Many multimedia systems are intended solely for entertainment. In contrast, educational multimedia refers to several different classes of software that are used to

achieve clearly identifiable educational goals. Educational multimedia consists of three categories: presentation tools, interactive programs, and learning environments, all of which represent an evolution in understanding the potential for technology in education. Each is generally associated with different theoretical and epistemological foundations.

2.1 Presentation Tools

Initial attempts at multimedia design tended to replicate existing teaching practices and technology. Today's computer presentation tools are quickly replacing analogue technology from the 1970s and 1980s such as overhead projectors, multi-vision slide/tape presentations, and interactive video forms.

2.1.1 Slide Shows

Slide show displays are presentations projected by overhead or slide-tape equipment. The advantages of a computer slide show are that software can speed the development process through the use of professional-looking templates and allow the integration of varying media, such as animation and video.

2.1.2 Web Pages

The primary advantages of web pages over slide shows are that web pages incorporate hyper-link capabilities and allow users to access information on the internet. Creating a web page tends to be more difficult than creating a slide show, but once established, a web page can be accessed from anywhere, thus eliminating the need to transport special equipment for remotely located presentations.

2.1.3 Kiosks

Educational kiosks are found in many museums, art galleries, zoos, universities, medical offices, and other environments, in which users access information expected to be useful in the intermediate setting. In general, information in a kiosk is organized for the anticipated users and developed to facilitate navigation. Kiosks generally incorporate all the features found in web pages and slide shows, but the customized navigation often considerably increases the development time and computer knowledge required of the developer. The role and potential benefit of presentation tools in education should be carefully considered. In particular, teachers and trainers should know the purpose of presented information and who should present. Many instructors' initial attempts to use presentation tools have been to deliver instructions to students. Slide shows, web pages, and information kiosks all represent manifestation of the delivery model.

2.2 Interactive Multimedia

Interactive multimedia differs from presentation tools in its focus of engaging users in activities requires sufficient mental processing to ensure learning. From this perspective it is assumed that

specific types of mental activity necessary for learning to occur can be encouraged by systematically manipulating instructional events.

Much of the early work with interactive multimedia applied instructional design principles to multimedia design. Instructional design places a heavy emphasis on instructional analysis, in which the skills that are needed to achieve a goal are identified, sequenced, classified, and taught explicitly. Prescriptions are applied to match instructional approaches with different skills to ensure that learning is effective and efficient (Gagné, Wagner, and Rojas, 1981).

Many early interactive multimedia systems incorporated high instructional support features that are commonly associated with approaches such as mastery learning, personalized system of instruction, and programmed instruction (Ross and Morrison, 1988) such as drill-and-practice and tutorials. The former software continues to be used today and is an excellent instructional method for learning lower-level procedures, skills, or concepts. The latter, at its most basic, involves presenting and guiding the learner through information or skills. Designers attempted to develop models that were more intelligent and more interactive. Some models incorporated adaptive systems based on Baysian probability theory (cf. Tennyson, Christensen, and Park, 1984), while others were created within expert system shells. Expert systems can be used to diagnose learning needs and recommend optimum instructional approaches based on the complexity of the content and the learners' experiences (Harmon, 1986).

In essence, sophisticated tutorials allowed for more interactivity and attempted to diagnose learning needs and prescribe instructional support, much like an effective classroom instructor world. The development of drills and tutorials has tended to reflect a behavioral orientation to teaching and learning. First, goals are decomposed into subtasks, which are taught explicitly. Next, students demonstrate proficiency in all subtasks through overt responses; correct responses are reinforced, and incorrect answers are resolved. Task mastery is used as evidence of effective learning.

Significant changes in theories of human learning have occurred in recent years. In psychological terms, this change is sometimes described as a shift to constructivism, whereas behaviorists once viewed learning as a process of building stimulus-response associations, and contemporary learning theorists focusing more on the importance of individual experience. Constructivism emphasizes teaching practices that help students to generate relationships between new information and prior knowledge while recognizing the importance of social interaction in the learning process. These changes have led the emergence of a new breed of educational multimedia known as learning environment.

3 Learning Environment

Perhaps the greatest change between learning environments and traditional educational multimedia is the shift in how the designer controls the learning activity. In drill-and-practice or tutorials, stu-

dents are directed to complete instruction in a predetermined sequence. In a sense, students are expected to adhere to the adage that the “teacher knows best”. Traditional educational multimedia build on the belief that, given appropriately motivated students, learning experiences can be organized to produce predictable results. Part of this process implies that designers can control instructional evens to ensure that learning occurs.

In a learning environment, in contrast, students are driven not so much by a sequence inherent in the materials rather by the problems, questions, or projects they are encouraged to unravel or address. Within a learning environment, students are provided with resources that can be used to help understand and resolve problems (Jonassen, 1998). Based on a constructivist belief that designers cannot and should not attempt to control “what is learned”, The role of the designer shifts to developing experiences that help diverse learners in developing personal interpretations of the knowledge.

Wilson (1996) defined a learning environment as “a place where learners may work together and support each other as they use a variety of tools and information resources in their guided pursuit of learning goals and problem-solving activities”. Jonassen, Peck, and Wilson (1999) identified five characteristics of a learning environment: a problem space, related case information resources, cognitive tools, and conservation tools.

3.1 Problem Space

A problem space contains the central problem around which student activity revolves. The selection of appropriate problems is critical because it assumes that students will find the problem interesting enough to invest effort into its solution. Savery and Duffy (1996) provide guidelines for the problem generation. First, the problem must focus on relevant content. Hence, the designer must begin by identifying content that is essential for students to learn. Second, problems should not be simplified to reduce ambiguity; Students should not be attempting to solve textbook problems that have clear right and wrong solutions. Third, problems must be authentic; to encourage students to take ownership of a problem, they must believe that a problem is real and that it affects their everyday lives.

3.2 Related Cases

There is a growing understanding that expertise and the transition from the classroom to the real world evolve from experience (Lave and Wenger, 1991). Without experience students are often unable to practice effective decision making. One way to stimulate experience is to provide a database of related cases. Studying cases stimulates development of knowledge which can be used to guide judgement. Developing expertise involves understanding the multiple dimensions that influence a problem. In real life, resolving complex problems generally involves applying previous experiences that guide towards the solution.

3.3 Information Resources

In addition to developing experience with cases, learners need to learn and use domain-relevant knowledge and skills to solve problems. In a learning environment, relevant information can be provided for students in diverse data banks; multimedia documents, interactive multimedia, videos, and data sources on CD-Rom or the internet may be valuable information resources.

3.4 Cognitive Tools

Cognitive tools help learners in developing the level of processing needed to complete a task. In general, they are resources for recording, analysing, and organizing information. Some cognitive tools may use standard application software, such as spreadsheet, to experiment with diverse scenarios. Other tools encourage users to construct and explore.

3.5 Conservation Tools

Conservation tools provide opportunities for students to establish on-line communities. Communicating with other students can improve the quality of learning (Johnson and Johnson, 1989), although precisely how such communities influence the learning process is open to debate (Slavin, 1992). Collaboration provides a user with insights into other people's thinking processes and experiences. It also provides an opportunity to gauge one's personal understanding in relation to that of others. Collaborative environments also increase opportunities for help and practice

3.6 Knowledge Integration Environment

Knowledge integration environment (KIE) (Bell, Davis, and Linn, 1995) is an example of a learning environment that moves away from the model of teaching through telling and testing. Instead, students are encouraged to build connections between their own experiences and their interpretations of everyday observations and practices. Students explore, test and explain various scientific phenomena and are provided with diverse experiences and tools to encourage these activities. Students are initially presented with problems that they find intrinsically interesting.

Learning environments present two important advantages over other designs. First, the problem-based approach, around which learning environments are constructed, appears to have important effective consequences. Solving real-world problems make education more relevant and encourage students to take ownership of their learning. Authenticity develops deeper knowledge structures and improves transition in to other situations (Grabinger, 1996). Second, learning environments appear to have considerable potential as just-in-time learning tools. Although the software designer may supply problems, recent attention has focused on environments that allow users to posses their own problems. Such systems have important potential in business settings in which users can learn on a need-to-know basis, and may have considerable impact on school settings in which students work on ill-defined problems. As software and hardware continue to evolve, educational technol-

ogy's success appears to be determined more by what the learner contributes to the learning environment than by what the technology can deliver. Bereiter and Scardamalia (1989) explained that learners in supportive environments have high levels of self-efficacy and self-motivation and use learning as a primary transformation.

4 Motivation in Learning

Keller (1983, 1999) explained that motivation refers to a person's determinations in pursuing a goal or performing a task, manifested by the choice of goals and effort (persistence plus vigour) in pursuing the goal. To design effective learning environments or to develop historic programs of human performance development, the designer must understand and integrate effort, performance, and satisfaction. The motivational element is particularly important because it pertains to a person's basic decision in whether or not to accept responsibility for a task and to pursue a given goal. Without this initiation of behaviour, none of the other things matter.

Three basic assumptions underlying systematic motivational design should be accepted. The first assumption is that people's motivation can be influenced by external events. Even though this might appear to be a truism, it runs counter to a frequently held assumption of many teachers and instructional designers who believe that their job is to provide the best-quality instruction they can and it is the student's responsibility to want to learn the material. Ultimately, students do have control over their motivation, but even motivated students will become uninterested if the instruction is boring and disorganized, just as they may be inspired by an enthusiastic teacher. Teacher behaviour, instructional materials, and other elements of learning environment will all affect motivation.

The second assumption is that motivation is a means, not an end, in relation to learning and performance improvement. Too often, educators equate motivation with entertainment and fun; they believe that if learners are truly motivated, they will be smiling and having fun. Certainly, it is enjoyable when learning is fun, but that is not the primary goal of motivation design. The goal is to have learners engaged in learning or work activities, not just to be entertained by them.

The third assumption is that systematic design can be used to predictably and measurably influence motivation. Instructors sometimes, maybe often, believe that to be motivating one must have charisma and wit. On the contrary, there are fundamental characteristics of motivation, and processes for influencing it, that can assist teachers in having motivating instruction regardless of their personality.

4.1 Intrinsic and Extrinsic Motivation

Deci & Ryan (1975) explained differences between intrinsic and extrinsic motivation: intrinsic motivation occurs when one engages in a task for which there is no apparent reward except the pleasure of engaging in the activity. In contrast, according to Deci (1975) and Stipek (1998), ex-

trinsically motivated individuals engage in task for rewards associated with successful accomplishment. Naturally, there can be a mixture of the two elements in a given situation; there can also be conflicts such as extrinsic rewards reducing one's intrinsic motivation for learning.

4.2 Trait and State

A state is a condition brought on by a situational stimulus or process, whereas a trait is a stable psychological need or drive. Berlyne (1965) indicates that curiosity, for example, can be one trait, but it also has state characteristics; that is, people differ in their stable, trait-level degree of curiosity, but some situations will awaken a curious state more than others. Rotto (1994) made the same point in regards to intrinsic motivation, and virtually all motivational characteristics have both trait and state features. It is reasonable to assume that because many elements of motivation are at the state level, they will be influenced by immediate situational factors and will change from time to time during a period of instruction (Visser and Keller, 1990). Therefore, motivational design models must accommodate both the stable trait and changeable state aspects of motivation and incorporate means for identifying and responding to both during audience motivation analysis.

4.3 Affective and Cognitive Domain

If motivation is defined as an internal determinant of the force and direction of effort that drives a student to learn (Keller, 1983), then motivation must be viewed as having both effective and cognitive components. For example, attribution theories of motivation (for example, Rotter, 1966; Weiner, 1974) are primarily cognitive. These theories considers people's interpretations on the causes of outcomes, combined with the value they attach to the outcomes, as a major influence on whether people will pursue given goals. However, emotions, which are an effective component, must also be considered because of their influence on motivation and behaviors (Astleitner, 2000). Motivation is a complex internal construct embedded in experiences, expectations, and perceptions.Theoretical Framework of Learning with PAs

The Cognitive theory of learning with a pedagogical agent (PA) was described by Moreno (2005), as the knowledge process of a student while learning with a pedagogical agent in multimedia. It is an important theory for this study because it warns against the danger of causing cognitive overload through duplicate information. The other related theory is the social cues theory (Mayer, 2005) which discusses a chain reaction of social cues from the learners' environment while students are learning via pedagogical agents in multimedia.

4.4 Cognitive Theory and Learning with PAs

Cognitive Load is a term that refers to the load on working memory during instruction. This instruction may be aimed at teaching learners' problem solving skills as well as thinking and reasoning skills (including perception, memory, language, etc.) (Sweller, 1988). The Cognitive theory of

multimedia learning is based on three assumptions: dual-channel, limited capacity and active processing assumptions. The first, dual-channel, is a difference channel to proceeding representations between visual-pictorial and auditory-verbal (Baddeley, 1992; Paivio,1986), meaning that images and text are received through the eyes, while sound, voices and voice narrations are received through the ears. Second, limited capacity is a limited processing of only one type of data per channel at one given time (Baddeley, 1992; Sweller, 1999). This means that when an image or picture is being narrated by a voice, with text narration displayed as well, an overload of the channels emerges. Third, the active processing assumption assumes that the student must take an active role in receiving the information and integrating it into existing knowledge (Mayer and Moreno, 2003). The diagram of cognitive learning via an animated Pedagogical agent (Fig. 4) displays the expanded channel of input and processing in gaining advantage of higher output. In general, multimedia learning is designed basing on screen presentation. However, it is essential, because of the limited number of channels, to avoid overloading the channels through excessive images and sounds (Moreno, 2005).

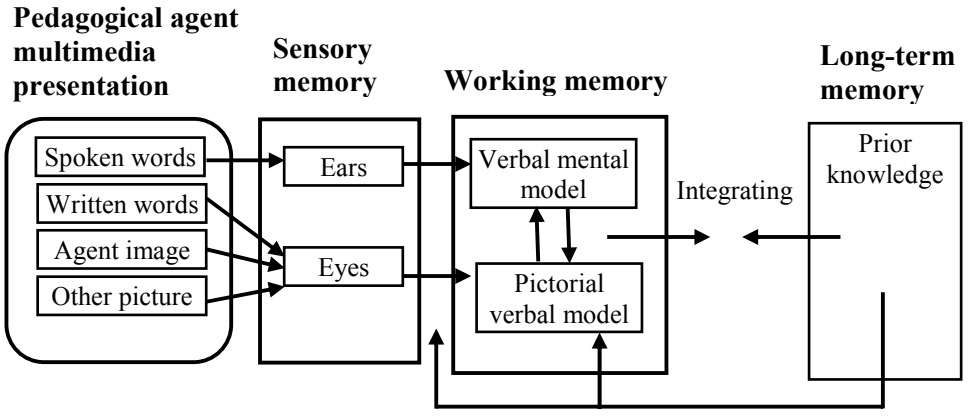


Fig. 3: Cognitive models for multimedia learning with animated pedagogical agents

Cognitive load theory has broad implications for Instructional design (Sweller, 1999). This theory provides a general framework for instructional designers, for it allows them to control the conditions of learning within an environment, or more generally within most instructional materials. Specifically, it provides empirically-based guidelines that help instructional designers to decrease extraneous cognitive load during learning, and refocuses that learner's attention toward germane materials, thereby increasing germane (schema related) cognitive load. This theory differentiates between three types of cognitive load: intrinsic cognitive load, germane cognitive load, and extraneous cognitive load (Sweller, et. al. 1998)

4.5 Types of Cognitive Load

Cognitive load theory has broad implications for Instructional design (Sweller, 1999). This theory provides a general framework for instructional designers as it allows them to control the conditions of learning within most instructional materials.

4.5.1 Intrinsic Cognitive Load

The term "Intrinsic cognitive load" was first described by Chandler and Sweller (1991). Accordingly all instruction has an inherent difficulty associated with it (e.g., the calculation of 2 + 2, versus solving a differential equation). This inherent difficulty may not be altered by an instructor. However many schemas may be broken into individual "subschemas" and taught in isolation to be later brought back together and taught as a combined whole (Kirschner, et al., 2006).

4.5.2 Extraneous Cognitive Load

Extraneous cognitive load is generated by the manner in which information is presented to learners and is under the control of instructional designers (Pollock, Chandler & Sweller, 2002). This load can be attributed to the design of the instructional materials. Sweller provides a wonderful example of extraneous cognitive load in his 2006 book in which he describes two possible ways to describe a square to a student (Kirschner, et al., 2006). A square is visual and should be described using a visual medium. Certainly an instructor can describe a square in words, but it takes less time and far less effort to understand what the instructor is talking about when a learner is shown a square. In this instance, the efficiency of the visual medium is preferred. This is because it does not unduly load the learner with unnecessary information. This unnecessary cognitive load is described as extraneous cognitive load.

4.5.3 Germane Cognitive Load

Germane load was first described by Sweller, Merrienboer and Paas in 1998: a load devoted to the processing, construction and automation of schemata. While intrinsic load is generally thought to be immutable, instructional designers are capable of manipulating extraneous and germane load. It is suggested that they limit extraneous load and promote germane load (Sweller, et al., 1998).

4.6 Social Cues for Pedagogical Agent

Social cues play an important role in deeper multimedia learning. Social cues are the use of sights and sound already familiar to the person from their environment (Mayer 2005). Examples of social cues are personalization cues, voice cues, and image cues. (Personalization cues; according to Mayer (2005)), Pedagogical agents which narrated in a conversational style yielded higher learning results than when the pedagogical agent narrated in a formal style. Likewise, pedagogical agents which spoke in standard-accented human voice rather than foreign-accented or computer-generated ones also had higher learning results.

According to Mayer's social cues, learners seemed to respond better to the human voice of the pedagogical agent, especially when the agent spoke in the native language. In contrast, synthesized and foreign-accented voices diminished the learner's social response to the message. Although the image cues of the pedagogical agent (appearing on screen or not appearing) did not highly effect

the learning (Mayer, 2005), this may be because the information is coming through the voice (voice principle) rather than through the image.

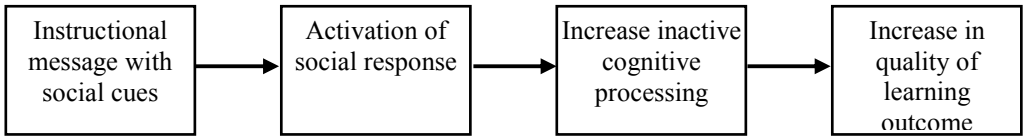


Fig. 4: Social cues proceeding with Pedagogical agent media (Mayer, 2005)

Social cues improve to social response as well as increase cognitive processing, resulting in increased learning performances (Fig. 3); on-screen characters may serve as cognitive aids by directing the learner's attention through pointing or gesturing (Mayer, 2005). In addition, the conversational style and accent of pedagogical agent have substantial effects on how well learners understand the media. However, the physical presence of a character on the screen may not be an important social cue in affecting the learner (Mayer, 2005).

5 Pedagogical Agents

This topic discusses the innovation of human-like pedagogical agent on screen, the interesting point being that not only are they animated characters speaking to people but also they have a variety of characteristics; previous researchers studied the influence of external and internal properties of the pedagogical agent such as anthropomorphism, voice, gender, realism, instructional roles, and ethnicity.

5.1 Background of Computer Agents

The intelligent agent team coined by Oliver Selfridge in 1958, may be considered one of the first computer agents (Levis, 2006). However, the most well-known software agent was imagined by Arthur C. Clark in 1986. The idea of the software agent was named “HAL 9000”, presented as a fictional computer character in the scientific film “*2001: Space Odyssey*”. HAL was a sophisticated computer system that could reason with humans and interact with his environment. Later, animated Clip-pit became the earliest form of pedagogical agents used within office software from Microsoft. This was the first agent widely known by the PC-using public in that the assistant communicated via text; the more recent versions incorporated text-to-speech in order to allow pedagogical agents to communicate via a synthetic voice (Levis, 2006).

Pedagogical agents are animated life-like characters designed to facilitate learning in computer-mediated learning environments (Johnson et al., 2000). They are called pedagogical because they are used to promote learning and transfer information. Entertainment is just one consideration (Levis, 2003). There are two different types of pedagogical agents, one is the traditional pedagogical agent and the other is the artificially intelligent pedagogical agent. Traditional pedagogical agents are the most frequently used form of pedagogical agent to this point. They are two-

dimensional miniature full-body animated cartoon figures that appear to float over an interface that can range from a stand-alone environment to a web page (Smith, 1999). Artificial intelligence pedagogical agents are more technologically advanced than the traditional pedagogical agents in that, they have tremendous power, feature new forms of input/output devices, and are continuously updating contextually customized libraries of text, images, and animation that appear just in time (FitzGerald, 1997).

Another form of pedagogical agents is autonomous agents that support human learning by creating an interface students within the context of interactive learning environments (Johnson, 1994). Animated pedagogical agents are a form of software agents, entities that function continuously and autonomously on behalf of the users in a virtual (computer-base) environment (Bradshaw, 1997; Laurel, 1997). Intelligent agents are defined as software entities supported by an artificial intelligence engine and characterized by human-like characteristics, such as reasoning, reaction, and the ability to display emotion either in speech or text form (Veletsianos et al., 2006). Similarly, interactive animated pedagogical agents are animated computer characters that assist humans in their learning process by their artificial intelligence (Starter, 2000).

5.2 Properties of Pedagogical Agents

Students' invested efforts in processing subject matters is most likely to increase when pedagogical agent makes the learning task more interesting or motivating either through their internal or external properties (Moreno et al., 2001). Pedagogical agents are generally figures on screen that are used to interact with students in multimedia learning. The figures themselves may have many different internal and external properties attached to them. External properties may be their voice, gender, ethnicity, and realism. Examples of internal properties may be the different roles they play in the learning process, such as the expert, motivator or learning assistant.

5.2.1 Internal Properties (performance) of Pedagogical Agents

Internal properties consist of the actions or instructional methods that the agent may carry out during its instruction with a student in order to facilitate or enable learning, such as reducing the cognitive load from multimedia environments (Moreno, 2004). Active processing of the materials is most likely to occur when the pedagogical agent is endowed with internal properties that promote students' engagement in the cognitive processes of selection, organization, and integration of the materials (Moreno and Mayer, 2002).

5.2.2 External Properties (Appearance) of Pedagogical Agents

External properties involve the visual and auditory presence of the agent, social features hypothesized to affect learning by making the learning experience more interesting, believable, or natural. Agents with external properties are also referred to as embodied, interfaced, or personified agents.

The potential learning effects corresponding to their visual and auditory presence has been called the persona effect (Lester et al., 1999).

5.2.3 Anthropomorphism and Ethnicity of Pedagogical Agents

People unconsciously attribute mental stages to computers, generally believing that computers are at a lower mental stage than humans. However, computers are quite adept at relating to and communicating with other people based on the findings that interaction with computers can evoke human social responses (Reeves and Nass, 1996). According to Baylor and Kim, the African-American agents (in the role of "expert") led to significantly improved learning compared to the Caucasian-American agents even though both had identical messages. Students working with the African-American experts also experienced enhanced concentration and focus (Baylor and Kim, 2004).

5.2.4 Voice of Pedagogical Agents

According to Lewis (2003), many studies have confirmed that students who learn from multimedia presented with animation and narration consistently perform better than those who learn from animation and text-based materials (Lewis, 2003). As for the use of machine and human generated voices used by pedagogical agents, the human voice was found to be far more effective (Baylor et al., 2006). Similarly, other studies have shown that human voices are preferable to computer generated voices (Kim et al., 2003). In addition, the study showed that the type of voice (i.e. strong or calm) also affected motivation. The strong voice was overall most motivating, while both human voices (strong or calm) were perceived as more affable, credible, and facilitating than the computer-generated voice (Kim et al., 2003).

Learning outcomes are further affected by the use of voice and pedagogical agents. Students who learn by communicating with a pedagogical agent via a personalized dialogue recall more and are better able to use what they have learned to solve problems than students using a non-personalized monologue (Moreno et al., 2005). Furthermore, learning outcomes are affected by practical techniques in use a non formal language such as the use of "your..." and "My..." rather than formal conversations. As well as making sentences in which the teachers make direct comment to the students, findings by Moreno and Mayer further support the use of voice; agents who communicate with the learner using spoken words are more likely to lead to meaningful learning than those that communicate with the learner using on-screen text (Moreno and Mayer, 1999). Agents should communicate with the learner using spoken words alone rather than with redundant narration and on-screen text (Moreno and Mayer, 2002).

5.2.5 Gender of Pedagogical Agents

According to Baylor, male agents' personalities were perceived as more extroverted and agreeable than the female agents. Essentially, students applied their perception of human stereotypes to the pedagogical agents. Perhaps the significant findings in terms of learning and motivation were that

male agents influenced learner satisfaction and self-regulation more positively than the female agents (Baylor, 2003). The presence of a male agent led to significantly more self-regulatory behaviour than the presence of a female agent (Baylor and Kim, 2004).

5.2.6 Realism of Pedagogical Agents

There are two dimensions to work with when using pedagogical agents: realistic (3D), and cartoon (2D) styles. The potential value of more realistic agent images, particularly for male students, positively affected learning. According to Baylor and Kim, designing pedagogical agents that closely resemble human beings, can affect learning results positively (Baylor and Kim, 2004). Commercial e-learning tools show an enhanced tendency to incorporate 3D animation, although their production is rather costly compared to the production of 2D animations. Empirical studies evaluating the educational value are scarce. According to Juk and Floto, the educational value of a 2D and 3D animation were rather similar when compared with each other (Huk and Floto, 2003). In fact, the studies of Moreno and Mayer indicate that agents highly visible and animated are less likely to lead to meaningful learning than agents that are invisible or static (Moreno and Mayer, 1999; Moreno et al., 2001).

