

**MOTIVATION, USABILITY AND THEIR INTERRELATIONSHIPS  
IN A SELF-PACED ONLINE LEARNING ENVIRONMENT**

**Ying Hu**

Dissertation submitted to the  
Faculty of the Virginia Polytechnic Institute and State University  
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY  
IN  
INDUSTRIAL AND SYSTEMS ENGINEERING

Advisory Committee:

Tonya L. Smith-Jackson, Ph.D., Chair  
Brian M. Kleiner, Ph.D.  
Glenda R. Scales, Ph.D.  
Janis P. Terpenney, Ph.D.

August 29, 2008  
Blacksburg, Virginia

Keywords: motivation, usability, ARCS model, e-learning

© 2008, Ying Hu

# MOTIVATION, USABILITY AND THEIR INTERRELATIONSHIPS IN A SELF-PACED ONLINE LEARNING ENVIRONMENT

Ying Hu

## ABSTRACT

This study addressed how usability improvement and motivational design affect learners' motivation and learning performance in a self-paced, online learning environment. The study also investigated the interrelationships between commonly-used usability measures and the motivation measures based on Keller's ARCS model. A two-phase study approach was used. In Phase I, an existing self-paced, online safety training tutorial was used as the baseline. Two alternative designs were developed with improved usability and motivational design based on the ARCS model. In Phase II, the effects of the three interface designs were evaluated through a three-group, generalized randomized block covariate design experiment. A total of seventy-two college students (48 males and 24 females) participated in the usability testing and the online training session using one of the interface designs. Both quantitative and qualitative data were collected and analyzed.

Results suggested a significant interface design effect on learner motivation. Learners who used the interface design with both usability improvement and motivational design applied (the UM group) showed the highest level of motivation. In particular, the *attention* level of the learners in the UM group was significantly higher than the baseline group. Results also indicated motivation differences between genders. Females showed higher scores than males in overall motivation score and in each of the four subscales of *attention*, *relevance*, *confidence*, and *satisfaction*. No significant difference in learning performance was found among the three treatment groups using different interface designs. None of the usability or motivation measures was a significant predictor of learning performance.

Small to medium positive correlations were found between *usability satisfaction* and three motivation measures, i.e., *attention*, *relevance* and *satisfaction*. Content analysis identified a number of interface design components to be relevant to learners' motivation components: overall appearance, graphics/multimedia, text appearance, page layout, navigation, and paging/scrolling. Implications and design recommendations for online tutorial interface design were discussed. Additional discussion was provided regarding the online learning environment and the integration of usability, motivation, and instructional design and technology.

## DEDICATION

*This dissertation is dedicated to the memory of my Grandpa,*

*Who unconditionally loved me ever since I was born.*

*I wish you could stay a few more months to see all of my amazing accomplishments.*

*I wish I could hold your hands and tell you that I am going to be a PhD and a new mom.*

*I wish you could hold the little hands of your grand-grand kid,*

*Just like the way you did when I was a little girl.*

*I never got the chance to say good bye but never wanted to.*

*You are truly missed, Grandpa.*

*I love you!*

## ACKNOWLEDGEMENT

I am grateful to my beloved husband Wen, father of our unborn baby, who shared the journey with me for completing the Human Factors PhD program at Virginia Tech, who listened to and challenged my research ideas, and who did whatever he could to comfort me and reduce pressure on me during my pregnancy days. He is my partner in research and in life. Wen, I love you!

To my advisor, Dr. Tonya Smith-Jackson, I thank you for your guidance throughout the dissertation process. I am forever grateful for the encouragement and support that you never hesitated to give me, especially at the end of the dissertation work. Thank you for providing experiment facilities and arranging special phone advising slots for me when I am off-campus. You are the role-model of mine for being a positive, energetic and productive researcher. It is amazing that sometimes even a few word or symbols from your email could keep up my morale for completing my work.

I give my sincere appreciation to my committee members: Dr. Brian Kleiner, Dr. Glenda Scales, and Dr. Janis Terpenney. Each of you challenged my ideas, provided valuable input for this research, and always responded timely when I needed help. Thank Dr. Scales for the fresh perspectives of the qualitative research methods.

Special appreciation goes to Amber and other anonymous evaluators and coders who spent their valuable time evaluating the interface designs and read learner comments. Thanks Yu-Hsiu for helping me to build up the prototype homepage. The final study would not have been possible without them.

I would like to extend my appreciations to my families and friends for years of encouragement. I owe endless thankfulness to my parents in China who were determined to give their only daughter every opportunity to stretch her wings, including pursuing education far far away from them at the other side of the earth. Thanks PENG Cheng, my best friend from college, who kept email conversations with me daily from China and who brought me simple but valuable pleasures even in those hardest days of writing. Thanks LI Weihui, mother of a two-year-old and an unborn baby, who showed me how to balance the life of completing a PhD degree and being a new mother. Thanks Dingding for running all around the campus to get my final paperwork completed on time while I was off-campus. I am thankful to countless colleagues and friends in ACE lab and HFEE program for their concerns and friendship.

Thanks to Dr. Philip McGee for permission to use the training tutorials on [www.free-training.com](http://www.free-training.com) website and include screen shots of the website in this document.

Thanks to Dr. John Keller for providing the IMMS questionnaire to be used in this study.

Portions of this research were conducted while I was supported by the John Grado/Alexander E. Walter Fellowship from the Grado Department of Industrial and Systems Engineering (2007).

## TABLE OF CONTENTS

List of Figures .....	viii
List of Tables .....	ix
1 INTRODUCTION .....	1
1.1 Problem Statement .....	1
1.2 Research Objectives .....	6
1.3 Approach .....	6
2 LITERATURE REVIEW .....	8
2.1 Motivation and Learning .....	8
2.1.1 Motivation theories .....	8
2.1.2 The ARCS model .....	11
2.1.3 Motivation assessment .....	13
2.1.4 The role of motivation in online learning environments .....	16
Motivation vs. Achievements .....	16
Motivation vs. Attrition .....	17
Motivation vs. Other Learning Outcomes .....	18
Motivation, Self-efficacy and Self-regulated Learning .....	19
Motivation Factors .....	20
2.1.5 Summary .....	21
2.2 Usability of the Online Learning Environment .....	22
2.2.1 Overview of usability in e-learning .....	22
2.2.2 Challenges of usability evaluation in the e-learning context .....	23
2.2.3 Effects of interface design on learning .....	25
2.3 Usability and Motivation: The Road toward Integration .....	27
2.4 Summary .....	29
3 METHOD .....	31
3.1 Overview .....	31
3.2 Interface Design and Development .....	34
3.2.1 Safety training tutorial .....	34
3.2.2 Learner analysis .....	35
3.2.3 Improving usability .....	36
3.2.4 Motivational design .....	37
3.2.5 Validity check .....	39
3.3 Experiment .....	43
3.3.1 Experiment design, independent variables and dependent variables .....	43
3.3.2 Measurement of variables .....	45
Interface Design .....	45
Gender .....	45

Learner Motivation .....	45
Learner Course Motivation .....	46
Mental Effort.....	47
Learning Performance.....	47
Usability.....	49
3.3.3 Participants.....	50
3.3.4 Procedure .....	50
3.4 Qualitative method .....	51
3.4.1 Overview .....	51
3.4.2 Post-session questionnaire .....	52
3.4.3 The coding system .....	52
3.4.4 Coding process.....	53
4 RESULTS .....	55
4.1 The Learners: Pre-session Questionnaire .....	55
4.2 RQ1: How Do Designs Affect Learner Motivation?.....	56
4.2.1 H1a: Interface design effect on overall learner motivation .....	56
4.2.2 H1b: Learner motivation differences by interface design group .....	56
4.2.3 H2a: Interface design effects on the ARCS motivation components .....	57
4.2.4 Learner motivation differences by gender .....	58
4.2.5 H2b: Motivation components and tutorial design.....	59
4.2.6 Summary of RQ1 .....	63
4.3 RQ2: How Do Designs Affect Learning Performance?.....	63
4.3.1 H3a, H3b: Learning performance by interface design group .....	63
4.3.2 H4: Remembering and applying scores by interface design groups.....	64
4.3.3 Summary of RQ2 .....	65
4.4 RQ3: Usability Measures vs. Motivation Measures.....	65
4.4.1 H5a: Correlations between usability and motivation measures .....	65
4.4.2 H5b: Usability, motivation and tutorial design components .....	66
4.4.3 Summary of RQ3 .....	67
4.5 RQ4: Predicting Learning Performance .....	68
4.5.1 H6: Predicting learning performance.....	68
4.6 Other Results .....	68
4.6.1 Usability improvement.....	68
4.6.2 The learning environment .....	70
5 DISCUSSION .....	72
5.1 Overview .....	72
5.2 Online Learner Motivation.....	73
5.3 Interface Design vs. Learner Motivation.....	75
5.4 Interrelationships between Usability and Motivation .....	79
5.5 Learning Performance .....	81

5.6	Gender Difference .....	85
5.7	The Learning Environment .....	86
5.8	Motivation, Usability and Instructional Design and Technology .....	88
5.9	Design Recommendations and Implications .....	89
5.9.1	Focus on attention .....	89
5.9.2	Recommendations for interface design.....	92
5.10	Limitations.....	97
6	CONCLUSIONS.....	99
6.1	Usability, Motivation and Online Learning .....	99
6.2	Future Research.....	102
	REFERENCES .....	106
	APPENDICES .....	116
	Appendix A— IRB Approval.....	117
	Appendix B— Pilot Study Surveys .....	120
	Appendix C— Usability Evaluation Checklist.....	123
	Appendix D— Remembering Test .....	127
	Appendix E— Applying Test .....	129
	Appendix F— Benchmark Tasks of Usability Testing .....	132
	Appendix G— Participant Recruitment Flyer and Email.....	133
	Appendix H— Pre-session Questionnaire .....	134
	Appendix I— Informed Consent Form .....	136
	Appendix J— Post-session Questionnaire.....	139
	Appendix K— Permission Letter to Reprint Screen Shots .....	140
	Appendix L— Sample Screenshots of Interface B, U and UM.....	141

## LIST OF FIGURES

Figure 1.1: Four Types of Learning Interactions in the E-learning Context: learner-content, learner-instructor, learner-learner, and learner-interface interaction .....	4
Figure 3.1: Method Framework .....	32
Figure 3.2: Hazard Communication Course Menu Page .....	34
Figure 3.3: Learner Analysis.....	36
Figure 3.4: Motivational Design Steps .....	37
Figure 3.5: WebMAC Scores: Stimulating, Meaningful, Organized and Easy-to-use.....	41
Figure 3.6: WebMAC Scores: Expectancy-Value Grid.....	41
Figure 3.7: Usability Evaluation of Interface B, U and UM.....	42
Figure 4.1: Learner Demographics .....	55
Figure 4.2: Online Learning Experience.....	56
Figure 4.3: Mean IMMS Score By Group .....	57
Figure 4.4: IMMS Subscales by Gender.....	59
Figure 4.5: Group Means of Essay Question Score .....	64
Figure 4.6: Effectiveness, Efficiency, and CSUQ by Group .....	69
Figure 4.7: Where Would You Normally Do Online Learning? .....	70
Figure 4.8: What Would You Do Differently from the Lab Environment? .....	71

## LIST OF TABLES

Table 2.1: Definitions of Motivation in the Context of Learning.....	10
Table 2.2: Methods of Motivation Assessment .....	15
Table 2.3: ISO Definition of Usability .....	22
Table 2.4: Four Types of Interaction .....	25
Table 3.1: Research Questions and Hypotheses .....	33
Table 3.2: Motivational Design Matrix .....	38
Table 3.3: Description of Interface Designs .....	40
Table 3.4: Summary of Variables, Measurements and Data Analysis .....	44
Table 3.5: Usability Measures .....	49
Table 3.6: The Coding System.....	53
Table 4.1: Group Means of Attention, Relevance, Confidence and Satisfaction .....	57
Table 4.2: Post Hoc Test (Tukey HSD) on Attention.....	58
Table 4.3: Gender Differences on IMMS .....	59
Table 4.4: Code Frequencies of Tutorial Design Components vs. Motivation Components .	60
Table 4.5: Most Frequent Interface Design Sub-codes vs. Motivation Components .....	61
Table 4.6: Example Quotes of Learner Comments regarding Tutorial Design Components and Motivation Components.....	61
Table 4.7: Group Means of Learning Performance Scores.....	64
Table 4.8: Pearson’s Correlation Coefficients between Motivation and Usability Measures	65
Table 4.9: Shared Codes between Correlated Usability and Motivation Measures .....	66
Table 4.10: ANOVA Group Effects for Effectiveness, Efficiency and Satisfaction.....	69
Table 4.11: Post Hoc Test (Tukey HSD) on Effectiveness, Efficiency and Satisfaction .....	69
Table 5.1: Summary of Research Questions, Hypotheses, and Results.....	72
Table 5.2: Learner Comments of Motivational Design .....	77
Table 5.3: Applying Test Scores and Item Difficulty Index.....	83

Table 5.4: Recommended Attention Strategies for Interface Design ..... 91

Table 5.5: Recommendations for Interface Design of Online Self-paced Tutorials..... 93

# **1 INTRODUCTION**

## **1.1 Problem Statement**

The world of e-learning is growing at a tremendous pace. The 2006 survey of online learning of over 2,200 colleges and universities in the United States, shows that nearly 3.2 million students took one or more online courses in 2005, representing close to 17 percent of all higher education students (E. Allen & Seaman, 2006). The number of online students has shown an average of 20% growth annually since 2002, with the largest percentage increase in 2005 (an increase of 35% from 2004). Similar to its growth in academic programs, e-learning has become an increasingly important delivery format in workplace training. Survey data (ASTD, 2006; CLO, 2006) suggest that about 22%-32% of the normal learning content was delivered online. It is also predicted that e-learning would become the dominant form of training within organizations in the near future (Kim & Bonk, 2005).

The application of e-learning extends to a range of industries including information technology, financial services, education, manufacturing, government, consulting, military, and healthcare (Bonk, 2002). According to Bonk's survey, popular skills taught online include computer applications and software skills, technical skills, job-related skill development, communication skills, computer systems or programming skills, management or supervisory experience, personal growth, and customer service skills. In addition to these fields, e-learning has also been applied for training emergency response (Kincaid, Donovan, & Pettitt, 2003), road safety (Hogge & Sherlock, 2005), cockpit avionics (Sheller & Ruffner, 2003), office ergonomics (Rucker, 2003), hazard communication (Mills, 1999), and safety in construction (Johnson & Ruppe, 2002) and manufacturing (Duffy, 2000) industries.

With the dramatic growth of e-learning and its revolutionary impact on traditional classroom teaching, researchers have expressed concerns regarding learner experience and the quality of online learning (Ettinger, Holton, & Blass, 2006; Hamid, 2001; Sloman, 2002). How to improve learning and enhance learner experience becomes a central challenge. Among various efforts, two categories of research are of considerable interest: motivational design and usability engineering.

Motivation is vital for online learning. It is well-acknowledged that distance learners are likely to feel isolated and may slow down or even give up learning. One can easily blame the students for their lack of self-motivation, self-direction, persistence or commitment. However, the difficulties associated with the nature of online learning should not be underestimated. According to ASTD (2006), about 90% of online learning is self-paced, and requires a high degree of learner motivation (Horton, 2000). The high drop-out rate of online courses can also be considered as an indicator of motivation problems (Keller, 1999). Online instruction can encourage persistence and reduce attrition, to the extent that the design and implementation of the course recognize and tap into how individuals may want to learn (Martinez, 2003). Unfortunately, most online courses do not achieve this; and it has long been a challenge for researchers, designers, instructors and trainers to explore ways to design online courses that engage students, encourage persistence and reduce attrition.

Recent motivation research focuses on effective motivational designs and one of the most well-known models is Keller's ARCS model, acronym of *attention*, *relevance*, *confidence* and *satisfaction* (Keller, 1987a, 1987c). Many instructors find the ARCS model useful because it not only explains the motivation construct, but also provides a systematic motivational design process and series of motivational tactics (Keller & Burkman, 1993; Keller & Suzuki, 1988). The ARCS model has been successfully applied through numerous studies in different e-learning settings, and in multiple countries and cultures (Astleitner & Hufnagl, 2003; Astleitner & Keller, 1995; Bohlin, Milheim, & Viechnicki, 1993; ChanLin, 1994; Chyung, 2000; Gabrielle, 2005; Keller, 1999; Keller & Kopp, 1987; Keller & Suzuki, 1988, 2004; Lim, 2004; Patronis, 2005; Perrin, 2005; Song & Keller, 2001; Visser, 1999; Zumbach & Reimann, 1999).

While many field studies reported positive experiences of applying ARCS-based motivational design to enhance students' motivation, the effects of motivational design received limited experimental support, especially in the relatively new context of computer-based learning or online learning. Only two experimental studies have been identified. One was Gabrielle's (2005) study in semester-long, technology-mediated undergraduate courses. The other was a three-group experiment on a short-term, computer-assisted instruction (CAI) program for tenth-grade students by Song and Keller (2001). In the relatively new field of

online learning, no experimental results are available and the specified design guidance is limited.

The other research category applies usability engineering to e-learning system design to help improve the online learning experience. In the context of e-learning, an interface is the electronic medium where learners interact with the instructional content and participate into learning activities. In online learning, such interface usually refers to the Web pages that display the instructional information and the organization of those pages. The design of interface in online learning becomes crucial since learner-interface interaction (Hillman, Willis & Gunawardena, 1994) links all other learning interactions together, i.e., learner-content interaction, learner-instructor interaction, and learner-learner interaction (Miltiadou & Savenye, 2003) (see Figure 1.1).

Developed since 1970s, usability has been recognized as an important attribute of interaction quality and an indispensable process in software development. In e-learning, usability techniques help create easy-to-use learning applications and has gained increasing attention in many contemporary e-learning designs (Bach & Lai, 2006; Cousineau, Franko, Ciccazzo, Goldstein, & Rosenthal, 2006; Nahm, 2005; Pavolka, Mount, Neymeyr, & Rhodes, 2005; Tao, Guo, & Lu, 2006). Notess (2001) introduced several commonly-used usability approaches and discussed their applicability to online learning systems, including usability testing, heuristic evaluations, design guidelines, cognitive walkthrough and participatory design. The importance of usability and its testing/evaluation process have also been discussed in several e-learning design guides and books (Boling & Frick, 1997; Dillon & Zhu, 1997; Feldstein & Neal, 2006; Zaharias, 2004).

It should be noted that an online learning system is not just a piece of software, and learning tasks are different from routine software user tasks. Researchers have expressed concerns that current usability practices may not be able to reflect all facets of users' learning experiences, and thus cannot meet the needs of instructional designers. As Lohr (2000) concluded after discussing the challenges of instructional interface design, the problem is not that designers don't have access to the design principles, but that there are too many of them and they are difficult to use. In designing an online learning system, one central concern is

the learner experience and the effectiveness of learning. While a few researchers argue that usability should be separated from learning outcome and instructional design (Dillon & Zhu, 1997), the majority agree that guidelines from pedagogy and instructional design should be integrated into usability study so that they can be effectively applied to the e-learning context (Feldstein, 2002; Nam, 2003; Squires & Preece, 1999; Zaharias, 2004).

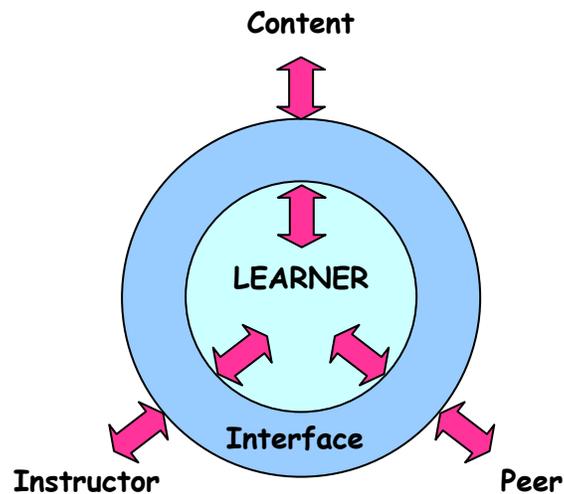


Figure 1.1: Four Types of Learning Interactions in the E-learning Context: learner-content, learner-instructor, learner-learner, and learner-interface interaction

It has also been suggested that when usability practitioners focus on macro tasks or learning goals instead of specific user tasks, the methodology of usability testing is able to answer some instructional questions such as whether the learners are able to achieve their learning objectives (Notess, 2001). Unfortunately, it appears that such potentials of usability testing have not been fully developed. The current usability practices in e-learning are still restricted to the traditional concept of usability in software use. In addition, some efforts (Bach & Lai, 2006; Parlangeli, Marchigiani, & Bagnara, 1999) to reveal the relationship between usability and learning turned out to be inconclusive. These studies seem to support the view that poor usability has some negative impact on a student's learning activity; but good usability does not necessarily lead to better learning. However, no significant result is available, so far, regarding the interrelationship between usability and learning outcome.

When considering the research on motivation and usability together, one can find some connections between the two. First, both motivational design and usability engineering have the primary goal of enhancing learners' experience and performance in the online teaching-learning environment. Second, both can evaluate the learner's experience and interactions with the learning interface. Usability usually focuses on *effectiveness*, *efficiency* and learner *satisfaction* (ISO 9241-11, 1998; ISO/IEC 25062, 2006); while learner motivation can be assessed through *attention*, *relevance*, *confidence* and *satisfaction* (Keller, 1987a, 1987c). Lastly, an underlying relationship seems to exist between the measurements of motivation and usability. Motivation theories suggest that a learner's motivation is influenced in part by experience. Any positive or negative experiences during the learning process serve as feedback of their original motives and may lead to a redirection of effort, a revised set of expectancies or a revision of values (Keller, 1979). In an online learning environment, a significant amount of such feedback comes from the learner's interaction with the interface. Since usability measurements are generally considered as indicators of the quality of these interactions, they are likely to be associated with learner motivation.

In fact, the idea of integrating usability and motivation research is not completely new. Some combined discussions of the two have been documented in literature. In his discussion of seven categories of motivation research issues in Web-based instruction, Song (2000) listed "Web feature and motivation" as one of them. Shilwant and Haggarty (2005) focused their discussion on the definition of usability in e-learning and suggested that "usability = usable + learnable + useful + motivating". From the perspective of usability studies, Liebel (2006) described an approach to focus on user motivation through usability testing with goals and tasks. In another study, Zaharias (2006) developed a usability questionnaire for e-learning, which included motivation as a new measure of usability.

However, none of the above studies provided decisive support to integrate motivation as a new measurement of usability, or established validated relationships between the two. In design and/or evaluation of an online learning environment, many questions remain unanswered. For example, "Will students be more motivated to learn when the usability of the interface is better?" "When a learner feels satisfied, is he/she motivated? Or vice versa?" "How do motivation and/or usability affect learning outcome, and to what extent?" "How can we make the interface design both motivational and usable?"