5.2.7 Instructional Role of Pedagogical Agents

Generally, agents perceived as less intelligent lead to significantly improved self-efficacy (Baylor, 2004). The motivational agents (motivator and mentor) were significantly more engaging, human-like and facilitative of learning than the expert agent, yet less credible. The agents with expertise (expert and mentor) were significantly more credible and led to better performance on the transfer knowledge than the motivator agent, but nevertheless less supportive and human-like (Baylor, 2003).

5.2.8 Influence of Pedagogical Agents

Pedagogical agents were designed to facilitate learning in computer-mediated learning environments (Baylor, 2005). It was found that pedagogical agents showing a human-like or anthropomorphic characteristic create a more positive learning experience (Elliot et al., 1999). While there is no main effect of realism on perceived intelligence, and engagement, Studies have shown that a realistic face is perceived as slightly more intelligent, likable, and engaging than other faces, though not significantly (Koda and Macs, 1996). People's impressions of a face are different when they see a face in isolation versus when they interact with a face within a task. Personified pedagogical agent help users engage in a task and are well suited for entertainment. Other studies have found that the perceived intelligence of a face is determined not by the agent's appearance but by its competence. There is a dichotomy between user groups which have opposite opinions about personification. Thus, agent-based interfaces should be flexible to support the diversity of users' preferences and the nature of tasks. The agent is embodied meaning it has visual representation and can detect external stimuli such as keystrokes and mouse clicks (Koda and Macs, 1996), while

the artificial intelligence has a mood and behaviour system to simulate human emotions (Stater, 2000).

5.2.9 Advantages of Pedagogical Agents

Despite the recent decline in interest in intelligent agent research, the vision of employing a computer as an agent, called an intelligent tutor, in assisting a student by learning has been continuously pursued since the early 1970s by Carbonell, (1970). Six advantages of pedagogical agent multimedia learning are: Firstly, the learner can take as much as needed. Secondly, the learner can learn at his/her convenience. Thirdly, the learner can adjust the interactions according to his/her performances. Fourthly, the learner is encouraged to reflect on his/her thinking process. Fifthly, the learner has a willing collaborator if desired for the learning process. Finally, the learner has a selection of teachers at his/her disposal (Chou et al., 2003). The majority of educational websites consist of static hypertext pages, meeting above features 1 and 2. The challenge is to develop advanced web-based educational applications that offer interactivity and adaptability (feature 3 through 6), which an agent-based learning environment could offer (Baylor, 2002).

5.2.10 Pedagogical Agent's Abilities

The ability of pedagogical agents consist of 1) adaptation; a pedagogical agent evaluates the learner's understanding throughout interaction, much like a human teacher would, and adjust the lesson plan accordingly, 2) motivation; pedagogical agents can prompt students to interact by asking questions, offering encouragement and giving feedback, 3) engagement; pedagogical agents have colourful personalities, interesting life histories, and specific areas of expertise, and 4) involvement; pedagogical agents can be revised and updated as frequently as necessary to keep learners up-to-date in a rapidly accelerating culture (Starter, 2000).

5.2.11 Responsibilities of Pedagogical Agents

Many research projects developed and investigated various pedagogical agents to achieve learning and facilitating in media-learning environments. Different genders, ethnicities, instructional roles, realities, and responsibilities of pedagogical agents were addressed for educational benefit.

Character of Pedagogical agent	Responsibility	Developer	Reference
 1 2 3	1 & 2=Realistic human face 3=Line-draw face	ND= not detected	Koda and Maes (1996)
 4 5 6	4 & 5=Caricature human face 6=Caricature dog face 7=Invisible man (without face)		
 1 2 3	1=Expert 2=Motivator 3=Mentor	Pedagogical agent learning system Research lab	Ryu and Baylor, 2005

Fig. 5 Characters and responsibilities of pedagogical agent gathered from previous researches

5.3 Overview of Manga

Manga is a Japanese word referring to comics and printed cartoons (Fig. 6). Outside of Japan, it usually refers specifically to Japanese comics. It was developed from a mixture of Japanese wood-block printing and foreign styles of drawing, taking its current form shortly after the Second World War. It was printed mainly in black and white colour with the exception of the cover (Wikipedia, 2007b). Manga literally translated means 'random or whimsical pictures'. The word manga was first used in the late 18th century with the publication of Suzuki Kankei in 1771 (Wikipedia, 2006c). It became well known and is increasingly one of the most popular cartoons around the world. Recently, the first manga school was established in Japan. Kyoto Seika University offers courses in creating manga, and studying the various effects of manga on society (Majoring in manga, 2002). The prominent characteristics of manga cartoons compared with other cartoons are as follows (Wikipedia, 2006).

- A white cross-shaped bandage symbol denotes pain.
- A large sweat drop on the side of the face denotes a broad spectrum of emotions, usually embarrassment or exasperation.
- A red cheek denotes embarrassment or blushing.
- A balloon dangling from one nostril indicates sleep.
- Electricity shoots out on the eyes of two characters when they are fighting.

- A common artistic pun is nosebleeds, usually caused by shocking sights especially those with a sexual undertone.
- There are many eye symbols; such as love-hearts, crosses, flames, stars, and spirals.
- Tear drops everywhere indicate intense joy or sadness.
- An ellipsis appearing over a character's head indicates an awkward and speechless moment

[1]

Fig. 6: An example of manga drawing style in a “Detective Conan” comic book

5.4 Manga Animation (Anime)

Anime is an abbreviation from animation. This term is mostly used in reference to manga animation originating in Japan. In western countries, it is considered a subset of animation. In English, it is defined as a Japanese style of motion-picture animation (Wikipedia, 2007). In Japan manga can refer to both animation and comics (see Fig. 7).

[1] Detective Conan; Gosho Aoyama (2004), Vibulkij Publishing, Bangkok, Thailand.

Fig. 7: An example of anime group as shown in Television

5.5 Summary

This study aims to learn about the influence of manga characters in with calculus multimedia working as a pedagogical agent, aimed to reduce a cognitive load from it's complex content and make studying more enjoyable while students study alone. Thus, products of this research are a variety of calculus multimedia more than the original one by applying animated learning assistance. Instructional design models become an important guide to creating a manga character in calculus multimedia: We started by surveying the preference of participants on manga characteristics and voices style to set the goals of the experiment. Regarding learning environment, the problem space warned us to focus on relevant content (Savery and Duffy, 1996). Educational multimedia was a parts of this study by offering the proper way in republishing the media in this time period, while in previous research we designed to make it on-line interactive multimedia, However for this situation we had to repeat it and make it in a simple CD-Rom format more appropriate for our students in the present time. While pedagogical agents show advantages in learning with multimedia regardless of cognitive result or motivational interest, manga and anime (manga animation) as a forn of education have high acceptability from people not only of younger generations but also from adolescents in many parts of the world. These were the reasons why we developed the manga characters and studied the influence of there characteristics when combined with calculus multimedia.

Part II Empirical Studies

As described in the general introduction, the present study concerns the use of pedagogical agents in calculus multimedia learning in increasing the learning outcomes by decreasing cognitive loads, and to increase media motivation for Thai undergraduate students.

The purpose of this part is to first to state the objectives and research questions and hypotheses posed by the researcher. Second, to describe the preliminary survey of students and teachers in assessing whether or not there is interest in a pedagogical agent, and what characteristics would be preferred. Third, the descriptive of the manga characters as pedagogical agent production. Fourth and finally, to describe the three experiments and surveys used to assess the effectiveness of pedagogical agents in calculus multimedia.

1 Questions and Hypotheses

Niegemann (2006) claimed technology-supported learning can be an efficient way to foster successful learning, but often cognitive overload can prevent good results. Therefore, for the past twenty years a theory of cognitive load on multimedia learning has been developed (Mayer, 2005). Moreover, Johnson (1994) defines pedagogical agent as an autonomous agent that supports human learning by interfacing with students in the context of interactive learning environments. Then, we created the manga animation as pedagogical agents and combine it with calculus multimedia, testing it with Thai students through the questions as follows:

1.1 Research Questions

- How would a manga agent supplemented in this calculus multimedia impact task knowledge and the acceptability of the participants?
- Which manga agents' characteristics and voices style would impact learning and acceptability in calculus multimedia?
- Do manga agents gain more educational value and acceptability than human video agents in calculus multimedia?
- Do students learn better with a greater prior knowledge?

1.2 Objective of the Empirical Studies

- To investigate the influence of animated manga agents in calculus multimedia.
- To investigate the impact of characteristics and voices styles of manga agents
- To compared the impact between animated manga agents and human video agents.
- To confirm the impact of prior knowledge.

1.3 Hypotheses

- The influence of manga agent: Two types of media were investigated in order to compare results with and without manga agent. It was hypothesized that manga agents enhance certain types of knowledge and facilitation.
- The influence of characteristics of manga agents: Two characters “agent Conan” (cute) and “agent Newton” (prestigious) combined with two voices (calm and amuse) were established and studied during various manga agent performances, thus giving a matrix of four interactions. The hypothesis based that one agent would be different treatment on knowledge and/or acceptability.
- The influence of manga and human video agent: Two characters (manga agent representing from the second study, and one human-video agent) were studied in terms of performances and preference. The hypothesis based that one agent would be more distinction regarding progressive knowledge and/or acceptability.
- Students with a greater prior knowledge should learn better.

2 Methods of the Empirical Studies

First, to search for requirements of an agent's characteristic on calculus multimedia in students and teachers, a questionnaire was used to survey. Second, after receiving the answers about the scope of preference, three sets of experiments were undertaken. Two types of media were investigated in order to compare results: without a manga agent and with a manga agent possessing the cute characteristics and a calm voice. It was hypothesized that the manga agents enhanced specific knowledge and facilitation. It would be a model on character improvement in the following step.

Third, in order to search for proper characteristics to combine in calculus multimedia, two characters (one having the characteristic of being prestigious and the other being cute) and two voice styles (both having calm and amusing voices) were established and studied on various manga agent performances, thus giving a matrix of four interactions. It was hypothesised that the one manga agent would enhance the learning of the students the most.

Finally, while computer software can be used to create an interesting manga agent, while the present technology; web-camera can create a small size of video-clips in the form of animated characters with narration in one step. To answer this question, two characters (a manga agent represented from the second study and one human agent) were established and studied in terms of performances and preferences. It was hypothesised that the manga agent would be more acceptable to the students and therefore encourages higher learning results from the students than the human video agent, based on the fact that one agent would be a distinctive treatment on progressive knowledge and acceptability.

2.1 Surveying of Preferences on Manga Characteristics

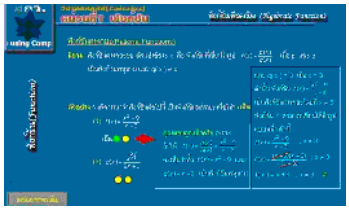
The present study was conducted during the first school semester of 2006 with 54 undergraduate Engineering students at Rajamangala University of Technology at Lanna, Thailand. The purpose was to find out the answer of "Which manga's characteristics, voices and instructional roles would be preferred and effect to learning results when supplemented in calculus multimedia?" The students as well as mathematics teachers were surveyed in order to assess whether or not the manga agent was necessary for teaching calculus aimed to survey the interesting of participants. We expected that manga agent supported learning would be more interesting for students.

2.2 The Influence of Manga Agent

This preliminary experiment aimed to answer the questions, "How would manga agents supplemented in this calculus multimedia impact the task knowledge and the acceptability?" We hypothesized that manga agents had an unequal amount of enhanced specific knowledge and facilitation.

Participants were divided into two groups, each containing 26-28 persons. Individual groups received different forms of media in CD-ROM format together with a demonstration. The first group learned without a manga agent and the second group learned with a manga agent: "Agent Conan", who possessing a calm voice. After a week of studying by themselves, progress, knowledge and preferences were measured by post-tests and questionnaires.

Tab. 2: Research design between with agent and without agent

Media type	Agent Conan supported	Without manga agent supported
Screen-shot		
Sample size	28	26

The questionnaire of preferences was presented in percentage form. The statistical analysis determined the distinction between pre-test and post-test results, and between post-tests of two treatments by ANOVA with the use of SPSS 15 program.

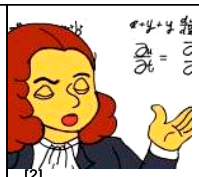
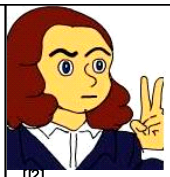
2.3 The Influence of Characteristics of Agents

In this experiment, the main purpose was to find out the answer of "Which manga agents' characteristics and voices style would impact learning and acceptability in calculus multimedia?" Two manga agents "Agent Conan" (cute) and "Agent Newton" (prestigious) were combined with two

different voice types: calm and amusing, to assess which type of voice works best with the character. This resulted in four interactions being evaluated during the first semester of 2006 with 90 undergraduate Science students at Rajamangala University of Technology at Lanna. We expected that at least one variable would be an outstanding treatment on progressive knowledge and acceptability. First, the students learned the chapter regarding Functions in the classroom. Thereafter a pre-test measured the prior knowledge of the students using a multiple-choice test. They were divided into four groups containing 20-24 persons each. Individual groups received different agents in multimedia CD-ROM format together with a demonstration.

The first group learned with the "Agent Conan" (cute) using a calm voice, and the second group with "Agent Conan" (cute) using an amusing voice, the third group with "Agent Newton" (prestigious) using a calm voice, and the fourth group with "Agent Newton" (prestigious) using an amusing voice.

Tab. 3: Research design between characteristics and voice styles

Media type	 [1]	 [1]	 [2]	 [2]
Agent name	Conan	Conan	Newton	Newton
Voice style	calm	amusing	calm	amusing
Sample size	24	20	22	23

After a week of studying by themselves, progressive knowledge and attitude were measured by post-tests and questionnaires. In addition, the acceptability of the manga's characteristics was measured with a questionnaire.

The statistical analysis determined the distinction between pre-test and post-test by ANOVA, while preference tests were analysed by MANOVA with the use of SPSS program.

2.4 The Influence of Manga and Human Video Agents

The third study was performed during the first semester of 2007 with 121 undergraduate Engineering students at Rajamangala University of Technology at Lanna. First, the students studied the chapter regarding "functions" in the classroom. Thereafter a pre-test measured the prior knowledge of the students using a multiple choice test. The students were randomly divided into two groups

[1] Detective Conan; Gosho Aoyama (2004), Vibulkij Publishing, Bangkok, Thailand.

[2] Issac Newton: Gravitational discoverer, Hitoshi Takeuchi (2004). Amarin Printing and Publishing Co. Ltd. Bangkok Thailand.

each containing 59-62 persons. Individual groups received different agents in calculus multimedia CD-Rom format together with a demonstration.

The first group learned using a selected manga agent from the second study, and the second group with the human video agent, who possessed a calm voice. After a week of studying by themselves, progress of knowledge and attitude were measured by post-tests calculus questions. In addition, the acceptability of the manga's characteristics and human video were measured by the results of a questionnaire.

The statistical analysis showed a difference between pre-test and post-test, between groups in terms of knowledge and preference tests.

Tab. 4: Research design of manga agent and human-video agent

Media type	 [1]	 [2]
Agent name	Conan	Abhinan
Sample size	62	59

2.5 Calculus Content

Calculus (Latin, calculus, a small stone used for counting) subject is an advanced mathematics field that studies "limits", "derivatives", "integrals", and "infinite series"; it constitutes a major part of science and technology university education. Basically, calculus is the study of change, the same way geometry is the study of space. Calculus builds on algebra, trigonometry, and analytical geometry and includes two major branches, differential calculus and integral calculus (Calculus-Wikipedia, 2008). The chapter regarding functions was used in this study. There were four units in this chapter: "function definition", "domain and range of function", "types of function", and "algebraic and composite functions". Each unit was performed in terms of specific knowledge, activities, examples, exercises, and scoring systems. The exercises were constructed in the form of randomized systems for both questions and answers. All content was presented in Thai language.

3 Media Construction

The learning material consisted of three parts. First, three agents were established: two manga agents and one human-video agent. Manga characters as animated pedagogical agents were created

[1] Detective Conan; Gosho Aoyama (2004), Vibulkij Publishing, Bangkok, Thailand.

[2] Aphinan Jitjaroen (2007). Live web-camera captured, Erfurt, Germany.

using a 2D animated program. Two manga agents were involved in this study. One was named "agent Conan" and the other was "agent Newton". The former was constructed based on a cute manga boy that is very famous as a miniature criminal detective. The latter was constructed based on a prestigious adolescent, the very famous Scientist "Issac Newton" in combination with calculus calculation establishment. The human video agent was representative of a male lecturer captured by web camera and recorded in AVI format.

Second, calculus learning media was adapted from previous calculus on-line learning research (Jitjaroen et al., 2005). It was republished using animated manga characters and human video in combination with Authorware 6.

Finally, narration scripts were written by one of the Mathematics teachers at the university. Narration voices were recorded in Thai language using a headset microphone on the researcher's computer. The voices were then combined with the images. The media was then produced in CD-ROM format.

The manga character was created by means of free-hand drawing with the use of "the TAB 2.2" program. They were exported in the form of Macromedia flash (SWF). The manga agent construction was presented in detail as shown below.

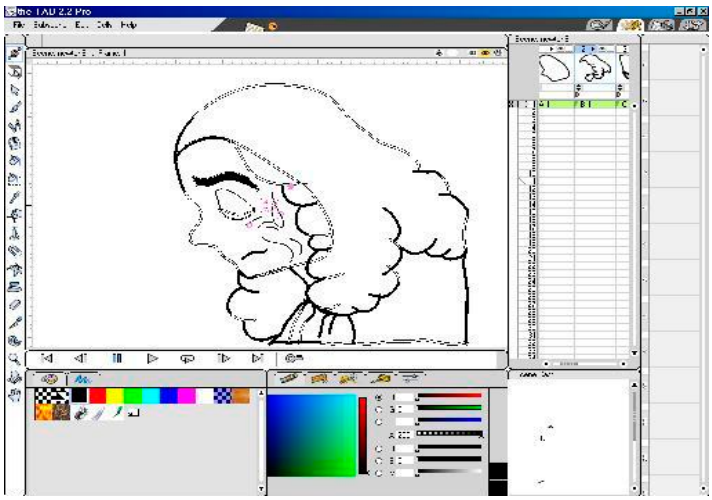


Fig. 8: Representative screen-shot constructed of manga agent

Human video agents were created using a web camera and a microphone head set. Videos with voices were captured directly onto the computer by "AmCap PC VGA Camera" program in the form of a video-clip. Video output was formatted with the aspect ratio 4:3, dimensions 160 x 120 pixels, and 30 frames per second. The thirty four videos were used in this experiment (Fig. 9).

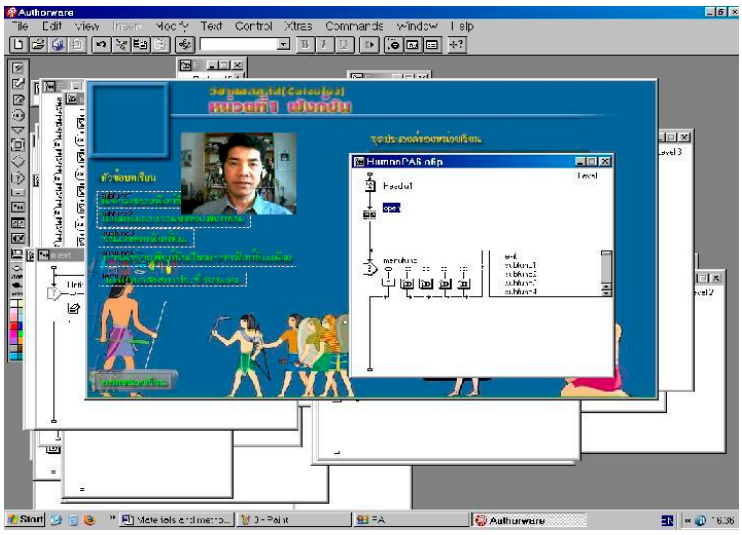


Fig. 9: Screen-shot of agent Abhinan construction

Tab. 5: Representative of three agents with social cue and narration script

Agent	Agents	Narration script
 [1]	Conan	*"A very important tool of function is balancing or equating. There are many numbers, we usually use X as a representative, for example X is a value added in function, and then Y is output from function. In this case, X is an independent variable and Y is the dependent variable."*
 [2]	Newton	*"Hello, there. I'm Professor Newton. Calculus is one of my master-pieces from the last 3 Centuries. You can select appropriate self-tuition topics from the menu below".*
 [3]	Abhinan	*We can make a conclusion of domain and range of functions. Domain is possible value of independent variable [X] of functions. Range is possible value of dependent variable [Y]. In mathematics is called "set". There are two methods to solve domain and range of functions.*

Meas-urement

The results were determined by two measurements for the calculus knowledge test, and two types of questionnaires: Surveying of preferences before manga agents' production and the preferences test questionnaire for students after using the agents.

[1] Detective Conan; Gosho Aoyama (2004), Vibulkij Publishing, Bangkok, Thailand.

[2] Issac Newton: Gravitational discoverer, Hitoshi Takeuchi (2004). Amarin Printing and Publishing Co. Ltd. Bangkok Thailand.

[3] Aphinan Jitjaroen (2007). Live web-camera captured, Erfurt, Germany.

4.1 Calculus Knowledge Test

The calculation test was designed for the calculus pre-test and post-test using the same difficulty levels regarding the function definition, domain and range of function, type of function, and algebraic and composite functions. Both tests were adapted from the previous research (Jitjaroen et al., 2005). On the multiple-choice questions, each item on the test for the procedural and transfer tasks was scored from 0 (not responding or wrong response) to 1 point (answered correctly).

4.2 Surveying of Preferences

The questionnaire on surveying of preferences on manga characters was designed (Fig. 2.24). The preferences on manga was evaluated in terms of characteristics, voice styles, range of age, level of movement, explanation, guidance and entertainment, rated from 1 to 5 as very satisfied (5), satisfied (4), indifferent (3), unsatisfied (2), or very unsatisfied (1), (necessity scored yes (0) or no (1)). These questions were asked to make a decision in establishing the first agent.

4.3 Preference Test

The questionnaire assessed two types of preferences; the first referred to the determination of quality acceptability to agents, and the second to the facilitation of agents. The questionnaires were defined using 5 Likert scales. Acceptability and facilitation of manga agents in terms of size, colour, friendly, character, speaking, voice, and usefulness were measured as very satisfied (5), satisfied (4), indifferent (3), unsatisfied (2), or very unsatisfied (1). The forms also asked students to record free-form responses. At the conclusion of the session, students were thanked and given the opportunity to make comments or ask questions about the study.

5 Manga Characters Production Tools

In order to create the manga pedagogical agent, pen-tablet was used instead of drawing with a mouse because of its ease and usefulness in creating graphics that can be easily transferred to the computer. In conjunction with pen-tablet, the software “the TAB 2.2” (Toonz animation board) was used to animate the cartoon picture. This was very important for the creation of the manga pedagogical agent, because of the ability of the software to zoom in and out and pan on the character, essentially helping to make the cartoons more life-like and enjoyable. This application possesses the capability for creating animated cartoons.

5.1 Pen-Tablet

Also known as graphics tablet, digitizing tablet, graphics pad, or drawing tablet, it is a computer input device that allows one person to hand-draw images and graphics, similar to the way one draws images with a pencil or paintbrush on paper or board. A graphics tablet consists of two pie-

ces: a flat surface upon which the user may draw image using an attached stylus (a pen-like drawing apparatus).

The image generally does not appear on the tablet itself but, rather, is displayed on the computer monitor, but most professional versions use a large monitor touch-screen, giving a real feeling of being a computer artist. Moreover, a tablet is an alternate type of input device that can be used in place of, or in conjunction with, a mouse, trackball, or other pointing device. It consists of two parts, a flat surface for drawing, and a pen, stylus, or puck that is programmed to work with the tablet. Therefore, instead of a mouse, a pen-tablet and a drawing plate were used as a special device needed for creating an animated manga agent in the study.

5.2 The TAB 2.2 (Toonz Animation Board) Program

The TAB 2.2 has the ability of quick 2D animation production without the need for paper, eliminating the tediousness the hand-drawn animation. It exploits the powers of vectors without the restrictions, such as constant thickness lines, flat colors and control points which cause complex management. Drawings can be animated by modifying vectors. It creates original animation content for the web application. Therefore, it capable in the construction of 2D manga animation in the form of flash file compatible with calculus multimedia published by Authorware program in the present study.

5.3 Macromedia Authorware Program

Authorware is a flowchart-based graphical programming language. It is used for creating interactive programs that can integrate a range of multimedia content, particularly e-learning applications. The flowchart model differentiates from other authoring tools, such as “Flash” and “Director”, in that they rely on a visual stage, time line, and script structure.

This program is a visual authoring tool for creating multimedia to deliver on corporate networks, CD/DVD, and the web developing accessible applications that comply with learning management system (LMS) standards. In the present study, the calculus e-learning was modified from Jitjaroen et al (2005) constructed by using Authorware program. The continuity was further studied with the supplementation of manga agents into the media. Consequently, the narration voice was synchronized and republished in CD-ROM format.

5.4 EXP Studio Audio Editor

EXP Studio Audio Editor is audio editing software that allows editing of existing audio files as well as recording new files from a microphone or any other input device. It offers visual editing: cut, copy, delete silence, paste, paste from file, mix, mix from file with various effects, including amplify, delay, equalizer, fade, invert and others. It can also apply different filters to the selected

part of an audio file, insert noise or silence in an audio file, insert and change information audio markers, and edit the artist information.

This program supports formats WAV, PCM, MP3, MP2, VOX, WMA, RAW, CDA and OGG. The software provides all the standard audio editing features and more, but only includes very basic documentation. The license of this audio software is shareware. The ease of operation and high efficiency as a full audio studio function as well as flexible type of wave form gave suitable results to apply to the study.

5.5 Accessories

This study used some more accessories to complete the target such as media captures and questionnaires in evaluating students' preferences.

5.5.1 Web Camera and Headset Microphone

Both were used to capture and record human's image and voice producing a clip-video. The video scales clips were imported properly into the media without any adjustment. This is an advantage in reducing the complicated steps of media production.

5.5.2 Calculus Knowledge Examination

Knowledge test, as a tool, were used to evaluate learning progression in calculus subject. It is used to develop the manga agents' character and choose the most appropriate to supplement into the calculus multimedia system. These calculus questions originated from previous research in Thailand (Jitjaroen et al., 2005).

5.5.3 Calculus Multimedia

A main point of this study, research in Thailand showed that students learning with calculus multimedia had greater progressive knowledge and understanding than when only studying in the classroom. The unit of function was representative of calculus multimedia learning system as a host. The continuity of different agent characters was integrated into the media to reduce learners' cognitive load, and moreover, to increase interest and enjoyability while learning by oneself with the media.

5.5.4 Compact Disk

Calculus multimedia was designed as a self tutoring system. Therefore, CD-ROM was applied into this study resulting from low cost incentive, and was the most convenient for students wanting to study on demand. Although currently, our students are not much capable to have internet connection in their dormitories, personal computers are a necessity and normal for studying now.

6 Study I: Manga Surveying

In order to discover which manga characteristics (such as voice styles, etc.) would be used in calculus multimedia, questionnaires were taken by participants, undergraduate calculus students and teachers. The hypothesis stated that learning with the supporting manga agent ought to have an unequal effect in enhancing specific knowledge and facilitation. Before the experiments were conducted, a questionnaire was used to survey the preference level of participants regarding manga characteristics. The results showed that the majority of students preferred the "cute" characteristic, while the teachers were more interested in the "prestigious" characteristic. The students' questionnaire results indicated *indifference* for "amusing" and "calm" voice styles, while the teachers preferred the "amusing" voice style. Therefore, the first manga agent (Japanese comics' character) was created according to the preferences of the students. This pedagogical agent was named "agent Conan" and had the characteristics of "cute" and "amusing" voice style.

6.1 Methods of Study I

In order to find out which manga characteristics (such as voice styles, etc.) would be preferred in Calculus multimedia, questionnaires were taken. The participants were undergraduate calculus students and mathematics teachers. The hypothesis stated that learning with the supporting manga agent should have a higher effect in enhancing specific knowledge and facilitation.

6.2 Results of Study I

6.2.1 Preferences of Students

The survey results show that most students were as interested in the "cute" manga characteristic as the "prestigious" one, at 46 and 42 percent respectively. The preference in voice styles shows that the majority (42%) of the students were interested in both the "calm" and "amusing" voice styles at *indifferent* levels, and the minority (35%) chose similarly at "*satisfied*", meaning that most of students would pay attention to both types of voice styles (Tab. 6).

Tab. 6: Percentage of student's preference in comic's characters

Preference items	Percentage of participants (%), (n=56 persons)				
	Very unsatisfied	Unsatisfied	Indifferent	Satisfied	Very satisfied
Cute characteristic	0	4	27	46	23
Prestigious characteristic	0	8	27	42	23
Calm voice	4	16	42	35	3
Amusing voice	0	15	42	35	8

Span of age	3	4	54	31	8
Movement	0	4	50	23	23
Response for explanation	0	0	46	31	23
Response for guidance	0	8	23	42	27
Response for entertainment	0	0	19	46	35
Manga necessity in lesson	Yes = 85		No = 15		

The most prominent properties were age and movement; these questions were more detailed for students; score of used age was 1=1-3 yr., 2=4-10 yr., 3=11-19 yr., 4=20-45 yr., 5=45-60 yr. This range of age was divided by social of the people in Thailand. The results show approximately 50% rated indifferently. It clearly indicated that they did not prefer elderly ages nor moving agent in the calculus multimedia. Furthermore, the internal property showed that 46% of students were *indifferent* about needing explanations, while the responsibility as a guide and entertainer was marked at 42% and 46% at "*satisfied*" levels. The necessity of adding manga agents into the calculus multimedia was requested by 85% of students. It shows that most students expect to have manga agents acting as educational assistant and facilitator, making learning more interesting.

6.2.2 Preference of Mathematics Teachers

The questionnaire surveying the preferences of manga's characteristics was provided to calculus teachers, the purpose being to gather their opinion based on student's requirements. The results of instructors on manga characteristics preferences were present in the form of number as shown in Tab. 7.

Tab. 7: Mathematics teachers' preferences on manga characteristics

Preference item	Number of teachers (n=5)				
	Very unsatisfied	Unsatisfied	Indifferent	Satisfied	Very satisfied
Cute			4		1
Prestigious					5
Calm voice			4		1
Amusing voice		1		4	
Span of age			4		1
Movement				4	1
Explanation					5
Guidance				1	4
Entertainment				4	1
Manga necessity	Yes=5		No=0		

As a result, most teachers were "*indifferent*" about manga characteristics with respect to cute characteristics, calm voice and span of age, while most were "*satisfied*" with amusing voice, and movement. A large majority favoured manga possessing a prestigious characteristic able to explain the lesson, the responsibility as a guide was expected by most mathematics teachers.

6.3 Conclusion of Study I

Most participants (greater than 50% ranking from "satisfy" to "very satisfied") preferred the use of the manga character for explanation, guidance, and entertainment. Thus, supplementation of manga agents in the learning media was considered according to the wishes of the students as users and instructors as teachers.

Mathematics teachers were also given the same survey as the students. While the students were most interested in both characters (Conan "cute" and Newton "prestigious") and voice styles as well as expecting the manga pedagogical agent to not only be responsible for explanation but also for entertainment, all mathematics teachers clearly preferred "Newton" characteristics. However, the mathematics teachers had a similar opinion as the students in that not only did they expect the pedagogical agent to act as a knowledgeable assistant giving explanation and guidance but also as an entertainer. Thus, the use of manga characters as pedagogical agents in calculus media as instructor and stimulator were considered according to the assessment of the participants. It has to be emphasized that students rated mainly at satisfactory levels, whereas teachers often rated "very satisfied".

6.4 Summary

This study created manga agents in accordance with the findings of its performance in reducing a cognitive load (overlapping of content) in calculus multimedia. The results indicated that most of the students (more than 40%) preferred both the "cute" and "prestigious" characteristics.

7 Study II: Influence of Manga Agent

This experiment aimed to answer the question, "How would manga agents supplemented in calculus multimedia influence the task knowledge and the acceptability?" The experiment was done by testing two separate groups of students using pre and post-tests. After the pre-test was administered to both groups to evaluate their current knowledge of calculus, each group received a diskette containing calculus multimedia material to study by themselves. The first group's calculus multimedia material was without a pedagogical agent, while the second group's calculus multimedia material contained the pedagogical agent "Agent Conan". We hypothesized that learning with the manga agent ought to have an effect in enhancing specific knowledge and facilitation.

Huk and Floto (2003) found that the educational value of a 2D and 3D animation were rather similar. Also, the studies of Moreno and Mayer (1999), and Moreno et al. (2001) confirmed that agents highly visible and animated are less likely to lead to meaningful learning than agents that are invisible or static. Therefore, we decided to create the manga pedagogical agents in 2D format, because of 3D production coast compared to the production of 2D animations. The reason for selecting manga characters as a type of cartoons was simple; "manga", a Japanese comics book and "anime" manga animation cartoon on television, were highly popular with young people in Thailand. Therefore, in order to assess the most suitable characteristics for the manga pedagogical agent to be used in calculus classes, students and teachers were asked to fill out a questionnaire.

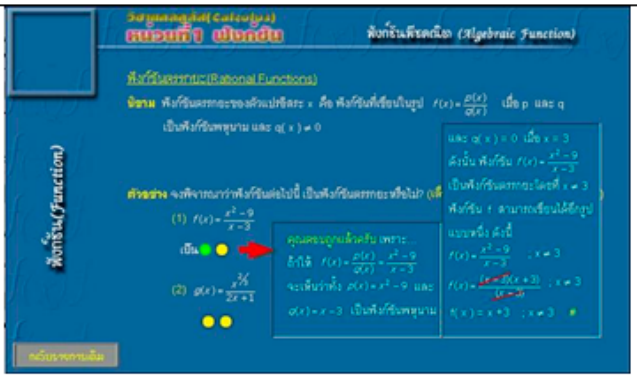
7.1 Methods of Study II

The present study was conducted during the first school semester of 2006 with 54 undergraduate Engineering students at Rajamangala University of Technology at Lanna. Two groups of participants were surveyed in this study. One group learned calculus multimedia with manga "Agent Conan" possessing a "calm" voice and the other group learned using the same media but without the agent.

The students first learned the chapter regarding Functions in the classroom, thereafter a multiple-choice pre-test was administered in order to measure the knowledge of the students prior to the experiment. They were randomly divided into two groups containing 26-28 persons each. Individual groups received different media in CD-ROM format together with a demonstration.

After a week of studying by themselves, progress, and satisfaction were measured by post-tests and questionnaires. The preferences of participants were measured by questionnaires and presented in percentage form. The statistical analysis determined the distinction between pre-test and post-test results, and between post-tests of two treatments by t-test with the use of the SPSS program.

Tab. 8: Research design between with and without manga agent

	Media type	Sample size
Agent Conan supported		28
Without manga agent supported		26
Hypothesis:	H_1 : μ_1 > μ_2	
Dependent variable	Calculus pre-test and post-test: corrected scores	
Independent variable	Media type: with and without agents supported	

7.2 Students' Preferences on Manga

Prior to producing the first manga agent, a preferences survey on manga characteristics was conducted on participants during the first school semester of 2006 with 56 undergraduate Engineering students at Rajamangala University of Technology at Lanna. The purpose was to discover which manga characteristics, voices, and instructional roles would be preferred when supplemented in calculus multimedia. We expected that manga character supplementation would be garner high interest. Students as well as mathematics teachers were surveyed in order to assess whether or not manga agents were necessary in teaching calculus. The questionnaire asked the students to respond to each characteristic (such as "cute", "prestigious", "calm voice", etc.) using a scale of 1-5. The number 1 represented *very unsatisfied* preference, 2 *unsatisfied*, 3 *indifferent*, 4 *satisfied*, and 5 representing they were *very satisfied*. The results were presented in percentage form; most students and teachers preferred to have manga agents in calculus multimedia. Then, we created the first animated manga agents as pedagogical agents corresponding to their opinion.

7.3 Construction of Manga Character

The manga character was created by free-hand drawing with the use of "*the TAB 2.2*" program and "*pen-tablet"* as a special device connected to a computer. They were exported in *Macromedia flash* (*.SWF) form. The manga agent construction is presented in detail as shown below.

7.3.1 Drawing

The manga agent was drawn closed-line using a mouse pen on the tablet. Each object was independent and addressed in particular layers so that they can be moved later and dragged to a suitable position (Fig. 10).

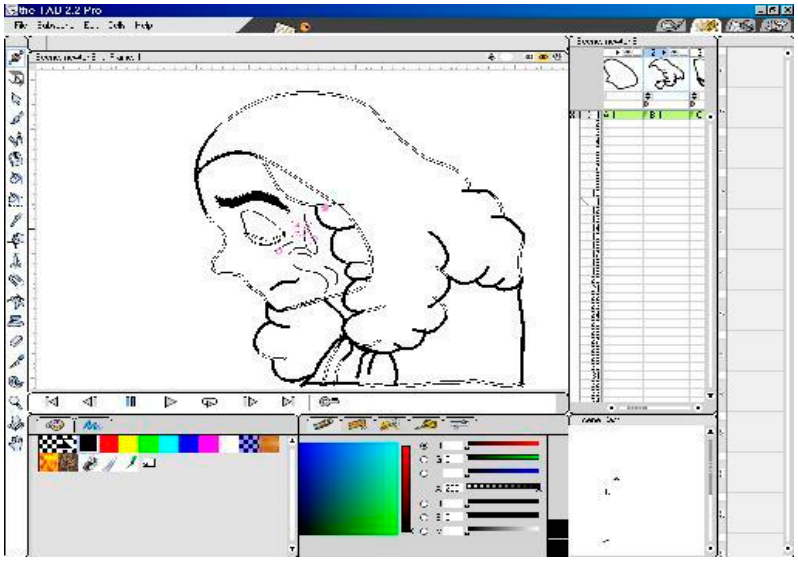


Fig. 10: Screen shot of manga drawing as a multilayer view mode

7.3.2 Painting

The selected colours were poured onto individual objects. This step depicts the real close line drawing because if just a little point is not completely enclosed the colour cannot be poured. Techniques to solve this problem were corrected by using the zoom function with the mouse wheel supported by drag-and-drop line technique (Fig. 11).

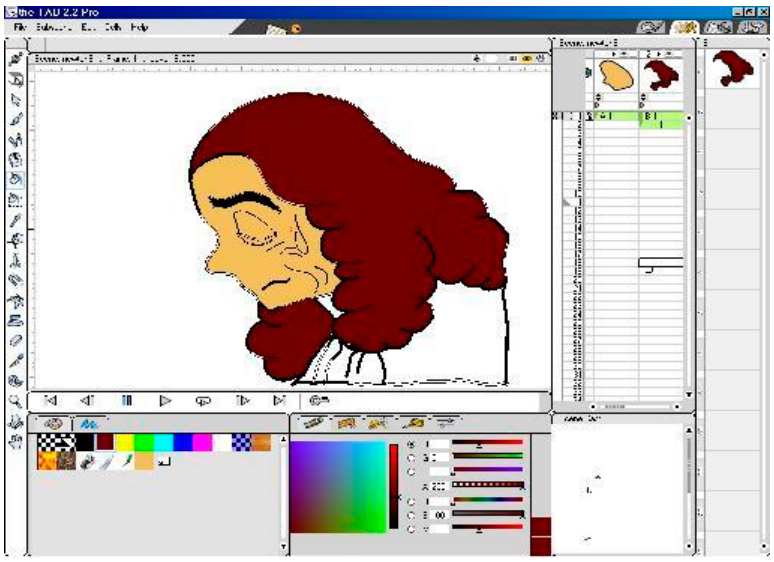


Fig. 11: Screen shot of project viewed as multi-layer pictures

7.3.3 Animation

The objects were animated with the addition of frames in concurrence with the agent's presentation time. It was dragged from the first frame to the destination. Each object was independent. Sub-scene techniques were used to create the manga's various background images. The animation was previewed via the camera mode, ready to export as an animation character file (Fig. 12)

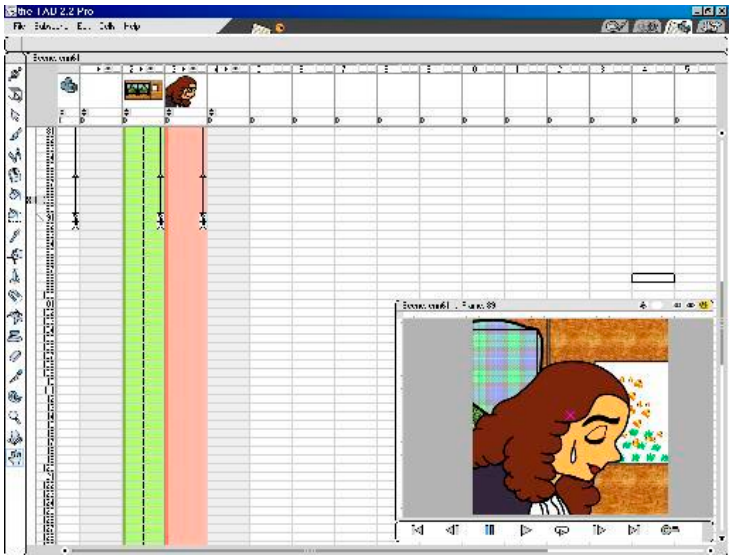


Fig. 12: Screen shot showed a camera view during manga's animation

7.3.4 Exporting

Dimensions and frame rate were set up at the levels of 150x150 pixels and 12 frames per second respectively, suitable sizes for calculus multimedia resolution at 800x600 pixels, while the animation was exported as flash file without voices. The fact that, when produced in the form of AVI and

MOV file with complete narration, importing the manga agent with the media not only blurred the image but the resulting file size of the complete media would be too big. With flash the line of characters were sharpened (Fig.13). Noteworthy is, even if *the TAB* program could make animation with voice, the *Authorware* program would have trouble in supporting it.

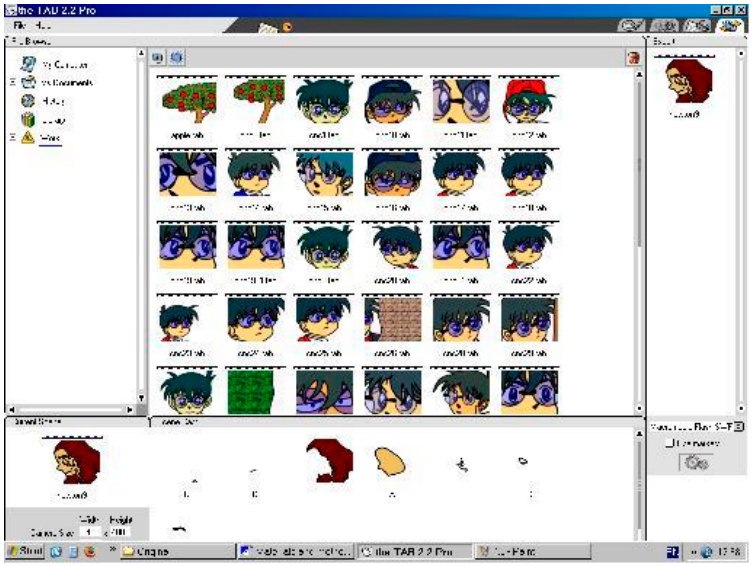


Fig.13: Screen shot showed a exporting action of the project

7.3.5 Agent's Narration

Narration voices in Thai were recorded through a microphone head set directly into the computer. Mangas were narrated with two voice styles; amused and calm, while human video agents were narrated with a calm voice, representative of classroom lecture style. Narration script was used for all agents (Fig. 2.20-2.22). The file was formatted into an uncompressed PCM wave file (*.wav) at 22.050 kHz, 16 bit mono, further trimming, booting or cutting through "*Expstudio audio editor 2.2*" program (Fig.14).

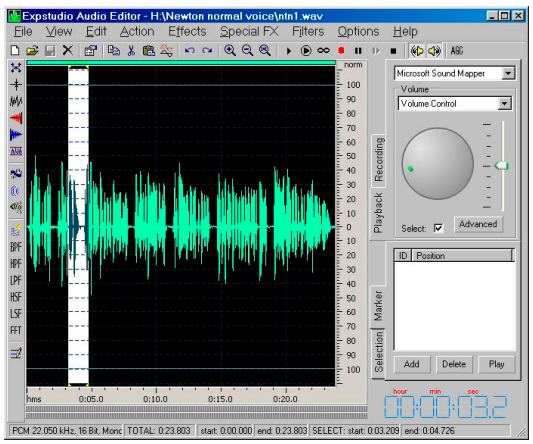


Fig.14: Recording and editing sound narration for manga agent through "Expstudio audio editor"

7.3.6 Combination

After the construction of manga agents and narration voices, they were combined into calculus multimedia with the sequence of narration scripts by *Authorware 6.0*. The position of agents was scaled and located to the upper-left of the screen (Fig.15 and Fig.16).

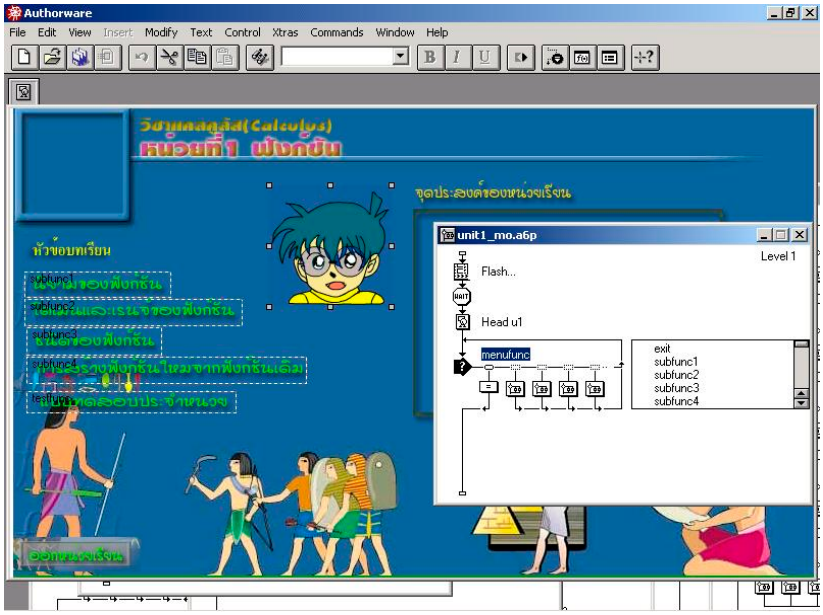


Fig.15: Manga characters during combination with calculus multimedia

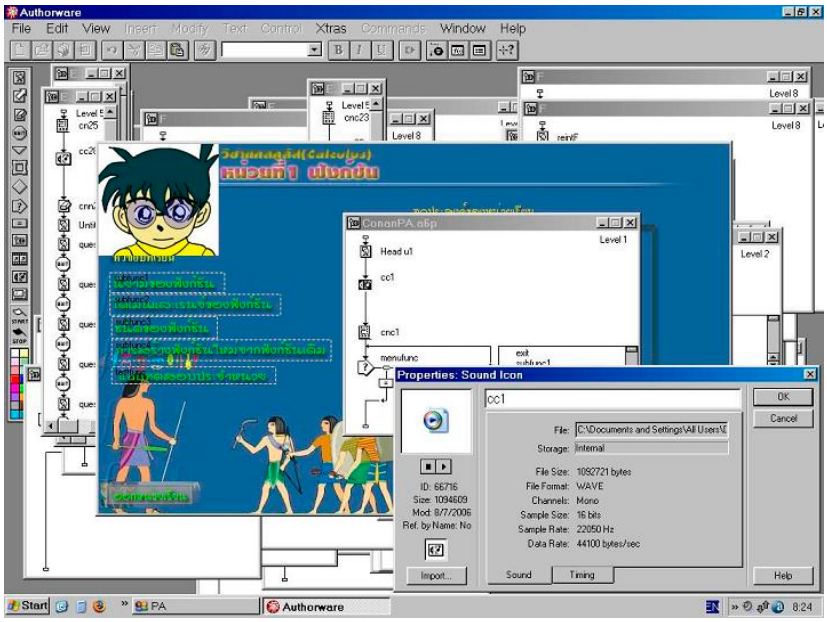


Fig.16: Agent's narration during merging with manga characters into calculus multimedia

Tab. 9: Character of Agent Conan with different social cue and narration scripts.

Agent Conan	Social cue	Narration script
	-Guidance	*"Hi! I'm agent Conan. Let's go to the mysterious story of mathematics established by Professor Newton, over 300 years ago. You can choose interesting episodes from the menu below".*
	-Expert	*"A very important tool of function is balancing or equating. There are many numbers, we usually use X as a representative. For example X is a value added in function, and then Y is output from function. In this case, X is the independent variable and Y the dependent variable."*

7.4 Results of Studies II

In the effort to evaluate the value of adding manga agent in the media, mangas were created with cute and young characteristics, calm voice, movability, and as assistants in primary media.

7.4.1 Progressive Knowledge between Pre and Post-Tests

Pre-test and post-tests were administered to all of the students in order to find out their level of knowledge before and after studying by themselves with the help of calculus multimedia. The results were analysed by "Student's t-test" shown in Tab. 10.

Afterwards, the group that learned with the pedagogical agent was given another questionnaire in order to find out the preferences of the students' regarding the "Agent Conan" after working with the pedagogical agent when using the calculus multimedia.

Tab. 10: Paired sample statistics of participants' pre and post-tests

Paired	Test	Mean	SD	Mean diff.	n	t	Sig. (2-t.)	ES (*d*)
With agent	Pre-test	4.14	2.013	1.65	28	4.082	.000*	0.82
	Post-test	5.79	1.663					
Without agent	Pre-test	3.85	1.782	1.30	26	3.049	.005*	0.73
	Post-test	5.15	1.567					

The knowledge levels of students studying with the manga agent clearly increased by 1.65 points (total=8 point), while the knowledge of students who studied without the manga agent increased by 1.3 points; This concluded that average scores per student improved after learning with calculus multimedia under both conditions.

7.4.2 Differences Concerning Post-Tests

An "independent sample t-test" was used to evaluate the data of the post-test between the two groups that learned with and without manga agents. In this experiment, the significant value of the statistic is 0.16, indicating that, although the average of 0.64 points was more from the manga agent group, the reduced cognitive load of the calculus content negligible (Tab. 11).