## 1.2 Research Objectives

The study had two major goals. The first goal was to test the effects of usability and motivational design on learners' motivation and learning performance in self-paced online learning environments. In this study, a self-paced online learning environment refers to the situation where learning is undertaken asynchronously over the Internet via posted course materials without an instructor; and the learner controls the pace or flow of the learning material. Results from this study filled the current lacunae in experimental data in the self-paced online learning environment, and demonstrated the benefits of usability engineering and the ARCS-based motivational design.

The second goal was to investigate the associations between usability measures and motivation measures. This was an exploratory approach and would lead to a better understanding of the interrelationship between usability and learner motivation in online learning environments; and provide a basis for future studies to formally develop design guidelines and/or usability metrics in the e-learning context.

This study posed four major research questions. Specifically, the study aimed to explore the following aspects in online self-paced learning environments:

**RQ1:** How do usability improvement and motivational design affect learners' motivation to learn?

**RQ2:** How do usability improvement and motivational design affect learning performance?

**RQ3:** What are the interrelationships among commonly-used usability measures and ARCS-based motivation measures?

**RQ4:** What are the relationships among interface usability, learner motivation, mental effort and learning performance?

## 1.3 Approach

In an endeavor to answer the above research questions, the study involved redesigning an online tutorial and evaluating the effects of usability improvement and motivational design on learners' motivation and learning performance using a three-group generalized

randomized block covariate design experiment. Both quantitative and qualitative data were collected.

The complete study consisted of two phases: I) Design and Development, and II) Experiment and Data Analysis.

In Phase I, an existing self-paced, online safety training tutorial was used as the baseline. The baseline tutorial was analyzed through a pilot study of learner analysis. Two alternative designs were then developed with improved usability and motivational strategies. The three interface designs were evaluated by expert evaluators for their usability and motivation levels before they were used in the experiment in the next phase.

In Phase II, the effects of the three designs on learner motivation and learning performance were tested through a three-group, generalized randomized block covariate design experiment. A total of 72 college students (48 males and 24 females) participated into the study. Participants completed a usability testing session and an online training session using one of the three interfaces developed in Phase I. Usability, learner motivation and learning performance data were collected. Qualitative data were collected through open-ended questions in the post-session questionnaire. Finally, statistical analysis tested the hypotheses with reference to each research question. Content analysis was used to identify and classify important motivational implications, which were triangulated with the quantitative data to enrich the answers to the research questions. Details of the research method are discussed in Chapter 3.

## **2 LITERATURE REVIEW**

### **2.1 Motivation and Learning**

#### *2.1.1 Motivation theories*

The study of motivation has a long history. In the field of learning and training, two branches of motivation theories exist. One branch originated from the studies of employee motivation in the workplace, and can be traced back to the movement of scientific management in the early 20th century. Many employee motivation theories attribute motivation to the satisfaction of needs, and a group of theories have been developed to explore different types of human needs. These theories are called content theory and examples include Maslow's (1954) Hierarchy of Needs, Alderfer's (1972) ERG Theory, Herzberg's (1966) Motivation- Hygiene Theory, etc. Another group of motivation theories, known as process theory, focuses on the rational process of motivation, and are characterized by Adams, S. J.'s (1963) Equity Theory, Vroom's (1964) Expectancy Theory and Goal theory (Locke, 1968; Locke & Lantham, 1990).

While the major concerns of most workplace motivation research are job performance and employee retention, all the aforementioned workplace motivation theories are considered important in the design of training systems, so that employees can be more motivated to learn during training (Goldstein & Ford, 2002). Current training motivation studies mainly focus on establishing models to predict training motivation or training effectiveness. The identified predictors of training motivation include both individual characteristics (e.g., locus-of-control, age, cognitive ability, self-efficacy, goal-orientation, perceived utility/importance, attitude, job involvement) and contextual variables (e.g., training climate, incentives, social support) (C. S. Clark, Dobbins, & Ladd, 1993; Colquitt, LePine, & Noe, 2000; Dawn, Dennis, Kacmar, Patrick, & Gary, 2000; Fecteau, Dobbins, Russell, Ladd, & Kudisch, 1995; Spiros, 2003; Tai, 2006; Tsai & Tai, 2003). Training motivation has also been found to be positively related to learning performance (Tai, 2006), time spent in learning (Kenneth, 2005), training retention (Dan & Amanuel, 2005), participation in future training and development (Phyllis, 2001), and self-reported training outcomes (Spiros, 2003).

The second branch of motivation theory is related to educational psychology research, with a focus on motivation and learning performance. Pintrich and Schunk (1996)

summarized a full range of theories stemming from early psychological and philosophic views of motivation such as *volition, will, instinct, psychical energy* (Freud), etc. Some theories that are still actively studied in literature that represent the primary areas of motivation research include attribution (Weiner, 1974), expectancy-value (Eccles, 1983; Eccles & Wigfield, 1995), self-efficacy (Bandura, 1977a), social learning theory (Bandura, 1977b; Rotter, 1954), locus of control (Rotter, 1966), intrinsic/extrinsic motivation, needs theory (Maslow, 1954), goal theory, self-regulation, and models of interest and affect. Note that none of these is a single theory but a label denoting a group of studies, and some overlaps occur among them. For example, the expectancy-value theory is a macro-level theory which aggregates groups of concepts and theories. Several formulations of this theoretical perspective exist (Eccles, 1983; Eccles & Wigfield, 1995; Porter & Lawler, 1968; Rotter, 1954; Vroom, 1964). The basic assumption of expectancy-value theory is that motivation is a function of expectancies and values. It suggests that people are motivated to achieve a goal if (1) the goal is perceived to have a positive value, and (2) they have a positive expectancy for success.

Despite these common theories, no uniform definition of motivation has been agreed in research, and this fact has been discussed by a number of researchers (Hodges, 2004; Pintrich & Schunk, 1996; Wlodkowski, 1999a). Beyond the very general concept that motivation explains why people think and behave as they do, no standard definition or explanation has been identified. Even the latest motivation textbooks and reviews (Schunk, Pintrich, & Meece, 2008; Steers, Mowday, & Shaprio, 2004) express different views on the mechanism of motivation and the role of different motivation theories. Wlodkowski (1999a) once commented that “any more specific discussion of the meaning of motivation brings in a cornucopia of differing assumptions and terminology” (p. 1).

This study aimed to focus on a discussion of the issues of motivation and usability in the online training and learning environment. In this topic, the concept of motivation to learn was explored. Some contemporary definitions of motivation considered relevant to learning are listed in Table 2.1. While the definitions are still worded in different ways, the following common points can be found:

1. Motivation is related to the goal.
2. Motivation initiates, mediates, and sustains people’s learning activities.

3. Motivation is manifested by effort, choice, and persistence.

In a sense, the existence of various motivation theories highlights the importance and attractiveness of motivation research and study. However, such a variety of theories and the lack of standards or agreements among theorists pose great challenges for empirical studies and practices. The different theoretical positions representing multiple threads of rationale can be daunting for any practitioner who expects a synthesized answer from all the theories. As a result, the application of motivation theories in teaching and learning has long relied on the instructor’s intuition, common sense, and trial and error. Such unorganized and fragmented approaches can hardly achieve consistent results in terms of motivating learners (Wlodkowski, 1999a); and motivation was considered as the neglected “heart” of instructional design and technology (Keller, 1979; Spitzer, 1996).

Table 2.1: Definitions of Motivation in the Context of Learning

G- goal, I- initiate, M- mediate, S- sustain, E- effort, C- choice, P- persistence

Author	Definition of Motivation	G	I	M	S	E	C	P
Wlodkowski (1982, p. 5)	Motivation is the word used to describe those processes that can (a) arouse and instigate behavior, (b) give direction or purpose to behavior, (c) continue to allow behavior to persist, and (d) lead to choosing or preferring a particular behavior.		x	x	x		x	x
Dweck & Elliott (1983)*	The factors and processes that initiate and direct the magnitude, persistence, and quality of goal-directed behaviors.	x	x	x	x			x
Keller (1983, p. 389)	Motivation, by definition, refers to the magnitude and direction of behavior. In other words, it refers to the choices people make as to what experiences or goals they will approach or avoid, and the degree of effort they will exert in that respect.	x	x	x	x	x	x	x
Keller (2007, p. 84)	Motivation refers to a person’s desire to pursue a goal or perform a task, which is manifested by choice of goals and effort (persistence plus vigor) in pursuing the goal.							
Pintrich & Schunk, (1996, p. 4)**	Motivation is the process whereby goal-directed activity is instigated and sustained.	x	x		x	x	x	x
“APA dictionary of psychology” (2006)***	Def #1: <i>The</i> impetus that gives purpose or direction to human or animal behavior and operates at a conscious or unconscious level.  Def #3: A person's willingness to exert physical or mental effort in pursuit of a goal or outcome.	x	x		x	x		

\*Cited by Paulsen & Feldman (1999).

\*\* In a later section of the same book, *choice of tasks, effort, and persistence* are listed as indexes of motivation.

\*\*\*There are 4 definitions listed. Def #2 is used in Conditioning. Def #4 is related to leadership.

### 2.1.2 *The ARCS model*

As discussed above, the variety of motivation theories greatly challenges practical work. Current motivation studies mostly use motivation models instead of directly applying a specific motivation theory. Two motivation models that apply motivation principles and theories to instructional design are available: Wlodkowski's (1985) Time Continuum Model and Keller's ARCS model (1983). The ARCS model is the most widely-used motivational model applied to the design and development of computer-assisted instruction programs (ChanLin, 1994; Keller, 1999; Keller & Suzuki, 1988; Song & Keller, 2001) and online learning environments (Astleitner & Hufnagl, 2003; Keller & Suzuki, 2004; Lim, 2004; Patronis, 2005; Perrin, 2005; Zumbach & Reimann, 1999). Applying the ARCS model has also been reported to reduce attrition rate in distance learning programs (Chyung, 2000; Visser, 1999) and improve learners' self-directed learning (Gabrielle, 2005). In this study, the ARCS model is used as the theoretical framework for motivational design of an online tutorial.

Keller's ARCS model (1987a, 1987c) has four major motivation categories: attention, relevance, confidence and satisfaction. The four categories are considered as a macro-level frame of the motivation concept, and are further broken down into sub-categories, providing guidance for more specific subsets of motivational tactics (Keller, 1987c). The ARCS model is grounded in a number of motivational theories and concepts (Keller, 1979, 1983), most notably expectancy-value theory, which suggests that motivation is a function of expectancies and values. Keller (1979) proposed the concept framework of motivation. Besides individual abilities, knowledge and skills, the framework suggests that learning performance is influenced by learner motivation. As a result from the value-expectancy dynamics, motivation directly influences effort and effort contributes to performance. Keller also states that "effort is usually measured in terms of persistence, or magnitude of action"; and "effort is a direct indicator of motivation, while performance is an indirect measure, because it is also influenced by other variables" (p. 27). This is consistent with the views of other researchers that the behavior indicators of motivation include choice of tasks, effort and persistence, while choice, effort and persistence raise task achievement (Pintrich & Schunk, 1996).

The ARCS model is also a systematic design process. The full-featured process consists of ten steps: 1. obtain course information; 2. obtain audience information; 3. analyze audience; 4. analyze existing materials; 5. list objectives and assessments; 6. list potential tactics; 7. select and design tactics; 8. integrate with instruction; 9. select and develop materials; and 10. evaluate and revise. The ten-step design process is a system design approach, where audience motivation analysis is emphasized, and the selection of tactics is based on the audience. The ARCS design process is also considered capable of being integrated with the instructional design process (Keller, 1987a; Main, 1993). To enable quick and efficient design, Keller (1999; 2007) also recommended a simplified approach known as the motivational design matrix. The matrix consists of the four categories of the ARCS model (attention, relevance, confidence and satisfaction) and can be used in both audience analysis and motivational tactics selection.

Under the general ARCS model, a series of motivation-stimulating strategies and tactics have been published. These strategies and tactics are based on both research studies and practitioners' experience, and provide valuable guidelines for designing instructor-led courses (Keller, 1987c), textual material (Keller & Kopp, 1987), and computer-based instruction (Keller & Suzuki, 1988). Keller and Burkman (1993) also suggested ten categories, and over 50 detailed motivation principles specifically for instructional message design. Note that while the ARCS model and the suggested tactics provide helpful frameworks to improve motivational design, they by themselves "do not tell how many or what types of strategies to use, or how to design them into the instruction" (Keller, 1987c, p. 7). These decisions are made by instructors, designers and practitioners based on the actual instructional situation.

As mentioned above, the ARCS model has been applied to a number of e-learning design and development applications. Among these applications, two experimental studies are of particular interest. In one study, Gabrielle (2005) designed and applied technology-mediated instructional strategies (TMIS) based on the ARCS model. Forty-eight undergraduate course sections were randomly divided into control (traditional teaching methods) and experimental groups (TMIS). In the experimental group, TMIS were delivered through Personal Digital Assistant (PDA), web, CD-ROM, and other technologies up to six times during semester. A total of 784 students participated in the study. Students' motivation, self-directed learning

and academic performance data were collected. Results suggested that students who accessed the TMIS had significantly higher levels of academic performance than control group students. Treatment group students also showed significant higher levels of motivation and proclivity to be self-directed learners than control group students.

The other study was conducted by Song and Keller (2001). The effects of a prototype of motivationally-adaptive computer-assisted instruction (CAI) were examined. Sixty tenth-grade students were randomly assigned to three versions of CAI: motivationally saturated, motivationally adaptive, or motivationally minimized. The motivation strategies used in the CAI were developed, based on the ARCS model. The average time used to study the CAI was about 30 minutes. Results suggested that the CAI treatments had an effect on components of motivation, specifically attention [ $F(2, 57) = 5.07, p < .01$ ] and relevance [ $F(2, 57) = 4.24, p < .05$ ]. Pair-wise comparison revealed that students in the motivationally adaptive CAI showed higher scores in both attention and relevance than the other two treatments. Students in the motivationally adaptive CAI also showed the highest achievement scores ( $p < .05$ ).

The findings from the above two studies suggest that systematically-designed motivational strategies can positively affect students' motivation and learning outcome. In the field of self-paced online learning, unfortunately, no experimental study has been conducted to validate such effects. One major goal of this study was to validate such effects of motivational design on learners' motivation and learning performance in a self-paced online learning environment.

### *2.1.3 Motivation assessment*

As stated above, this study aimed to test the effects of motivational design on learners' motivation and learning performance, which requires a comprehensive but practical way to assess learners' motivation. Assessing motivation has been an important topic for researchers and practitioners to enable them to understand the operation of motivational processes and to find ways to optimize learner motivation. Pintrich and Schunk (1996) summarized three types of approaches to assess motivation: direct observations, ratings by others and self-reports.

Direct observations refer to behavioral instances of motivation indicators. As discussed in Section 2.1.1, most researchers agree that the presence of motivation can be inferred from three behavioral indicators: choice of tasks, effort, and persistence. It is acknowledged that the selection of a task under free-choice conditions is indicative of motivation to perform the task. In addition, high effort, especially on difficult tasks, indicates motivation. Lastly, persisting at work for a longer time, especially when one encounters obstacles, is associated with higher motivation. Direct observations require little inference on the part of observers, and thus can provide a relatively objective report of motivation. On the other hand, direct observations may be superficial as they focus only on overt actions. For example, some learners show similar level of effort, but their reasons for trying hard may differ greatly. These reasons represent important cognitive and affective processes that motivation researchers are interested in.

Another approach to assess motivation is to ask observers to provide judgment ratings on learners' motivation based on various characteristics indicating motivation. With observers' inference, such ratings often attempt to capture underlying motivational processes that are not attainable through direct observations. They are considered to be more objective than self-reports. At the same time, ratings by others can also give rise to observers' biases due to the selective memory of learners' behavior. Sometimes it may be difficult to judge learners' levels of cognitive engagement or interest in learning.

Self-reports collect data by requesting learners to make judgments and statements about themselves, through questionnaires, interviews, stimulated recalls, think-alouds, and dialogues. Self-reports are typically easy to administer and are widely used. Similar to all other self-report measurements, some concerns arise regarding the accuracy of self-reported information compared to actual behavior, social desirability and the capability of young children to self-report (Pintrich & Schunk, 1996). Among all self-report approaches, the self-report questionnaire is perhaps the method that is most often used to assess motivation. The Motivated Strategies for Learning Questionnaire (MSLQ) by Pintrich, Smith, Garcia and McKeachie (1993) and the two questionnaires by Keller (1987b) namely Course Interest Survey (CIS) and Instructional Material Motivation Survey (IMMS) are the most widely used. These questionnaires all consist of multi-dimensional measurements. The MSLQ consists of a total of 15 scales, organized in two sections: motivation section (6 scales) and learning

strategies section (9 scales). The CIS and IMMS both contain four sub-scales corresponding to the four categories of the ARCS model, i.e., attention, relevance, confidence and satisfaction. The CIS is used for classroom instruction while the IMMS is designed for self-directed instructional materials. All these questionnaires have been through psychometric testing in terms of reliability and validity. More details on MSLQ and IMMS can be found in Section 3.3.1.

In addition to the three types of direct assessment, i.e., direct observations, ratings by others and self-reports, suggested by Pintrich and Schunk (1996), motivation can also be assessed through some indirect indicators such as learning performance or achievement. Many research studies have observed positive relations between achievement and motivation, and achievement (e.g. exam scores) is often viewed as an indirect index of motivation. Motivation is also found to be associated with many other factors such as course satisfaction, self-regulated strategy use, self-efficacy, epistemological beliefs, metacognition, etc. More detailed discussion on these aspects can be found in Section 2.1.4.

Table 2.2 summarizes the above mentioned methods for motivation assessment.

Table 2.2: Methods of Motivation Assessment

<b>Category</b>	<b>Definition</b>
<b>Direct observations</b>	Behavioral instances of choice of tasks, effort, persistence.
<b>Rating by others</b>	Judgments by observers of students on characteristics indicative of motivation
<b>Self-reports</b>	People’s judgments of themselves
Questionnaires	Written ratings of items or answers to questions
Interviews	Oral responses to questions
Stimulated recalls	Recall of thoughts accompanying one’s performance at various times
Think-alouds	Verbalizing aloud one’s thoughts, actions, and emotions while performing a task
Dialogues	Conversations between two or more persons
<b>Indirect Assessment</b>	Correlation of motivation to other indexes such as achievement, course satisfaction, self-regulated strategy use, self-efficacy, etc.

Adapted from Schunk, Pintrich and Meece (2008), Table 1.3, p.13. The original table had only the top three categories. “Achievement” was discussed as a fourth indicator along with choice-of-tasks, effort and persistence. Here a fourth category “Indirect Assessment” was added and “achievement” was considered as an instance under this category.

Motivation assessment poses many challenges to researchers. As discussed earlier, a variety of motivation theories exist with some disagreements about the nature of motivation and the operation of motivational processes. No agreement has been reached regarding the constructs of motivation, neither in the number of constructs or their names. As a result, the concept of motivation is multi-dimensional and loosely bound. Many different theoretical positions represent multiple threads of rationale. In addition, the underlying fact in all different definitions and theories of motivation is that motivation is a hypothetical construct, i.e., an invented concept used to provide possible explanations of human behavior (Wlodkowski, 1999b) Thus, we cannot observe or measure motivation directly, but can only measure its indicators or other associated factors

Currently, a holistic view states that motivation is both traits and states, both intrinsic and extrinsic, and belongs to both the affective and cognitive domains (Keller, 2007). It is generally acknowledged that no single best type of measurement exists for motivation. The choice of methods should match the purpose of the assessment and the research problem. A mixed approach is usually considered effective to solve practical problems. Situational and multiple scale measurements are often used. In this study, the IMMS was used as the major instrument to assess learner motivation in an online self-paced learning environment. In addition to IMMS, the Mental Effort Scale by Paas (1992) was used to assess learners' effort during learning, which is one of the key indicators of motivation. Learning performance data were also collected as an indirect assessment. Furthermore, qualitative data, e.g., learners' comments to open-ended questions upon completing the learning session, were collected and analyzed to back up and enrich the information provided by the quantitative data. Chapter 3 will discuss the instruments and procedures in detail.

#### 2.1.4 The role of motivation in online learning environments

##### Motivation vs. Achievements

Motivated learners are likely to achieve higher levels of success, and motivation is considered an important factor in online learning success. Learners, especially adult learners who maintain high motivational levels during the course of their learning are likely to be successful (Semmar, 2006). Plenty of research evidence has shown a positive correlation

between motivation and learning achievement, or proved that motivation is an important factor predictive of achievement. Therefore, learning achievement has been viewed as a valid, indirect index of motivation (Pintrich & Schunk, 1996).

One of the strongest pieces of evidence of the link between motivation and learning achievement is the correlation between motivation measures and students' course or exam grades. Pintrich et al. (1993) found that most of the motivation subscales and learning strategy subscales of MSLQ showed significant correlations with college students' final course grades [ $r(378) > .13$ ;  $\alpha = .05$ ]. The "self-efficacy for learning and performance" scale showed the largest correlation coefficient of .41. Similarly, Keller (1987b) reported that all the four subscales of CIS have significant positive correlations with college students' course grades [ $r(198) = .19$  to  $.49$ ;  $\alpha = .05$ ]. The correlation coefficient between the total CIS scale and the course grade is .47. Similar correlations with student grades were also found in Herman and Gomez's (2006) study using a different motivation measurement questionnaire.

Motivation to learn is also a significant predictor of learning achievement. In a study of students taking Web-based agriculture courses, Shih and Gamon (2001) analyzed motivation, attitude, and learning style. The results revealed that motivation was the only significant factor predictive of achievement, which explained 28% ( $p < .05$ ) of the variance. Significant positive correlation was also found between motivation and achievement score [ $r(75) = .53$ ,  $p < .05$ ]. In another study, Waschull (2005) found that among a number of student characteristics, self-discipline/motivation was the only factor predictive of success in a course on online psychology [ $r(55) = .36$ ,  $p < .01$ ]. Motivation to learn was also reported as a significant predictor of self-reported training outcomes for Web-based training, after controlling the demographics, prior experience, and training methodology preferences (Spiros, 2003). Lastly, Sankaran and Bui (2001) conducted a pre-post test analysis of a Web-based business information systems course, which showed that motivation is not only correlated with final test performance [ $r(114) = .575$ ,  $p < .01$ ], but also correlated with gains in incremental scores [ $r(114) = .273$ ,  $p < .01$ ].

### Motivation vs. Attrition

It is generally acknowledged that online learning requires a higher degree of learner motivation. Distance learners are likely to feel isolated and may slow down or even give up

learning. Motivational factors contribute to the retention of students (Irizarry, 2002; Kim, 2004), and the high drop-out rate of online courses can be considered as an indicator of motivation problems (Keller, 1999). Xie, Debacker and Ferguson (2006) found some correlations between students' participation in an online discussion board and their intrinsic motivation [ $r(121) = .183$  to  $.249, p < .05$ ]. The above mentioned study by Sankaran and Bui (2001) also shows that the correlation between motivation and performance is stronger in Web settings [ $r(44) = .575, p < .01$ ] than face-to-face lectures [ $r(68) = .317, p < .01$ ]. Kim's (2004) case study confirms that in self-directed learning settings, lack of motivation is the major reason for student drop-outs. The study also found that computer-learner interaction is critical for motivating online learning environments.

It is also commented that online instruction can encourage persistence and reduce attrition, to the extent that the design and implementation of the course recognize and tap into how individuals may want to learn (Martinez, 2003). While this has long been a challenge for researchers, designers, instructors and trainers, some efforts have been made and some pleasant results have been achieved. Among them are two notable studies based on Keller's ARCS model. One study is the longitudinal case study by Chyung (2000). The study adopted a systematic approach by applying the ARCS model, Kaufman's Organizational Elements Model and Kirkpatrick's evaluation model to solve the high drop-out problem of an online degree program. The ARCS model was used to systematically design the interventions and modify the existing instruction. As a result, the attrition rate decreased from 44% to 22%, three semesters after the intervention. The other study by Visser (1999), developed the Motivational Message Support System (MMSS) based on the ARCS model, resulting in a doubled program completion rate.

### Motivation vs. Other Learning Outcomes

Besides achievement and attrition, motivation is also reported to be associated with many other learning outcomes. For instance, Klein, Noe and Wang (2006) found that in addition to course grades, motivation to learn was significantly related to course satisfaction and metacognition. The incremental variances explained by motivation for course satisfaction and metacognition are .13 and .14 respectively ( $N = 157, p < .01$ ). Brown (2005) tracked employees with access to e-learning courses for acquisition of computer skills for a

year. The results suggested that motivation to learn was an important factor in determining aggregate time spent in e-learning courses, and the time spent on the courses predicted subsequent differences in computer-related skill and performance improvement. In addition, Paulsen and Feldman (1999) found that some motivation constructs are significantly correlated to college students' epistemological beliefs. Lastly, Colquitt et al. (2000) reported a significant corrected meta-analyzed correlation between motivation to learn and declarative knowledge ( $r_c = .27$ ), skill acquisition ( $r_c = .16$ ), affective reactions ( $r_c = .45$ ), transfer ( $r_c = .58$ ), and post-training self-efficacy ( $r_c = .18$ ).

### Motivation, Self-efficacy and Self-regulated Learning

Motivation is associated with self-efficacy and self-regulated strategies. Successful learners are most likely to be those “who possess a strong sense of efficacy, employ a wide range of self-regulatory strategies, and maintain high motivational levels during the course of their learning”(Semmar, 2006, p. 1). Bandura (1994) defined global self-efficacy as the beliefs held by people about their capabilities to perform certain tasks and accomplish specific goals; and self-efficacy affects human functioning in cognitive, motivational, affective and selection processes. Self-regulated learning or self-regulation refers to “an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior, guided and constrained by their goals and the contextual features in the environment” (Pintrich, 2000, p. 453)

Motivation, self-efficacy, and self-regulated learning are all important social cognitive constructs, which are hypothetical. They are invented concepts used to provide possible explanations of human behavior (Wlodkowski, 1999b). In the context of learning, motivation, self-efficacy beliefs, and self-regulated strategies all play crucial roles in academic achievement. From the above definitions of the three concepts, one can find cross-references and interactions among each other. The literature also indicates some similarities; that motivation, self-efficacy, and self-regulated learning (1) can affect learning performance; (2) are associated with both cognitive and affective processes; (3) can be influenced by external factors; and (4) can be improved or strengthened through appropriate educational practices.

Regardless of the way in which they influence each other, motivation, self-efficacy, and self-regulated learning offer a valuable theoretical framework to understand and explain learners' behavior and learning performance. In this study, motivation is used as the main framework to explore online learning in a self-paced environment. Note that while self-efficacy and self-regulation are not explicitly highlighted in this study, they are already incorporated in the motivation theories and instruments used in the study. Motivation is an important factor in self-regulated strategy use (Miltiadou & Savenye, 2003). One of the two sections of the aforementioned motivation questionnaire MSLQ is "learning strategies scale". Similarly, Self-efficacy is regarded as an "expectancy-related" concept (Keller, 2007) under the expectancy-value theory, and one of the motivation subscales of MSLQ is "self-efficacy for learning and performance". The confidence component of Keller's ARCS model can also be considered as relevant to self-efficacy.

### Motivation Factors

Many factors have been found to influence or to be associated with motivation. Cornell and Martin (1997) identified three factors that influence motivation in online learning: course design, the degree of interaction, and the role of the site facilitator. Learners' perceptions regarding barriers and enablers also impact their motivation to learn (Klein et al., 2006). Furthermore, Kim (2004) found that the flexibility and convenience of self-paced online learning is the primary motivator for adults when choosing an online training option; however, these factors may not be enough for them to persist with the course. In such self-paced settings, learners' motivation can change over time as they undergo instruction. The lack of interaction during learning is the major reason for learners getting bored or even dropping-out. Interactive features such as animations and simulations help engage students' learning in self-paced online courses. This is consistent with the *attention* strategies suggested by Keller's ARCS model. Learners are also interested in real-world application and hands-on experience, which support Hodges' (2004) study, that *relevance* is the most successful motivator. While the lack of human-interaction was identified by some participants as a negative aspect of online instruction, most participants preferred control over the sequence of instruction so that they could skip familiar content and spend more time on unfamiliar content that they needed to learn. Finally, Bates and Khasawneh's (2004) study suggested that motivation is significantly correlated ( $p < .01$ ) with previous success in Online

Learning Technology (OLT) [ $r(286) = .68$ ], OLT anxiety [ $r(286) = .52$ ], and instructor-led training [ $r(286) = .18$ ].

Like other psychological characteristics, motivation characteristics have been conceptualized as both traits and states (Brophy, 1983; Keller, 1983, 2007). A trait is a stable psychological status, while a state is a condition brought on by a situational stimulus. While motivation traits are not likely to change, they can be identified and instruction can be designed to accommodate them. The design of instruction becomes even more crucial for motivation states that are influenced by immediate situational factors and change during a period of instruction. Therefore, both the stable trait and changeable state aspects of motivation should be considered when designing online tutorials, carrying out audience analysis and selecting tactics.

#### 2.1.5 *Summary*

From early theories and philosophies to today's field of e-learning, there is little doubt about the growing interest in motivation. Researchers have tried to understand the basis of learners' motivation and identify methods to motivate them, especially in e-learning settings where a high level of motivation is required. Motivational design is a process of arranging resources and procedures to change motivation levels. E-learning provides such a platform that all types of motivation-related research can play a role on it.

Keller's ARCS model is the most validated motivational design model in terms of empirical support, including a number of studies in e-learning settings. The ARCS model is grounded in the expectancy-value theory, and has a problem-solving approach through a systematic design process. In the strictest sense, the ARCS model is more heuristic than prescriptive. That is, it provides guidance for the selection and application of motivation tactics, but personal judgment of the instructor or designer is required to analyze the training needs and create activities that represent the tactics. As discussed, the lack of agreement in motivation theories, the loosely-bound motivation concepts, and the situational and multi-dimensional characteristics of motivation add to the complexity of assessing motivation and designing motivating online instruction. There is no "cookbook" available in the field of

motivational design (Hodges, 2004), and a good design should take the relevant factors into consideration as much as possible.

In spite of the increasing interest in motivation research, conclusive results are insufficient, especially in the relatively new field of online learning. Further research studies are required to validate existing motivation theories and models in an online environment. More importantly, the following questions need to be answered: What motivates online learners? How does the interface design affect their motivation to learn? How can online tutorials be designed to be more motivating?

## 2.2 Usability of the Online Learning Environment

### 2.2.1 Overview of usability in e-learning

The international standard defines usability as “the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use” (ISO 9241-11, 1998) (Table 2.3). Generally speaking, usability refers to both the characteristics of a product, and the technique, process or approach developed to create usable products. Usability was introduced in the software industry in the 1970s and has brought many benefits such as increased productivity, increased customer satisfaction, reduced development time and cost, decreased training time, reduced maintenance cost, and increased sales and revenues (Nielsen, 1993).

Table 2.3: ISO Definition of Usability

---

<b>Usability</b> refers to the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use	
<b>Effectiveness</b>	the accuracy and completeness with which users achieve specified goals
<b>Efficiency</b>	resources expended in relation to the accuracy and completeness with which users achieve goals
<b>Satisfaction</b>	freedom from discomfort, and positive attitudes towards the use of the product

---

With the emergence of distance learning and the educational use of the Internet and the Web (Neal & Miller, 2005; Somers, 2005), usability has gained increasing attention in

contemporary e-learning design. Usability evaluation has been incorporated in the design and development process of many newly published e-learning design applications (Bach & Lai, 2006; Cousineau et al., 2006; Meyen, Aust, Bui, Ramp, & Smith, 2002; Nahm, 2005; Pan, Gay, Saylor, Hembrooke, & Henderson, 2004; Pavolka et al., 2005; Storey, Phillips, Maczewski, & Wang, 2002; Tao et al., 2006). The importance of usability and its testing/evaluation process have also been discussed in several e-learning design guides and books (Boling & Frick, 1997; Dillon & Zhu, 1997; Feldstein & Neal, 2006; Zaharias, 2004).

Notess (2001) introduced several commonly-used usability approaches and discussed their applicability to online learning systems, including usability testing, heuristic evaluations, design guidelines, cognitive walkthrough and participatory design. Boling and Frick (1997) discussed the use of holistic, rapid-paper prototyping for the Web design of an online course and suggested that early usability testing is essential. Feldstein and Neal (2006) described two usability tools that could be easily applied to design self-paced e-learning courses: personas and heuristic evaluations. They also emphasized the fact that usability engineering would increase the likelihood of learners completing the course or achieving their learning goal.

### *2.2.2 Challenges of usability evaluation in the e-learning context*

Some concerns have been raised that usability evaluations may not fit the e-learning context. The major concern is that an online learning system is not a mere piece of software, and learning tasks are different from routine software user tasks. Since current usability practices are still restricted to those measurements based on software use, they may not be able to reflect all facets of users' learning experiences. Therefore, they cannot address some of the issues that interest instructional designers such as learning outcome or learner motivation.

Some usability practitioners argue that usability should focus only on the software aspect to ensure "willing" users are capable of interacting with the application, while aspects such as learning performance should be left to instructional designers (Dillon & Zhu, 1997). This seems like a fair allocation of workload and a plausible approach for cooperation; however, such allocation can hardly be achieved in the real world. First, in an online learning

environment, the computer interface is the single medium where most interactions take place. It is difficult to differentiate between the interaction with the software and the interaction with the learning content. The effects of both interactions are integrated, and thus it is not possible to evaluate each aspect separately. Secondly, from the user's or learner's perspective, a normal person facing an online learning system cannot think of him/herself in the dual roles of "software user" and "learner". An online learner cannot behave separately according to the treatment of "software" or "instruction". Learners merely respond to the whole system! Lastly, one of the important goals of usability is user satisfaction. Satisfaction cannot be separated from the entire learning experience.

Many researchers suggest that guidelines from pedagogy and instructional design should be integrated into usability study so that they can be effectively applied to the e-learning context (Nam, 2003; Notess, 2001; Squires & Preece, 1999; Zaharias, 2004). Some researchers have proposed a series of new heuristics, guidelines or principles that are "more suitable" for the learning context (Ardito et al., 2004; Evans & Sabry, 2003; Mehlenbacher, 2002; Reeves et al., 2002; Squires & Preece, 1999; Vrasidas, 2004). Some have designed rating tools or checklists for evaluation (Lohr & Eikleberry, 2001; Sonwalkar, 2002). Some have suggested focusing on cognitive goals instead of simple tasks when conducting usability testing to assess whether learners can achieve their learning goals (Feldstein, 2002; Liebel, 2006; Notess, 2001). Lastly, some have called for new definitions or new interpretations of usability in the e-learning context (Ardito et al., 2004; Lohr, 2000; Shilwant & Haggarty, 2005; Zaharias, 2006).

Unfortunately, such a variety of opinions doesn't make life easier for e-learning designers. As Lohr (2000) concluded after discussing the challenges of instructional interface design, the problem is not that designers don't have access to design principles, but too many principles exist and they are difficult to apply. The loosely bound and multi-dimensional nature of usability, the number of its existing definitions and interpretations (ISO 9241-11, 1998; ISO 13407, 1999; ISO/IEC 25062, 2006; Nielsen, 1993; Ryu, 2005; Shackel, 1991; UPA, 2007), and the disarray in current practice of measuring usability (Hornbaek, 2006) all make it difficult to effectively evaluate online learning systems. As a result, while the potential of usability testing to answer some instructional questions has been discussed, little evidence is available to show that it has been achieved. Current usability practices in e-

learning are still largely restricted to the traditional concept of usability in software use or Web page navigation. It is desirable to achieve a holistic and standardized usability approach in the context of online learning environment; however, before it is achieved, further research needs to be conducted to explain such issues as the effect of interface design on learning, the extent to which learning is affected, the aspects that are measured or can be measured by usability studies, and finally the relationship between these measurements and learning outcome or other pedagogically meaningful concepts such as learner motivation.

### 2.2.3 *Effects of interface design on learning*

Moore (1989) identified three types of interaction in a distance education course: *learner-content*, *learner-instructor* and *learner-learner* interaction. Hillman, Willis and Gunawardena (1994) identified a fourth type of interaction: *learner-interface* interaction. (Table 2.4) The authors describe learner-interface interaction as a process of manipulating tools to accomplish a learning task. In an online self-paced learning environment, such tools may include the computer interface, the Web page interface, program instructions, help menus, and computer peripherals. In this study, the Web interface and the relevant instructions as well as help menus presented on the Web pages are of most interest.

Table 2.4: Four Types of Interaction

<b>Learner-Content Interaction</b>	the intellectual interaction between the learner and the topic of study (Moore, 1989)
<b>Learner-Instructor Interaction</b>	occurs between learners and instructors or team of subject-experts who prepared the course material (Moore, 1989)
<b>Learner-Learner Interaction</b>	occurs among the learners of an online environment with or without the real-time presence of instructors (Moore, 1989)
<b>Learner-Interface Interaction</b>	a process of manipulating tools to accomplish a task (Hillman et al., 1994, p. 34)

Good learner-interface interaction allows the learner to focus on learning and communication rather than how to access instructional content and communicate with others (Lohr, 2000). Learner-interface interaction links the other three together, and is a prerequisite for learners to access the other three types of interactions, i.e., to communicate with

instructors, peers, and the course content (Miltiadou & Savenye, 2003). (See Figure 1.1) Without learner-interface interaction, the other three types of interaction cannot take place. In a self-paced online learning environment, where learner-instructor and learner-learner interactions are barely available, the learner-interface interaction becomes even more crucial because it serves as the only medium for learners to access or learn the course content.

Since usability represents the quality and good practices of an interactive system, it is reasonable to infer that usability plays a role in the quality of learner-interface interaction in an online learning environment. Therefore usability may have some influence on the learning outcomes. In fact, the effect of usability on learning has been discussed by a number of researchers (Ardito et al., 2004; Lohr & Eikleberry, 2001; Squires & Preece, 1999; Storey et al., 2002; Xie et al., 2006). We also often hear complaints from learners that certain features or flashy objects in a learning Website are so distracting that they cannot focus on the learning content.

Surprisingly, such effects of usability on learning received insufficient experimental support. A number of usability studies failed to find a significant difference in learning performance. In an early study by Parlangeli, Marchigiani and Bagnara (1999), a CD-based, multimedia courseware was developed, and a thorough usability evaluation was conducted including both heuristic evaluation and user testing. The results revealed many problems and a low level of usability. In a subsequent experiment, this courseware CD was compared with two alternative tools: the printed pages of the same CD and a book having the same didactic content. A total of 36 students divided into three matched groups were asked to perform the same learning tasks using the three different tools respectively. The results of the learning test showed no significant difference among the three groups [ $F(2, 33) = 0.29, p > .05$ ]. While the authors ascribed the result to the complex structure of the courseware, i.e., the poor usability of the courseware failed to show the “superiority of multimedia”; no further research has been conducted to validate the existence of such superiority. Similarly, Bach and Lai (2006) evaluated two versions of speech-enabled reading tutor application for adults. Findings indicated small usability improvements but no significant difference in learning between versions. McManus (2000) conducted a factorial design, evaluating the effects of the presentation of instructional materials in terms of non-linearity (low, med, high) and advanced organizer (with, without). Again, no significant differences were found in learning

achievement scores. Finally and interestingly, the study by Tallen-Runnels et al. (2005) found a reversal relationship [ $r(129) = .26, p = .003$ ], which indicated that the more frequently graduate students experienced technology problems or the more severely their problems impeded learning, the higher they evaluated the instructor and the course.

While no direct evidence supporting usability effects on learning has been identified, some pieces of information indicate the possible effects of technology or interface design on some learning outcomes. For instance, a study of 183 e-learning users found that users' intention of continuing to use information technology is determined by satisfaction, which in turn, is jointly determined by perceived usability, perceived quality, perceived value, and usability disconfirmation (Chiu, Hsu, Sun, Lin, & Sun, 2005). Segall, Doolen and Porter (2005) reported that a PDA-based quiz is more *efficient* than a paper-and-pencil quiz [ $t(56) = 2.35, p = .03$ ], but no differences in *effectiveness* and *satisfaction* were found between the two quiz types. In another study (Gemino, Parker, & Kutzschan, 2005), three technology-mediated collaborative interfaces were compared: no graphic, relevant graphic and irrelevant graphic. The results suggested no significant differences in comprehension; however, transfer scores showed significant differences [ $F(2, 17) = 3.97, p = .04$ ]. The transfer scores of the treatment group with context-relevant graphics were significantly higher than the “no graphic” group [ $t(70) = 2.28, p = .03$ ] and “irrelevant graphic” group [ $t(70) = 2.07, p = .04$ ]; while the “irrelevant graphic” group was not significantly different from the “no graphic” group [ $t(70) = .06, p = .95$ ].

From the above review of literature, no sufficient direct evidence is available to suggest the effects of usability or interface design on learning performance. Different interface designs may influence students' learning behavior. Poor usability can have some negative impacts on students' learning activity. Good usability may affect participation, but does not necessarily lead to better learning.

### **2.3 Usability and Motivation: The Road toward Integration**

In some discussions of online learning motivation, usability has been identified as an important factor. Song (2000) summarized seven categories of research issues of motivation in Web-based instruction, and “Web feature and motivation” is listed as one of them. In the

study of online discussions mentioned earlier (Xie et al., 2006), the usability of the system was also reported as an important factor that could affect participation in addition to intrinsic motivation. As Stoney and Wild (1998) commented, “User interface to instructional multimedia is strategically important: if it is poorly designed, students will not be intrinsically motivated to make use of the product or to learn with it. Interfaces that motivate learners are realistic, easy-to-use, challenging and engaging.” (p. 40)

From the other side, some usability researchers incorporated motivation into usability studies. Liebel’s (2006) approach described framing tasks as goals in usability testing, to focus on user motivation. Shilwant and Haggarty (2005) specifically discussed usability testing for e-learning and defined usability as “usable + learnable + useful + motivating”. Rumpradit (1999) found that among five types of Web pages, the participants’ confidence increased for the user interface that included an image-map feature with a context path. Zaharias (2006) developed a usability questionnaire for e-learning, which included motivation as a new measure of usability.

Zaharias’ (2006) study extended conventional Web-usability criteria and integrated them with criteria derived from instructional design. The new usability evaluation questionnaire had intrinsic motivation as a new usability measure. The questionnaire was tested and refined by two pilot studies in corporate training settings, with sample sizes of 113 (63 male and 50 female) and 256 (110 male and 146 female) respectively. The final questionnaire (version 3) had good internal consistency ( $\alpha=0.93$ ), containing a total of 49 items: 39 items that measured e-learning usability parameters and 10 items that measured motivation to learn.

Despite the seminal effort, some drawbacks and limitations can be identified in Zaharias’ study. First, the study only discussed the reliability of the proposed questionnaire and did not address its validity. The questionnaire was not compared with any other existing usability questionnaires. The scale of motivation was not cross-validated with other motivation questionnaires such as MSLQ or IMMS either. In addition, the necessity of including motivation as a new usability measure was not well-supported. In the questionnaire development process, the motivation items were treated separately from the usability items. The motivation items were not included in the factor analysis in any of the three rounds of data analysis. No evidence was presented to claim that the proposed motivation items could

form a new factor in the questionnaire. It is also not clear whether the proposed motivation measure was correlated with the rest of the usability factors resulting from factor analysis.

Zaharias' efforts in linking motivation with usability can be construed as an attempt to discover new definitions or new interpretations of traditional usability measures in a new e-learning context. Such attempts can also be found in studies in other contexts such as mobile phone usability. For instance, Ryu (2005) developed a new Mobile Phone Usability Questionnaire (MPUQ) tailored to measure the usability of electronic mobile devices, which incorporated new criteria such as pleasurability and specific tasks performance. These studies reflect the new challenges posed to usability studies as traditional usability measures of effectiveness, efficiency and satisfaction may not be adequate for new contexts of use such as technology supported learning (Hornbaek, 2006). In another study, Lohr (2000) compared usability and formative evaluation and suggested that a working definition of usability in the instructional environment should include the "interpretation of instructional function" in both measures of effectiveness and efficiency. Ardito et al.(2004) reported a user study involving a group of e-students, and proposed a usability evaluation framework for an e-learning system, which addressed four general dimensions (presentation, hypermediality, application proactivity and user's activity) of e-learning usability with working interpretations of effectiveness and efficiency suggested for each dimension.

However, introducing motivation as a new usability measure is still premature. As discussed above, the effects of interface design on learning is even now unclear. The experimental results with reference to the effects of usability on learning performance are limited and lead to mixed answers. No experimental study has revealed the link between motivation and usability, or the correlations between their measurements.

## **2.4 Summary**

Motivation is considered by many researchers as an important factor in successful instruction (Dick, Carey, & Carey, 2005; Keller, 1983; Schunk et al., 2008; Wlodkowski, 1999b). Motivation can influence what, when, and how we learn (Schunk, 1991). Motivated learners are apt to engage in learning activities, have higher levels of self-efficacy, are willing to put in more effort, are more persistent, and use learning strategies more effectively.

Keller's ARCS model is so far the most widely-applied, motivational design model. Since it was introduced, the ARCS model has been supported by numerous studies, including those in e-learning settings. Most of these studies, however, are experience-based case studies. More experimental research studies are needed to further validate the ARCS motivational design model, especially in the relatively new field of online learning.

The user interface of an online learning system serves as the only conduit where all learning interactions take place. Learners can access the learning content only through the learner-interface interaction. Usability is strategically important for designing the learning interface. It is suggested that the usability of an online learning system can affect learning performance and learner motivation, though the mechanism and extent of such effects are still unclear.

While the combined approaches of motivation and usability have been discussed, the interrelationship of the two continues to remain a myth. For example, both the ISO definition of usability and the ARCS motivation model have a dimension named *satisfaction*, but no study has been conducted to identify whether they measure the same construct. Nor has any study examined the correlation between the two satisfaction measurements or the correlation between other commonly-used, motivation measurements and usability measurements. The multi-dimensional nature and non-standardized definitions of both motivation and usability make validation of the association between the two very challenging. The complete answer cannot be provided by a single study.