Tab. 11: The statistics of post-test of participants

Groups	Mean	SD	n	diff.	t	Sig.
with agents	5,79	1,66	28	0,64	1,43	0.158^{ns}
without agents	5,15	1,57	26			

Confidence interval=.95, ns=non significantly p>.05

7.4.3 Questionnaire

Following the post-test measurement, a questionnaire was given to the students who learned with the "Agent Conan". This aimed to find out the preferences of participants in regards to "Agent Conan's" characteristics and his function as pedagogical agent in relation to knowledge assistance, general characteristics, voice-style, how many agents were preferred, movement, and internal properties. The results were presented in percentage form shown in Tab. 12.

Tab. 12: The percentage of general acceptability of participants on manga agent

Preference item	Percentage of participant (%) (n=56)				
	Very unsatisfied	Un satisfied	In-different	Satis-fied	Very unsatisfied
How much did you learn from Conan?	3	17	40	23	17
Would you like more agents in the lesson?	7	13	43	33	4
Do you like the level of cuteness in Conan?	4	10	36	37	13
Do you like Conan's voice?	3	17	20	53	7
Do you like Conan's level of movement?	13	10	44	23	10
How much did Conan explain the content to you?	0	7	33	40	20
How much did Conan entertain you?	10	3	23	47	17
How much did Conan guide you?	3	7	40	33	17

Agents being able to help students comprehend was rated by 40% and 43%, at *indifferent* levels, while 23% and 33% marked at *satisfied* respectively, showing that they were impressed by agents in calculus multimedia at satisfactory levels. The third, forth and fifth questions asked about effect of the external properties (appearance) of manga agent.

With the respect to cuteness 37% and 36% rated *indifferent* and *satisfied*, meaning that "Agent Conan" was attractive, while, the voice of the agent was rated at *satisfied* levels at 53%. This means that amusing voice style should be suitable for "Agent Conan". The question of movement was an important one, since producing a manga agent overly animated could disrupt learning; 44% of students were *indifferent* about the agent's movement, meaning that the movement was set up at an acceptable level.

The internal properties of "Agent Conan" asked about the role of social cue in the last three questions. The result showed that most of students (40%) favoured the explanation of "Agent Conan" in the lesson at *satisfied* levels, supported by 33% and 20% at *indifferent* and *very satisfied* levels respectively; acting as entertainer revealed the second score being 47% *satisfied* followed by 23% and 17% with *indifferent* and *very satisfied* responses respectively, clearly showing the "Agent Conan" performed exceptionally as a pedagogical agent in the calculus multimedia as designed. 40% of students graded at *indifferent* for guidance of "Agent Conan" followed by the 33% and 17% with *satisfied* and *very satisfied*, these result showing that "Agent Conan" not only acted well as educator and entertainer but also in guiding the students in understanding the calculus multimedia as well.

7.5 Conclusion of Study II

- Effect of manga agents: Students learned equally with or without manga agents.
- Preferences: Students highly preferred manga agents in calculus multimedia learning.

8 Study III: Influence of Characteristics

The main experiment's purpose was to find out which manga' characteristics and prior knowledge levels would impact learning and acceptability in calculus multimedia. Two manga characters "Agent Conan" (cute) and "Agent Newton" (prestigious) were combined with two different voice styles; calm and amusing, to assess which type of characteristics works best with calculus multimedia.

This resulted in four interactions being evaluated during the second semester of 2006 with 90 Science undergraduate students at Rajamangala University of Technology at Lanna. We expected that at least one of characteristics would be an outstanding help on knowledge progression and acceptability. Since the students' questionnaire results indicated a high preference for "Agent Conan", the second manga character was created following the teachers' preferences. This pedagogical agent was named "Agent Newton" and had the "prestigious" characteristics (Fig. 17).

Fig. 17: First page of calculus multimedia with Agent Newton

8.1 Methods of Study III

The experiment was expanded by giving both agents (Conan and Newton) both types of voices: "calm" and "amusing", resulting in four varieties of pedagogical agents: 1) "Agent Conan" with a "calm" voice; 2) "Agent Conan" with an "amusing voice"; 3) "Agent Newton" with a "calm" voice; and 4) "Agent Newton" with an "amusing" voice. This experiment aimed to classify which types of manga agents yielded better results in both learning and acceptability.

First, the students learned the calculus subject in the chapter regarding Functions in a normal classroom. Thereafter, a pre-test measured the prior knowledge of the students using a multiple-choice test.

Tab. 13: Research design between characteristics and voice styles

Media				
Agent type	Cute	Cute	Prestigious	Prestigious
Agent name	Conan	Conan	Newton	Newton
Voice styles	calm	amusing	calm	amusing
Sample size	24	20	22	23
Hypothesis H1:	$\mu_1 \neq \mu_2 \neq \mu_3 \neq \mu_4$			
Dependent variable	Calculus post test: corrected scores			
Independent variable	1. Agent types: Conan calm, Conan amusing, Newton calm, and Newton amusing 2. Prior knowledge: Less 0-4, More 5-8 (Total=8)			

The students were randomly divided into four groups each containing 20-24 people. Individual groups received different agents on CD-ROM together with a demonstration. The first learned with the manga “Agent Conan” using a calm voice and the second group with the manga “Agent Conan” using an amusing voice.

Fig. 18: Calculus multimedia with Agent Conan supported

The third group learned with the manga “Agent Newton” using a calm voice, and the fourth group with the manga “Agent Newton” using an amusing voice. After a week of studying by themselves, progressive knowledge and attitude were measured by post-tests and questionnaires. In addition, the acceptability of the manga’s characteristics was measured with a questionnaire. The first questionnaire was ment to evaluate students’ attitude on external properties (appearance) of manga

agents. The second questionnaire was purposed to evaluate students' attitude on internal properties (performance) of manga agent. The statistical analysis determined the distinction of knowledge between pre-test and post-test evaluated by ANOVA, while preferences tests were analysed by 2 x 2 Factorial MANOVA with the use of SPSS program.

Fig. 19: Calculus multimedia with Agent Newton supported

To answer the question which manga agents' characteristics would affect learning and acceptability in calculus multimedia, an experiment was designed by using a 2 x 2 factorial with two independent variables: two characteristics as type of task with the conditions of cute (agent Conan) and prestigious (agent Newton) and two voices styles. The dependent variables were the number of correctly-solved problems on the calculus test and score of acceptability from questionnaires. It hypothesized that the students who took the learning with four different agents, based on the probability of statistical analysis, at least one treatment would distinguish itself from the others.

After students learned the chapter of Functions in the classroom, four different manga agents on calculus multimedia in the form of CD-ROM were distributed to students for a week to study by themselves within random groups. Knowledge tests and questionnaires were evaluated differently than calculus knowledge, quality, and acceptability of manga agents in the final step. In addition, Mathematics teachers measured the quality and acceptability of manga agent using the same questionnaire. The results were analysed using ANOVA comparing post-test, and MANOVA the questionnaires.

8.2 Results of Study III

The statistical method showed the difference of calculus knowledge in the post-test between two main factors of characteristics and voice styles and four combinations. Task performances under the various conditions of study are summarized by ANOVA and descriptive statistics in Tab. 14.

Although in the consideration of individual Characteristics factors F(1, 85) = 0.374, p = 0.542, voice factor F(1, 85) =1.353, p = 0.248, and four interactions F(1, 85) =1.311, p=0.255 there were no significant differences amongst treatments.

Tab. 14: ANOVA results of the differences of knowledge between pre-test and post-test

Source	F	Sig.
Characteristics	0.374ns	0.542
Voices	1.353ns	0.248
Interaction	1.311ns	0.255

Confidence interval=.95, ns=non significant p>0.05

Tab. 15: Mean scores and standard deviations of the post-test on manga agent characteristics

Treatment	Mean	SD	N
Characteristics	ns		
-Conan (cute)	3.91	2.083	44
-Newton(Prestigious)	4.18	2.073	45
Voice	ns		
-Calm	4.30	2.075	46
-Amusing	3.79	2.079	43
Interaction	ns		
-Conan x calm	4.42	2.104	24
-Conan x amusing	3.40	2.371	20
-Newton x calm	4.18	1.943	22
-Newton x amusing	4.17	1.875	23

Confidence interval=.95, ns=non significant p>0.05, (n=89)

8.2.1 Knowledge Results

Prior knowledge was analysed by median of pre-test and classified the students into two groups having less and more prior knowledge. The mean score differences of two main effects lead to an interesting effect as well. The study group of "Conan with calm voice" tended to have higher scores than “Newton with calm”, “Newton with amusing”, and “Conan with amusing” with 4.42, 4.18, 4.17, and 3.40 points, respectively.

Tab. 16: Descriptive Statistics with dependent variable: post-test

Treatment	Median	Mean	SD.	N
Conan calm	low PK.	2,82	1,662	11
	high PK.	5,77	1,363	13
	Total	4,42	2,104	24
Conan amuse	low PK.	1,83	1,115	12
	high PK.	5,75	1,669	8
	Total	3,40	2,371	20
Newton calm	low PK.	3,44	2,297	9
	high PK.	4,69	1,548	13
	Total	4,18	1,943	22
Newton amuse	low PK.	2,70	1,636	10
	high PK.	5,31	1,109	13
	Total	4,17	1,875	23
Total	low PK.	2,64	1,722	42
	high PK.	5,34	1,434	47
	Total	4,07	2,071	89

N= number of students, PK. = Prior Knowledge

Tab. 17: Tests of Between-Subjects Effects with dependent variable: post-test

Source	F	Sig.	η^2
Characteristics	.385	.764	.014
Prior knowledge	65.126	.000	.446
Interaction	2.617	.057	.088

These results show that all treatments were able to stimulate student's learning in the similar levels, excluding "Conan with amusing voice". The mean score differences of two main effects lead to an interesting effect as well: on average, students with more prior knowledge had a clearly higher score at 5.34 points than students with less background at 2.64 points.

The statistical method interpreted the different levels of knowledge on the calculus post-test between the four main factors of characteristics and the two levels of prior knowledge. Task performances under the various conditions of study are summarized by ANOVA and descriptive statistics in Tab.16.

Although in the consideration of the individual characteristics factor $F(3, 81) = 0.385$; $p = 0.764$, and interactions of treatment with prior knowledge $F(3, 81) = 2.617$; $p = 0.057$ there were no significant differences amongst treatments. However, prior knowledge shows differences between those less and more prior knowledge by $F(1, 81) = 65.13$; $p < .001$. Partial Eta square = .45 repre-

senting a large effect. It was concluded that some degree of prior knowledge had an effect independent from agent characteristics.

8.2.2 Preference Results

The participants were measured in the degree of satisfaction using the 5-Likert scale questionnaire, evaluating in terms of external and internal properties of manga agents.

8.2.2.1 Preference of Students on Agents Appearance

Appearance (external properties) involves the visual and auditory presence of the agent (Lester et al., 1999). Four sets of two-way MANOVA were conducted to examine how manga agent characteristic and voices affected learning, facilitation of learning, motivation, and perception of manga agent. The alpha level was set at .05 to determine statistical significance. The results of external properties on manga agent were shown in Table 5.4 and 5.5; characteristics as a main factor were not significant in the acceptability of all attributes, meaning that both characteristics were of similar acceptability.

Tab. 18: Mean scores and standard deviations of students on appearance of manga agent

Factor	Interesting		Usefulness	
	Mean	SD	Mean	SD
Voice	*		*	
Calm	2.704b	0.714	3.296b	852
Amusing	3.250a	0.718	3.798a	859

Confidence level 0.95, ns = not significant, * = Significant different $p < 0.05$, (n=89)

Tab. 19: MANOVA results of students on appearance of manga agent

Source	Variable	F	Sig.	η^2
voice	Interesting	13.490	0.000*	0.132
	usefulness	8.035	0.006*	0.083

Confidence interval=.95, * Significant $p \leq 0.05$

Voices as a reinforcement factor performed the amusing style has ability to make significantly different in two stages of duty as “interesting” and “usefulness” in the lesson $F (1, 85) = 13.490$, $p < 0.01$ and $F (1, 85) = 8.035$, $p < 0.01$, but was not significantly different in other attributes as well as in four combinations. However, regarding the interaction of “Agent Conan with amusing voice” the mean score tend to dominate in particular with size, colour, friendly, interesting, and voice. “Agent Newton with calm voice” and “Agent Newton with amusing voice” had slightly higher score in attributes of speaking and usefulness. It interpreted that most students were impressed learning with young agent possessing cuteness with an informal (amusing) voice.

8.2.2.2 Preference of Students on Manga Performance

Agents performance (internal properties) consists of the actions or instructional methods, the agent may carry out during its instruction with a student while facilitating or enabling learning, such as reducing the cognitive load from multimedia environments (Moreno, 2004).The results of internal properties on manga agent were illustrated in Tab. 20 and Tab. 21.

Tab. 20: Results of students on performances of manga agent

Source	Variable	F	Sig.	η^2
Characteristics	Need manga in other lessons	6.739	0.011*	0.07
Voice	Manga help more concentrate	5.513	0.021*	0.06
Interaction	Voice help more concentrate	7.269	0.008*	0.07

Confidence interval=.95, * Significant $p \leq 0.05$, ns=non Significant $p > 0.05$

Characteristics as a main factor were significantly different in the topic of "needing mangas in other lessons". The agent Conan had the highest score at 3.60 points $F(1, 89) = 6.739$, $p < 0.01$, and Partial Eta square = 0.07 representing a medium effect. Voice as a sub factors was significantly different in the category of "mangas can help concentrate more" with 3.18 points by amusing voice $F(1, 89) = 5.513$, $p = 0.021$, and Partial Eta square = 0.06 represented a medium effect. The cooperation between task and reinforcement revealed that there were significant differences in the catagory "voice helping to concentrate more". The mixtures of "Conan with amusing voice", and "Newton with calm voice" were significant different from other characteristics and similarly prominent at scores of 3.28 and 3.04 points, respectively $F(1, 89) = 7.263$, $p < 0.01$, and Partial Eta square = 0.07 representing a medium effect.

Tab. 21: Scores of participant on performances of manga agent

Factor	Manga help more concentrate		Voice help more concentrate		Need Manga in other lessons	
	Mean	SD	Mean	SD	Mean	SD
Characteristics	ns		ns		*	
Conan (cute)	3.059	0.807	2.903	0.909	3.601a	0.800
Newton (Prestigious)	2.910	0.809	2.918	0.912	3.172b	0.795
Voice	*		ns		ns	
Calm	2.788b	0.908	2.782	0.908	3.350	0.797
Amusing	3.182a	0.912	3.039	0.912	3.423	0.798
Interaction	ns		*		ns	

Conan x calm	2.880	0.881	2.520b	0.918	3.440	0.712
Conan x amusing	3.238	0.831	3.286a	0.956	3.762	0.889
Newton x calm	2.696	0.559	3.043a	0.928	3.261	0.689
Newton x amusing	3.125	0.900	2.792b	0.833	3.083	0.881

Confidence interval = .95, * Significant $p \leq 0.05$, ns = non significant $p > 0.05$, (n=89)

8.2.2.3 Preference Results of Mathematics Teachers

The Mathematics teachers evaluated the degree of preferences using the questionnaire evaluating the external (appearance) and internal (performance) properties of the manga agent. The data was shown in the form of mean scores and standard deviations.

8.2.3 Satisfaction on Agent's Appearance

The satisfaction of manga agent appearance (external property) is illustrated in Tab. 22 and Tab. 23. The colour's score of Agent Conan with calm voice was slightly higher at 3.40 points compared to the others, while Conan with the amusing voice was highest in interesting variables at 3.0 points. Furthermore Newton with calm voice received the highest in term of voice at 2.80 points. However, agent Newton with the amusing voice was the most prominent in terms of size, friendliness, and speaking 2.60, 3.40, and 3.40, respectively. Therefore, it can be concluded that most instructors tend to prefer the Agent Newton as a prestigious figure speaking with on informal (amusing) voice style.

Tab. 22: Score of Mathematics teachers on external properties of Manga agent

Factor (n=5)	Size		Colour		Friendly		Interesting	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Conan x calm	2.40	0.548	3.40	0.548	2.60	0.548	2.80	0.837
Conan x amusing	2.20	0.837	3.20	0.447	1.60	0.548	3.00	0.707
Newton x calm	2.20	0.837	3.20	0.447	3.00	0.000	2.80	0.447
Newton x amusing	2.60	0.894	3.20	0.447	3.40	0.548	2.20	0.447

Tab. 23: Score of Mathematics teachers on external properties of Manga agent

Factor(n=5)	Speaking		Voice		Usefulness	
	Mean	SD	Mean	SD	Mean	SD
Conan x calm	3.00	0.000	2.60	0.548	3.00	0.000
Conan x amusing	2.40	0.548	2.60	0.548	2.60	0.548
Newton x calm	3.00	0.000	2.80	0.447	3.00	0.707
Newton x amusing	3.40	0.548	2.60	0.548	3.00	0.707

8.2.4 Satisfaction on Agent's Performance

The satisfaction of manga agent performance (internal properties) is represented in Tab. 24 and. The score of the Agent Conan with the calm voice was outstanding at 3.40 points compared to the

other characteristics in the categories “easy to comprehend”, “help to solve problem” and “need manga in other subjects”.

Tab. 24: Scores of Mathematics teachers on internal properties of manga agent

Factor (n=5)	Easy to comprehend		Help to solveing problem		Make more funny		Manga's quantity	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Conan x calm	3.40	0.548	3.40	0.548	2.80	0.447	2.60	0.548
Conan x amusing	2.40	0.548	2.40	0.894	2.80	0.447	2.20	0.447
Newton x calm	3.00	0.000	3.00	0.707	2.60	0.548	2.80	0.447
Newton x amusing	2.60	0.548	2.60	0.548	2.60	0.548	2.40	0.894

The second favourite is the Agent Newton with amusing voice with 3.0 points in categories “manga helped concentrate more”, and “voice helps concentrate more”, while, Agent Newton with the calm voice scored only the highest in category “quantity of mangas in the media” at 2.80 points.

Tab. 25: Scores of Mathematics teachers on internal properties of manga agent

Factor(n=5)	Manga help concentrate more		Voice help concentrate more		Need manga in other lessons		Need manga in other subjects	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Conan x calm	2.40	0.548	2.60	0.548	2.60	0.548	3.40	0.548
Conan x amusing	2.40	0.548	2.20	0.837	2.60	0.548	2.40	0.894
Newton x calm	2.60	0.548	2.60	0.548	2.60	0.548	2.20	0.837
Newton x amusing	3.00	0.707	3.00	0.000	2.60	0.548	2.40	0.894

In addition, the instructor’s results regarding needing manga agents in other lessons scored 2.60 points in all categories. It could be seen that mathematics teachers tended to appreciate the internal properties belonging to Agent Conan with cute characteristics speaking with a formal (calm) voice the most.

8.3 Conclusion of Study III

- Effect of agents’ characteristics: Students in both groups did not show differences learning with cute or prestigious manga agents.
- Effect of agents’ voice style: Students in both groups did not show differences learning with amusing or calm voice styles.
- Effect of interaction between characteristics and voice style: no differences in test results.

- Effect of prior knowledge: Students with more prior knowledge learn better than students with less background.

8.4 Summary

In the present study, different manga agents were given two main features (characteristics, voices) and four interactions. In consideration of calculus assessment scores, there was no significant difference in terms of the main factors and their combinations. It could be seen that the supplementation with various manga agents did not diminish the cognitive load of calculus content. It was supported by Baylor (2003) that the presence of basic animation for pedagogical agents may help promote learning but also may negatively impact motivation toward the content. In contrast Baylor and Kim (2004) reported that the agent roles were not only perceived by the students to reflect their intended purposes but also led to significant changes in learning and motivation.

Results from these studies also showed that most general external properties of participants on different manga voices were not significantly different, with the exception of the “interest” and “usefulness” of the “amusing voice” being absolutely more prominent when compared with the “calm voice”. It may be due the participants' age as a teenager; it could be assumed that they favoured the “amusing voice” in general.

The students and teachers had different results from one another. The goal of creating this media is ultimately for the students; therefore, the preferences of the students were of primary importance. The results of this research indicated that the two factors of characteristics and voices were different; the hypothesis of the study has been confirmed. Therefore, the cute manga with the amusing voice should be supplemented in calculus multimedia, for Thai students in having higher test results and greater enjoyment.

9 Study IV: Manga vs. Human Agents

The fourth study was performed during the first semester of 2007 with 121 engineering undergraduate students at Rajamangala University of Technology at Lanna, aimed to compare the progression of calculus results and preferences of the students between manga and human video agents with a new parameter: the effect of prior knowledge levels of students learning with calculus multimedia. Learning with manga agent characters as a pedagogical agent was interesting, but time consuming and the cost of production can not be ignored, even with a simple pedagogical agent not possessing artificial intelligence. Video technology is common nowadays, with simple steps of production and low cost as well. This research expanded the boundaries to study the influence of manga agents compared with human video agents and the influence of prior knowledge of students. We expected that students would have differences in scores and be interested in manga agents as a pedagogical agent in calculus multimedia.

9.1 Methods of Study IV

First, the students learned the chapter regarding Functions in the classroom. Thereafter a pre-test measured the prior knowledge of the students using a multiple choice test. The students were randomly divided into two groups each containing approximately 60 people. Individual groups received different agents on CD-ROM together with a demonstration.

In finding the difference of students' knowledge gained between two groups, the first group of students learned using a selected manga agent from the second study, and the second group with the human video agent who possessed a calm voice. After a week of studying by themselves, progress of knowledge and attitude were measured by post-tests. In addition, the acceptability of the manga's agent and human-video agent was measured by the results of a questionnaire. The statistical analysis determined the distinction between groups in terms of differences between post-test, influences of prior knowledge, and preference tests by ANOVA and MANOVA with the use of a SPSS program.

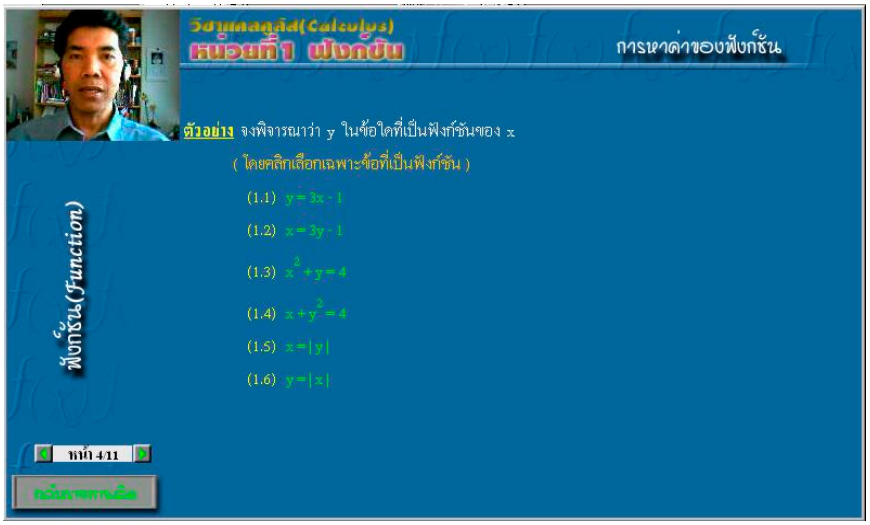


Fig. 20: Representative screen-shot of "Abhinan agent" on screen

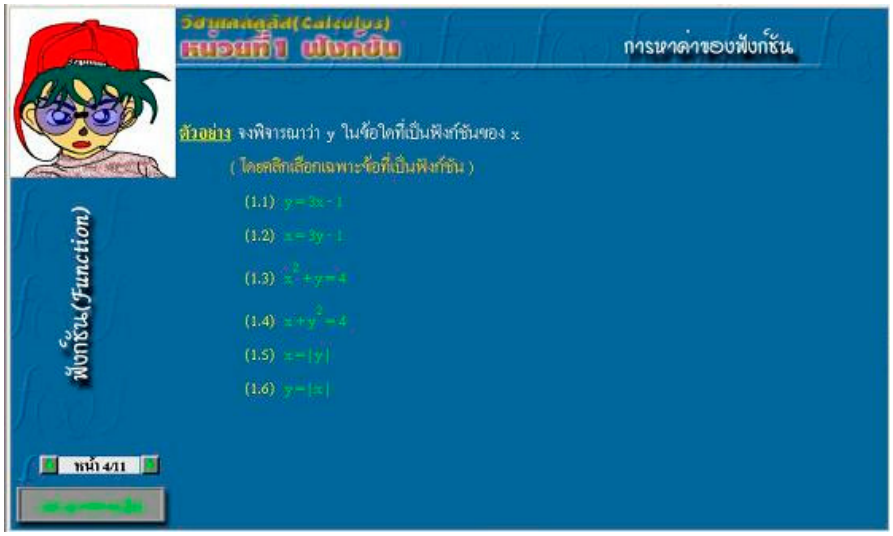


Fig. 21: Representative screen-shot of "agent Conan" on screen

Tab. 26: Research design between manga agent and human-video agent

Media		
Agent type	Manga	Human
Agents name	Conan	Abhinan
Sample size	62	59
Hypothesis H1:	$\mu 1 \neq \mu 2$	
Dependent variable	Calculus post-test: corrected scores	
Independent variable	1. Agent types: agent Conan and agent Abhinan 2. Prior knowledge: Low 0-4, High 5-8 (Total=8)	

9.2 Human Agent Production

Human agents were created using a web camera and a microphone head set. Videos with voices were captured directly into the computer by "*AmCap PC VGA camera*" program in the form of video Clip. Video output was formatted with the aspect ratio 4:3, dimensions 160 x 120 pixels, and 30 frames per second. Thirty four videos were used in this experiment (Fig. 22-Fig. 24).