This study aimed to shed some light on the issues of motivation and usability by redesigning two alternative interfaces to an existing self-paced online learning tutorial, and evaluating their effects on learner motivation and learning performance. Specifically, the study evaluated the effects of usability improvement and the effects of motivational design. In addition, correlations between the ARCS-based motivation measurements and the usability measures of effectiveness, efficiency and satisfaction, were examined. Results from this study were expected to provide new knowledge of usability and learner motivation in the e-learning context. The next chapter will discuss the methods and procedures in detail.

## **3 METHOD**

### **3.1 Overview**

The overall framework of this study consisted of two phases (Figure 3.1), which are described below:

#### **Phase I: Design and Development**

In Phase I, an existing self-paced online safety training tutorial was used as the baseline (B). The usability of interface B was evaluated and a new interface with improved usability (U) was developed. Based on interface U, motivational design was applied, which led to a third interface design (UM). The three interfaces were used in the experiment in Phase II. Section 3.2 will discuss Phase I in detail.

#### **Phase II: Experiment and Data Analysis**

Phase II of this study included a three-group generalized randomized block covariate design experiment and the corresponding analysis to answer the research questions. Participants completed a usability testing session and an online training session using one of the three interfaces developed in Phase I. Usability, learner motivation and learning performance data were collected. Both quantitative and qualitative data were analyzed. A complete list of research questions and the corresponding hypothesis is shown in Table 3.1. Section 3.3 will further explain the experiment design and the variables. Details of the qualitative method can be found in Section 3.4.

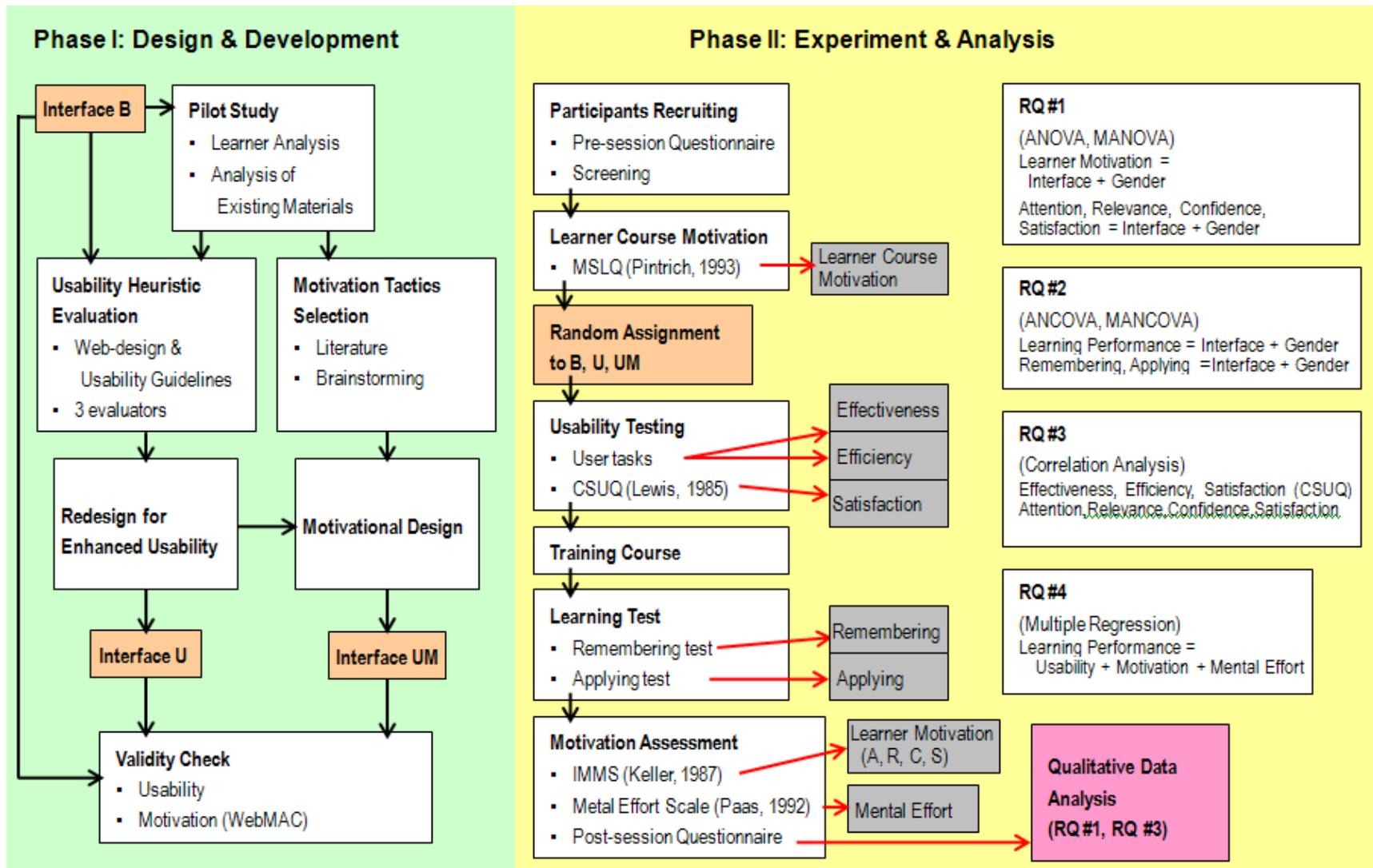


Figure 3.1: Method Framework

Table 3.1: Research Questions and Hypotheses

Research Question	Hypothesis	Analysis
<b>RQ1: How do usability improvement and motivational design affect learners' motivation to learn?</b>	H1a: <i>Learner Motivation</i> will be different across the three treatment groups.	ANOVA
	H1b: Learners in group UM will have the highest level of motivation compared with group B and U.	Learner Motivation = Interface + Gender
	H2a: There will be differences among <i>Attention, Relevance, Confidence</i> and <i>Satisfaction</i> caused by the <i>Interface Design</i> .	MANOVA Attention, Relevance, Confidence, Satisfaction = Interface + Gender
	H2b: The motivation components will be associated with certain components of the tutorial design.	Qualitative Analysis: Content analysis. A coding system to map the ARCS components (Attention, Relevance, Confidence, and Satisfaction) to tutorial design components (Interface design, content, learning support and implementation)
<b>RQ2: How do usability improvement and motivational design affect learning performance?</b>	H3a: <i>Learning Performance</i> will be different across the three treatment groups.	ANOVA
	H3b: Learners in group B will have the lowest <i>Learning Performance</i> compared with group U and UM.	Learning Performance = Interface + Gender
	H4: There will be some differences among <i>Remembering</i> and <i>Applying</i> scores caused by the <i>Interface Design</i> .	MANOVA Remembering, Applying = Interface + Gender
<b>RQ3: What are the interrelationships among commonly-used usability measures and ARCS-based motivation measures?</b>	H5a: Usability and motivation measures will be correlated.	Correlation Analysis: Effectiveness, Efficiency, CSUQ Attention, Relevance, Confidence, Satisfaction
	H5b: Correlated usability and motivation measures will be associated with tutorial design components.	Qualitative Analysis  To identify common codes of tutorial design components that are associated with usability and motivation measures.
<b>RQ4: What are the relationships among interface usability, learner motivation, mental effort and learning performance?</b>	H6: <i>Learning Performance</i> can be predicted by <i>Usability, Motivation</i> and <i>Mental Effort</i> .	Multiple Regression Learning Performance = Usability + Motivation + Mental Effort

## 3.2 Interface Design and Development

### 3.2.1 Safety training tutorial

An online self-paced safety training tutorial on Hazard Communication<sup>1</sup> was used as the targeted training course for this study. The original tutorial consisted of six sections, including introduction, labeling, material safety datasheets (MSDSs), physical hazards, health hazards and protective measures. Each section was presented in a number of pages in a slide-show style with a few “quick check” quiz questions in between some of the pages. The tutorial also included a course test with 16-item multiple choice questions. Figure 3.2 shows the screen shot of the course menu page.

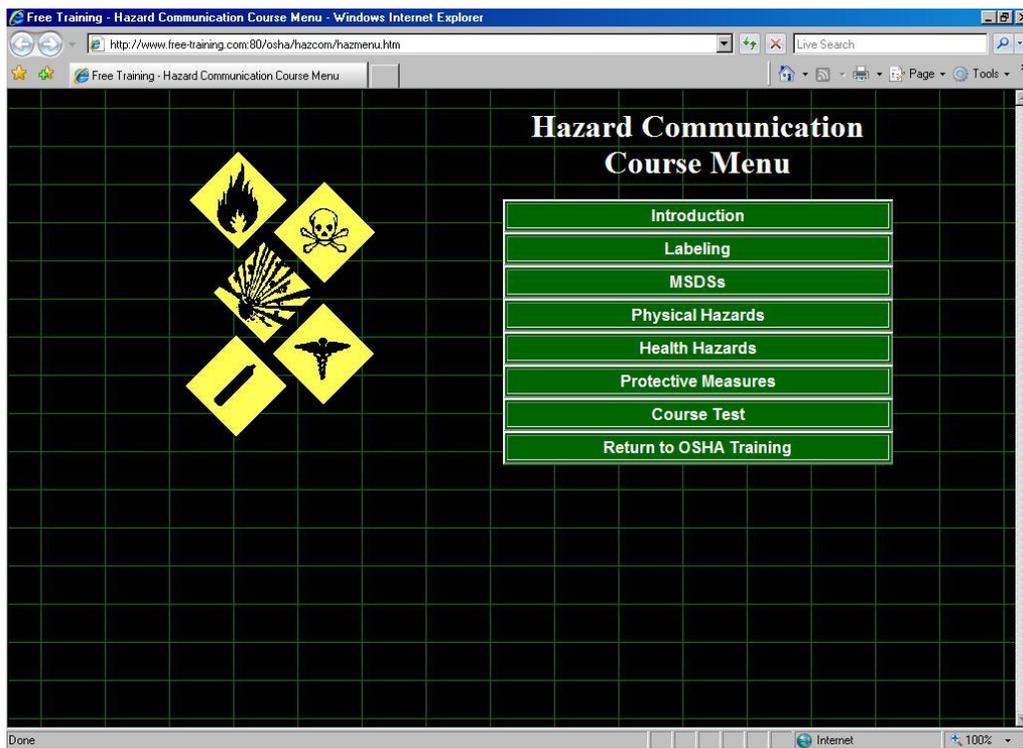


Figure 3.2: Hazard Communication Course Menu Page  
(Copyright of Instructional Designs, Inc. Used herein with permission.)

<sup>1</sup> Web site: [www.free-training.com](http://www.free-training.com) Copyright ©2008 Instructional Designs, Inc.

### 3.2.2 Learner analysis

A pilot study was conducted to analyze learners' need in terms of both motivation and usability. The pilot study included a sample training session and two surveys with both close-ended and open-ended questions. Thirteen college engineering students (5 females and 8 males) from an *Introduction to Human Factors* class participated in the pilot study. Participants were asked to complete the first survey regarding their past online learning experiences, prior subject knowledge, demographic information (age group, gender and academic classification) and learning expectations of this course. After that, participants were asked to complete a short sample training course on *Back Safety* and a 6-item multiple choice course test. The *Back Safety* tutorial was located on the same Website as the *Hazard Communication* course and had similar Webpage design. Upon completing the course and test, participants were asked to complete a second survey. In this survey, participants were asked to rate and comment on their positive and negative experiences with the tutorial they just learned. Participants were also asked to provide redesign suggestions. Both surveys were administered online through survey.vt.edu, an online survey tool<sup>2</sup>. The complete surveys are included in Appendix B.

The pilot study revealed important information about learner characteristics and their attitudes toward online learning (Figure 3.3). Results suggested that learners were mostly college juniors and seniors. They had good computer and Internet skills. They were also generally positive about online learning and considered it as an interesting and worthwhile experience. The results provided valuable insights into the usability/motivation problems of the current tutorial. Learner analysis results served as input for later redesign to improve usability and development of motivational tactics (see Section 3.2.3 and 3.2.4 for more details).

---

<sup>2</sup> Survey.vt.edu is a Web-based survey tool, which allows the survey author to design the look and feel of a survey, and collects, shows, and exports the responses. The service is available to all Virginia Tech faculty, staff and students.

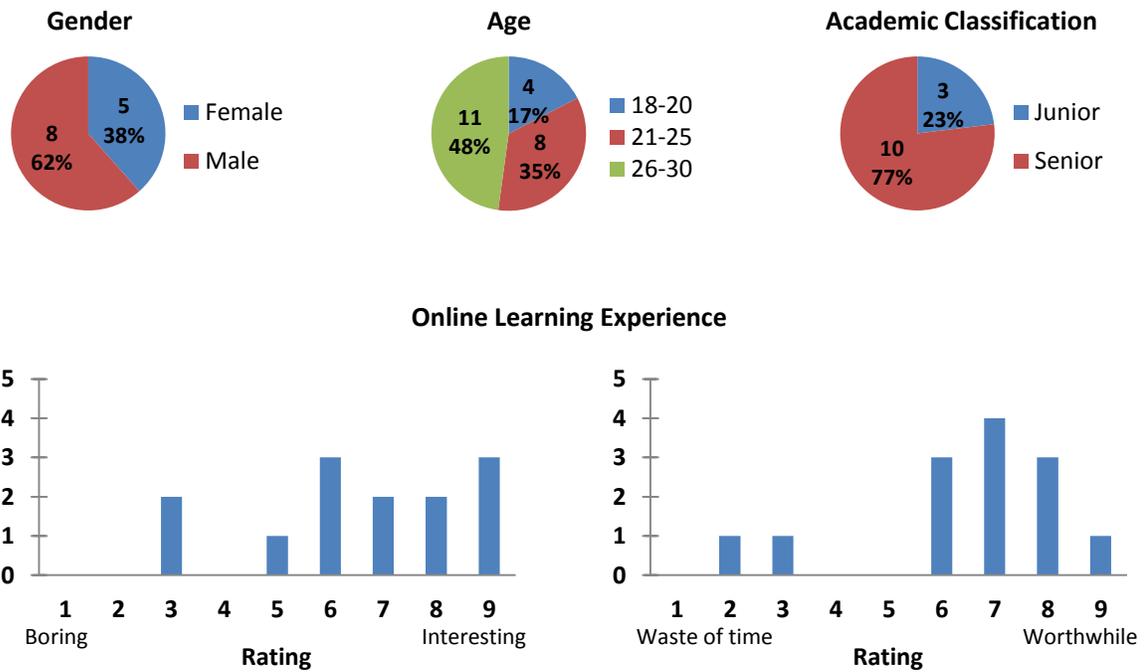


Figure 3.3: Learner Analysis

### 3.2.3 Improving usability

The usability of interface B was inspected through heuristic evaluation. Three human factors graduate students who had usability evaluation and testing experiences served as expert evaluators to evaluate the usability of the interface. A description of user characteristics based on pilot study results and an evaluation sheet were provided to each evaluator as guidance of the evaluation. The evaluation sheet contained a series of usability guidelines based on the well-recognized Research-Based Web Design and Usability Guidelines book (HHS & GSA, 2006). The guidelines selected from applicable chapters were adapted to be presented in a checklist format (Appendix C). Each evaluator reviewed the usability of the tutorial separately according to the guidelines provided, and were asked to assign each guideline a problem severity rating from 0 (no problem) to 4 (usability catastrophe) based on the frequency, impact and persistence of the problem. According to Nielsen and Mack (1994), using the mean of a set of severity ratings from three evaluators is

satisfactory for many practical usability inspection purposes. The evaluators were also asked to provide examples and redesign suggestions for each problem identified.

Based on all evaluators' evaluation and the results from pilot study, a new interface U was designed and prototyped using CourseLab™ 2.3 software. Then the interface U was evaluated through validity check (see Section 3.2.5).

### 3.2.4 Motivational design

With improved usability, interface U was further revised through a systematic motivational design process based on Keller's ARCS model (Keller, 1987a, 1987c). The original full-featured process included ten steps (Keller, 2007). In this study, the ten steps were merged into three major steps, as shown in Figure 3.4. The motivation matrix (Keller, 1999; 2007) was applied in Step II.

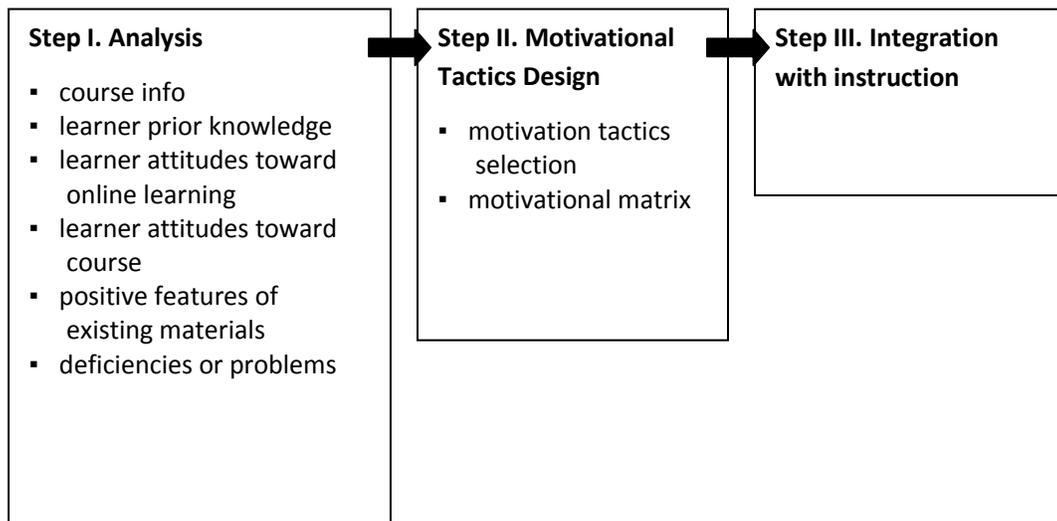


Figure 3.4: Motivational Design Steps

Step I, information obtained from the pilot study (Section 3.2.2) was further summarized and analyzed, including course information, audience information (learner prior knowledge, attitudes toward online learning, attitudes toward course, etc.), analysis of audience (motivational profile, root causes, modifiable influences, etc.) and analysis of existing

materials (positive features, deficiencies or problems, related issues, etc.). This covered Step 1-4 of Keller's full model.

Step II, motivational design objectives were developed based on the above analysis. Potential tactics were listed, both from literature (Keller, 1987c; Keller & Burkman, 1993; Keller & Kopp, 1987; Keller & Suzuki, 1988) and brainstorming sessions. The tactics were further selected and summarized in a motivational matrix form categorized by attention, relevance, confidence and satisfaction (Table 3.2). These corresponded to Step 5-7 of Keller's full model.

Table 3.2: Motivational Design Matrix

<b>Motivation Strategies in Literature</b>	<b>Motivational Design Applied</b>	<b>A</b>	<b>R</b>	<b>C</b>	<b>S</b>
Changes in the organization and presentation of content can stimulate the learners' attention and curiosity.	Vary background color of different modules. Vary positions of pictures and texts in consecutive slides.	X			
People are usually most interested in things that are related to their existing knowledge and skills.	Design navigation bar and status bar in a format that are common to see in Web applications and online tutorials.		X	X	
Provide criteria for success and answers to exercises to encourage students to use self-evaluation of performance.	Provide criteria based on course test scores.			X	
Include learner options to promote an internal sense of control on the part of the learner.	Provide "Ask a question" feature which allows learner to ask questions at anytime of learning.			X	
Allow learners to go at their own pace to increase motivation and performance.	Allow learner to jump between slides. When quiz answer is "incorrect", encourage learner to go back but technically allow navigating forward.			X	
Learner confidence and efforts to succeed are increased in proportion to the perceived credibility of the source.	Redesigned website with more "professional" looking.	X		X	
Reward accomplishment by using positive feedback following success at a challenging task.	Use positive language for "correct" answers			X	X
To build learner satisfaction, use congratulatory comments for performances that meet the criteria for success.	Use positive language at the end of each section. Give congratulations after course test.				X
Stimulate the learner's feelings of pleasure by including enthusiastic comments which model positive feelings					
Make initial perceptions of courseware seem easy, rather than difficult, to read	Use animation at the beginning to explain how to use the tutorial.	X		X	X

<b>Motivation Strategies in Literature</b>	<b>Motivational Design Applied</b>	<b>A</b>	<b>R</b>	<b>C</b>	<b>S</b>
and use in order to gain and maintain attention and to build confidence.					
Use a familiar typeface and size that follow standard typesetting conventions to maintain learner attention.	Use "Arial" or "Times New Roman".	X			
Make each line around eight to ten words and 10 to 12 point type to make text easier to read, maintain learner	Use 10pt font and 8-10 words per line.	X		X	
Make the layout of course ware easy to perceive in order to maintain learner attention and build confidence	Enlarge headings on each page. Use color coding for highlighted key words.	X		X	
Include pictures that include novelty and drama to maintain learner attention.	Use animation and animated character.  Use animated character in the middle of the longest section to maintain attention and encourage persistence.  Use animated character to prompt for unread slides before quitting each section.	X		X	
Create interest as early as possible to gain learner attention.	Use animated agent only in Introduction section.	X		X	

Finally, in Step III, the selected motivation tactics were integrated into the redesign of the training tutorial, and the third interface UM was prototyped using CourseLab™ 2.3 software. To this stage, Step 1 through 9 of Keller’s motivational design process was applied with the exception that no new course materials were developed. The final evaluation step (Step 10) of Keller’s full process was addressed later in this study through a validity check (Section 3.2.5) and an experiment (Section 3.3).

### 3.2.5 Validity check

All interface designs (B, U, and UM, see Table 3.3) were evaluated for their usability and motivation level before being used in the experiment. Three Human Factors graduate students who had usability evaluation and testing experiences served as expert evaluators for usability evaluation. The usability evaluators rated the usability U and UM using the same evaluation guidelines as those used in Section 3.2.3 (see Appendix C). Three graduate students majored in Instructional Design or had teaching and/or training experiences served as expert evaluators for motivation evaluation. The motivation evaluators rated the

motivation level of interface B, U, and UM based on the Website Motivational Analysis Checklist (WebMAC) (Small & Arnone, 1999).

Table 3.3: Description of Interface Designs

<b>Description</b>	
<b>Interface B</b>	The original interface.
<b>Interface U</b>	A revised design based on Interface B with improved usability.
<b>Interface UM</b>	A further revised design based on Interface U with ARCS-based motivational design.

The WebMAC is an instrument created based on a number of motivation theories and models, notably the expectancy-value theory (Vroom, 1964) and Keller’s (1987a; 1987c) ARCS model. The WebMAC is a set of eight instruments designed for use in educational or business context to assess the motivational quality of Websites. “The WebMAC instruments may be used to identify areas for improvement of an existing Web site, provide guidance for the design of a new Web site, or allow comparison of multiple Web sites.” (Small & Arnone, 2006, p.1 )

In this study, the WebMAC Professional 2.0 version was used, which was “designed for professional educators to assess Websites for use in classroom instruction or for student use in homework assignments or projects” (Small & Arnone, 2004, p.1). The instrument contained a total of 32 items, 8 for each of the four major categories of motivation criteria: Stimulating (S), Meaningful (M), Organized (O) and Easy-to-use (E). Each item was a statement regarding the Webpage. The rater was asked to rate on a four-point Likert scale from 0 (strongly disagree) to 3 (strongly agree), or NA (not applicable).

The scores of items corresponding to each category added up to the category score of S, M, O, and E (Figure 3.5). The scores of S and M further added up to the V score, representing the Value dimension of motivation. Similarly, the scores of O and E added up to the XS (expectancy) score. The WebMAC scores were visualized on an expectancy-value scoring grid (Figure 3.6).

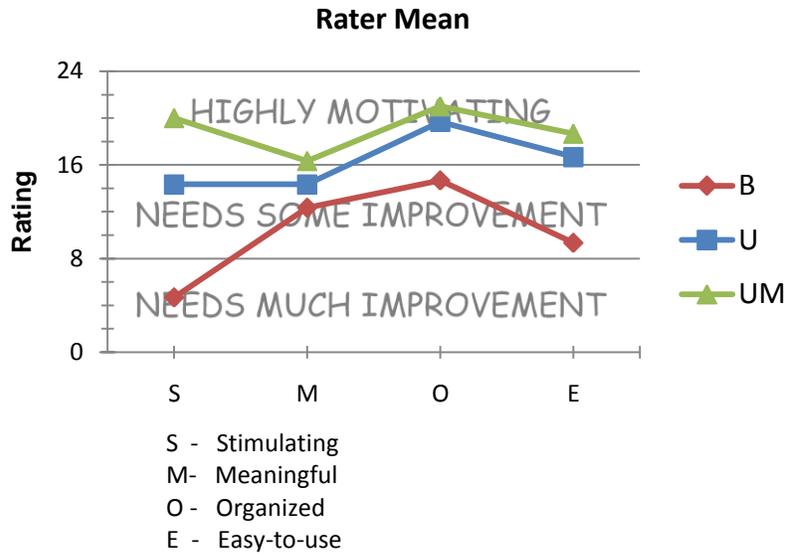


Figure 3.5: WebMAC Scores: Stimulating, Meaningful, Organized and Easy-to-use

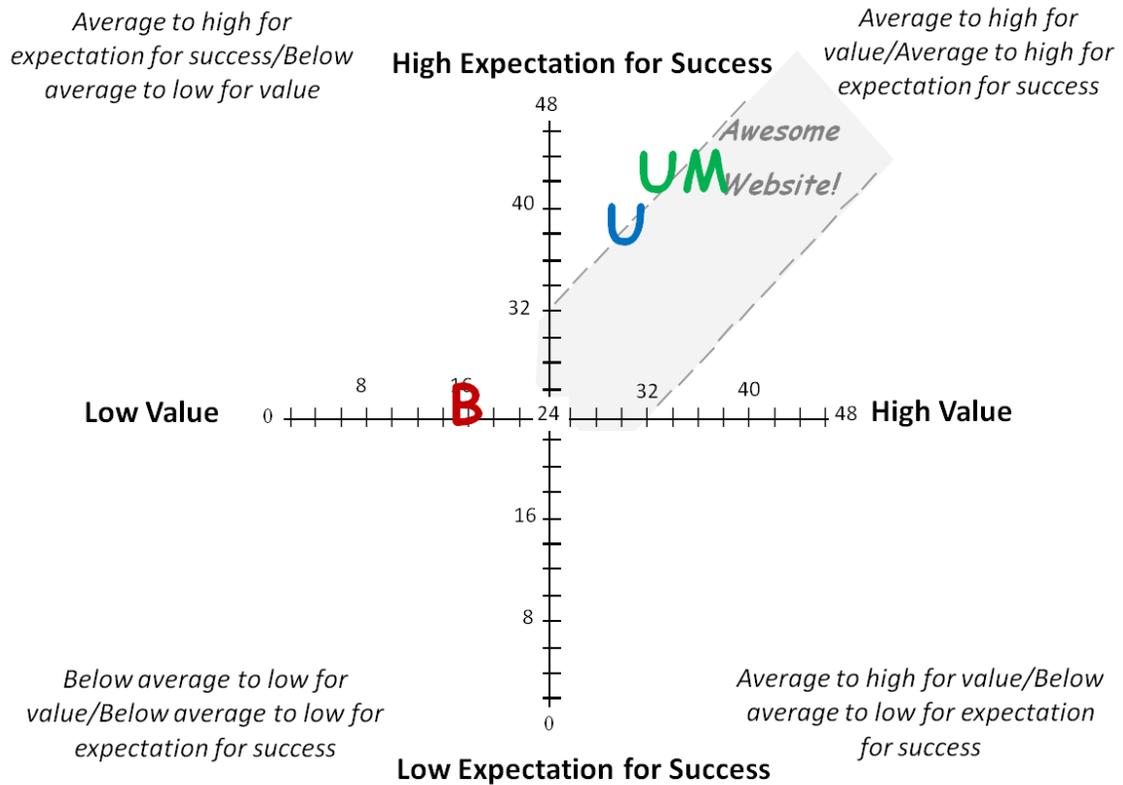


Figure 3.6: WebMAC Scores: Expectancy-Value Grid

From Figure 3.5, the WebMAC evaluation results indicated that the motivation feature of the baseline interface B apparently needed some improvement, while the motivation levels of interface U and UM were higher with interface UM having the highest level of motivation. Similarly, Figure 3.6 suggested that the expectation and value of interface UM had been improved from interface B.

The usability evaluation results are shown in Figure 3.7. Compared with the baseline interface B, all major usability problems (severity rating  $\geq 3$ ) in U and UM were eliminated, suggesting an improvement in usability.

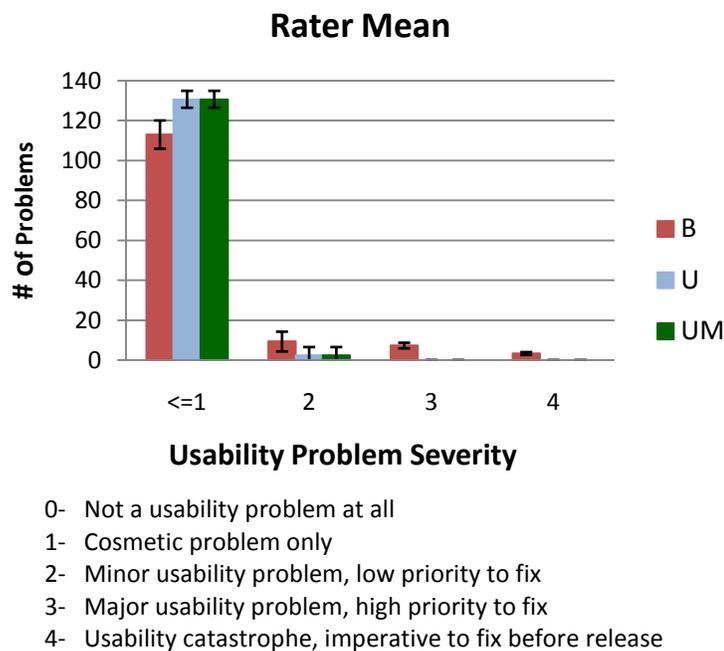


Figure 3.7: Usability Evaluation of Interface B, U and UM  
(Error bars show standard deviations.)

Inter-rater reliability was analyzed for rating scores of both motivation and usability evaluations after all experts completed their evaluations. Intra-class correlation coefficients (ICC) were calculated to assess the level of agreements between raters. For usability evaluation, the rater agreement was  $icc = .98$ . For WebMAC motivation evaluation, the rater agreement was  $icc = .92$ . Both coefficients indicated high agreements (Shrout & Fleiss, 1979).

### 3.3 Experiment

#### 3.3.1 Experiment design, independent variables and dependent variables

This study aimed to explore four research questions and six corresponding hypotheses in self-paced online learning environments (Table 3.1). The experiment was a three-group generalized randomized block covariate design with participant gender as the blocking variable.

Gender was used as a blocking variable in this study to account for treatment variability in terms of learning performance and motivation between males and females. Some research evidences support gender differences in an online learning environment in learning performance, motivation and behavior. In one study (Lim & Kim, 2002), researchers found that female students showed a significantly higher degree of learning and learning application scores than males ( $p < .01$ ). In another study (Price, 2006), females obtained significantly higher scores than males on both continuous assessment scores [ $F(1, 266) = 10.35; p = .001$ ] and on the examination [ $F(1, 264) = 12.41; p = .001$ ]. For motivation, females studying online were more academically engaged in terms of self-confidence [ $F(1, 23) = 13.63; p = .001$ ] and their willingness to learn from other students [ $F(1, 23) = 5.97; p = .023$ ] (Price, 2006). Males and females were also different in other motivation elements such as values (Inglehart & Brown, 1987), goal orientation (Bouffard, Boisvert, & Vezeau, 1995), and intrinsic and extrinsic motivation (Karsenti & Thibert, 1994). In addition, gender differences were found in their social and interactive behavior (Barrett & Lally, 1999; Hoskins & van Hooff, 2005), learning strategy use (Lim & Kim, 2002), and the identified strengths and weakness of the online environment (Sullivan, 2001).

Participants of this study were college engineering students that were currently enrolled in safety related classes. Since the experimental tutorial was assigned as optional course homework, it was expected that students' general motivation toward the course would be related to his/her motivation for the tutorial. Therefore, *Learner Course Motivation*, i.e., learner's general motivation toward the course, was designed as the covariate. Table 3.4 summarizes all variables, their measurements and uses in the analysis. All major variables were measured using standardized instruments, and will be explained in Section 3.3.2.

Table 3.4: Summary of Variables, Measurements and Data Analysis

Variable Name	Measurement/ Instrument	Description	Data Analysis
Gender	Demographic questionnaire	Male/Female	Blocking variable
Interface Design	--	Three levels corresponding to the three interface designs: Interface B, U, UM.	Independent variable
Learner Motivation	IMMS	Four subscales ( <b>Attention, Relevance, Confidence, Satisfaction</b> ) and a total score were used.	Dependent variable in analysis of RQ1,2; Correlation analysis of RQ3;  Independent variable in analysis of RQ4.
Mental Effort	Mental Effort Scale	A nine-point single dimension scale.	Independent variable in analysis of RQ4
Learner Course Motivation	MSLQ	The total score was used.	Covariate
Learning Performance	Remembering Test & Applying Test	<b>Remembering</b> score, <b>Applying</b> score and the total score were used.	Dependent variable in analysis of RQ1, 2, 4.
Usability	Usability testing + CSUQ	<b>Effectiveness</b> and <b>Efficiency</b> are measured by usability testing. <b>Satisfaction</b> was measured by CSUQ.	Correlation analysis of RQ3;  Independent variable in analysis of RQ4.

Statistical analysis and hypothesis tests were performed to address the research questions:

**RQ1:** How do usability improvement and motivational design affect learners' motivation to learn?

**RQ2:** How do usability improvement and motivational design affect learning performance?

**RQ3:** What are the interrelationships among commonly-used usability measures and ARCS-based motivation measures?

**RQ4:** What are the relationships among interface usability, learner motivation, mental effort and learning performance?

For research question RQ1 and RQ2, the dependent variables were *Learner Motivation* and *Learning Performance* respectively. The independent variable was *Interface Design*, which had three levels: B, U, and UM (see Table 3.3). During the experiment, *Usability* of the interfaces was evaluated through usability testing, and was used in correlation analysis with *Motivation* to address RQ3. For RQ4, *Usability*, *Motivation* and *Mental Effort* were

independent variables and *Learning Performance* was the dependent variable. See Phase II in Figure 3.1 for an illustration of the experiment design and analysis. Qualitative analysis was used to triangulate with quantitative statistical analysis for RQ1 and RQ3 (see Section 3.4). More details on data analysis result will be discussed in Chapter 4.

### 3.3.2 *Measurement of variables*

#### Interface Design

As discussed earlier (Section 3.2), three different interface designs (B, U, and UM) were developed of the same online tutorial on *Hazard Communication*. These three interface designs were used as three treatment levels in this experiment:

**Interface B** – The original interface.

**Interface U** – A revised design based on Interface B with improved usability.

**Interface UM** – A further revised design based on Interface U with ARCS-based motivational design. (See also Table 3.3)

#### Gender

Considering the above mentioned gender differences in online learning environments, participant gender was used as a blocking variable in this study, accounting for treatment variability in terms of learning performance and motivation between males and females. Participant gender (male/female) was collected from the pre-session questionnaire, and each of the gender groups were randomly divided into treatment groups (B, U, and UM). This guaranteed that the genders were equal across treatment groups.

#### Learner Motivation

Learner motivation toward the experimental tutorial was assessed through Keller's (1987b) Instructional Materials Motivation Survey (IMMS). The IMMS was designed to measure students' motivational reactions to self-directed instructional materials. The instrument consisted of 36 statements. Participants were asked to think about each statement in relation to the instructional materials they had just studied, and rate on a five-point scale from 1 (not true) to 5 (very true). The 36 items were categorized into four subscales of motivation and the survey was scored for each of the four subscales and the total score. The

four subscales were *attention, relevance, confidence* and *satisfaction*, corresponding to the four categories of motivation in the ARCS model. Some example items were:

--“These materials are eye-catching.”(Attention)

--“It is clear to me how the content of this material is related to things I already know.” (Relevance)

--“As I worked on this lesson, I was confident that I could learn the content.” (Confidence)

--“Completing the exercises in this lesson gave me a satisfying feeling of accomplishment.” (Satisfaction)

In this study, for some questions, the original wording “this material” and “this lesson” were replaced by “this tutorial”, which allowed them to be applied to the online training tutorial used in this study. Cronbach’s alpha coefficients for the IMMS collected in this study indicated moderate to high reliability. The total scale had an alpha coefficient of .81, which indicated that the instrument was reliable based on the widely accepted recommendation of .70 (Nunnally, 1978). Item 26 from the Relevance scale was dropped because of very low inter-item correlations. The resulting alpha coefficients of the four subscales ranged from .67 to .84. The final IMMS had 35 items with possible score range from 35 to 175.

### Learner Course Motivation

Learner course motivation was measured by the Motivated Strategies for Learning Questionnaire (MSLQ) (Pintrich, Smith, Garcia & McKeachie, 1991). The MSLQ was a self-report instrument designed to assess college students’ motivational orientations and their use of different learning strategies for a college course. The scales were based on a general social-cognitive model of motivation that proposes three general motivational constructs: expectancy, value, and affect. The MSLQ has been translated into multiple languages and has been used by hundreds of researchers and instructors throughout the world. More extensive discussions on the development of MSLQ, its applications, and reliability are available from Duncan and McKeachie (2005), and Pintrich et al. (1993).

The MSLQ consisted of a motivation section and a learning strategies section. The motivation section comprised 6 scales that assessed students’ goals and value beliefs for a course, their beliefs about their skills to succeed in a course, and their anxiety about tests in a course. The learning strategy section contained 9 scales regarding students’ use of different cognitive and metacognitive strategies, as well as student management of different resources.

The final version of the MSLQ included 81 items. Items were scored on a 7-point Likert scale, from 1 (not at all true of me) to 7 (very true of me). Scale scores were constructed by taking the mean of the items that make up that scale.

In this study, the MSLQ was adapted to an online questionnaire and the total score of the MSLQ was designed to be used as the covariate to control for student general motivation toward the course. The reliability (Cronbach's  $\alpha$ ) of the overall scale was .90, which indicated that the instrument was reliable based on the widely accepted recommendation of .70 (Nunnally, 1978).

### Mental Effort

As discussed earlier in Section 2, effort was one of the key indicators of motivation. The Mental Effort Scale (Paas, 1992), a single-dimension scale, was used to measure learners' mental effort during the online learning process. Participants were asked to report the perceived amount of mental effort invested in the total learning process on a 9-point symmetrical category scale into a numerical value from 1 (very, very low mental effort) to 9 (very, very high mental effort). The mental effort score provided important complementary information regarding learner's motivation in addition to the IMMS score.

### Learning Performance

Two knowledge tests were provided to participants after they learned through the tutorial. The first test was the *remembering* test, which was developed based on the original course test. The original course test consists of 23 multiple-choice or true-false questions. A review of the test questions suggested that these questions focused on the recall and recognition of information presented in the tutorial, and assessed learners' *remembering* of knowledge according to Bloom's Revised Taxonomy (Anderson & Krathwohl, 2000). These questions were used as the basis for developing the *remembering* test used in this study. Since the original course test was provided with the tutorial as an optional section to all participants, the questions must be modified so that when they were used as the remembering test in this study, the participants were evaluated on the actual knowledge or fact that they remembered, instead of the correct answer codes recalled from the original course test. The modified test included the following changes: 1) The sequence of questions was reordered. 2) Some true-false questions were combined into one multiple-choice question, e.g., "Which

of the following statements are true?” 3) The wording of some true-false questions was reversed so that the correct answer was changed from true to false or vice versa. 4) For some multiple-choice questions, the choices listed as possible responses were replaced with alternative items based on the content of the tutorial. 5) Some multiple-choice questions were revised into the “check all that apply” form. The final remembering test used in this study consisted of 15 objective questions (true-false, multiple choice, and check-all-that-apply) with a total score of 40 points (Appendix D). Five copies of the remembering test were developed with randomized question order and randomized order of choices for multiple choice questions. During the experiment, one of the five copies was randomly selected for each participant. When grading the remembering test, each correct answer to a true-false or a multiple-choice question was given the full points of that question. For a check-all-that-apply question, the points earned was the full points of the question divided by the total number of correct answers and multiplied by the number of correct answers checked.

The second test was developed to include four open-ended application oriented questions with a total score of 35 points (Appendix E). The test required learners to make use of the information in new situations (Question #1, #2 and #3) or to solve problems in new scenarios (Question #4). The objective of this test was to assess learners’ *applying* of knowledge (Anderson & Krathwohl, 2000). The development of the *applying* test followed six steps. Step 1, the objectives of the test were defined. Step 2, initial test questions were created from textbooks, Internet resources and brainstorming. Step 3, questions were selected from the initial question pool based on the following criteria: a) Each question must provide a new application scenario for learners to apply knowledge learned from the training course. b) The complete test covers the knowledge from all major sections of the training course, including labeling, MSDSs, physical hazards, health hazards, and protective measures. c) The questions should vary in terms of difficulty and the amount of required knowledge. d) The expected completion time of the test is no longer than 30 minutes. Step 4, grading points were assigned to each of the test questions based on the level of question difficulty and the expected amount of effort in completing the answer. Step 5, a rubric was developed for each question of the *applying* test. The process of rubric development was based on Stevens & Levi (2004). Each rubric provided the expected achievement levels as well as the corresponding assessment criteria of one to three grading dimensions (see Appendix E). For instance, the rubric of

Question #4 defined the achievement levels as “Excellent”, “Good”, “Needs Improvement” and “Unacceptable”. The rubric also described the criteria from three grading dimensions: knowledge comprehension, application and reasoning. Step 6, the selected questions were assembled into a complete test with written directions.

The total score of the *remembering* test and the *applying* test were used to assess overall *Learning Performance*. Both tests were administered online.

### Usability

The usability of the three interfaces (B, U, UM, see Table 3.3) were measured through the usability testing session. During the usability testing session, participants were asked to complete five tasks using the tutorial website (Appendix F). The three most commonly-used dimensions of usability were measured: effectiveness, efficiency and satisfaction (Table 3.5). Effectiveness was measured by the percentage of correctly completed tasks. Efficiency was measured by the correctly completed tasks divided by the total time spent on tasks. Satisfaction was measured by IBM Computer System Usability Questionnaire (CSUQ) (Lewis, 1995), one of the standard usability evaluation instruments. The CSUQ is a 19-item self-report questionnaire designed to evaluate the overall user satisfaction with a computer system. The CSUQ has three subscales: system use, information quality, and interaction quality. In this study, only the overall score was used to measure satisfaction and the Cronbach’s coefficient  $\alpha$  of the overall scale was .94, which indicated high reliability based on the recommendation by Nunnally (1978).

Table 3.5: Usability Measures

<b>Usability Construct</b>	<b>Measured By</b>
<b>Effectiveness</b>	#of correctly completed tasks/total # of tasks
<b>Efficiency</b>	#of correctly completed tasks/total time spent*
<b>Satisfaction</b>	CSUQ total score

\* For an incomplete task, the time spent on that task was defined as:  $\text{task time} = Q3 + 1.5 * (Q3 - Q1)$ ; Q1 and Q3 are the first and the third quartiles respectively.

### 3.3.3 *Participants*

A total number of 72 college engineering students (48 males and 24 females) from two safety related classes participated in the study. Mean age was 21 ( $SD = 2.25$ ). Recruiting flyers and emails (Appendix G) were sent to the class and volunteers were screened for suitability of participation. Participants must be able to use normal computers in a computer lab without special accommodations. Those who were experienced in hazard communication related research projects or had received formal trainings were also excluded. The reason to exclude these experienced learners is that evidence has shown that the effectiveness of instructional techniques depends very much on levels of learner expertise, known as the “expertise reversal effect” (Kalyuga, Ayres, Chandler, & Sweller, 2003). Therefore the motivational design applied in this study may not be suitable for expert learners. Participants were randomly assigned to one of the three groups (B, U, and UM) with equal number of males and females for all groups. Participation of the study was assigned as optional homework and participants were compensated with course credits.

### 3.3.4 *Procedure*

Brief consent information was included in the recruiting emails, which introduced the purpose of this study and informed participants for completing two surveys before coming to the lab. Participants were asked to complete 1) the online MSLQ and 2) an online pre-session questionnaire (Appendix H) on their prior online learning experience, subject knowledge and demographic information such as age group, gender and academic classification. Participants were then scheduled to come to the lab individually. The experiment was conducted in the ACE lab with two desktop computers. Upon coming to the lab, the participant received a brief introduction of the experiment by the researcher and signed the written consent form (Appendix I). The participant was then led to the computer room and one of the three interfaces (B, U, and UM) was randomly selected for him/her to use. The first task for all participants was the usability testing session. During the usability testing, the participant completed five user tasks using the interface (Appendix F). The experimenter moderated the usability testing session and the participant was asked to “think aloud” while doing the tasks. The experimenter observed the participant’s actions for critical incidents and asked a few

questions accordingly. When all user tasks were finished, the participant was given the satisfaction questionnaire (CSUQ). The usability testing process took approximately 20 minutes and was recorded by Camtasia 3.0™ screen capturing software.