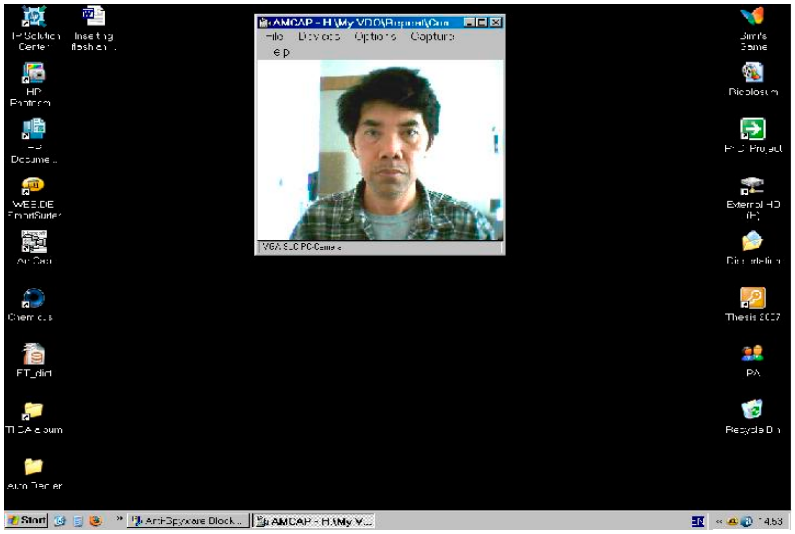


Fig. 22: Screen-shot of human-video agent capturing

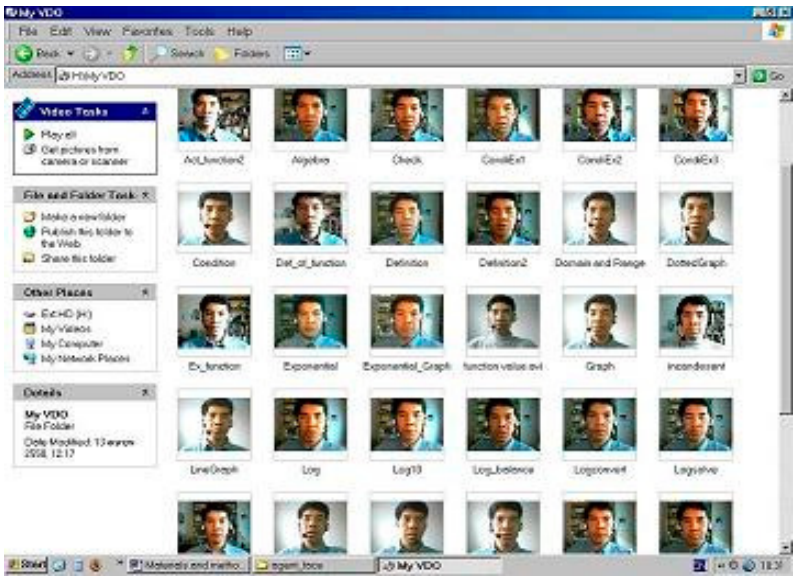


Fig. 23: Screen-shot of human-video agent catalogue

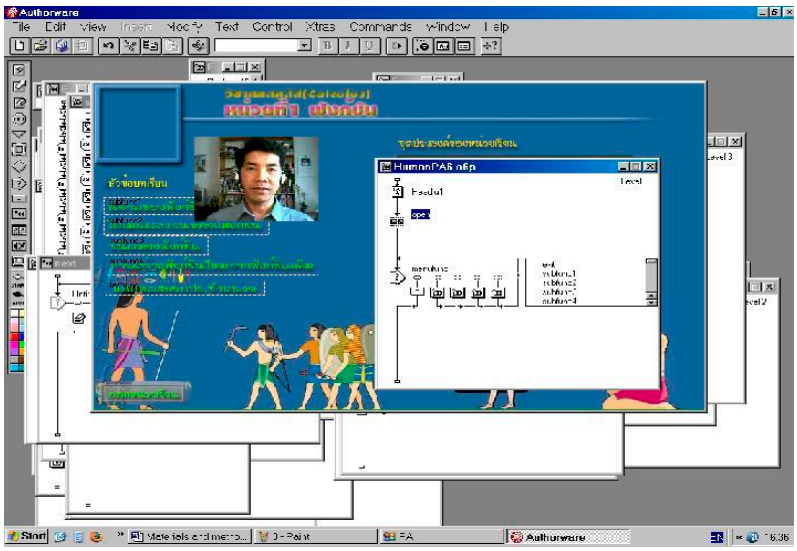


Fig. 24: Screen-shot of combining human-video agent to the media

9.3 Construction of Manga Agents

The manga character was created by means of free-hand drawing with the use of "*the TAB 2.2*" program and pen-tablet. They were exported in *Macromedia flash* (SWF) form. The manga agent construction was presented in detail as shown in studies II.

9.4 Results of Study IV

This study measured the different scores of the post-tests between two groups and the preferences of participants on the external and internal properties of these agents after learning with calculus multimedia. Two groups of participants were measured in this study. One learned calculus multimedia with "Agent Conan", and the other using the same media combined with human video, namely "Agent Abhinan". The calculus questions were investigated before and after students learned with the media by themselves.

9.4.1 Knowledge Results

ANOVA was used to evaluate the data of post-tests between two groups learning with Agents Conan, and Abhinan. The independent variable was the agent type and prior knowledge, while the dependent variable was the calculus tests results.

Tab. 27: Descriptive Statistics of dependent Variable: post-test

Treatments	Prior knowledge	Mean	SD.	N
Agent Abhinan	less prior	5.21	1.663	28
	more prior	6.39	1.542	31
	Total	5.83	1.693	59
Agent Conan	less prior	6.21	.499	28

	more prior	6.35	1.012	34
	Total	6.29	.818	62
Total	less prior	5.71	1.317	56
	more prior	6.37	1.282	65
	Total	6.07	1.334	121

Tab. 28: Tests of between-subjects effects, dependent variable: post-test

Source	**F**	**Sig.**	**η^2**
Treatment	4.396	.038*	.036
Prior knowledge	8.105	.005*	.065
Interaction	5.040	.027*	.041

Confidence interval= 0.95, *= significantly different: $p< 0.05$

In the present study, the significant value of the treatment was F(1, 117) = 4.4, and p = .038 with partial eta squared = 0.4, representing a small effect , while prior knowledge showed a highly significant difference at F(1, 117) = 8.1, p < 0.01 with partial eta squared = .065, representing a medium effect. Also, interaction between treatments and prior knowledge were significantly different at F (1, 117) =5.0, p=.027 with partial eta squared = .04 representing a small effect. It can be concluded that on average 0.5 more points were received by manga agent students group than the other (Tab. 27) Students with less prior knowledge learned better with manga agents while students with more had no differing outcomes between agent types (Fig. 25).

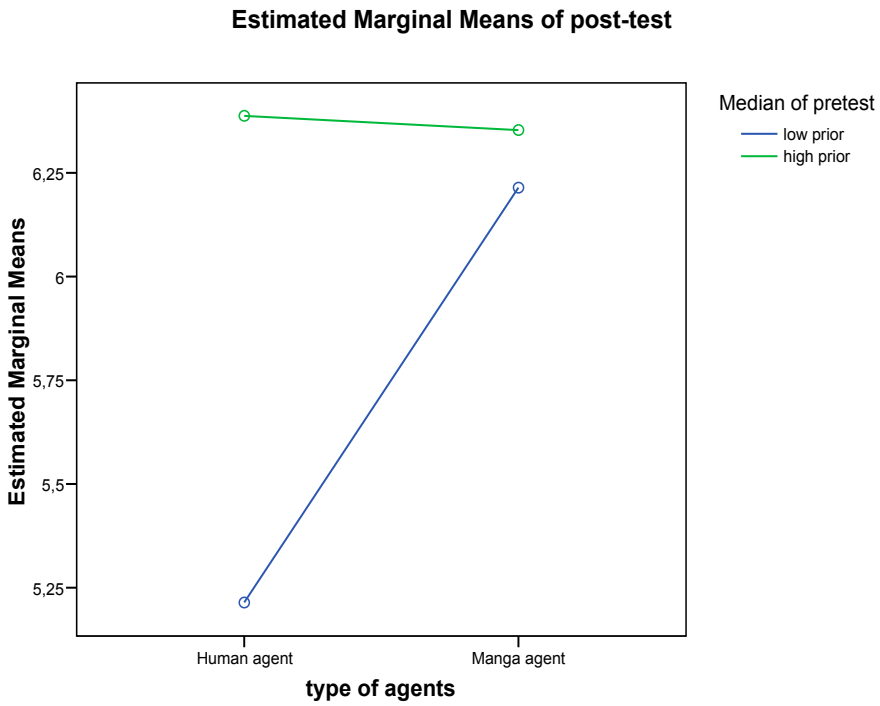


Fig. 25: Mean scores of students' post-test

9.4.2 Preference Results

The following step of the post-test used the 5-Likert scale questionnaire answered by the students learning with agents Conan and Abhinan. The general acceptability of participants on both agents in calculus multimedia was evaluated using MANOVA. The results measured the degree of satisfaction and acceptability regarding Agents Conan and Abhinan (Tab. 29).

Tab. 29: Research design of preference of students

		Value Label	N
Treatment	1	Human-video	55
	2	Manga agent	61
Gender	1	male	75
	2	female	41

9.4.3 Preference on Manga's Appearance

The two sets of experiment were conducted to examine the agent's external properties in regards to general characteristics and perception of the agent. The alpha level was set at 0.05 to determine statistical significance with the results shown in Tab. 30 and Fig. 26.

Tab. 30: Results of external properties (appearance) of agents

Source	Dependent Variable	F	Sig.	η^2
Treatment	Size	,063	,802	,001
	Colour	,065	,799	,001
	Friendly	,813	,369	,007
	Character	1,440	,233	,013
	Voice	,160	,690	,001
	Speaking	,215	,644	,002
	Usefull	1,482	,226	,013
Gender	Size	,816	,368	,007
	Colour	,229	,633	,002
	Friendly	,014	,905	,000
	Character	2,003	,160	,018
	Voice	,002	,960	,000

	Speaking	,460	,499	,004
	Usefull	,000	,995	,000
Interaction	Size	4,554	,035	,039
	Colour	,370	,544	,003
	Friendly	,008	,928	,000
	Character	2,535	,114	,022
	Voice	1,153	,285	,010
	Speaking	3,005	,086	,026
	Usefull	,358	,551	,003

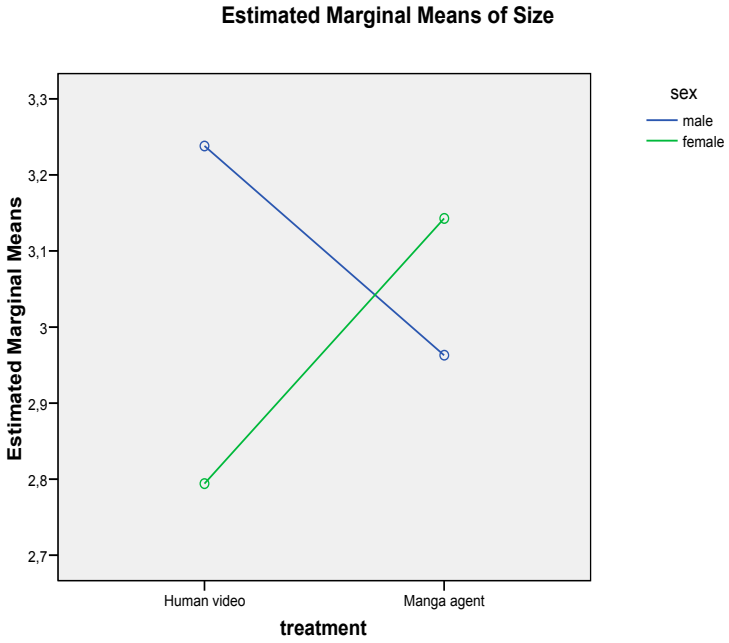


Fig. 26: Preference of students in agents

The scores for both agent groups varied from 2.96-2.98 (size), 3.10-3.13 (colour), 3.15-3.31 (friendly), 3.22-3.23 (character), 2.95-3.09 (voice), 2.98-3.05 (speaking), to 3.55 - 3.75 (usefulness) points for the Conan and Abhinan groups respectively. The standard deviations of each agent were less than 1.0, whereas the agent Conan was slightly lower than the other. Most attributes were not significantly different, meaning that both agents were similarly received. Regarding size of agents, male students preferred the human video size, while female students preferred the size of manga agent at $F(1, 112) = 4.554$; $p = .03$ with partial eta square = .039 representing a small effect. It can be concluded that the preference of participants on external properties of agents in general were not significantly different, with confidence interval of 95%.

9.4.4 Preferences on Manga's Performance

The preferences on performance (internal properties) of manga and human agents were evaluated in terms of being easier to comprehend, helping to solve problem, making it more fun, the agent quantity in lesson, helping to concentrate more, the voice helping to concentrate more, and needing agents in other topics and subjects. The results were shown in Tab. 31.

Tab. 31: Results of internal property (performance) of agents

Source	Dependent Variable	F	Sig.	η^2
Treatment	Comprehend	,269	,605	,002
	Solving	2,710	,103	,024
	Funny	,461	,499	,004
	Amount	,099	,754	,001
	Char help	1,464	,229	,013
	Voice help	,000	,993	,000
	Topics	,313	,577	,003
	Subject	,272	,603	,002
Gender	Comprehend	1,149	,286	,010
	Solving	,001	,979	,000
	Funny	,052	,820	,000
	Amount	,099	,754	,001
	Char help	,131	,718	,001
	Voice help	,904	,344	,008
	Topics	,912	,342	,008
	Subject	,876	,351	,008
Interaction	Comprehend	,682	,411	,006
	Solving	,650	,422	,006
	Funny	1,513	,221	,013
	Amount	,431	,513	,004
	Char help	3,691	,057	,032
	Voice help	2,535	,114	,022
	Topics	,000	,995	,000

	Subject	,235	,629	,002

The average mean scores both agents received varying results as follows: 3.04 - 3.18 (easy to comprehend), 2.91- 3.16 (help to solve problem), 3.00- 3.10 (made more fun), 2.96 - 2.85 (agent quantity in lesson), 2.89 - 3.00 (agent helped to concentrate more), 2.87 - 2.89 (voice helped to concentrate more), 3.35 - 3.33 (need agent in other topics), and 3.42 - 3.38 (need agent in other subject). The standard deviations of each agent were less than 1.0, whereas manga agents tended to have similar results than the others. All attributes were not significantly different, meaning that both agents were similarly accepted. It can also be concluded that the preference of participants for internal property of agents not due to manga or human video agents was not significantly different with a confidence interval of 95%.

9.5 Conclusion of Study IV

- Effect of agent types: Students learned more with manga agents than human agents; therefore they seem to be more appropriate.
- Effect of prior knowledge: students with more prior knowledge learned better than students with less background.
- Interaction effect: students with less prior knowledge performed better when presented manga agents rather than the human ones. In contrast, students with more prior knowledge showed equal results regardless with manga or human agents.

9.6 Summary

This experiment aimed to compare a human video with manga as a pedagogical agent while narrating with the same script. These results compared the learning outcomes and acceptability of the students. The results showed that the "Agent Conan" was more helpful and acceptable than human video agents. The manga agent affected the learning by reducing the cognitive load of the media; it also affected the preference levels of participants. The post-test scores were significantly different in the groups learning with the manga agent. It had clearly higher mean scores than the human video agent groups. The data was supported by statistical analysis regarding the post-test when compared between the two groups. Students' learning with manga agents had comparatively higher scores than those using the human video agent.

Part III General Discussion

The first survey was a preliminary study aimed to find out the preferences of participants on characteristics of manga agents. The second study aimed to reveal the influence of manga agents in calculus multimedia. The third study aimed to evaluate the impact of manga characteristics on learning results, and the fourth study was done to compare effects of a manga and a human agent on learning outcomes and acceptability. Furthermore, the effect of prior knowledge was tested on its effect on students learning during the third and the fourth studies.

The second study was done by testing two separate groups of students using pre and post-tests. After the pre-test was administered to both groups to evaluate their current knowledge of calculus, each group received a CD-ROM containing calculus multimedia material to study by themselves. The first group's calculus multimedia material was without a pedagogical agent, while the second groups' calculus multimedia material was supported with the manga named "Agent Conan".

Since the students' questionnaire results indicated a high preference for agent Conan, the third experiment created the second manga character based on the teachers' preferences. This pedagogical agent was named "Agent Newton" representing "prestigious" characteristics. The experiment was augmented by giving both agents (Conan and Newton) both types of voices: (calm and amusing). The results were four version pedagogical agents: 1) "agent Conan" with a "calm" voice, 2) "agent Conan" with an "amusing" voice, 3) "agent Newton" with a "calm" voice, and 4) "agent Newton" with an "amusing" voice. This experiment aimed to classify which types of manga agents yielded better results in both learning and acceptability, agent Conan with amusing voice receiving the best results.

The fourth experiment was to investigate human video as a pedagogical agent while using the same script as the manga agents. The results showed that students learning with "agent Conan" earned higher scores than students learning with human agents.

1 Survey

In order to find out which manga characteristics (such as voice styles, etc.) will be used in calculus multimedia, 56 undergraduate calculus students and 5 Mathematics teachers were surveyed using a 5-Likert scale questionnaire.

1.1 Students' Preferences

The questionnaire asked the students to respond to each characteristic (such as "cute", "prestigious", "calm voice", etc.) using a scale of 1-5. The number 1 representing *very unsatisfied* 2 *unsatisfied* 3 *indifferent* 4 *satisfied* and 5 representing that they were *very satisfied*. The results presented in percentage form.

The survey showed that most students were interested in the “cute” manga figures as much as the “prestigious” one, at 46 and 42 percent respectively. The preference in voice styles shows that the majority (42%) of the students were interested both in the “calm” and “amusing” voice styles at indifferent levels, and the minority (35%) chose satisfied similarly, meaning that most of students paid attention to both conditions of voice styles. The most prominent properties were age and movement; the results show approximately 50% responded with indifferent. It clearly indicated that they did not prefer older ages and moving agents in the calculus multimedia. Furthermore, the results of agent performance showed that 46% of students needed explanations at indifferent levels, while the responsibility as a guidance and entertainer were marked 42% and 46% at satisfied. The necessity of adding manga agent into calculus multimedia was extremely prominent amongst 85% of students. It showed that most students expected to have the manga agent act as assistant and facilitator of calculus learning and that agent could enhance learning.

1.2 Teachers Preferences

The survey on the requirements of manga's characteristics was provided to Calculus teachers. The purpose was to gather their opinion in order to complement student’s preferences. The results were presented in the form of number of teachers and their preferences of manga characteristics.

The result was that most teachers appreciated manga characteristics with respect to cute characteristics, calm voice and span of age at indifferent levels, while amusing voice, movement, and entertainment were rated with satisfied. All of them favoured mangas possessing prestigious characteristics able to explain the lesson at levels of very satisfied; furthermore, the responsibility as a source of guidance was expected by most teachers.

2 Influence of Manga Agents

To fine out the influence of manga agents as pedagogical agents in calculus multimedia, two groups of participants were investigated in this study. One group learned calculus multimedia with “Agent Conan” with a “calm” voice, and the other group learned using the same media but without the agent.

2.1 Knowledge Influence

A pre-test and post-test were administered to all of the students to find out their knowledge level before and after studying by themselves with the help of the calculus multimedia. The results were analysed by “paired sample t-test”.

2.1.1 Increased Knowledge

The students that learned with the pedagogical agent were given another questionnaire in order to find out their preferences regarding “Agent Conan” after interacting with the agents in calculus multimedia.

The knowledge levels of students studying with the pedagogical agent clearly increased more than the students who studied without the pedagogical agent. The standard deviations for pre-test and post-test measurements revealed that students were more varying in their opinion with respect to manga agent than the students studying without the pedagogical agent. Based on the significant value between pre-test and post-test in both groups, it was concluded that, under both conditions average scores improved per student after learning with calculus multimedia.

2.1.2 Difference Between two Groups

An independent sample t-test evaluated the data of the post-tests between the two groups learning with and without manga agents. On average, the manga agent group received a similar score to that of the control group which learned without the manga agent, indicating that although more points were received by the manga agent, the students did not learn much more to make a difference. This means that manga agents were not enough to reduce cognitive load of students while learning with calculus multimedia.

2.1.3 Preferences Results

A 5-Likert scale questionnaire was given to the students who learned with the "Agent Conan". The aim being to find out the preferences of participants in regards to Agent Conan's characteristics and his function as a pedagogical agent: knowledge assistance, voice-style, how many agents are preferred, movement levels, and internal properties (performance). The results were presented in percentage form.

Most participants rated in terms of assistance with comprehension as well as the amount of Agent Conan, at indifferent levels, while some marked at satisfied levels, indicating that they were impressed by agents in calculus multimedia. The third, fourth and fifth questions asked about the appearance of Agent Conan; with the respect to the cute characteristics, students rated between indifferent and satisfied, meaning that "Agent Conan" was attractive for them, while the voice of agent was appreciated from satisfied up to very satisfied. This means that an amusing voice style should be suitable for "Agent Conan" (especially with cute characteristics). The question of movement was an important one, since producing an overly animated character could prevent learning and needed to be avoided: most students were indifferent regarding Agent Conan's movement, meaning that the movement was suitably set up. The performance of "Agent Conan" was asked in the last three questions. The results showed that most of students favoured the explanation of "Agent Conan" in the lesson as well as it acting as entertainer at satisfied levels, supported by nearby levels at indifferent and very satisfied respectively. It clearly means Agent Conan thoroughly performed as a pedagogical agent in the calculus multimedia as designed. Students graded at indifferent levels for the guidance of "Agent Conan" followed by satisfied and very satisfied, these result rated Agent Conan not only good as an educator and entertainer but also in guiding the students to following the calculus multimedia as well.

3 The Influence of Characteristics

To answer the question which manga agents' characteristics and prior knowledge levels would impact learning and acceptability in calculus multimedia, an experimental method was design possessing two independent variables: four characteristics with the conditions of cute (Agent Conan) and prestigious (Agent Newton), and two voices styles with the conditions of calm and amusing. This was applied to two levels of prior knowledge divided by the median of pre-test (less and more) results of the students, with the specific purpose to discover the real need of students while learning with manga agents. The dependent variables were the number of correctly-solved problems from calculus knowledge test and the acceptability score from questionnaires. It hypothesized that with students who took the learning system with four different manga agents, based on the probability of statistical analysis, at least one treatment would distinguish from the others.

After students learned the chapter "Functions" in the classroom, four different manga agents supported forms of calculus multimedia were distributed as a CD-ROMs to students for a week so they could study by themselves with random groups. Knowledge tests and questionnaires were evaluated differently than their calculus knowledge, quality, and acceptability of manga agent in the final step. In addition, instructors in mathematics measured the quality and acceptability of manga agent using the same questionnaire. The results were analysed by using ANOVA for comparing post-tests and MANOVA for questionnaires.

3.1 Influence to Knowledge

The statistical method interpreted the difference of knowledge of calculus post-test between four main factors of characteristics and two levels of prior knowledge. These results show that all treatments were able to stimulate a student's learning at similar levels the best results coming from "Conan with amusing voice". The mean score differences of two main effects lead to an interaction effect as well. The study group with "Conan with calm voice" tended to have higher scores than "Newton with calm voice", "Newton with amusing voice", and "Conan with amusing voice". Prior knowledge seemed to have an effect; on average, students with higher prior knowledge had clearly higher scores than those with less background.

In consideration of individual characteristics and interactions of treatment with prior there were no significant differences among treatments. However, it was confirmed that the learning outcome was most different between students based on having more or less background knowledge.

3.2 Preferences of Students

The students' opinions were measured using the 5 Likert scale method, evaluating in terms of appearance and performance of the manga agent.

3.2.1 Manga's Appearance

Four sets of two-way MANOVA were conducted to examine how manga agent figures and voices affected learning, facilitation of learning, motivation, and perception manga agent. The results of appearance on manga agents showed that figures as a main factor was not significant in all attributes, meaning that both figures were of similar quality, while voices as a reinforcement factor showed that an amusing style had the ability to make significant differences in being interesting but was not significantly different in other attributes as well as in all four combinations. However, the interaction of "Agent Conan with amusing voice" mean score tended to dominate in relation to size, colour, friendliness, interest, and voice of agents while "agent Newton with calm voice", and "agent Newton with amusing voice" had slightly higher scores in attributes of speaking and usefulness. This showed that most of these students were impressed with learning with a young agent possessing cute characteristics and speaking with informal (amusing) voice.

3.2.2 Manga's Performance

The results of manga agent performance showed that the figures were significantly different in the topic "need manga in other lessons" with Agent Conan having the highest score. There were significant differences regarding "manga can help concentrate more". The interaction between figures and voices revealed that there were significant differences in the case of the voice helping to concentrate more. The mixture of "Conan with amusing voice", and "Newton with calm voice" were significantly different from other characteristics.

3.3 Teachers and Manga Agents

The Mathematics teachers evaluated the degree of likability using the 5-Likert scale method, in terms of appearance and performance of the manga agent. The data was shown in the form of mean scores and standard deviations.

3.3.1 Preferences on Appearance

Regarding the appearance of the manga agent, the score of Agent Conan with calm voice was slightly higher as compared to the others while Conan with amusing voice was the most interesting. Furthermore Newton with calm voice received slightly higher scores in terms of voice style. However Agent Newton with amusing voice was the most prominent in the categories of size, friendliness, and speaking. The usefulness score performed equally in most treatments, with the exception of Conan with amusing voice being slightly lower. Therefore, it can be concluded that most instructors tended to prefer characteristics belonging to Agent Newton as a prestigious figure speaking with an informal (amusing) voice style.

3.3.2 Performance Preferences

The score of Agent Conan with calm voice was outstanding when compared to the other characteristics in the topics of "easy to comprehend", "helped to solve problem" and "need manga in other

subjects". The second favourite was Agent Newton with amusing voice, having a score beyond the other characteristics for both "helped concentrate more", and "voice helped to concentrate more", while Agent Newton with calm voice score was the highest in "presence of manga". In addition, the instructors wanted manga agents supplemented in the other lessons at equal scores in all treatments. It could be seen that mathematics teachers tended to appreciate the internal properties belonging to Agent Conan as a cute figure speaking with a calm formal voice.

4 Manga and Human Agent

As Clark & Feldon (2005) concluded multimedia studies of agents, the different rates of learning should not depend on the body of agents but rather due to their teaching method. The biggest question for this study was is the animated pedagogical agent the only way to deliver these types of instructional methods in a multimedia learning environment? If alternative ways can deliver the same instruction with the same learning and motivation, but less cost, shouldn't we choose the least expensive option?

Even though learning calculus multimedia combined with manga characters as a pedagogical agent is interesting for the students, it is also time consuming and cost of production can not be ignored, particularly regarding the need of a multimedia team as well as grant support. On the other hand, video technology is common in present-day with simple steps of production and low cost. This research expanded the boundaries in studying the influence of manga agents while comparing with human video agents.

4.1 Knowledge Discussion

To understand the differences between learning outcome of the students, two groups of participants were measured in this study. One learned calculus multimedia with manga "Agent Conan", and the other learned using the same multimedia combined with human video "Agent Abhinan". The calculus questions were investigated before and after learning a week by themselves with the media. The results were analysed by ANOVA.

The prior knowledge of students was classified by median of pre-test as less and more. It showed that the more advanced group was greater than the other. This result indicated the students with less prior knowledge that learned with Agent Conan had clearly higher scores than learning with Agent Abhinan groups, while the students with greater prior knowledge learning with Agent Conan was similar to the other groups. The standard deviation for manga agent and human agent were double the value, while there was a standard deviation regardless of educational background. It revealed that student scores were less varies when learning with Agent Conan.

The different scores of post-test between two groups were analysed to evaluate the data of post-test between two groups learning with Agent Conan and Abhinan. In the present study, the mean score of agents-type were significantly different. The mean scores of prior knowledge were significantly

different. Also, the mean score of interaction were significantly different. It can be concluded that the students learned more with Agent Conan and students with greater prior knowledge learned better.

4.2 Preference Discussion

The 5-Likert scale questionnaire was answered by students learning with agents Conan and Abhinan. The general acceptability of participants on both agents in calculus multimedia was evaluated by using MANOVA. The results determined the degree of satisfaction and acceptability of agents Conan and Abhinan.

4.2.1 Students and Agents' Appearance

The MANOVA was conducted to examine the agent's external properties in the view of general characteristics and perception of the agents. The scores for both agent groups varied a little between Agents Conan and Abhinan groups. The standard deviations of each agent were less than 1.0, whereas Agent Conan was slightly lower than the other. Most attributes were not significantly different, meaning that both agents were similarly accepted. Regarding the size of agents, male students preferred human agent size while female students preferred the size of manga agents. It can be concluded that the preference of participants for external property (appearance) of agents in overall is not due to manga or human agents acting as pedagogical assistants.

4.2.2 Students and Agents' Performance

The performance (internal properties) of manga and human agent were demonstrated in terms of being easier to comprehend, helping to solve problem, making learning more fun, agent quantity in lesson, the agent helping to concentrate more, the voice helping to concentrate more, and needing agent in other topics and subjects.

The average mean scores of both agents varied little. The standard deviations of each agent were less than 1.0; whereas manga agents tended to have lower variations than human ones. Nevertheless all attributes were not significantly different, meaning that both agents were similarly accepted. It can be concluded that the preference of participants on internal property of agents is not significantly different.

5 Summary

The results of this chapter show that the manga agent can help students to learn better only when compared with human video. Moreover, differences in manga characteristics did not affect learning of students, only their preferences. Nevertheless, these results strongly confirmed that the level of prior knowledge is most important when it came to the learning results. Furthermore, all types of manga agents clearly had an effect on students with less prior knowledge.

Part IV Implication for Practice

Beginning with the first surveying in the topic “Which types of manga characteristics would you like to add-in to a calculus multimedia?”, followed by the first experiment to find out the impact of the first manga agent combined with the calculus multimedia. Then, the main experiment, which finds out the differences between characteristics and voices styles of manga agent by producing another three manga agents, is informed. The end will return to the principle question “Is that manga agent really needed?” by comparing it with simplified character that easy to produce than any agent: “The human video agent”. In the present study, the manga characters “Agent Conan” and “Agent Newton” were developed from comic books. The two cartoon characters are Edogawa Conan (Sir Arthur Conan Doyle: Detective Sherlock Holmes’ Author), and Sir Isaac Newton, respectively. The former was a famous child detective, and the latter was a prestigious scientist, mathematician and physicist, who established calculus mathematically.

1 Students and Manga Characteristics

Before we created the manga agent as a pedagogical agent (to combined with calculus multimedia), the question “Which type of manga characteristics was appropriate to this job?” was created by questionnaire surveying. This survey was done with Thai undergraduate engineering students at Rajamangala University of Technology at Lanna, the results should be different if the participants were to study in other fields. Moreover, the most interesting groups of students learning calculus are those in high-school Math-science programs, which should have different opinions. The recommendation for further research in preferences surveying was that the amount of participants should be larger than this research to gain more accuracy and variety of age and fields of participants because these surveying results were representative of preferences to specifics group of students. Therefore, we decided to create the pedagogical agents in 2D format, because 3D production is rather costly. The reason for using manga characters is simple: manga and anime (manga animation); the Japanese cartoons on television are highly popular with young and also adults in Thailand.

While, pedagogical agents that communicating with the learner by voice clearly had higher results than text-based narration, it is also possible that voice as well as text could cause a cognitive over load. Human voice also shows higher results than computer generated voices. These helped us on make a decision to only use human voice in this study. Even though, studies on voice style found that strong voices have higher motivation, this study aimed not only to reduce cognitive loads from the calculus multimedia but also to increase enjoyability for students studying. Therefore we should select "amused" voice to parallel with cute characteristics of manga agent, while "calm" voice should be used to represent a standard lecture in any classroom. Unexpectedly, the two voice styles “calm” and “amusing” received similarly high markings in the survey. Thus, the “calm”

voice factor was selected to concur with manga for the conservative classroom environment. Therefore, the first manga should be constructed initially in cute characteristic, and calm voice, based on the slightly higher scores of cute characteristics.

Most participants preferred manga characters; therefore, supplementation of manga agents in the learning media was considered according to the desires of the students as users and instructors as supporters.

Mathematics teachers were also given the same survey as the students. While the students were most interested in both characteristics "cute" and "prestigious" and "amusing and calm" voice styles, all mathematics teachers clearly preferred only the "prestigious" characteristics. Thus, the use of manga characters as pedagogical agents in calculus media as instructors and stimulator was considered according to the needs of the participants. In the effort to evaluate the addition of a manga agent in the media, manga was created as a cute, young boy with calm voice, acting as a movable assistant in the primary media.

2 Manga Agent in Learningmedia

Agent-based learning environments can serve as a powerful research tool to investigate teaching and learning. Many research programs are implementing agents as learning assistance. The agent roles were not only perceived by the students to reflect their intended purposes, but also led to significant changes in learning and motivation. Additionally, the cognitive load has an important theory in instructional design for decreasing learning difficulty and, subsequently, for enhancing learning achievement as well as performance. In the present study, the relationship between pre-test and post-test was significantly different in learning with or without manga agent groups. There was no statistical different in term of the post-test when compared between two groups. It can be concluded that manga agents are insufficiently effective to decrease cognitive load in this study.

Therefore, although learning with and without manga agents supplement did develop the knowledge at the same level, it did encourage the learners in terms of a facilitator, entertainer, and guidance in the lesson corresponding to the preference scores. Despite the fact that the character is a kind of image, it could not stimulate knowledge by itself, voice cues should be the key to do that. These results show that the social cues must be improve to match the point of calculus questions in the next research.

3 Characteristics of Manga

Managing cognitive load is critical in effectively designing computer-based learning environments. Researchers have considered some agent features such as image, animation, and voice and their role with cognitive load. Prior research has indicated that voice has a superiority effect to visual appearance for communication in computer-based media. According to communications research, voice provides a powerful indicator of meaning. However, many studies examining the

effect of voice have focused on a presence/absence of voice rather than its nature, such as comparing computer-generated voice with human ones, although there have been other reports that indicate that a human voice is preferable for agents.

In the present study, different manga agents were conducted into two main features: characteristics, voices and four interactions. In consideration of calculus knowledge scores, there was no significant difference in terms of main factors and their combinations. It could be seen that the supplementation with various manga agents did not diminish cognitive load of calculus content.

The results from this studies show that most general external properties of participants on different manga voices were not significantly different, with the exception of “interesting” and “usefulness” of “amused voice” being absolutely prominent when compared to the “calm voice”. It may be due to participants' age as teenager. It could be assumed that they favoured “amusing voice” in general. This is confirmed by the result of manga's internal properties as the actions or instructional methods that the agent may carry out during its instruction with a student to facilitate or enable learning, such as reducing the cognitive load from multimedia environments, showing that the “amusing” voice assisted them in concentrating more during the lesson. The students needed to have a “Conan” with amuse voice, as well as the Newton with calm voice. It can be assumed that since Conan was a young boy, amusing voice style was with. On the other hand, Newton was presented as a young professor in the university, appropriately speaking with calm like lecturer style.

In addition, the external properties did not distinguish between the character of “Agent Conan” and “Agent Newton”, but in term of internal properties, such as participants needing “Agent Conan” in other lessons. It could be supported by two reasons. One is that they tended to favour “Agent Conan” based on satisfaction scores. The other is that participants are familiar with “Agent Conan” as a famous manga with a “cute” personality. On the other hand, “Agent Newton” as a prestigious character was not impressive amongst teenagers.

Contrary to the students, the mathematics teachers preferred the character of Newton with the “amusing” voice, as well as the character of Conan with calm voice. This may be due to different generations between students and teachers. The “Agent Newton” was designed an adolescent. Thus, teachers probably needed an agent representing their respectful and prestigious outlook, and in combination with an “amusing” voice, could encourage the learners. However, the teachers personally preferred agent Conan with a “calm” voice. It is assumed that agent Conan has attractive characteristics, and speaking with a “calm” voice may help reinforce the concentration of learners.

4 Manga and Human Video Agent

Pedagogical agent design has recently had greater emphasis placed on it, considering the importance of the agent as an actor rather than as a tool. Its image plays a very important role in impacting learning and motivational outcomes. The image is key because it directly impacts how the

learner perceives it as a human-like instructor The present study showed that the relationship between pre-test and post-test was significantly different only in the groups learning with manga agent. It had clearly higher mean scores than the human video groups. The data was supported by statistical different in terms of the post-test when compared between two groups. Students' learning with manga agents had appreciatively higher scores than human video ones. An explanation for this reason is that due to the manga's character and voice as a favourite cartoon is very attractive among adolescent-students in this decade, resulting in more enjoyability and interest during learning with the media. While human video is a representative image of a lecturer in the classroom narrated with calm voice, it was not attractive and less motivating for students in learning with this calculus multimedia. Therefore, it can be concluded that the manga agent is extremely effective in encouraging cognitive load in this study. Presentation and explanations are considered to be the major function of the pedagogical agent in the study. A traditional monologue lecture format of the human video agent may not be appropriate for adolescent learning. Currently, under the modern multimedia learning system, the Socratic dialog of teaching is employed to help students better understand and learn course content. It is also important to note that the dialogues and discussions, not only between teacher and students but also among students, are essential parts of a traditional classroom environment.

Students' invested efforts in processing the materials is most likely to increase when the pedagogical agent makes the learning task more interesting or motivating either through their internal or external properties. Considering the external property of agents, the preference scores were not significantly different between manga agent and human video; participants preferred both agents at unsatisfied to satisfied levels. It can be seem that human video-made learning was as interesting or motivating as the manga agents in this study. Although the degree of satisfaction was similar between both agents, manga agents tended to receive slightly higher scores than the human-video, particularly in regards to the "friendliness" attribute. The relation between students and manga agent were lead to a relaxing and stimulating learning atmosphere. This can be partly reasoned that participants learning with manga enhanced the progressive knowledge.

Internal properties comply with the actions or instructional methods that the agent may carry out during its instruction with a student to facilitate or enable learning, such as reducing the cognitive load from multimedia environments. In observation of the agent's internal properties, the preference scores were not significantly different between manga and human video agents. Participants preferred both agents at the levels of unsatisfied to satisfy. It can be seen that both agents similarly preferred in this study.

Reference

Aoyama, G., Detective Conan, Bangkok, Thailand,Vibulkij Publishing, 2004

Baylor, A. L. (2002). Agent-based learning environments for investigating teaching and learning. Journal of Educational Computing Research, 26, 3, 249-270.

Baylor, A. L. (2002). Expanding metacognitive awareness of instructional planning with MIMIC (Multiple Intelligent Mentors Instructing Collaboratively), an agent-based learning environment. Paper presented at the American Educational Research Association, New Oleans, L.A.

Baylor, A. L. and Kim, Y. (2004). Pedagogical agent design: The impact of agent realism, gender, ethnicity, and instructional role. International Conference on Intelligent Tutoring System, Maceio, Brazil.

Baylor, A. L. and Kim, Y. (2005). Simulating instruction roles through Pedagogical agents. International Journal of Artificial Intelligence in Education, 15, 2, 95-115. [On-line] available: http://iospress.metapress.com/(lycj312yn531wfenymeo5zjd)/app/home [07/09/06]

Baylor, A. L. (2003). The impact of three Pedagogical agent roles. Proceedings of the Second International Joint Conference on Autonomous Agents and Multi-agents, Melbourne, Australia, 928-929.

Baylor, A. L. (2005). Preliminary design guidelines for Pedagogical agent interface image. IUI'05, January 9-12, 2005, California, USA.

Baylor, A. L., Chang, S. (2002). Pedagogical agents as scaffolds: The role of feedback timing, number of agents, and adaptive feedback. Processing of International Conference of the Learning Sciences. Seattle, WA. USA.

Baylor, A. L. and Plant, E.A. (2006). Pedagogical agents as social models for engineering: The influence of agent appearance on female choice. [On-line] available: http://ritl.fsu.edu [18/09/2006].

Baylor, A. L., Shen, E. and Warren, D. (2004) Supporting learners with math anxiety: The impact of Pedagogical agent emotional and motivational support. Lecture notes in Computer science, Florida Stage University.

Berger, C. and Kam, R. (1996). Definitions of instructional design. The University of Michigan. [On-line] available: http://www.umich.edu/~ed626/define.htm. [24/05/2004]

Bickmore, T. and Cassell, J. (2001) Relational agents: a model and implementation of building user trust. Proceeding SIGCHI' 01, March 31–April 4, 2001, Seattle, WA, USA.

Bostock, S. (1996). Instructional design–Robert Gagné. The condition of learning. Learning Technology. [On-line] available: http://www.keele.ac. uk/depts/Stephen_Bostock/docs/atid.htm. [02/10/05].

Carbonell, J. R. (1970). AI in CAI: An artificial-intelligence approach to computer-assisted instruction. IEEE Transactions on Man-Machine System 11 (4): 190-202.

Cassell, J. and Thorisson, K. R. (1999). The power of a nod and glance: envelope vs. emotional feedback in animated conversational agents. Applied Artificial Intelligence 13(4-5): 519-538.

Center of Advance Research in Technology for Education (CARTE). (2006). [On-line] available: http://www.isi.edu/isd/carte/. [18/09/2006].

Chou, C.-Y., Chan, T.-W. and Lin, C.-J. (2003). Redefining the learning companion: the past, present, and future of educational agents. Computer and Education, 40, 225-269.

Chandler, P. & Sweller, J. (1991). Cognitive Load Theory and the Format of Instruction. Cognition and Instruction 8 (4): 293–332.

Clark, R. E. (2005). Five design principles for experiments on the effects of animated pedagogical agents. Journal of Educational Computing Research, 32, 3, 209-225. [On-line] available: http://baywood.metapress.com/.[27/05/06].

Clark, R. E., and Feldon, D. F. (2005). Five common but questionable principles of multimedia learning. In Mayer, R. (Ed.) Cambridge Handbook of Multimedia Learning. Cambridge, Cambridge University Press.

Cooper, B. and Brna, P. (2001). Fostering cartoon-style creativity with sensitive agent support in tomorrow's classroom. Educational Technology and Society 4, 2, 1436-4522.

Craig, S.D., Gholson, B. and Driscoll, D.M. (2002). Animated pedagogical agents in multimedia educational environments: Effects of agent properties, picture features, and redundancy. Journal of Educational Psychology, 2, 428-434.

Domagk, S. and Niegemann, H.M. (2006). Pedagogical Agents: Do their characteristics influence the learning process? Proceedings of Conference on American Educational Research Association, CA, USA.

Domagk, S., Poepperling, P. and Niegemann, H.M. (2006). Do people prefer the opposite sex? Characteristics of Pedagogical Agents. Deutsche Forschungsgemeinschaft.

Doyle, P. (1999). When is a communicative agent a good idea? The third International Conference on Autonomous Agents, Seattle USA.

Elliot, C., Rickel, J., and Lester, J. (1999). Lifelike pedagogical agents and affective computing: An exploratory synthesis. In Johnson, W. L. and Rickel, J. W. Animated pedagogical agents: face

to face interaction in interactive learning environments. International journal of artificial intelligence in education (2000) 11, 47-78.

Huk, T. and Floto, C. (2003). Computer-animations in education: The impact of graphical quality (3D/2D) and signals. Proceeding of E-Learn, 1036-1037.

IDKB. (2004). Instructional design knowledge base. [On-line] available: http://alassbeb.gmu.edu/ndabbagh/Resource/IDKB/models_theories.htm. [01/06/2004].

Jena-Claude, M., Stépanie, B., and Sarkis, A. (2006). 2D Gestural and multimedia behavior of users interacting with embodied agents. [On-line] available: http://www.limsi.fr/Individu/martin[12/04/2006].

Jitjaroen, A., Tomdaungkaew, C., Intachai, A., Buntawong, O., Jitjaroen, W. (2005). The construction and testing of an e-learning media for Calculus. Rajamangala University of Technology Lanna, Lampang, unpublished Research report.

Johnson, L., Shaw, E., and Ganeshan, R. (1998). Pedagogical on the Web. [on-line] available: http://www.isi.edu/isd/ADE/papers/its98/ITS98-WW.htm. [27.10.2007]

Johnson, W. L. (1994). Agents that learn to explain themselves. Proceeding of the twelfth national conference on artificial intelligence. AAAI Press, Menlo park, CA. 1257-1263.

Johnson, W. L., Rickel, J. W. and Lester, J. C. (2000). Animated pedagogical agents: face-to-face interaction in interactive learning environments. International Journal of Intelligence in Education, 11, 47-78.

Kim, Y., Baylor, A. and Read, G. (2003). The impact of image and voice with pedagogical agents. Proceedings of World Conference on e-learning in Cooperate, Government, Health care, and Higher education, 2237-2240.

Kirschner, P. A., Sweller, J., and Clark, R. E. (2006). Why minimal guidance during instruction does not work: an analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. Educational Psychologist 41 (2) 75-86

Koda, T. and Maes, P. (1996). Agents with faces: The effect of personification of agents. HCL'96, London, UK. [On-line] available: http://www.cs.kent.edu/nyhijazi/youssef/ROMAN_paper.pdf. [27/05/2006].

Lewis, D. (2003). Pedagogical agents: a tool for the design and development of web-base Instruction. [On-line] available: http://www.coedu.usf.edu/agents/. [17/09/2006].

Leigh, D. (2003). A brief history of instructional design. Performance improvement global network. [On-line] available: http://www.pignc-ispi.com/articles/education/brief%history.htm. [24/05/2004].

Malachowski (2004). Addie based five-step method towards instructional design.[On-line] available: http://fog.ccsf.cc.ca.us/~mmalacho/Online/ADDIE.html. [24/05/2004].

Majoring in Manga (2002). University Teaches Students How to Produce Comics. [On-line] available: http://www.kyoto-seika.ac.jp/eng/index.html. [28.12.2006]

Mayer, R. E. (2001). Multimedia Learning. New York, Cambridge University Press.

Mayer, R. E. (2005). The Cambridge Handbook of Multimedia Learning. Cambridge University Press. 201-212.

Mayer, R.E. and Moreno, R. (2003). The Cambridge Handbook of Multimedia learning. Cambridge University Press. 509-510.

Mayer, R.E. and Moreno, R. (2003). Nine ways to reduce cognitive load in multimedia learning. Educational Psychologist, 38, 43-52.

Moreno, R., Mayer, R. and Lester, J. (2000). Life-like pedagogical agents in constructivist multimedia environments: cognitive consequences of their interaction. The World Conference on Educational Multimedia, Hypermedia, and Telecommunication, Montreal, Canada. [On-line] available: http://research.csc.ucsu.edu/intellimedia/papers/ed-media-dap.pdf. [27/05/2006].

Moreno, R. Mayer R. E., Spires, H. A., and Lester, J. (2001). The case for social agency in computer-based teaching: Do students learn more deeplywhen they interact with animated pedagogical agents? Cognition and Instruction, 19(2), 117-213.

Morozov, M., Tanakov, A., and Bystrov, D. (2004). A Team of Pedagogical Agents in Multimedia Environment for children. Educational Technology and Society, 7(2), 19-24.

Miller, O. (2001). Talking heads. [On-line] available: http://www.memphis.edu/magazine/v19i2/index.html. [10/09/2006].

Mitrovic, T. (2000). Evaluating an animated pedagogical agent. Proceeding of ITS 2000. [On-line] available: http://www.cosc.canterbury.ac.nz/tanja. mitrovic/seminar00/index.htm. [09/10/2006].

Mulken, S. V., Andre', E. and Müller, J. (1998). The persona effect: How substantial is it ? German Research Center for Artificial Intelligence. Proceeding for HCI-98, Berlin.

Niegemann, H. M. (2006). Integrating and Conveying Knowledge on How to Design Multimedia Learning Environments – The Development of an Elearning Design Assistant.Proceeding of the Ninht IASTED International Conference Computers and Advance Technology in Education, October 4-6 2006, Lima, Peru.

Ossimitz, G. Information Communication and Social awareness. [on line] available: http://www.uni-klu.ac.at/~gossimit/pap/go_icsa.pdf

PMK Learning environment. (2006). Project management knowledge learning environment. [on line] available: http://php.cin.ufpe.br/~pmk/p/english.php. [10/09/2006].

Ray, B. (2005). Online learning's frontier: Researchers gives a 'human' face. [on line] available: http://www.fsu.edu/news/2005/11/15/online.frontier/ [10/09/2006].

Moreno, R., and Mayer R.E. Pedagogical Agents in constructivist multimedia environments: The role of Image and Language in Instructional communication. [on-line] available: http://www.unm.edu/~moreno/PDFS/Roundtble.pdf

Ryu, J. and Baylor, A.L. (2005). The psychometric structure of pedagogical agent persona. Tech. Inst. Cognition and Learning, 2, 291-319.

Seels, B. and Glasgow, Z. (1998). Making instructional design decisions. 2nd ed., Upper Saddle River, NJ: Prentice-Hall, Inc. [On-line] available: http://www.personal.psu.edu/users/m/r/mrs331/history_of_isd.htm. [01/06/2004]

Sing, O. S., Fung, C. C., Depickere, A., and Hoe, L. S. (2005). Object-based learning with concept mapping embodied intelligent agent. Proceedings for the second international conference on eLearning for knowledge-based society, August 4-7, 2005, Bangkok, Thailand.

Smith, T., Affreck, G., Lees, B. and Branki, C. (2007) Implementing a generic framework for a web-based pedagogical agent. [on-line] available: http://www.ascilite.org.au/conferences/brisbane99/papers/smithaff leck.pdf. [28.10.2007].

Starter, D. (2000) Interactive animated pedagogical agents. Stanford University. [On-line] available: http://ldt.stanford.edu/%7Eslater/pages/agents/. [10/09/2006].

Stocky, T. and Cassell, J. (2002). Shared reality: Spatial intelligence in intuitive user interface. MIT media lab. Cambridge, MA, Proceeding IUI' 02, January 13-16 2002, California, USA.

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning". Cognitive Science 12 (1): 257–285.

Sweller, J. (1994). Cognitive load theory, learning difficulty, and instructional design. Learning and Instruction, 4, 295-312.

Sweller, J., Van Merriënboer, J., & Paas, F. (1998). Cognitive architecture and instructional design. Educational Psychology Review 10: 251–296.