After completing the usability test, the experimenter left the room and the participant completed the online tutorial by him/herself. The process was also recorded by Camtasia. No time limit was given and the participant was encouraged to feel free to learn in his/her own way. When finishing the tutorial, the participant completed the *remembering* test immediately followed by the *applying* test (See Section 3.3.2). Five copies of the *remembering* test were prepared with questions in randomized order and the participant was randomly given one of the five copies. After that, the participant was asked to complete the IMMS and the mental effort scale. The order of IMMS and mental effort scale was counterbalanced. In the end, the participant was given a post-session questionnaire (Appendix J) with mostly open-ended questions regarding his/her experience during the learning (see Section 3.4.2 for details on post-session questionnaire).

## **3.4 Qualitative method**

### *3.4.1 Overview*

Qualitative data were collected during the experiment through open-ended questions in the post-session questionnaire (Appendix J). The objective of using qualitative data and analysis was to map tutorial design aspects to motivation and/or usability components so as to further answer research question RQ1 and RQ3. Specifically, qualitative methods were used to analyze two hypotheses: H2b and H5b (see Table 3.1).

*H2b: The motivation components will be associated with certain components of the tutorial design.*

*H5b: Correlated usability and motivation measures will be associated with tutorial design components.*

By triangulating the qualitative analysis and the quantitative statistical analysis, further insights were gained relating to tutorial design, learner motivation, usability and the inter-relationships among them.

### 3.4.2 *Post-session questionnaire*

The post-session questionnaire consisted of a series of open-ended questions. Each question asked the participants to comment on how they perceived the influence of tutorial design on their learning experience in terms of motivation or usability components. There were six questions, each mapped to one of the ARCS motivation components (attention, relevance, confidence, and satisfaction) or usability components (effectiveness, efficiency, and satisfaction). For example, the attention question says “Please describe how the tutorial did or did not catch your attention?” Note that only one satisfaction question served as both a motivation component and a usability component. Three additional questions asked about other commonly used motivation indicators, i.e., effort, interest (choice of task) and persistence (The effort question was placed at the end of the mental effort scale). At the end of the post-session questionnaire, participants were also given the opportunity to comment and compare the learning environment in the lab with their normal learning environment. The complete text of the post-session questionnaire is included in Appendix J.

### 3.4.3 *The coding system*

A revised coding system based on Huang, Diefes-Dux, Imbrie, Daku and Kallimani. (2004) was used to analyze the responses to the open-ended questions in the post-session questionnaire. The coding system included four major tutorial design category codes: Interface Design, Content, Learning Support and Implementation. During the coding process, a fifth category code emerged and was named as “Personal Factors”. Under the Interface Design category, sub-codes were first assigned as they emerged and then revised according to the classification used in the Research-Based Web-Design and Usability Guidelines book (HHS & GSA, 2006). For the remaining four major categories, sub-codes were assigned as they emerged through the coding process. The complete coding system is shown in Table 3.6.

Table 3.6: The Coding System

<b>Tutorial Design Component Code</b>	<b>Sub-code</b>
<b>Interface Design</b>	General appearance (color/style/appearance; easy to use; credibility/professionalism; standardize task sequences) Homepage Page Layout Navigation (provide feedback on user's location) Paging/Scrolling Heading/Label Link to supportive information Text Appearance (background/contrast; font/size; color coding; highlighting) List Screen-based control Graphics/Multimedia (pictures; auditory; animated character; flash; other media) Search function
<b>Content</b>	Information/Topic Content organization (modules; repetition; concise/clear) Introduction/Summary/Examples Writing
<b>Learning Support</b>	Quiz questions Course test Quiz/test feedback Ask a question Game/other activity
<b>Implementation</b>	Self-paced Online/Computer-based/Easy-access Other format of learning Other (fast/free)
<b>Personal Factors</b>	Interest Current Needs Future Needs Other

#### 3.4.4 Coding process

Two graduate students with usability, instructional design and survey research experiences coded the responses in the post-session questionnaire. The coders were first given a two-hour training session which included an introduction of the background of this study, a description of the coding system, and a free-play session to familiarize with the three interface designs. The coders were asked to first code the responses into the four major categories and then assign the sub-codes. To coordinate the assignment of sub-codes, coders

met together after coding a randomly selected set of approximately one third of the responses. During the meeting, the coders discussed the labeling of the sub-codes and reached a consensus. A fifth category also emerged and was named as “Personal Factors”. After the meeting, the coders went back and independently re-coded all the responses according to the agreed coding system (Table 3.6). The mean frequencies between coders were used to report the final result. The intra-class correlation of the two coders coding results regarding the major category code frequencies was  $icc = .96$ , indicating a high agreement (Shrout & Fleiss, 1979).

## 4 RESULTS

### 4.1 The Learners: Pre-session Questionnaire

The pre-session questionnaire included similar questions as used in the pilot study to obtain information regarding learners' past online learning experiences, prior subject knowledge, and demographic information (age group, gender and academic classification). It was suggested that the total number of 72 learners (48 males and 24 females) were mostly juniors and seniors. Most of them (65%) were between the ages of 21-25 and the mean age was 21.39 ( $SD= 2.25$ ) (Figure 4.1).

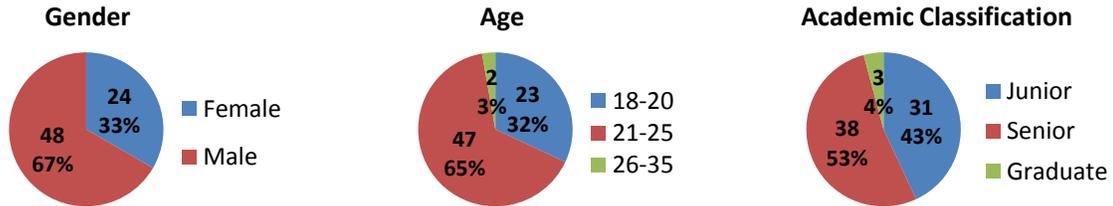


Figure 4.1: Learner Demographics

Regarding their online learning experiences, all learners (100%) used the Internet on a daily basis and most thought of their past online learning as interesting and worthwhile (Figure 4.2). Over 90% of the learners had used the Internet for some learning activities such as reading or searching research articles or access course related information from a course management system (e.g. Blackboard). Over half of the participants had experiences in learning an asynchronous online learning tutorial. Over one-third had completed a semester-long or equivalent online course.

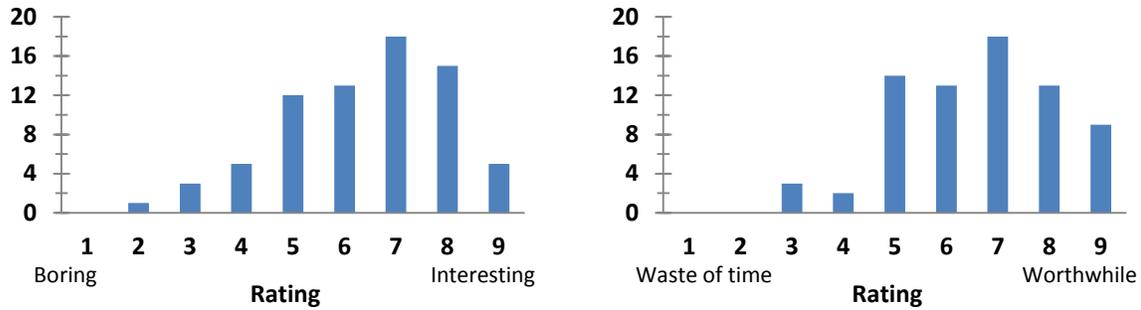


Figure 4.2: Online Learning Experience

## 4.2 RQ1: How Do Designs Affect Learner Motivation?

*RQ1: How do usability improvement and motivational design affect learners' motivation to learn?*

### 4.2.1 H1a: Interface design effect on overall learner motivation

*H1a: Learner Motivation will be different across the three treatment groups.*

Learner Course Motivation, as measured by MSLQ was originally designed a covariate of the experiment. However, correlation analysis suggested no significant correlations between the MSLQ score and the IMMS score [Pearson's  $r(70) = .06, p = .61$ ]. Thus the covariate was eliminated and a two-way analysis of variance was conducted using motivation (IMMS score as the dependent variable). The independent variables were interface design and gender. A significant main effect for interface design was found,  $F(2, 68) = 3.14, p = .049$ . The hypothesis H1a was supported, indicating that learner motivation was different across the three treatment groups (B, U, and UM).

### 4.2.2 H1b: Learner motivation differences by interface design group

*H1b: Learners in group UM will have the highest level of motivation compared with group B and U.*

Linear contrasts suggested that motivation in the UM group was higher than the B group,  $F(1, 68) = 5.72, p = .019$ . However, post hoc tests using Tukey HSD revealed no significant

mean differences among the three groups ( $\alpha=.05$ ). Trends indicated that the UM group had the highest mean motivation score, but the differences between groups were not significant. The mean IMMS scores of the three groups are shown in Figure 4.3 and Table 4.1. Note that each IMMS subscale has a different maximum possible score. In Figure 4.3, the error bars show standard error of the mean, and the Y axis starts from 100.

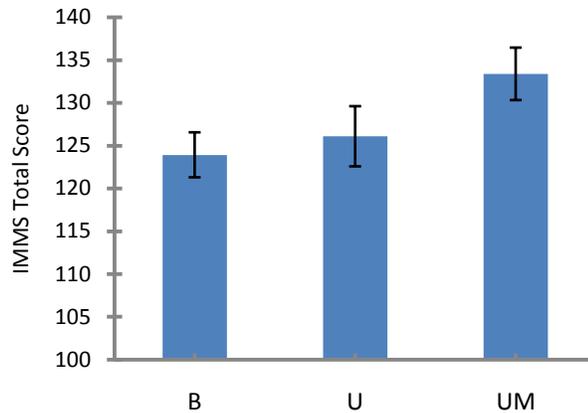


Figure 4.3: Mean IMMS Score By Group  
(Error bars show standard errors of the mean.)

Table 4.1: Group Means of Attention, Relevance, Confidence and Satisfaction

Subscale	Points Possible	Interface B		Interface U		Interface UM		p-value
		M	SEM	M	SEM	M	SEM	
Attention	60	41.13	1.27	42.29	1.65	45.92	1.42	.034*
Relevance	40	25.33	.72	26.17	.89	26.71	.85	.477
Confidence	45	37.71	.61	38.17	.94	38.96	.71	.484
Satisfaction	30	19.75	.78	19.46	.90	21.79	.97	.108
<b>Total Scale</b>	175	123.92	2.63	126.08	3.51	133.38	3.07	.049*

\* $p < .05$

#### 4.2.3 H2a: Interface design effects on the ARCS motivation components

*H2a: There will be differences among Attention, Relevance, Confidence and Satisfaction caused by the Interface Design.*

A two-way MANOVA was conducted with Attention, Relevance, Confidence and Satisfaction subscale scores entered as the dependent variables in the model. The independent variables were Interface Design and Gender. Results suggested non-significant group effects, Wilks' Lambda = .88,  $p = .36$ .

While the MANOVA result was non-significant, considering the significant interface design effect found on learner motivation (IMMS) total score (see Section 4.2.1), the univariate analysis was still performed. The univariate analysis suggested significant interface design effect for *Attention*,  $F(2, 68) = 3.54, p=.034$ . The post hoc tests (Tukey HSD) revealed that learners in group UM ( $M=45.91, SEM=1.42$ ) showed significantly higher attention than those in group B ( $M =41.12, SEM =1.27$ ), but not group U ( $M =42.29, SEM =1.64$ ) (Table 4.2). Regarding relevance, confidence and satisfaction, the UM group showed the highest mean scores but the differences were not significant (Table 4.1).

Table 4.2: Post Hoc Test (Tukey HSD) on Attention

	<b>Interface (I)</b>	<b>Interface (II)</b>	<b>LS Mean Diff (I-II)</b>	<b>Lower CL</b>	<b>Upper CL</b>
Attention	UM	B	4.79*	.30	9.29
	UM	U	3.63	-.87	8.12
	U	B	1.67	-3.33	5.66

\*Significant difference.  $\alpha=.05$

The univariate analysis showed that attention was affected by the three interface designs. The group that incorporated both usability and motivational design interventions (UM) had higher level of attention compared with the baseline group (B), but the difference between UM and U was not significant. No significant group differences were found regarding relevance, confidence or satisfaction.

#### 4.2.4 Learner motivation differences by gender

The ANOVA results suggested a significant gender difference,  $F(1, 68) = 16.26, p<.0001$ . Females were more motivated than males in both the total IMMS scale (female:  $M=137, SEM=2.33$ ; male:  $M =123, SEM =2.20; p=.0001$ ) and in each of the four subscales ( $p<.05$ ). Gender differences on IMMS total scale and subscales are shown in Table 4.3. Note

that each IMMS subscale has a different maximum possible score. Figure 4.4 showed the subscales in percentage in relation to their full points.

Table 4.3: Gender Differences on IMMS

Subscale	Points Possible	Male		Female		p-value
		M	SEM	M	SEM	
Attention	60	41.04	1.04	47.25	1.16	.0003*
Relevance	40	25.31	.61	27.58	.65	.024*
Confidence	45	37.52	.52	39.79	.74	.014*
Satisfaction	30	19.31	.64	22.38	.73	.004*
<b>Total Scale</b>	175	123.19	2.20	137.00	2.33	.0001*

\* $p < .05$

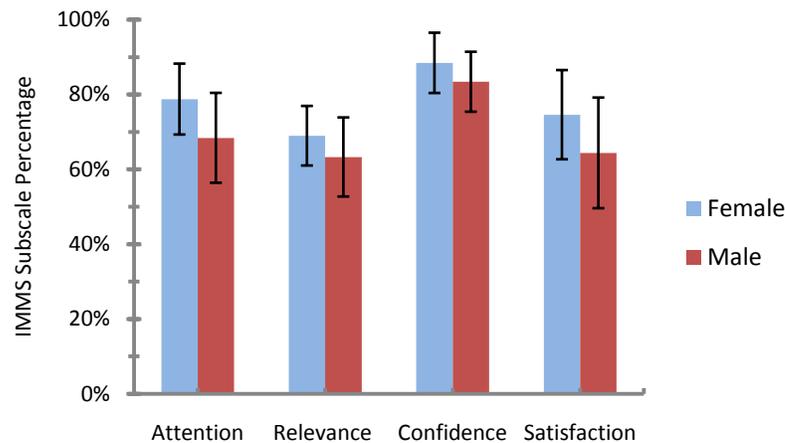


Figure 4.4: IMMS Subscales by Gender  
(Error bars show standard deviations.)

#### 4.2.5 H2b: Motivation components and tutorial design

*H2b: The motivation components will be associated with certain components of the tutorial design.*

Content analysis was used to analyze this hypothesis. Seven questions relating to motivation components (attention, relevance, confidence, satisfaction, interest, persistence, and effort) from the post-session questionnaire were coded into four major tutorial design components (interface design, content, learning support and implementation) based on the

coding system described in Section 3.4.3 (see Table 3.6). The code frequencies are shown in Table 4.4.

Table 4.4: Code Frequencies of Tutorial Design Components vs. Motivation Components  
(Mean frequency between 2 coders. Coder agreement *icc* = .96)

<b>Code</b>	<b>Attention</b>	<b>Relevance</b>	<b>Confidence</b>	<b>Satisfaction*</b>	<b>Interest</b>	<b>Persistence</b>	<b>Mental Effort</b>
Interface Design	107 64.4%	8 7.4%	12 11.3%	105 45.5%	4 5.5%	27 43.5%	61 44.5%
Content	44 26.6%	29.5 27.3%	28 26.4%	59 25.5%	10 13.7%	20 31.5%	29 21.2%
Learning Support	11 6.3%	1 0.9%	59 55.7%	54 23.4%	0 0.0%	11 17.7%	41 29.9%
Implementation	1 0.6%	0 0.0%	3 2.4%	5 2.0%	9 12.3%	2 2.4%	1 0.7%
Personal Factors	4 2.1%	70 64.4%	5 4.3%	9 3.7%	50 68.5%	3 4.8%	5 3.6%
<b>Total # of Codes</b>	166 100%	108 100%	106 100%	231 100%	73 100%	62 100%	137 100%

\*Only one satisfaction question served as a component in both motivation and usability.

The code frequencies in Table 4.4 indicated that *Interface Design* was a major factor that was associated with multiple motivation components, especially *attention*. Interface Design assumed 64.4% of the codes of the Attention question. This influence of Interface Design on Attention may help explain the only significant group effect found in terms of only Attention as discussed in hypothesis H2a (see Section 4.1.3), since most changes made to the tutorial in U and UM were interface design changes. In addition to attention, *Interface Design* was also the largest tutorial design factor that could influence learner *satisfaction* (45.5%), *mental effort* (44.5%) and *persistence* (43.5%).

Besides *Interface Design*, other tutorial design components contributed to some influences of the motivation components. *Learning Support* activities helped to boost *confidence* and could also influence *mental effort*, learner *satisfaction* and *persistence*. Tutorial *Content* played an important role in every aspect of learner motivation. The Implementation of the tutorial could affect learners' interest for further studies.

In addition to the above four tutorial design components, *Personal Factors* emerged during the coding process as the fifth factor which largely affected the perceived *relevance* of the tutorial (64.4%) and learners' *interest* for further studies (68.5%).

To further explore what aspects of Interface Design were key factors that could influence learner motivation, the sub-codes of Interface Design in relation to the four most influenced motivation components (attention, satisfaction, persistence and mental effort) were analyzed. The most frequent sub-codes are shown in Table 4.5.

Table 4.5: Most Frequent Interface Design Sub-codes vs. Motivation Components  
(Mean frequency between 2 coders. Coder agreement *icc* = .90)

Code	Attention	Satisfaction*	Persistence	Mental Effort
Total # of Codes	166	231	62	137
<b>Overall Appearance</b> (color/style/appearance; easy to use; credibility/professionalism)	37 <b>22.0%</b>	45 <b>19.5%</b>	4 <b>5.6%</b>	10 <b>6.9%</b>
<b>Graphics/Multimedia</b> (pictures; auditory; animated characters; flash; other media)	29 <b>17.5%</b>	13 <b>5.6%</b>	7 <b>11.3%</b>	18 <b>13.1%</b>
<b>Navigation</b> (provide feedback on user's location)	3 <b>1.8%</b>	17 <b>7.1%</b>	13 <b>21.0%</b>	6 <b>4.0%</b>
<b>Page Layout</b>	9 <b>5.4%</b>	18 <b>7.8%</b>	1 <b>1.6%</b>	5 <b>3.6%</b>
<b>Text Appearance</b> (background/contrast; font/size; color coding; highlighting)	21 <b>12.7%</b>	3 <b>1.3%</b>	0 <b>0.0%</b>	8 <b>5.8%</b>
<b>Paging/Scrolling</b>	5 <b>2.7%</b>	2 <b>0.9%</b>	5 <b>7.3%</b>	6 <b>4.0%</b>

Table 4.5 suggested that the *Overall Appearance* mainly affected learner satisfaction (19.5%) and attention (17.8%). *Graphics and multimedia* could influence attention (17.5%), mental effort (13.1%) and persistence (11.3%). *Navigation* was an important factor to persistence (21.0%). Lastly, *text appearance* could also help to catch attention (12.7%). Some example quotes from learner comments are shown in Table 4.6.

Table 4.6: Example Quotes of Learner Comments regarding Tutorial Design Components and Motivation Components

Motivation Component	Example Quotes
<b>Attention</b>	The tutorial looked rather bland. ( <b>Overall Appearance: color/style/appearance</b> )  The tutorial did catch my attention since there (are) colored pictures used. ( <b>Graphics/Multimedia: picture</b> )  Caught my attention because ... the font was big, with a topic at the top, and a picture on the side. ( <b>Page Layout</b> )

Motivation Component	Example Quotes
	<p>The blue screen with the yellow and red text was actually kind of difficult to read. (<b>Text Appearance: background/contrast</b>)</p> <p>The guy that would pop up was very humor(o)us. (<b>Graphics/Multimedia: animated character</b>)</p>
<b>Satisfaction</b>	<p>The basic outline of the home page and navigation however seemed a bit disorganized. (<b>Page Layout; Navigation</b>)</p> <p>It is (a) very user friendly tutorial. (<b>Overall Appearance</b>)</p> <p>I was not looking forward to the tutorial, however as I was going through(,) the layout, design, and activities made it easy and enjoyable. I never felt frustrated. I knew what buttons to click in order to continue the tutorial. (<b>Overall Appearance; Navigation</b>)</p> <p>..., that pop up character would say stuff like keep going you are almost done and if I didn't move he would fall asleep. Overall, excellent, once again very good job and I definit(e)ly enjoyed this tutorial. (<b>Graphics/Multimedia: animated character</b>)</p>
<b>Persistence</b>	<p>I wanted to quit sometimes because I did not know how far along I was in each section. (<b>Navigation</b>)</p> <p>It supported my persistence because each slide was relatively short so it feels like you're accomplishing something when you learn a slide. (<b>Paging/Scrolling</b>)</p> <p>The pictures and quiz(z)es made it helpful to continue to the end. (<b>Graphics/Multimedia: picture</b>)</p> <p>It was cute and helpful to my drive to have the "little guy" pop up mid way and say that i was half way there and to keep going. it made me laugh and broke up the feeling of having so far to go. (<b>Graphics/Multimedia: animated character</b>)</p> <p>On the top of the page, I could see how far along I was, so I knew if I just went on a little further, I would be able to finish soon. (<b>Navigation</b>)</p>
<b>Mental Effort</b>	<p>Pictures say 1000 words and they are helpful in conveying the message. (<b>Graphics/Multimedia: picture</b>)</p> <p>The fact that there was not too much information on a slide was very good. (<b>Paging/Scrolling</b>)</p> <p>The easy and organized layout of the material saves a lot of time and effort. (<b>Overall Appearance; Page Layout</b>)</p> <p>The layout was east to follow, so I didn't have to hunt for information. (<b>Page Layout</b>)</p> <p>Bolded and highlighted words that stick out to me so that I do not have to read entire paragraphs. (<b>Text Appearance: highlighting</b>)</p> <p>...the constant blue background was not visually relaxing. (<b>Text Appearance: contrast</b>)</p> <p>It was also easy for me to go back to each section and use the navigation tool at the top that labeled each slide so that I could easily find the one that I was looking for. (<b>Navigation</b>)</p>

#### 4.2.6 Summary of RQ1

The research question RQ1 mainly concerned the effects of interface design on learner motivation. Results revealed significant group effect on motivation ( $p = .049$ ), especially on attention ( $p = .03$ ). Specifically, the interface design with both usability improvements and motivational design applied (UM) showed superiority over the baseline interface (B) in terms of both overall motivation and attention. On the other hand, qualitative analysis suggested that interface design was a major factor to catch attention, which supported the above mentioned group effect on attention from statistical analysis. Qualitative analysis also indicated some associations between tutorial design components and motivation components. These findings provided valuable information for future studies to design motivating online tutorials, both from interface design and other tutorial design components. Lastly, gender differences were found in terms of learner motivation. Females were more motivated than males in overall motivation as well as in each of the ARCS motivation components. More detailed discussion on designing motivating online tutorial and gender differences will be included in Section 5.2 and 5.3.