Sweller, J. (1999). Instructional design in technical areas. Camberwell, Australia: ACER Press.

Takeuchi, H. (2004). Issac Newton: Gravitational discoverer. Amarin Printing and Publishing Co. Ltd. Bangkok Thailand.

Thórisson, K.R. (2002). Natural Turn-Taking needs no manual: Computational theory and model, from perception to action. Multimodality in language and speech systems. D.H.B. Granström, I. Karlsson. Dordrecht, The Netherlands, Kluwer Academis Publishers: 173-207.

Veletsianos, G., Yerasimou, T., Doering, A. (2006). The role of intelligent agents on learner performance. [On-line] available: http://www.alicebot.org/articles/learner.pdf [27/05/2006].

Wilson, B.G., Jonassen, D.H. and Cole, P. (1993). Cognitive approaches to instructional design. In: G.M. Piskurich (ed.), The ASTD Handbook of Instructional Technology, New York: McGraw-Hill. [On-line] available: http://cudenver.edu/~bwilson. [09/03/2005].

Wikipedia (2007). Anime. [On-line] available: http://en.wikipedia.org/wiki/Anime. [22.03.2007]

Wikipedia (2006). Case_Closed. [On-line] available:http://en.wikipedia.org/wiki/Case_Closed_manga. [28.12.2006]

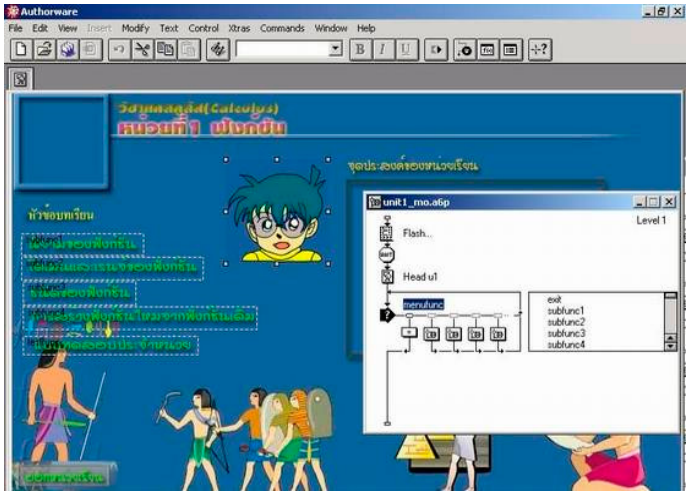
Wikipedia (2006b). Issac Newton. [On-line] available: http://en.wikipedia.org/wiki/Issac Newton. [28.12.2006]

Wikipedia (2006c). Manga. [On-line] available: http://en.wikipedia.org/wiki/Manga. [28.12.2006]

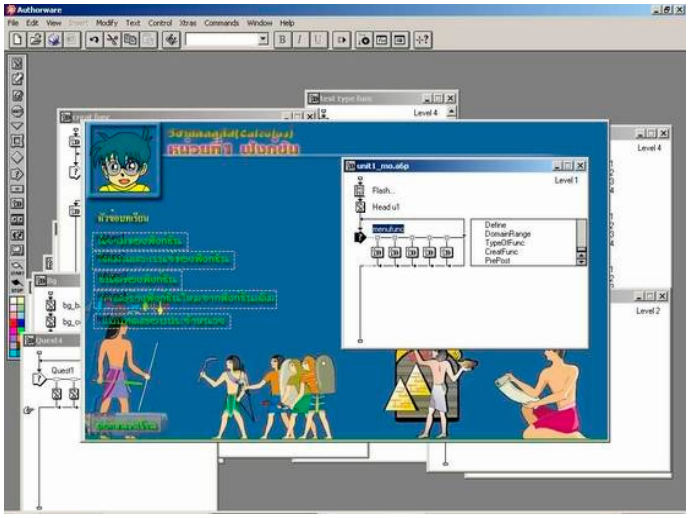
Wikipedia (2007b). Ukiyo-e. [On-line] available: http://en.wikipedia.org/wiki/Ukiyo-e. [22.03.2007]

Appendix

App. 1: Manga combination into the lesson for calculus multimedia



App. 2: Manga location on the calculus multimedia screen



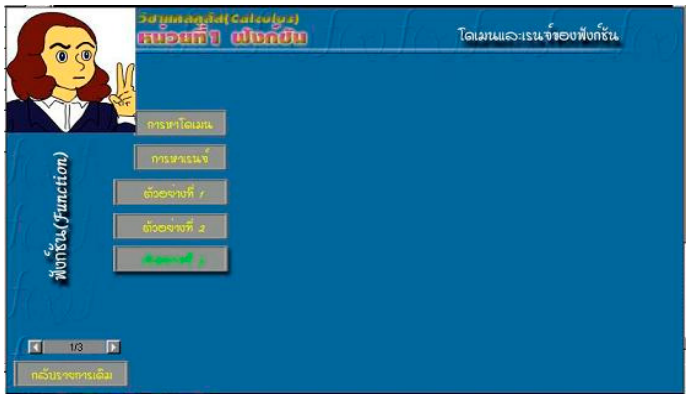
App. 3: Agent Newton responsible for self-introduction and guidance

App. 4: Agent Conan responsible for explanation Function definition

App. 5: Agent Newton responsible for explanation Function definition

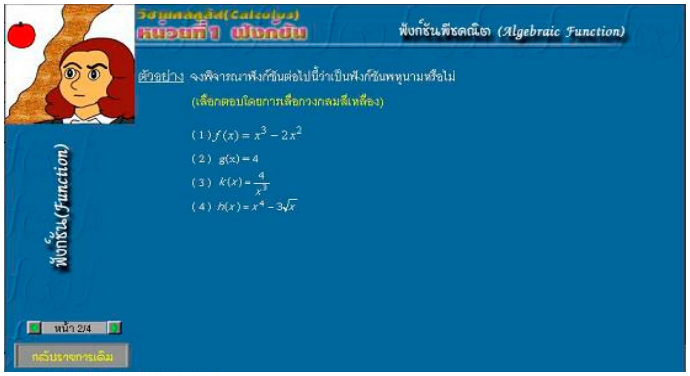
App. 6: Agent Newton responsible for explanation Domain and Range

App. 7: Agent Newton responsible for explanation and guidance

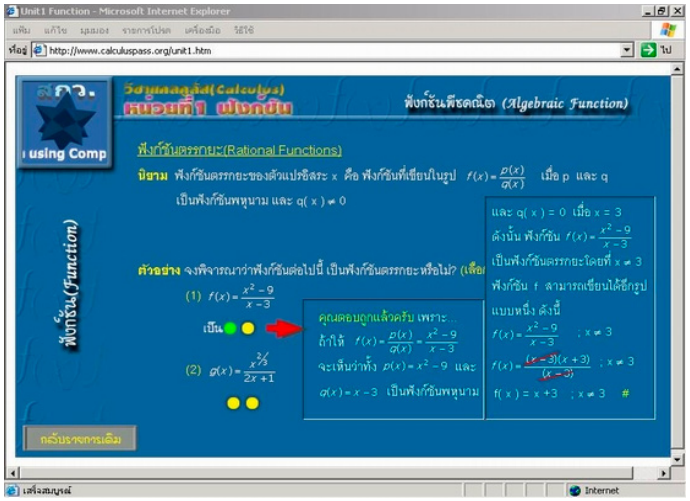


App. 8: Agent Conan responsible for explanation

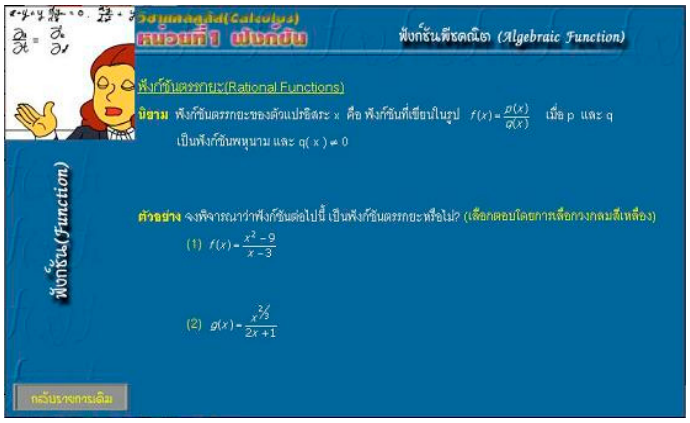
App. 9: Agent Newton responsible for explanation



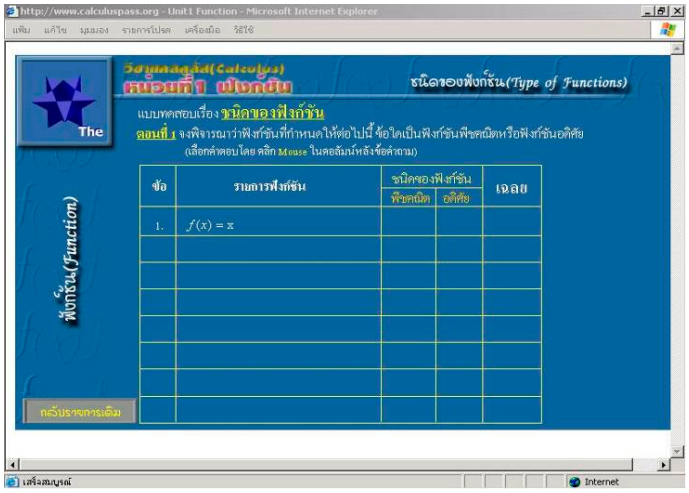
App. 10: Example in calculus multimedia



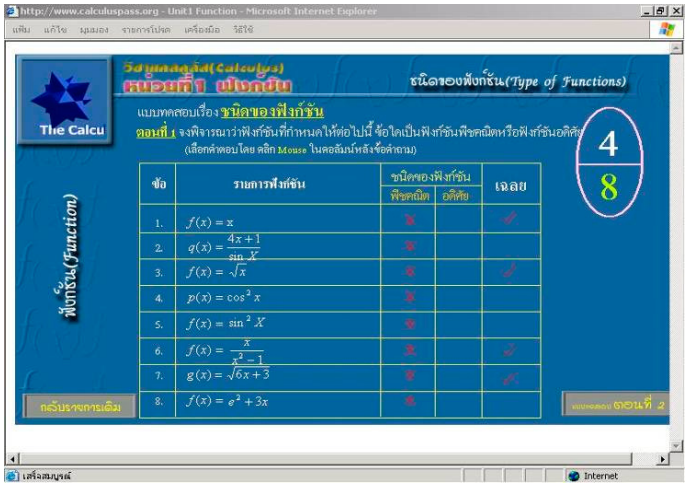
App. 11: Agent Newton responsible for explanation of definition



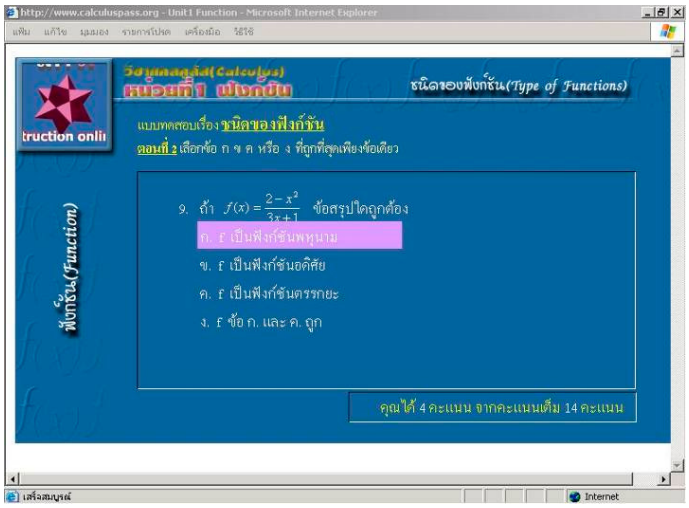
App. 12: Exercise as correct and incorrect systems



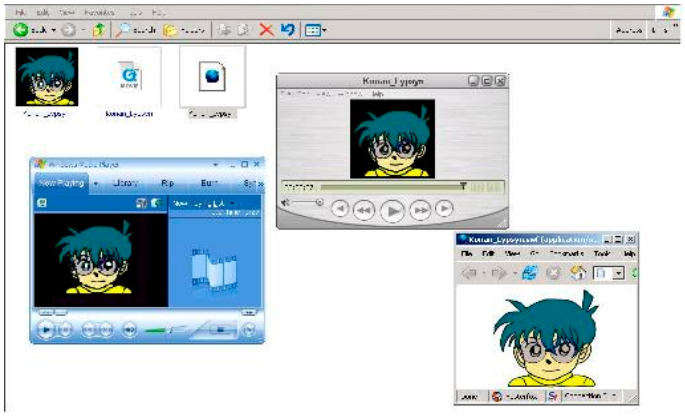
App. 13: Scoring system in calculus multimedia correspondent



App. 14: Exercise as multiple choices in calculus multimedia

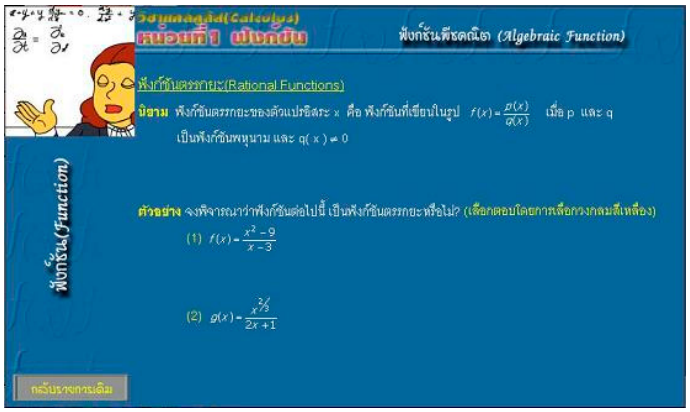


App. 15: Comparing steps of *.avi, *.mov, and *.swf file types

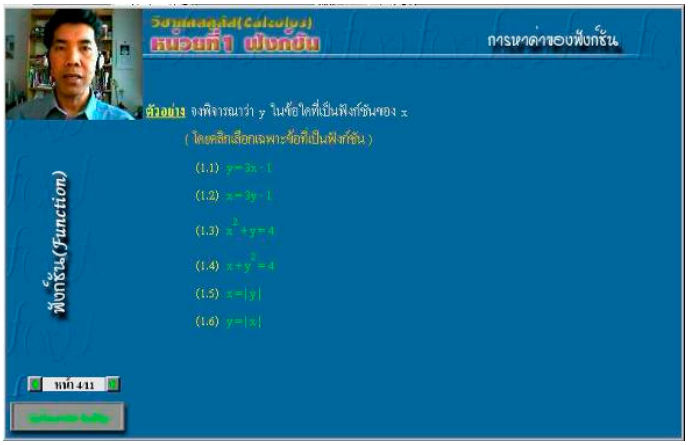


App. 16: Agent Conan responsible for an expert

App. 17: Agent Newton responsible for a tutor



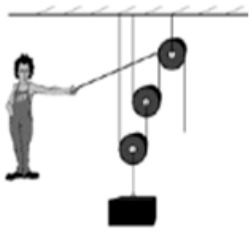
App. 18: Human -video “Abhinan Agent” responsible for tutor

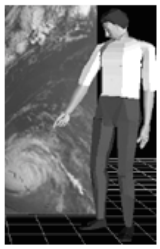
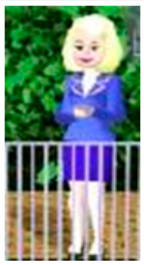


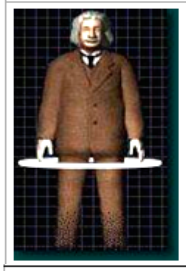
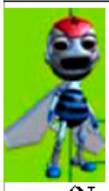
App. 19: The human Agent video-clips

App. 20: Collection of pedagogical Agents

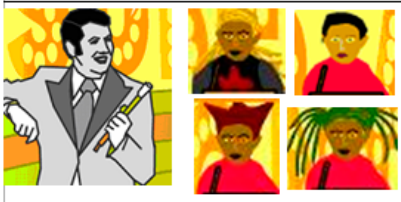
Character of Pedagogical Agent	Responsibility	Developer	Reference
 1 2 3	1=Expert 2=Motivator 3=Mentor	Pedagogical Agent learning system Research lab	Ryu and Baylor, 2005
 CFC CFR AFR AFC CMR CMC AMR AMC	1st letter: C=Caucasian, A=African 2nd letter: F=Female, M=Male 3th letter: C=Cartoon, R=Real	Pedagogical Agent learning system Research lab	Ryu and Baylor, 2005

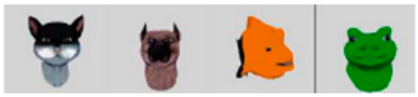
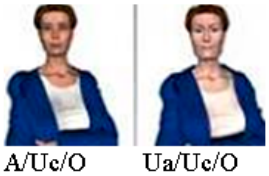
Character of Pedagogical Agent	Responsibility	Developer	Reference
 Steve	Training expert: demonstrate, answer question, watch, advice	Center for advanced research in technology for education, USC	Johnson et al. (2000), Starter (2000), CARTE (2006)
 Adele	Educator: advice, coaches, and tests	Center for advanced research in technology for education, USC	Johnson et al. (2000), Starter (2000)
 Herman the bug	Advisor	Intellimedia project, North Carolina State University	Johnson et al. (2000), Elliott et al. (1999), Starter (2000)
 Cosmo	Advisor	Intellimedia project at North Carolina State Univer-sity	Johnson et al. (2000), Starter (2000)
 WhizLow	Guidance	ND	Johnson et al. (2000)
 PPP Persona	Instructor	ND	Johnson et al. (2000) Mulken et al. (2002)

Character of Pedagogical Agent	Responsibility	Developer	Reference
 Jack	Weather presenter	ND	Johnson et al. (2000)
 Gandalf	Speaking conversa-tion	ND	Johnson et al. (2000)
 Tatyana and students	Teacher and students in learning action	ND	Morozov et al. (2004)
 Petya	Student	ND	Morozov et al. (2004)
 Masha	Student	ND	Morozov et al. (2004)
 Tatyana Mikhailovna	Teacher	ND	Morozov et al. (2004)
 Peddy	Multi-purpose Agents	Microsoft	Stater (2000)

Character of Pedagogical Agent	Responsibility	Developer	Reference
 Limsi	2D cartoon-like	ND	Jean-Claude et al. (2006)
 (Name is not detected)	The Agent with gestures	ND	Craig et al. (2002)
 MACK	Conversational Agents: kiosk	MIT media lab	Stocky and Cassell (2002)
 Einstein	Alife-personal tutor	ND	Stater (2000)
  (Name is not detected)	Supporter	ND	Sing et al. (2005)
 Nina Geek	Nina=non-stereotypical Geek=stereotypical	Pedagogical Agent learning system Re-search lab	Baylor (2005)
 ExCF ExAF ExCF ExAF	Ex=Expert Mo=Motivators C=CaucasianA=Afri	Pedagogical Agent learning system Re-search lab	Baylor (2005)

Character of Pedagogical Agent	Responsibility	Developer	Reference
 ExCM ExAM MoCM MoAM			
 1 2 3	1 & 2=Realistic human face 3=Line-draw face 4 & 5=Caricature human face 6=Caricature dog face 7=Invisible man (without face)	ND	Koda and Maes (1996)
 4 5 6 (Name is not detected)			
 (Name is not detected)	Ten expressions of the female caricature face	ND	Koda and Maes (1996)
 Alex Penelope	Assistance	ND	Veletsianos et al. (2006)
 Merlin	Assistance	Microsoft	Baylor (2002)
 Louisa	Advisor	ND	Cooper and Brna (2001)

Character of Pedagogical Agent	Responsibility	Developer	Reference
  Marco Marco is talking	Auto tutor	The University of Memphis	Miller (2006)
 SmartEgg	Animated pedagogical Agent	ND	Mitrovic (2000)
 Betty	Teachable Agents	ND	Blair et al. (2006)
 (Name is not detected)	Homework practice; game show	ND	Blair et al. (2006)
 Betty	Teachable Agents in educational game	ND	Blair et al. (2006)
 Victor	Tutoring and reflection	Project management knowledge learning environment	PMK Learning environment (2006)
 (Name is not detected)	Human-computer-interaction	Center for research of innovative technology for learning	Ray (2005)
 (Name is not detected)	ND	German research center for Artificial intelligence	Levis (2003)

Character of Pedagogical Agent	Responsibility	Developer	Reference
  	Non-human-like Agents - Colour - Shape - Aliveness - Complex	Pedagogical Agent learning system Research lab	Baylor (2005)
 Rea	Real-time, life-size conversation	MIT media lab	Bickmore and Cassell (2001)
 (Name is not detected)	Generic Agent	Pedagogical Agent learning system Research lab	Baylor et al. (2004f)
 A/C/Y Ua/C/Y  A/C/O Ua/C/O  A/Uc/Y/ Ua/Uc/Y  A/Uc/O Ua/Uc/O	Gender: male, female Attractiveness: attractive, unattractive Coolness: cool, uncool Age: younger ~25, Older ~45	Pedagogical Agent learning system Research lab	Baylor and Plant (2005)

Character of Pedagogical Agent	Responsibility	Developer	Reference
 A/C/Y Ua/C/Y			
 A/C/O Ua/C/O			
 A/Uc/Y Ua/Uc/Y			
 A/Uc/O Ua/Uc/O			
 (Name is not detected)	ND		Domagk et al. (2006)

App. 21: Questionnaire used in the preference test

No....

Questionnaire
Need assessment surveying
on Manga for Calculus multimedia

Gender..... Age.....

Please evaluate your preferences to Manga characters as a pedagogical agent in Calculus e-learning in the following order. Indicate it by checking the appropriate phrase.

For example:

Unwell known	X	2	3	4	5	Well known

Score		**1**	**2**	**3**	**4**	**5**
Preference level		**Very little**	**Little**	**Moderate**	**Much**	**Very much**
1. Character	cute					
	Prestigious					
2. Voice style	Calm					
	Amuse					
3. Age						
4. Movement						
5. Explanation						
6. Guidance						
7. Entertainment						

8. Manga necessity in Calculus e-learning

Yes ☐
No ☐

App. 22: A Preferences questionnaire of manga Agent characteristics

No…

Preference test on

Manga agent for Calculus multimedia

Gender…….. Age……

Please evaluate the pedagogical agent namely "**Conan**" from calculus e-learning in the following order. Indicate it by checking the appropriate phrase.

For example:

Well known	Very little	Little	Moderate	Much	Very much
	X				

A. Preference on Manga for Calculus e learning in external property

Preference level	Very little	little	moderate	much	Very much
Size					
Colour					
Friendly					
Character					
Voice					
Speaking					
Useful					

To be continue part B

B: Preference on Manga for calculus e learning in internal property

Preferences	very unsatisfied	Unsatisfied	Indifferent	satis-fied	Very satisfie
1. Conan presentation is easy to comprehend.					
2. Conan presentation is effective on solving the calculus problem.					
3. Conan presentation makes e learning more fun.					
4. Conan presentation is adequate for understanding in this lesson.					
5. Conan's characteristic help me more concentrate in elearning.					
6. Conan's voice help me more concentrate in e learning.					
7. I would like to have Conan presentation for other lessons.					
8. I would like to have Conan presentation for other subjects.					

App. 23: Descriptive Statistics of Study II –DV: post-test

Treatment	Prior knowledge	Mean	Std. Deviation	N
without PA	low	4,80	1,576	20
	high	6,33	,816	6
	Total	5,15	1,567	26
with PA	low	5,60	1,682	15
	high	6,00	1,683	13
	Total	5,79	1,663	28
Total	low	5,14	1,648	35
	high	6,11	1,449	19
	Total	5,48	1,634	54

App. 24: Tests of Between-Subjects Effects of Study II

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	η^2
Corrected Model	17,348(a)	3	5,783	2,329	,086	,123
Intercept	1434,546	1	1434,546	577,825	,000	,920
treatment	,605	1	,605	,243	,624	,005
Prior-knowledge	10,375	1	10,375	4,179	,046	,077
interactions	3,565	1	3,565	1,436	,236	,028
Error	124,133	50	2,483			
Total	1764,000	54				
Corrected Total	141,481	53				

a R Squared = ,123 (Adjusted R Squared = ,070)

App. 25: The Calculus questions used in pre-test

1. Which one is y not a function of x?

a. $6x - y = 5$ b. $x^2 + 3x + y = 1$

c. $x - 2y + y^2 + 3 = 0$ d. $|x| - y + 2 = 0$

8. If $f(x) = 2 - 5x$ and $g(x) = x^2 + x - 1$ Which one is equal to $g(2) - f(-1)$?

a. 2 b. -2

c. 12 d. -12

9. If $f(x) = \begin{cases} \end{cases}$ Which one is equal to f(5) ?

a. 17 b. 6

c. 29 d. 21

10. If $f(x) = x^2 = x + 1$ and $g(x) = 6x - 5$ Which one is equal to g(f(-1)) ?

a. 13 b. 1

c. 2 d. -5

11. If $f(x) = x+5$ and $g(x) = 2x-3$ Which one is equal to (fog)(x)?

a. 3x+2 b. 2x+7

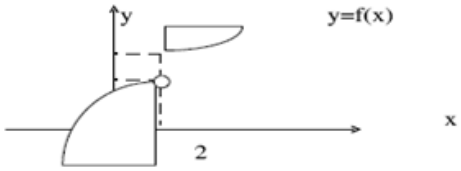
c. x-8 d. 2x+2

12. If $g(x) = \frac{x+2}{x-4}$ What is domain of g equal to ?

a. $\{x / x \neq 4\}$ b. $\{x / x \neq 4\}$

c. $\{x / x \neq -2\}$ d. $\{x / x \neq 2\}$

7. Look at a graph of function as follow. Which one is the range of f ?



a. $\{y / y < 3 \text{ or } y \geq 5\}$ b. $\{y / y > 3 \text{ or } y \leq 5\}$

c. $\{y / y \leq 3 \text{ or } y > 5\}$ d. $\{y / y < 3 \text{ or } y > 5\}$

8. Which one is not transcendental function?

a. $f(\theta) \tan \theta$ b. $g(x) = e^{2x}$

c. $h(x) = 4/x$ d. $k(t) = \ln t$

App. 26: The Calculus questions used in post-test

1. Which one is y not a function of x?

a. $6x - y = 5$ b. $x^2 + 3x + y = 1$

c. $x - 2y + y^2 + 3 = 0$ d. $|x| - y + 2 = 0$

2. If $f(x) = 2 - 5x$ and $g(x) = x^2 + x - 1$ Which one is equal to $g(2) - f(-1)$?

a. 2 b. -2

c. 12 d. -12

3. If $f(x) = \{$ Which one is equal to $f(5)$?

a. 17 b. 6

c. 29 d. 21

4. If $f(x) = x^2 = x + 1$ and $g(x) = 6x - 5$ Which one is equal to $g(f(-1))$?

a. 13 b. 1

c. 2 d. -5

5. If $f(x) = x+5$ and $g(x) = 2x-3$ Which one is equal to $(fog)(x)$?

a. $3x+2$ b. $2x+7$

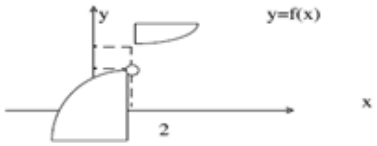
c. $x-8$ d. $2x+2$

6. If $g(x) \frac{x+2}{x-4}$ What is domain of g equal to?

a. $\{x / x \neq 4\}$ b. $\{x / x \neq 4\}$

• c. $\{x / x \neq -2\}$ d. $\{x / x \neq 2\}$

7. Look at a graph of function as follow. Which one is the range of f ?



a. $\{y / y < 3 \text{ or } y \geq 5\}$ b. $\{y / y > 3 \text{ or } y \leq 5\}$

c. $\{y / y \leq 3 \text{ or } y > 5\}$ d. $\{y / y < 3 \text{ or } y > 5\}$

8. Which one is not transcendental function?

a. $f(\theta) \tan \theta$ *b.* $g(x) = e^{2x}$

c. $h(x) = 4/x$ d. $k(t) = \ln t$

App. 27: Results on external properties of manga agents

Source	Variable	Sum of Squares	df	Mean Square	F	Sig.	η^2
Characteristic	Size	1.144	1	1.144	2.789	0.098	0.030

	Colour	0.467	1	0.467	1.147	0.287	0.013
	Friendly	1.187	1	1.187	1.811	0.182	0.020
	Interesting	0.742	1	0.742	1.452	0.231	0.016
	Speaking	1.651	1	1.651	3.394	0.069	0.037
	Voice	0.111	1	0.111	0.213	0.646	0.002
	Usefulness	0.400	1	0.400	0.550	0.460	0.006
Voice	Size	0.365	1	0.365	0.891	0.348	0.010
	Colour	0.233	1	0.233	0.572	0.451	0.006
	Friendly	0.908	1	0.908	1.386	0.242	0.015
	Interesting	6.893	1	6.893	13.490	0.000	0.132
	Speaking	0.078	1	0.078	0.160	0.690	0.002
	Voice	0.086	1	0.086	0.165	0.686	0.002
	Usefulness	5.834	1	5.834	8.035	0.006	0.083
Interaction	Size	0.875	1	0.875	2.135	0.148	0.023
	Colour	0.796	1	0.796	1.957	0.165	0.022
	Friendly	0.435	1	0.435	0.664	0.417	0.007
	Interesting	0.004	1	0.004	0.007	0.934	0.000
	Speaking	1.304	1	1.304	2.679	0.105	0.029
	Voice	0.447	1	0.447	0.854	0.358	0.010
	Usefulness	0.083	1	0.083	0.115	0.736	0.001
Error	Size	36.491	89	0.410			
	Colour	36.201	89	0.407			
	Friendly	58.307	89	0.655			
	Interesting	45.478	89	0.511			
	Speaking	43.304	89	0.487			
	Voice	46.567	89	0.523			
	Usefulness	64.621	89	0.726			

Significantly confidence interval=.95, * Significant $p \leq 0.05$, ns=non significant $p > 0.05$

App. 28: Results on internal properties of manga agents

Source	Dependent variable	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Character	Easy to comprehend	0.085	1	0.085	0.117	0.733	0.001
	Help to solve Problem	0.231	1	0.231	0.364	0.548	0.004
	Make more funny	0.052	1	0.052	0.062	0.803	0.001
	Manga's quantity in lesson	0.133	1	0.133	0.178	0.674	0.002

	Manga help more concentrate	0.512	1	0.512	0.787	0.378	0.009
	Voice help more concentrate	0.005	1	0.005	0.006	0.936	0.000
	Need Manga in other lessons	4.258	1	4.258	6.739	0.011	0.070
	Need Manga in other subjects	2.438	1	2.438	2.534	0.115	0.028
Voice	Easy to comprehend	1.659	1	1.659	2.277	0.135	0.025
	Help to solve Problem	0.497	1	0.497	0.783	0.378	0.009
	Make more funny	0.212	1	0.212	0.255	0.615	0.003
	Manga's quantity in lesson	2.048	1	2.048	2.739	0.101	0.030
	Manga help more concentrate	3.589	1	3.589	5.513	0.021	0.058
	Voice help more concentrate	1.529	1	1.529	1.853	0.177	0.020
	Need Manga in other lessons	0.121	1	0.121	0.191	0.663	0.002
	Need Manga in other subjects	0.022	1	0.022	0.022	0.881	0.000
Interaction	Easy to comprehend	1.260	1	1.260	1.729	0.192	0.019
	Help to solve Problem	0.103	1	0.103	0.163	0.687	0.002
	Make more funny	0.294	1	0.294	0.354	0.553	0.004
	Manga's quantity in lesson	1.019	1	1.019	1.363	0.246	0.015
	Manga help more concentrate	0.029	1	0.029	0.045	0.832	0.001
	Voice help more concentrate	5.993	1	5.993	7.269	0.008	0.075
	Need Manga in other lessons	1.444	1	1.444	2.285	0.134	0.025
	Need Manga in other subjects	0.109	1	0.109	0.113	0.737	0.001
Error	Easy to comprehend	64.855	89	0.729			
	Help to solve Problem	56.466	89	0.634			
	Make more funny	73.890	89	0.830			
	Manga's quantity in lesson	66.550	89	0.748			
	Manga help more concentrate	57.944	89	0.651			
	Voice help more concentrate	73.441	89	0.825			
	Need Manga in other lessons	56.238	89	0.632			
	Need Manga in other subjects	85.643	89	0.962			

App. 29: Knowledge test results of Study II

	Value Label	N
treatment	without PA	26
	with PA	28
prior knowledge	low	35
	high	19

N= sample size

App. 30: Descriptive Statistics of Study II

treatment	prior knowledge	Mean	Std. Deviation	N
without Agent	low	4,80	1,576	20
	high	6,33	,816	6
	Total	5,15	1,567	26
With Agent	low	5,60	1,682	15
	high	6,00	1,683	13
	Total	5,79	1,663	28
Total	low	5,14	1,648	35
	high	6,11	1,449	19
	Total	5,48	1,634	54

App. 31: Results of Study III; Between-Subjects Factors

		Value Label	N
treatment	1	Conan calm	24
	2	Conan amuse	20
	3	Newton calm	22
	4	Newton amuse	23
medianpre	1	low prior	42
	2	high prior	47

App. 32:Descriptive Statistics of Study III; Dependent Variable: post-test

Conan calm	low prior	2,82	1,662	11
	high prior	5,77	1,363	13
Conan amuse	low prior	1,83	1,115	12
	high prior	5,75	1,669	8
Newton calm	low prior	3,44	2,297	9
	high prior	4,69	1,548	13
Newton amuse	low prior	2,70	1,636	10
	high prior	5,31	1,109	13
	Total	4,17	1,875	23
Total	low prior	2,64	1,722	42
	high prior	5,34	1,434	47
	Total	4,07	2,071	89

App. 33: Tests of Between-Subjects Effects of Study III

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	184,624(a)	7	26,375	11,071	,000	,489
Intercept	1409,040	1	1409,040	591,446	,000	,880
treatment	2,752	3	,917	,385	,764	,014
medianpre	155,155	1	155,155	65,126	,000	,446
treatment * medianpre	18,705	3	6,235	2,617	,057	,088
Error	192,971	81	2,382			
Total	1850,000	89				
Corrected Total	377,596	88				

a R Squared = ,489 (Adjusted R Squared = ,445)

App. 34: Knowledge Results of Study IV

		Value Label	N
type of Agents	1	Human Agent	59
	2	Manga Agent	62
Median of pretest	0	low prior	56
	1	high prior	65

App. 35: Descriptive Statistics - Dependent Variable: post-test

type of Agents	Median of pretest	Mean	Std. Deviation	N
Human Agent	low prior	5,21	1,663	28
	high prior	6,39	1,542	31
	Total	5,83	1,693	59
Manga Agent	low prior	6,21	,499	28
	high prior	6,35	1,012	34
	Total	6,29	,818	62
Total	low prior	5,71	1,317	56
	high prior	6,37	1,282	65
	Total	6,07	1,334	121

App. 36: Tests of Between-Subjects Effects - Dependent Variable: post-test

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	η^2
Corrected Model	26,923(a)	3	8,974	5,629	,001	,126
Intercept	4388,645	1	4388,645	2752,488	,000	,959

treatment	7,009	1	7,009	4,396	,038	,036
medianpre	12,922	1	12,922	8,105	,005	,065
treatment * medianpre	8,035	1	8,035	5,040	,027	,041
Error	186,548	117	1,594			
Total	4666,000	121				
Corrected Total	213,471	120				

a R Squared = ,126 (Adjusted R Squared = ,104)

App. 37: Preference Results of Study IV

		Value Label	N
treatment	1	Human video	55
	2	Manga Agent	61
sex	1	male	75
	2	female	41

App. 38: Descriptive Statistics of Study IV

	treatment	sex	Mean	Std. Deviation	N
Size	Human video	male	3,24	,625	21
		female	2,79	,479	34
		Total	2,96	,576	55
	Manga Agent	male	2,96	,672	54
		female	3,14	,378	7
		Total	2,98	,645	61
	Total	male	3,04	,667	75
		female	2,85	,478	41
		Total	2,97	,611	116
Colour	Human video	male	3,14	,655	21
		female	3,12	,769	34
		Total	3,13	,721	55
	Manga Agent	male	3,07	,843	54
		female	3,29	,951	7
		Total	3,10	,851	61
	Total	male	3,09	,791	75
		female	3,15	,792	41
		Total	3,11	,789	116
Friendly	Human video	male	3,33	,730	21
		female	3,29	,579	34
		Total	3,31	,635	55
	Manga Agent	male	3,15	,856	54

		female	3,14	,900	7
		Total	3,15	,853	61
	Total	male	3,20	,822	75
		female	3,27	,633	41
		Total	3,22	,759	116
Character	Human video	male	3,24	,625	21
		female	3,21	,770	34
		Total	3,22	,712	55
	Manga Agent	male	3,17	,771	54
		female	3,71	,756	7
		Total	3,23	,783	61
	Total	male	3,19	,730	75
		female	3,29	,782	41
		Total	3,22	,747	116
Voice	Human video	male	3,24	,831	21
		female	3,00	,853	34
		Total	3,09	,845	55
	Manga Agent	male	2,93	,866	54
		female	3,14	1,069	7
		Total	2,95	,884	61
	Total	male	3,01	,862	75
		female	3,02	,880	41
		Total	3,02	,865	116
Speaking	Human video	male	3,19	,814	21
		female	2,97	,797	34
		Total	3,05	,803	55
	Manga Agent	male	2,93	,887	54
		female	3,43	,976	7
		Total	2,98	,904	61
	Total	male	3,00	,870	75
		female	3,05	,835	41
		Total	3,02	,854	116
Usefull	Human video	male	3,62	,973	21
		female	3,50	,663	34
		Total	3,55	,789	55
	Manga Agent	male	3,74	,805	54
		female	3,86	,900	7
		Total	3,75	,809	61
	Total	male	3,71	,851	75
		female	3,56	,709	41
		Total	3,66	,803	116

App. 39: Between-Subjects Effects of agents appearance on Study IV

Source	Dependent	Type III Sum of	df	Mean Square	F	Sig.	η^2

	Variable	Squares					
Corrected Model	Size	2,771(a)	3	,924	2,577	,057	,065
	Colour	,310(b)	3	,103	,162	,921	,004
	Friendly	,775(c)	3	,258	,442	,723	,012
	Character	1,875(d)	3	,625	1,124	,343	,029
	Voice	1,595(e)	3	,532	,706	,550	,019
	Speaking	2,339(f)	3	,780	1,070	,365	,028
	Usefull	1,527(g)	3	,509	,784	,505	,021
Intercept	Size	617,986	1	617,986	1723,835	,000	,939
	Colour	668,068	1	668,068	1050,405	,000	,904
	Friendly	700,008	1	700,008	1198,838	,000	,915
	Character	744,752	1	744,752	1338,947	,000	,923
	Voice	635,298	1	635,298	843,346	,000	,883
	Speaking	657,026	1	657,026	901,506	,000	,889
	Usefull	908,482	1	908,482	1399,975	,000	,926
treatment	Size	,023	1	,023	,063	,802	,001
	Colour	,041	1	,041	,065	,799	,001
	Friendly	,475	1	,475	,813	,369	,007
	Character	,801	1	,801	1,440	,233	,013
	Voice	,120	1	,120	,160	,690	,001
	Speaking	,157	1	,157	,215	,644	,002
	Usefull	,962	1	,962	1,482	,226	,013
sex	Size	,293	1	,293	,816	,368	,007
	Colour	,146	1	,146	,229	,633	,002
	Friendly	,008	1	,008	,014	,905	,000
	Character	1,114	1	1,114	2,003	,160	,018
	Voice	,002	1	,002	,002	,960	,000
	Speaking	,335	1	,335	,460	,499	,004
	Usefull	2,94E-005	1	2,94E-005	,000	,995	,000
treatment * sex	Size	1,633	1	1,633	4,554	,035	,039
	Colour	,235	1	,235	,370	,544	,003
	Friendly	,005	1	,005	,008	,928	,000
	Character	1,410	1	1,410	2,535	,114	,022
	Voice	,868	1	,868	1,153	,285	,010
	Speaking	2,190	1	2,190	3,005	,086	,026
	Usefull	,233	1	,233	,358	,551	,003
Error	Size	40,151	112	,358			
	Colour	71,233	112	,636			
	Friendly	65,397	112	,584			
	Character	62,297	112	,556			
	Voice	84,370	112	,753			
	Speaking	81,627	112	,729			
	Usefull	72,680	112	,649			
Total	Size	1069,000	116				

	Colour	1195,000	116				
	Friendly	1272,000	116				
	Character	1270,000	116				
	Voice	1142,000	116				
	Speaking	1140,000	116				
	Usefull	1624,000	116				
Corrected Total	Size	42,922	115				
	Colour	71,543	115				
	Friendly	66,172	115				
	Character	64,172	115				
	Voice	85,966	115				
	Speaking	83,966	115				
	Usefull	74,207	115				

a R Squared = ,065 (Adjusted R Squared = ,040)

b R Squared = ,004 (Adjusted R Squared = -,022)

c R Squared = ,012 (Adjusted R Squared = -,015)

d R Squared = ,029 (Adjusted R Squared = ,003)

e R Squared = ,019 (Adjusted R Squared = -,008)

f R Squared = ,028 (Adjusted R Squared = ,002)

g R Squared = ,021 (Adjusted R Squared = -,006)

App. 40:Manga performance of Study IV

		Value Label	N
treatment	1	Human video	55
	2	Manga Agent	61
sex	1	male	75
	2	female	41

App. 41: Descriptive Statistics of performance of Study IV

	treatment	sex	Mean	Std. Deviation	N
Comprehend	Human video	male	3,24	,625	21
		female	2,91	,668	34
		Total	3,04	,666	55
	Manga Agent	male	3,19	,754	54

		female	3,14	,690	7
		Total	3,18	,742	61
	Total	male	3,20	,717	75
		female	2,95	,669	41
		Total	3,11	,707	116
Solving	Human video	male	3,00	,548	21
		female	2,85	,657	34
		Total	2,91	,617	55
	Manga Agent	male	3,15	,810	54
		female	3,29	,756	7
		Total	3,16	,800	61
	Total	male	3,11	,746	75
		female	2,93	,685	41
		Total	3,04	,727	116
Funny	Human video	male	3,19	,814	21
		female	2,88	,729	34
		Total	3,00	,770	55
	Manga Agent	male	3,07	,949	54
		female	3,29	,951	7
		Total	3,10	,943	61
	Total	male	3,11	,909	75
		female	2,95	,773	41
		Total	3,05	,863	116
Amount	Human video	male	3,00	,632	21
		female	2,94	,736	34
		Total	2,96	,693	55
	Manga Agent	male	2,83	,694	54
		female	3,00	,816	7
		Total	2,85	,703	61
	Total	male	2,88	,677	75

		female	2,95	,740	41
		Total	2,91	,698	116
Charhelp	Human video	male	3,10	,625	21
		female	2,76	,781	34
		Total	2,89	,737	55
	Manga Agent	male	2,94	,998	54
		female	3,43	,787	7
		Total	3,00	,983	61
	Total	male	2,99	,908	75
		female	2,88	,812	41
		Total	2,95	,873	116
Voicehelp	Human video	male	3,19	,602	21
		female	2,68	,768	34
		Total	2,87	,747	55
	Manga Agent	male	2,87	,933	54
		female	3,00	,816	7
		Total	2,89	,915	61
	Total	male	2,96	,861	75
		female	2,73	,775	41
		Total	2,88	,836	116
Topics	Human video	male	3,48	,750	21
		female	3,26	,931	34
		Total	3,35	,865	55
	Manga Agent	male	3,35	,955	54
		female	3,14	,690	7
		Total	3,33	,926	61
	Total	male	3,39	,899	75
		female	3,24	,888	41
		Total	3,34	,894	116
Subject	Human video	male	3,62	,805	21

		female	3,29	,970	34
		Total	3,42	,917	55
	Manga Agent	male	3,39	,979	54
		female	3,29	,756	7
		Total	3,38	,952	61
	Total	male	3,45	,934	75
		female	3,29	,929	41
		Total	3,40	,931	116

App. 42: Performance Results of Study IV

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	η^2
Corrected Model	Comprehend	1,993(a)	3	,664	1,339	,265	,035
	Solving	2,276(b)	3	,759	1,453	,231	,037
	Funny	1,790(c)	3	,597	,796	,498	,021
	Amount	,575(d)	3	,192	,387	,762	,010
	Charhelp	3,215(e)	3	1,072	1,421	,240	,037
	Voicehelp	3,538(f)	3	1,179	1,721	,167	,044
	Topics	,860(g)	3	,287	,353	,787	,009
	Subject	1,486(h)	3	,495	,564	,640	,015
Intercept	Comprehend	653,078	1	653,078	1316,735	,000	,922
	Solving	633,228	1	633,228	1212,165	,000	,915
	Funny	648,346	1	648,346	865,494	,000	,885
	Amount	581,524	1	581,524	1176,019	,000	,913
	Charhelp	627,690	1	627,690	832,216	,000	,881
	Voicehelp	577,856	1	577,856	843,016	,000	,883
	Topics	734,801	1	734,801	904,095	,000	,890
	Subject	774,423	1	774,423	882,595	,000	,887
treatment	Comprehend	,133	1	,133	,269	,605	,002
	Solving	1,416	1	1,416	2,710	,103	,024
	Funny	,345	1	,345	,461	,499	,004

	Amount	,049	1	,049	,099	,754	,001
	Charhelp	1,104	1	1,104	1,464	,229	,013
	Voicehelp	4,92E-005	1	4,92E-005	,000	,993	,000
	Topics	,254	1	,254	,313	,577	,003
	Subject	,239	1	,239	,272	,603	,002
sex	Comprehend	,570	1	,570	1,149	,286	,010
	Solving	,000	1	,000	,001	,979	,000
	Funny	,039	1	,039	,052	,820	,000
	Amount	,049	1	,049	,099	,754	,001
	Charhelp	,099	1	,099	,131	,718	,001
	Voicehelp	,620	1	,620	,904	,344	,008
	Topics	,742	1	,742	,912	,342	,008
	Subject	,769	1	,769	,876	,351	,008
treatment * sex	Comprehend	,338	1	,338	,682	,411	,006
	Solving	,340	1	,340	,650	,422	,006
	Funny	1,133	1	1,133	1,513	,221	,013
	Amount	,213	1	,213	,431	,513	,004
	Charhelp	2,784	1	2,784	3,691	,057	,032
	Voicehelp	1,738	1	1,738	2,535	,114	,022
	Topics	2,60E-005	1	2,60E-005	,000	,995	,000
	Subject	,206	1	,206	,235	,629	,002
Error	Comprehend	55,550	112	,496			
	Solving	58,508	112	,522			
	Funny	83,900	112	,749			
	Amount	55,382	112	,494			
	Charhelp	84,475	112	,754			
	Voicehelp	76,772	112	,685			
	Topics	91,028	112	,813			
	Subject	98,273	112	,877			
Total	Comprehend	1181,000	116				

	Solving	1135,000	116				
	Funny	1166,000	116				
	Amount	1035,000	116				
	Charhelp	1096,000	116				
	Voicehelp	1042,000	116				
	Topics	1383,000	116				
	Subject	1438,000	116				
Corrected Total	Comprehend	57,543	115				
	Solving	60,784	115				
	Funny	85,690	115				
	Amount	55,957	115				
	Charhelp	87,690	115				
	Voicehelp	80,310	115				
	Topics	91,888	115				
	Subject	99,759	115				

a R Squared = ,035 (Adjusted R Squared = ,009)

b R Squared = ,037 (Adjusted R Squared = ,012)

c R Squared = ,021 (Adjusted R Squared = -,005)

d R Squared = ,010 (Adjusted R Squared = -,016)

e R Squared = ,037 (Adjusted R Squared = ,011)

f R Squared = ,044 (Adjusted R Squared = ,018)

g R Squared = ,009 (Adjusted R Squared = -,017)

h R Squared = ,015 (Adjusted R Squared = -,011)

Curriculum Vitae

04/1970-03/1973	Primary school, Tha-idt school, Uttaradit, Thailand
04/1973-03/1978	Secondary school, Chonrat-amrung school, Chonburi, Thailand
05/1978-04/1980	Certificate, Vocational Education in Agriculture, King-Mongkut's Institute of Technology, Thailand
05/1980-03/1982	Diploma, Farm Mechanic, Agricultural Engineering Training Center, Patoomthani, Thailand
06/1982-06/1984	Bachelor degree (BSc., Agriculture Education), Institute of Technology and Vocational Education, Thailand
1985-Present	Lecturer, Department of Mechanics, Rajamangala Universty of Technology Lanna, Lampang, Thailand
03/1991-11/1991	Training in Agricultural Mechanization, Tsukubu International Agricutural Training Center, Japan. Sponsored by Japan International Corporation Agency (JICA)
05/1997-07/2001	Master degree (M.Ed.., Educational Technology), Chiang mai University, Thailand
10/2003 - 02/2009	PhD. program, Faculty of Education, University of Erfurt, Erfurt, Germany

Ehrenwörtlichen Erklärung

„Ich erkläre hiermit ehrenwörtlich, dass ich die vorliegende Arbeit ohne unzulässige Hilfe Dritter und ohne Benutzung anderer als der angegebenen Hilfsmittel angefertigt habe; die aus fremden Quellen direkt oder indirekt übernommenen Gedanken sind als solche kenntlich gemacht. Bei der Auswahl und Auswertung des Materials sowie bei der Herstellung des

Manuskripts habe ich Unterstützungsleistung von folgenden Personen erhalten:

1. Prof. Dr Helmt Niegemann

2. Dr. Steffi Domagk

3. Frauke Kämmerer, M.A.

4. Antje Schatta, M.A.

5. Lisa Niegemann, M.A.

Weitere Personen waren an der geistigen Herstellung der vorliegenden Arbeit nicht beteiligt. Insbesondere habe ich nicht die Hilfe eines Promotionsberaters in Anspruch genommen. Dritte haben von mir weder unmittelbar noch mittelbar geldwerte Leistungen für Arbeiten erhalten, die im Zusammenhang mit dem Inhalt der vorgelegten Dissertation stehen.

Die Arbeit oder Teile davon wurden bisher weder im Inland noch im Ausland in gleicher oder ähnlicher Form einer anderen Prüfungsbehörde als Dissertation vorgelegt. Ferner erkläre ich, dass ich nicht bereits eine gleichartige Doktorprüfung an einer Hochschule endgültig nicht bestanden habe.“

Aphinan Jitjaroen

19.03.2009/ Erfurt