### 4.3 RQ2: How Do Designs Affect Learning Performance?

#### 4.3.1 H3a, H3b: Learning performance by interface design group

*H3a: Learning Performance will be different across the three treatment groups.*

*H3b: Learners in group B will have the lowest learning performance compared with group U and UM.*

Two-way analysis of variance was conducted with learning performance, as measured by the total score of the Remembering test and the Applying test, as the dependent variable. The independent variables were interface design and gender. Results suggested a non-significant main effect for interface design,  $F(2, 68) = .23, p=.79$ . Hypothesis H3a was not supported.

Post hoc tests (Tukey HSD) indicated no significant mean differences among the three groups (B, U, and UM) ( $\alpha=.05$ ). Hypothesis H3b was not supported. The mean learning performance scores of the three groups are shown in Table 4.7.

Table 4.7: Group Means of Learning Performance Scores

Subscale	Points Possible	Interface B		Interface U		Interface UM		p-value
		Mean	SEM	Mean	SEM	Mean	SEM	
Remember	40	35.71	.764	35.02	.794	34.98	.886	.781
Apply	35	26.13	.925	25.83	1.069	27.33	.993	.536
<b>Learning Performance</b>	75	61.83	1.236	60.85	1.642	62.31	1.671	.793

4.3.2 H4: Remembering and applying scores by interface design groups

H4: There will be some differences among Remembering and Applying scores caused by the Interface Design.

A two-way MANOVA was conducted with Remembering and Applying, as measured by corresponding test scores, as the dependent variables. The independent variables were interface design and gender. Results suggested non-significant group effects, Wilks' Lambda = .840,  $p = .50$ . The hypothesis H4 was not supported.

Interestingly, it was found that there was a significant main effect for interface design in the essay question score of the Applying test,  $F(2, 68) = 4.09, p=.02$ . The essay question was the last question on the applying test with 15 points (out of 35 points in total Applying score). Tukey HSD testing revealed that learners in group UM ( $M=11.88, SEM=.46$ ) showed significantly higher score than those in group B ( $M=9.75, SEM=.51$ ), but not group U ( $M =10.33, SEM =.62$ ). The group means of the essay score and the essay question text are shown in Figure 4.5. The complete Applying test can be found in Appendix E.

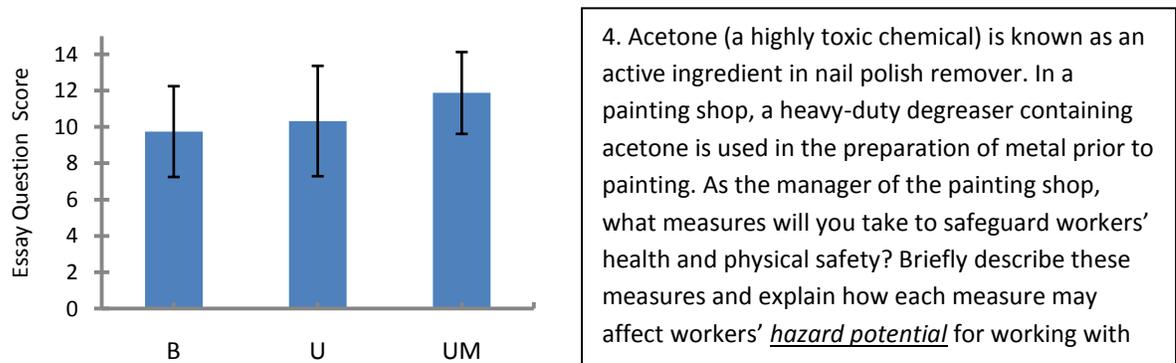


Figure 4.5: Group Means of Essay Question Score (Error bars show standard deviations.)

### 4.3.3 Summary of RQ2

The main objective of research question RQ2 was to explore how interface designs affect learning performance. Results from this study found no significant differences among the three treatment groups (B, U, UM) ( $p > .05$ ). Neither hypothesis H3 nor H4 was supported. The data, though, did suggest a significant group difference ( $p = .02$ ) in the essay question score of the Applying test. Further discussion can be found in Section 5.5.

## 4.4 RQ3: Usability Measures vs. Motivation Measures

### 4.4.1 H5a: Correlations between usability and motivation measures

*H5a: Usability and motivation measures will be correlated.*

Correlation analyses were conducted between usability measures (effectiveness, efficiency and satisfaction) and motivation measures (attention, relevance, confidence and satisfaction). The usability satisfaction was measured by the CSUQ and, to differentiate from motivation satisfaction, will be referred as CSUQ below. Pearson's  $r$  coefficient was used. Significant correlations were found between CSUQ and some motivation measures. Medium positive correlation was found between CSUQ and Attention [ $r(70) = .40, p < .05$ ]. Small to medium positive correlation was found between CSUQ and Satisfaction [ $r(70) = .30, p < .05$ ], and CSUQ and Relevance [ $r(70) = .25, p < .05$ ]. Except CSUQ, none of the four motivation measures was found to have significant correlations with effectiveness or efficiency. The correlation coefficient matrix is shown in Table 4.8.

Table 4.8: Pearson's Correlation Coefficients between Motivation and Usability Measures N = 72, shown only  $p < .1$ . Shaded areas were the correlations between motivation and usability measures.

	Attention	Relevance	Confidence	Satisfaction	Effectiveness	Efficiency	CSUQ
Attention	1						
Relevance	.50**	1					
Confidence	.47**	.23 ( $p = .056$ )	1				
Satisfaction	.72**	.60**	.42**	1			
Effectiveness					1		
Efficiency					.69**	1	
CSUQ	.40**	.25 ( $p = .034$ )	.21 ( $p = .08$ )	.30*	.44**	.43**	1

\* $p < .01$

\*\* $p < .001$

#### 4.4.2 H5b: Usability, motivation and tutorial design components

*H5b: Those correlated usability and motivation measures will share some associations with tutorial design components.*

To further study the associations among the correlated usability and motivation measures found in Section 4.3.1, sub-codes of the corresponding questions in the post-session questionnaire were analyzed. These questions were satisfaction, attention, and relevance. Note that the satisfaction question in the post-session questionnaire served as both a usability measure and a motivation measure. The code frequencies are shown in Table 4.9. The top five most frequent sub-codes were shaded. The shaded sub-codes that were shared by two measures could be considered as the explicators of the associations between the two measures. For example, Satisfaction and Attention shared the shaded codes of “Overall Appearance”, “General Content (Information/Topic)”, and “Content Organization”, indicating that these tutorial design aspects might accounted for the correlations between learner Satisfaction and Attention. As another example, Satisfaction and Relevance only shared the shaded codes of “General Content (Information/Topic)”, and “Content Organization”. These shared codes may help explain the correlations found earlier between these measures.

Table 4.9: Shared Codes between Correlated Usability and Motivation Measures  
(Mean frequency between 2 coders. Coder agreement  $icc = .94$ . Top 5 most frequent codes are shaded.)

Tutorial Design Component Code	Sub-code	Satisfaction*	Attention	Relevance
Total # of Codes		231	166	108
Interface Design	Overall Appearance (Color/style/appearance; easy to use; credibility/professionalism)	45 19.5%	37 22.0%	4 3.7%
	Graphics/Images/Multimedia (pictures; auditory; Animated character; flash)	13 5.6%	29 17.5%	2 1.4%
	Page Layout	18 7.8%	9 5.4%	2 1.9%
	Text Appearance (background/contrast; font/size; color coding; highlighting)	3 1.3%	21 12.7%	0 0.0%
	Navigation (provide feedback on user's location)	17 7.1%	3 1.8%	0 0.0%
	Paging/Scrolling	2 0.9%	5 2.7%	1 0.5%
	Other (heading/title/label/list/search)	6 2.4%	2 1.2%	0 0.0%

<b>Tutorial Design Component Code</b>	<b>Sub-code</b>	<b>Satisfaction*</b>	<b>Attention</b>	<b>Relevance</b>
<b>Content</b>	General Content (Information/Topic)	36 15.4%	18 10.8%	20 18.5%
	Content Organization (modules; repetition; concise/clear)	18 7.8%	12 6.9%	7 6.0%
	Introduction/Summary/Examples	4 1.5%	9 5.4%	1 0.9%
	Writing	2 0.9%	6 3.3%	2 1.9%
<b>Learning Support</b>	Quiz Questions	31 13.4%	10 6.0%	1 0.9%
	Quiz/Test Feedback	14 6.1%	0 0.0%	0 0.0%
	Course Test	5 1.9%	1 0.3%	0 0.0%
	Other	7 2.8%	0 0.0%	0 0.0%
<b>Implementation</b>	Self-paced/Online/Computer-based/Easy-access/Other(fast/free)	5 1.9%	1 0.6%	0 0.0%
<b>Personal Factors</b>	Needs (current, future)	1 0.4%	1 0.3%	43 39.8%
	Past experience/knowledge	1 0.4%	2 1.2%	18 16.7%
	Other	7 2.8%	1 0.6%	9 7.9%

#### 4.4.3 Summary of RQ3

The research question RQ3 aimed to investigate the associations among usability measures and motivation measures. Correlation analysis suggested small to medium positive correlations between CSUQ and Attention, CSUQ and Satisfaction, and CSUQ and Relevance. Except CSUQ, none of the four motivation measures was found to have significant correlations with effectiveness or efficiency. Content analysis further revealed some shared tutorial design codes between those correlated measures, such as general interface design, general content and content organization. More detailed discussion regarding the associations among usability measures and motivation measures will be discussed in Section 5.4.

## 4.5 RQ4: Predicting Learning Performance

### 4.5.1 H6: Predicting learning performance

*H6: Learning Performance can be predicted by Usability, Motivation and Mental Effort.*

Multiple regression was performed with Learning Performance score as the dependent variable. The independent variables were Usability, Motivation, and Mental Effort. The Learning Performance score was the sum of Remembering and Applying test scores. The Usability score was calculated by the sum of effectiveness, efficiency, and satisfaction (CSUQ), each scaled to 100 points, and then divided by 3. The total IMMS score was used as the Motivation score. Mental Effort was measured by the 9-point scale from the Mental Effort Scale (see Section 3.3.2).

Results suggested that Usability, Motivation and Mental Effort were not significant predictors of Learning Performance ( $p > .05$ ). Further discussion can be found in Section 5.5

## 4.6 Other Results

### 4.6.1 Usability improvement

To validate the usability improvement of the three interface designs, two-way MANOVA was performed with effectiveness, efficiency, and CSUQ as the independent variables. The dependent variables were group and gender. Result suggested significant group effects regarding the three usability measures, Wilks' Lambda = .262,  $p < .0001$ . Further univariate analysis found significant group differences in all three measures,  $p < .0001$  (Table 4.10). Post hoc Tukey HSD procedures revealed consistent results that Interface U and UM were more usable compared to Interface B in terms of effectiveness, efficiency and satisfaction (CSUQ), while no significant difference was found between U and UM (Table 4.11). Group means of usability measures (scaled to 100%) are shown in Figure 4.6. Note that the theoretical maximum value for efficiency measure was positive unlimited, therefore the maximum value from the sample was used.

Table 4.10: ANOVA Group Effects for Effectiveness, Efficiency and Satisfaction

Dependent Variable	Max Points	Interface B		Interface U		Interface UM		F	p-value
		M	SEM	M	SEM	M	SEM		
Effectiveness	1.00	.60	.040	.95	.022	.96	.020	50.02	<.0001*
Efficiency	1.91**	.24	.029	.96	.075	.84	.066	41.69	<.0001*
CSUQ	133	83.38	4.55	109.42	2.46	104.88	2.17	18.19	<.0001*

\*  $p < .05$

\*\* The maximum value from the sample.

Table 4.11: Post Hoc Test (Tukey HSD) on Effectiveness, Efficiency and Satisfaction

	Interface (I)	Interface (II)	LS Mean Diff (I-II)	LS Mean	
				Lower CL	Upper CL
Effectiveness	UM	B	.36*	.26	.46
	U	B	.35*	.25	.45
	UM	U	.01	-.09	.11
Efficiency	UM	B	.61*	.40	.81
	U	B	.73*	-.53	.93
	UM	U	-.13	-.33	.08
CSUQ	UM	B	21.50*	10.45	32.55
	U	B	26.04*	14.99	37.09
	UM	U	-4.54	-15.59	6.51

\*Significant difference.  $\alpha = .05$

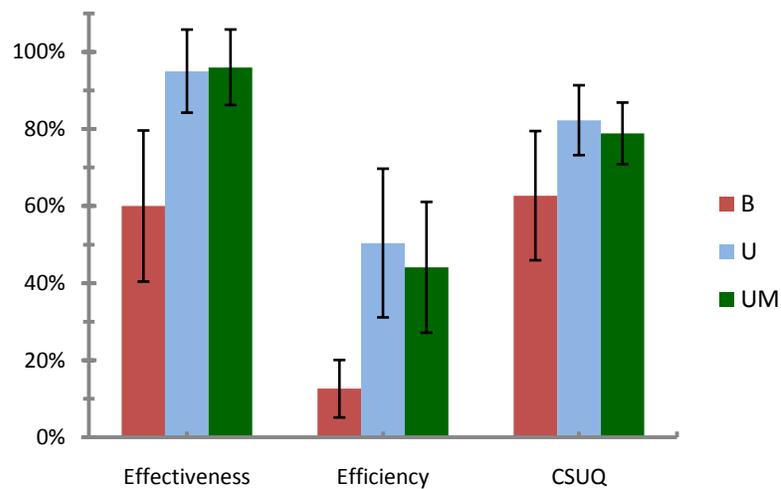


Figure 4.6: Effectiveness, Efficiency, and CSUQ by Group (Error bars show standard deviations.)

#### 4.6.2 The learning environment

At the end of the study (post-session questionnaire, see Appendix I), participants were asked to describe the environment where they would normally do the work for a self-paced online course. The results are summarized in Figure 4.7. It can be seen that most people would do online learning at their own personal spaces, and select a quiet place without distractions such as library or computer lab. When asked what they would do differently from the lab environment as in this study, the major responses were “nothing different” (Figure 4.8). It was interesting to note though that several participants reported that they would like to listen to music while learning online. While paper and pen were provided in the lab, some people still commented that they would only take notes when they were studying on their own, or they would take more notes than what they did in the lab. Some also commented on possible different learning behaviors such as focusing more, being more selective, memorizing better, and more in-depth learning.

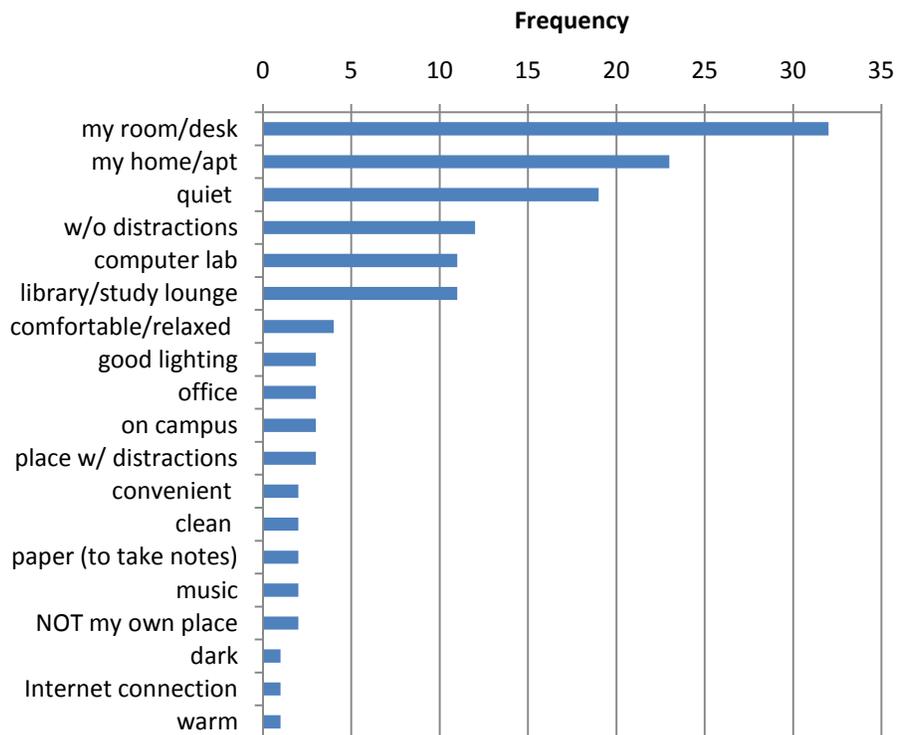


Figure 4.7: Where Would You Normally Do Online Learning?

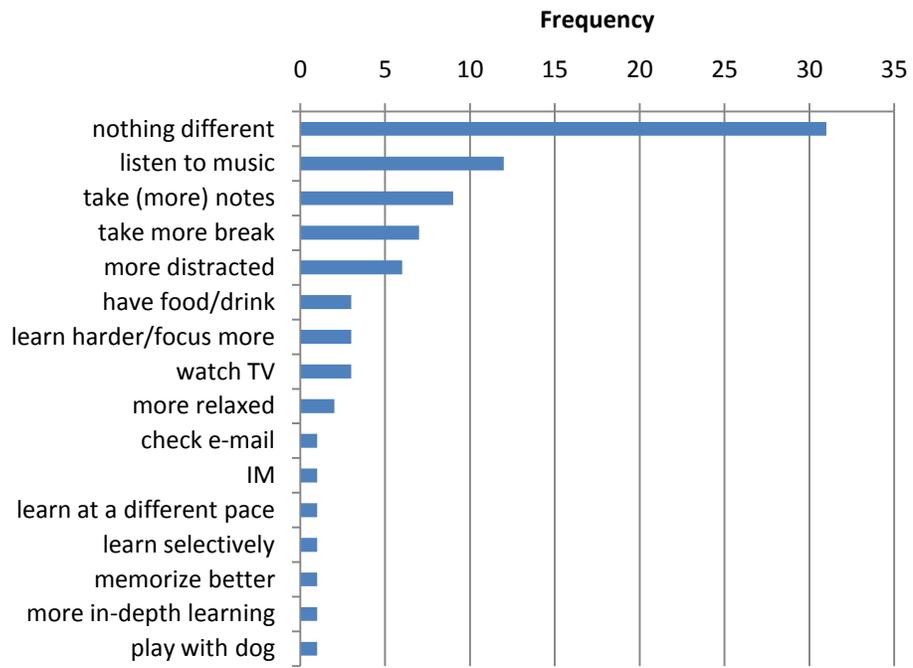


Figure 4.8: What Would You Do Differently from the Lab Environment?

## 5 DISCUSSION

### 5.1 Overview

This study had four major research questions and ten corresponding hypotheses. Results supported part of these hypotheses (see Table 5.1). The following sections will discuss these results in detail. Specifically, Section 5.2 and 5.3 will discuss the first research question (RQ1) regarding learner motivation. Section 5.4 will discuss the inter-relationships between usability and motivation (RQ3). Learning performance (RQ2 and RQ4) will be discussed in Section 5.5. Section 5.6-5.8 will discuss additional issues regarding gender difference, learning environment, and instructional design and technology. Design recommendations will be discussed in Section 5.9. Finally, Section 5.10 will discuss the limitations of this study.

Table 5.1: Summary of Research Questions, Hypotheses, and Results

Research Question	Hypothesis	Result
<b>RQ1: How do usability improvement and motivational design affect learners' motivation to learn?</b>	H1a: <i>Learner Motivation</i> will be different across the three treatment groups.	<b>Supported</b>
	H1b: Learners in group UM will have the highest level of motivation compared with group B and U.	<b>Partly Supported</b>
	H2a: There will be differences among Attention, Relevance, Confidence and Satisfaction caused by the <i>Interface Design</i> .	<b>Partly Supported</b>
	H2b: The motivation components will be associated with certain components of the tutorial design.	<b>Supported</b>
<b>RQ2: How do usability improvement and motivational design affect learning performance?</b>	H3a: <i>Learning Performance</i> will be different across the three treatment groups.	<b>Not Supported</b>
	H3b: Learners in group B will have the lowest learning performance compared with group U and UM.	<b>Not Supported</b>
	H4: There will be some differences among <i>Remembering</i> and <i>Applying</i> scores caused by the <i>Interface Design</i> .	<b>Not Supported</b>
<b>RQ3: What are the interrelationships among commonly-used usability measures and ARCS-based motivation measures?</b>	H5a: Usability and motivation measures will be correlated.	<b>Partly Supported</b>
	H5b: Correlated usability and motivation measures will be associated with tutorial design components.	<b>Supported</b>
<b>RQ4: What are the relationships among interface usability, learner motivation, mental effort and learning performance?</b>	H6: <i>Learning Performance</i> can be predicted by <i>Usability, Motivation</i> and <i>Mental Effort</i> .	<b>Not Supported</b>

## 5.2 Online Learner Motivation

One of the major research questions (RQ1) of this study was to investigate the effects of interface design, specifically usability improvement and motivational design, on learner motivation in the self-paced online learning environment. Results suggested that learner motivation was affected by the three interface designs used in this study. The learners using the design of UM, which had both usability improvement and motivational design applied, showed the highest mean scores of overall motivation as well as each of the subscales (attention, relevance, confidence and satisfaction). The design of UM was also found to have significantly enhanced overall motivation and *attention* compared with the baseline design B ( $p < .05$ ).

These findings demonstrate the positive effects of usability improvement and motivational design, when applied together, on learner motivation in the online learning environment. In particular, the ARCS model is applicable for designing motivationally enhanced instruction in the online learning environment. Therefore it is possible to implement systematic approaches to identify the motivational requirements of online learners and to design motivational enhancements that will predictably improve learner motivation and performance.

Results from this study also confirmed decades of research that revealed motivation characteristics as *states* or situational, i.e., external factors can have a positive effect on learners despite the idiosyncratic nature of motivation. Learners' positive or negative experiences during the learning process serve as feedback of their original motives and may lead to a redirection of effort, a revised set of expectancies or a revision of values (Keller, 1987a). In the online learning environment, a significant amount of such feedback comes from the learner's interaction with the interface (Miltiadou & Savenye, 2003). Therefore it is essential to select and apply proper interface designs in order to connect with the learner's motivation and direction of goals. Both usability approaches and motivational design can help with interface designs to enhance learner-interface interaction. On the one hand, many usability methods are applicable in the online learning environment, such as those discussed earlier in Section 2.2.1 and the guidelines described in relevant ISO standards (ISO 9241-11, 1998; ISO 13407, 1999; ISO/IEC 25062, 2006). On the other hand, motivational design,

whether integrated with instructional planning or used in addition to instructional planning, can help designers and instructors to support the students' commitment to the relevant processes of thinking and problem solving, and avoid the serious pitfall of blaming the learners for being unresponsive to instruction (Jarvela & Niemivirta, 1999; Wlodkowski, 1999a).

Along the line of exploring ways of designing online instruction to promote learner motivation and success, research studies are continuing into new and interesting areas. Miltiadou and Savenye (2003) discussed six motivational constructs and their implications for methods to be used to enhance student success in online distance education. The six motivational constructs included self-efficacy, locus of control, attributions, goal orientation, intrinsic vs. extrinsic motivation, and self-regulation. They also suggested that online course developers should consider a number of design and development issues and principles, i.e., audience analysis, instructional design models, Keller's ARCS motivational design model, goal orientation, course structure, interactivity, assignments, and evaluations. In another research, Dabbagh and Kitsantas (2004) focused on supporting self-regulation in student-centered Web-based learning environments by providing suggestions for specific categories of online pedagogical tools such as Web-based hypermedia tools, Web-based multimedia tools, content creation and delivery tools, and collaborative and communication tools. They also called for rethinking the instructor's role in supporting the development of self-regulated learners and illustrated how students could use those Web-based pedagogical tools.

As research continues to identify factors that positively influence students' motivation to learn, parallel efforts in research are being conducted in designing possible instructional interventions incorporating these factors in concrete applications within a learning environment. Song and Keller (2001) introduced a motivationally adaptive computer-aided instruction (CAI). They embedded motivational self-checks in the lessons and the computer determined the amount and type of motivational tactics to use in the subsequent section of the lesson based on the learner's responses to those self-checks. Results suggested that students in the motivationally adaptive CAI showed higher scores in both attention and relevance than the other two control groups. Gabrielle (2005) designed and applied technology-mediated instructional strategies (TMIS) based on the ARCS model in addition to existing college education courses. An experiment was conducted with 48 course sections

randomly divided into control (traditional teaching methods) and experimental groups (TMIS). Results indicated that students who accessed the TMIS had significantly higher levels of motivation than control group students. In a more recent study, Schmidt and Werner (2007) proposed the use of “future oriented instruction” to support and improve student motivation and self-regulation within online learning environments at a German university. More details regarding specific interface designs and learner motivation will be discussed in the next section.

### 5.3 Interface Design vs. Learner Motivation

Results from this study supported a significant interface design effect ( $p = .049$ ) on learners’ overall motivation among the three treatment groups (Section 4.1.1). This finding was consistent with the above mentioned two prior research studies that found significant difference of overall motivation between treatment groups (Song & Keller 2001; Gabrielle 2005). In particular, significant difference in learners’ *attention* was found between the group using the interface with both usability improvement and motivational design applied (UM) and the group using the baseline interface B (Section 4.1.3). This supported Song and Keller’s (2001) study, which found that significant differences occurred only in *attention* and *relevance* ( $p < .05$ ).

Qualitative data collected from the post-session questionnaire of this study also revealed that interface design was perceived as the most prominent tutorial design component that affected learner attention. Interface design was the most frequently mentioned factor that caught learner attention, and the code frequency of “Interface Design” accounted for 64.4% of the total number of *attention* codes (Section 4.1.5). For the other three motivation sub-components, especially *relevance* and *confidence*, interface design didn’t appear to have as strong influence as it had on attention.

Considering both the statistical results and the qualitative data, it is clear that designing motivational enhancements of online tutorials is possible when systematic design approaches are implemented. In particular, such design approaches can effectively affect learners’ *attention*. The fact that a majority of *attention* codes were interface design factors further supported the statistical findings of interface design effect on attention. In this study, the

design of interface UM applied a number of motivational strategies to catch and sustain learner attention, e.g., using animated characters (See Table 3.2 for all strategies used). While most of the motivational design changes were restricted to the interface design changes due to the experimental design, those designs turned out to be helpful based on learners' responses in the post-session questionnaire. Learners commented that the animated character was fun and humorous; and it helped with their persistence seeing that animated character telling them their progress during a long tutorial section.

According to Keller (1987a), attention is a prerequisite for learning. The motivational concern is not just for getting attention, but also sustaining it. This issue has implications for online tutorial design. At one level, it is fairly easy to catch attention. A bolded and enlarged word, a flashy object, or a sharp noise may all work. Example quotes from learner comments of this study can also shed some light on how to make the interface design attention-catching (see Table 5.2). However, the real challenge is how to sustain attention to remain at a satisfactory level throughout a period of instruction. This requires the instruction to respond to the sensation-seeking needs of students and their knowledge-seeking curiosity (Keller, 1987a). Some learner comments from this study indicated such needs beyond interface design. For instance, "*The tutorial catch(es) my attention because the information provided is needed.*" "*The subject matter caught my attention.*" "*It help(s) to catch my attention through the use of facts and pictures.*"

One the other hand, based on the results from this study, interface design did not seem to have an equal level of impact on other motivation components -- relevance, confidence and satisfaction-- as it has on attention. No significant statistical results were obtained for the interface design effect on relevance, confidence or satisfaction. Code frequencies of learner comments from post-session questionnaire (see Table 4.4) also suggested the differences of interface design influence on motivation components, as reflected by the proportion of codes. Except for *attention* (64.4%), Interface Design did not attain the majority of codes for motivation components including *relevance*, *confidence*, *satisfaction*, *interest*, *persistence*, and *mental effort*. While Interface Design still assumed a major proportion of codes of *satisfaction*, *persistence*, and *mental effort* (45.5%, 43.5% and 44.5% respectively), its proportions in *relevance*, *confidence* and *interest* were very low (7.4%, 11.3%, 5.5%). For *confidence*, Learning Support seemed to be the most influential factor (55.7% of the codes),

which included quizzes, course tests, feedbacks, online help features, etc. For *relevance* and *interest*, Personal Factors were the most important (64.4% and 68.5%), which involved learners' personal interests and their current and future needs.

Therefore, from the perspective of interface design, the most efficient way to connect to learners' motivation is through attention. Designers should consider giving priority to involve salience or attention-capturing design elements into the interface. Section 5.9.1 will discuss more details of attention strategies of interface design. Nevertheless, from a more holistic view of designing an entire online tutorial, careful thoughts must be taken about other above-mentioned factors that are associated with different motivation components.

Generally speaking, the motivational design applied in this study was successful in that almost all design changes received positive comments from the participants (see Table 5.2). While no explicit comments were found for the changes related to fonts, there were no complains, either. In contrast, in the baseline group (B), a number of negative comments were found regarding the text, background and contrast, e.g., *“The blue screen with the yellow and red text was actually kind of difficult to read.”* *“High contrasting colors are very irritating to look at, especially over long periods of time.”* If those negative comments of the baseline interface B indicated that learners were kind of bothered or annoyed by the text appearance and/or background contrast, the absence of comments regarding interface UM may suggest that those sources of annoyance has been eliminated, or at least reduced to neglectable levels.

Table 5.2: Learner Comments of Motivational Design

Motivational Design Applied	A	R	C	S	Learner Comment (quote)
Vary background color of different modules.	X				It caught my attention because it was colorful... ( <b>Attention</b> )
Vary positions of pictures and texts in consecutive slides.					
Design navigation bar and status bar in a format that are common to see in Web applications and online tutorials.		X	X		(It) helps with my persistence knowing my status and the site does that many ways with the progress bar on the top and progress counter at the bottom right. ( <b>Persistence</b> )
Provide criteria based on course test scores.			X		The tutorial provided goals. It was good to get a passing grade on the quiz(z)es, so it was persistent in my

<b>Motivational Design Applied</b>	<b>A</b>	<b>R</b>	<b>C</b>	<b>S</b>	<b>Learner Comment (quote)</b>
					learning. ( <b>Persistence</b> )
Provide "Ask a question" feature which allows learner to ask questions at anytime of learning.			X		Having the "type a question" and the help button really make is effective in learning. ( <b>Effectiveness</b> )  It was nice that you could type a question and have it sent. ( <b>Mental Effort</b> )
Allow learner to jump between slides. When quiz answer is "incorrect", encourage learner to go back but technically allow navigating forward.			X		It was very easy to navigate throughout the tutorial. ( <b>Satisfaction</b> )
Redesigned website with more "professional" looking.	X		X		The site was clean. ( <b>Attention</b> )
Use positive language for "correct" answers			X	X	I like the fact when getting a question wrong on the check up sections it did not give really negative feedback rather it said maybe you need to go back and see what the correct information is. ( <b>Confidence</b> )
Use positive language at the end of each section. Congratulation after course test.				X	What I really like was the feedback that is provided make you feel like you accomplish(ed) something important. ( <b>Satisfaction</b> )
Use animation at the beginning to explain how to use the tutorial.	X		X	X	Things moving at the beginning are good and they stopped, so it was attention getting but not distracting. ( <b>Attention</b> )
Use "Arial" or "Times New Roman".	X				N/A
Use 10pt font and 8-10 words per line.	X		X		N/A
Enlarge headings on each page. Use color coding for highlighted key words.	X		X		It did catch my attention by the big text used in the slides... and the bolded vocab words. ( <b>Attention</b> )  It caught my attention through the different coloring of the words. ( <b>Attention</b> )  The underlined and highlighted words also helped to focus my attention. ( <b>Attention</b> )
Use animation and animated character.  Use animated character in the middle of the longest section to maintain attention and encourage persistence.	X		X		The guy that would pop up was very humor(ous). ( <b>Attention</b> )  One of the sections was much longer than the others and half way through the animated figure tells you progress that helps with persistence. ( <b>Persistence</b> )

<b>Motivational Design Applied</b>	<b>A</b>	<b>R</b>	<b>C</b>	<b>S</b>	<b>Learner Comment (quote)</b>
Use animated character to prompt for unread slides before quitting each section.					If you had not completed all slides in a section, the course would ask you if you really wanted to quit at this time (also a nice feature). <b>(Satisfaction)</b>
Use animated agent only in Introduction section.	X		X		Things moving at the beginning are good and they stopped, so it was attention getting but not distracting. <b>(Attention)</b>

#### 5.4 Interrelationships between Usability and Motivation

Results from this study revealed a complicated relationship between usability and motivation. On the one hand, usability alone seemed to have no direct impact on learner motivation toward the self-paced learning tutorial used. There was no significant difference between U group and B group in either overall motivation or any of the four sub-components of motivation. This indicated that traditional usability methods and guidelines alone might not lead to a best solution when learning was concerned. Usability techniques can make the interface easier-to-use, but may not make it as interesting or engaging as what instructional designers desire it to be. This may help explain the inconclusive results found by other researchers (Bach & Lai, 2006; Parlangeli et al., 1999) regarding the effects of usability on learning.

As discussed earlier in Section 2.1.3, motivation is a hypothetical construct. The assessment of motivation is greatly challenged by the lack of agreement in motivation theories, the loosely-bound motivation concepts, and the situational and multi-dimensional characteristics of motivation. Therefore it is possible that the selected motivation assessments used in this study did not capture all facets of learner motivation under the given experiment situation. Thus the motivation measured was not sensitive enough to reflect the effects of usability changes, which led to the insignificant results. It is also possible that usability may have impacts on some learning-related behaviors which may or may not be directly related to learner motivation. Further research is needed to investigate what learning-related behaviors usability can affect and how they are affected.

On the other hand, correlation analysis suggested small to medium positive correlations ( $p < .05$ ) between usability satisfaction and three motivation measures, i.e., attention [ $r(70) = .40$ ], relevance [ $r(70) = .25$ ] and satisfaction [ $r(70) = .21$ ] (see Section 4.3.1). Content analysis further revealed some shared tutorial design codes between those correlated measures, such as overall appearance, general content and content organization. In addition, Interface Design assumed a major proportion of codes of attention, satisfaction, persistence, and mental effort (Table 4.4). Learner comments also indicated that certain interface design features— text appearance, navigation, page layout, color/style, paging/scrolling, etc. — did have some impacts on their motivation (Table 4.6). These results all indicate that usability of the tutorial, in some way, *is* associated with learner motivation. Furthermore, motivation—if we learn to measure it more validly—should be included as a part of the usability criteria in the e-learning context.

Therefore, it is argued that in a self-paced online learning environment, the usability engineering process can influence learner motivation provided that a systematic motivational approach, in this case ARCS-based motivational design, is integrated. Based on the tutorial used in this study, a number of usability concerns are also motivational concerns. For example, the early usability evaluation in this study suggested that the bright blue background of the original tutorial made the white text hard to read, and based on the usability guideline book (HHS & GSA, 2006), the improved version (Interface U) used dark text on plain white background. From motivational considerations, such “white on blue” text was hard to keep learner *attention* and might cause motivational problems. Thus from both usability and motivation perspectives, the background needed to be changed. Another example was the quiz feedback. In the baseline version (B), when learner answered a quiz question, the tutorial would “jump” to a new page saying either “*Correct. Let’s continue.*” or “*Your answer is not correct. Let’s go back and review.*” Both correct and incorrect pages were on the same gray background and all texts were in the same font, color and size. It was not easy at first glance to differentiate unless reading the text carefully and the original quiz question was no longer visible. The usability improved version (U) used color coded pop-up text boxes to display the feedbacks over the quiz question. A red box indicated an incorrect answer and a green box indicated a correct answer. It also enlarged and capitalized the text of “CORRECT” and “INCORRECT”. The initiatives for these changes were from usability

concerns only. Interestingly, later learner comments suggested that the feedback boxes were also perceived as a motivational stimulation to improve *confidence*. A learner commented: *“It did support my confidence in learning because whenever I answered a question correctly a window would pop up and say CORRECT! And it was also in green which is a positive color.”*

It is also important to note that traditional usability efforts alone may not be enough to successfully motivate learners. Usability can make the interface easy-to-use, make navigation simpler, and reduce download time. Based on previous discussions, usability can also help with interface design that captures learner attention, which is the most fundamental step in cognition and learning. However, learners’ needs, goals and aspirations are also important considerations for designing a good online tutorial. Some usability methods may still be helpful, such as user analysis and usability testing, but they need to be adjusted and reoriented to shift the focus to learner motivation or other learning related needs (Liebel, 2006). Integrating a systematic motivational design approach such as the ARCS model with the traditional usability engineering process may also benefit the design. For example, the user analysis and learner analysis phase can be combined so that we can have a more clear understanding of the users or learners. Such understanding is not limited to the simple demographics and computer skills, but also learners’ prior subject knowledge, motivational needs and attitudes toward online learning. By introducing new requirements or new assessment criteria, usability testing methods may also be used to evaluate the effectiveness of the selected motivational strategies. Further research is needed to find out feasible ways to integrate usability process with motivational design or other instructional design processes, and not to simply add one on top of another.

## **5.5 Learning Performance**

Based on the results of this study, no significant difference was found in learning performance among the three treatment groups, either Remembering, Applying or the overall score. Neither usability nor motivation was found to be a significant predictor of Learning Performance. On the one hand, the non-significant differences in learning performance suggested that the interface design changes made in group U and UM did not affect or “hurt”

participants' learning performance given that the tutorial content was kept identical across the three groups. This supported R.E. Clark's (2001) that "The media are mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in nutrition" (pp.2).

On the other hand, some factors may have possibly contributed to the non-significant results. One of them may be the "ceiling effect" of the learning test scores. The Remembering test consisted of 15 objective questions (true-false, multiple choice, and check-all-that-apply) with a total score of 40 points (Appendix D). The mean test score was 35.28 ( $SEM = .45$ ), or 88.19% of the total score. Over half of the learners (38 out of 72 or 52.78%) scored at least 36 points or 90% of the test. This indicated that a "ceiling effect" might be present and such effect might obscure the treatment effects (Bordens & Abbott, 1996). A possible explanation of the ceiling effect in Remembering test scores is that the test score questions were adapted from the quiz questions used in the tutorial. According to Gibbs and Simpson (2005), students selectively pay more attention to those aspects of a course which are assessed and determine accordingly what is studied and how. Therefore, it is likely that learners focused more on the content that was tested in quizzes as they went through the tutorial and thus recalled those content well when doing the Remembering test. In fact, when asked "What made the tutorial an effective learning tool?" in the post-session questionnaire, several learners mentioned the quizzes and indicated that the quizzes helped them to learn what they "are supposed to learn". Those comments, from another perspective, supported the above described selective learning phenomena.

For the Applying test, which consisted of four open-ended questions, similar "ceiling effect" also seemed to exist. For question #1 and #3, the mean scores were 4.44/5 and 4.46/5, or 88.89% and 89.17 % respectively ( $SEM = .14$  and  $.14$ ). Approximately three quarters (74% and 76% respectively, see Table 5.3) of the learners earned full credits for these two questions. Such a high percentage of full credits might have reduced the sensitivity or discrimination ability of those test questions, which might also lead to the non-significant differences between groups.

Table 5.3: Applying Test Scores and Item Difficulty Index

<b>Question</b>	<b>Q#1</b>	<b>Q#2</b>	<b>Q#3</b>	<b>Q#4</b>
Points	5	10	5	15
Mean	4.44 <b>88.89%</b>	6.88 <b>68.75%</b>	4.46 <b>89.17%</b>	10.65 <b>71.02%</b>
SEM	.14	.32	.14	.32
# of learners that scored 100% pts	53 <b>73.61%</b>	12 <b>16.67%</b>	55 <b>76.39%</b>	5 <b>6.94%</b>
# of learners that scored 90% pts	53	28	55	12
Item Difficulty Index	<b>.74</b>	<b>.39</b>	<b>.76</b>	<b>.17</b>

Another factor that may have contributed to the non-significant results was the individual differences. It is likely that some participants were good at learning and would perform better in the learning tests no matter which tutorial was given to them. The positive correlation between Remembering and Applying test scores [Pearson's  $r(70) = .41, p < .001$ ] supported such individual differences. The study was originally designed to use Learner Course Motivation (the MSLQ score) as a covariate to account for the individual learning abilities, based on some previous studies that suggested positive correlations between MSLQ score and learning achievements (Duncan & McKeachie, 2005; Pintrich et al., 1993). However, the MSLQ score was not found to be correlated with the Learning Performance score in this study. Thus the covariate was eliminated from the models of statistical analyses. As a result, no other variables in this study could be used to account for the individual differences in learning.

The lack of correlation between MSLQ and Learning Performance scores also supports the *state-trait* theory of motivation that learners' motivation toward the overall course does not necessarily relate to their motivation or performance in a specific learning task. A highly motivated and self-regulated learner (*trait*) may or may not be engaged in a certain instructional material or learning activity due to the specific learning situation (*state*) that the material or activity creates, and vice versa.

One interesting result from the Applying test was that learners in the UM group achieved a significantly higher score than those in the baseline B group only for the last essay question (Q#4) (see Section 4.3.2). The essay question provided a scenario of a painting shop and

asked the learner to discuss appropriate protective measures to safeguard workers' safety against acetone, a toxic chemical. The significant difference between treatment groups suggested further investigation of this question and how it was different from the other three questions. First of all, from Table 5.3, Q#4 had the lowest Item Difficulty Index. Item Difficulty Index was calculated as the number of learners that scored equal or more than 90% of the points of this question, divided by the total number of learners. The lower the Item Difficulty Index, the more difficult is the question. Thus Q#4 was considered as the most difficult question of the Applying test.

From another perspective, to answer this essay question Q#4, learners usually needed to write down much more words than the other three short answer questions. In other words, Q#4 requires more "effort" from the learners. According to motivation theories (Keller, 1983), effort is a more direct indicator of motivation than performance. A further investigation of the word count of answers to Q#4 suggested significant group differences,  $F(2, 68) = 3.90, p=.02$ . Learner answers from group UM had the most words (Group UM:  $M = 129.96, SEM = 12.69$ ; Group U:  $M = 87.25, SEM = 9.27$ ; Group B:  $M = 107.54, SEM = 9.27$ ). One possible explanation of such difference was that learners in the UM group was more motivated while learning the tutorial, and thus were willing to spend more effort while doing the tests.

The essay question Q#4 asked learners to propose appropriate protective measures against the toxic acetone for the painting shop. While categorized as an Applying question, this question actually required learners to think about the real workplace situation, the hazard level of acetone, and make specific protective plans based on a number of protective measures described in the tutorial. In some sense, this test question involves some of the "creating" level of learning according to Bloom's revised taxonomy (Anderson & Krathwohl, 2001). It requires "putting elements together to form a coherent or functional whole" (pp. 67-68). Based on Bloom's revised taxonomy, the "creating" level is the highest level of learning. The significant group difference found in this study supported earlier research that learner motivation is associated with higher-order learning or thinking (Donald, 1999; Stoney & Oliver 1999).

## 5.6 Gender Difference

Another interesting result from this study was the gender difference in motivation. In the online training environment used in this study, female participants were more motivated than males in all four subscales of motivation as well as the overall motivation (Section 4.1.4). This was accordance with Price's (2006) study which found that females studying online were more academically engaged in terms of self-confidence ( $p = .001$ ), more willing to learn from other students ( $p = .023$ ), and achieved better learning ( $p = .001$ ). Similarly, Lim & Kim (2002) found that females obtained significantly higher learning and learning applications scores than males ( $p < .01$ ). They also found that female and male students had utilized different learning strategies throughout the online course.

Recently, there has been considerable research interest in issues related to gender and the online learning environment. Some evidence suggests that male and female college students experience the online learning environment differently (M. Allen, 1994; Selfe & Selfe, 1994; Sullivan, 1999, 2001; Wojahn, 1994; Wolfe, 1999). Sullivan (2001) also found that online courses are of great value to nontraditional students, particularly female adult learners with children or family responsibilities. The findings of this study supported such differences and provided empirical data regarding motivational differences between males and females in the self-paced online learning environment. It seems clear that with proper design, online courses can benefit a wide variety of students, both males and females. Female students are in no disadvantage in an online learning environment compared with male students. Females can learn better, be more motivated and attain higher achievements.

The result from this study that females were more motivated than males, may be biased due to the fact that most of the participants were engineering junior and senior undergraduate students. According to Brainard & Carlin (1997), most women undergraduates who drop out or switch from engineering and science programs would do so by the end of their sophomore year; and for those who remain, the retention rates are very high. This indicates that the junior and senior female participants, who choose to continue in engineering, are likely to be those with higher academic achievement or motivation. More recent research studies suggest that female engineering students applies more effort in their studies (Vogt, Hocevar &

Hagedorn, 2007; GRG, 2002), and they are performing well, or even better than male students, in terms of persistence and GPA (NCES, 2000).

## **5.7 The Learning Environment**

This study was conducted in the laboratory environment. Participants were asked to come to the lab and complete the training tutorial using one of the lab computers. Before the study, it was suspected that participants might learn differently in such a lab environment compared with real life situations. Thus efforts had been made to make participants feel as comfortable as possible. Each participant was provided with a private room to learn the tutorial by him/herself. No time limits were given and participants were encouraged to take breaks whenever they wanted to. Feedbacks from the post-session questionnaire showed little environmental impacts on learning behavior. When asked what they would do differently if they were learning the tutorial in a place of their choice, the top response was “nothing different” (Figure 4.7). While some commented that the lab environment was quieter and free of distractions, the majority of participants indicated that in real-life, they would also select a quiet place without distractions such as their own room or library or computer lab (Figure 4.6). Therefore the results from this study can serve as a valid reference for real-world online learning situations.

It is also important to note that the learning environment plays a significant role in one’s learning. From the view of situated learning and context-based learning (Lave & Wenger 1991; Suchman 1987), learning takes place in the context and the environment shapes the learning process to create meaning. In addition, learning that takes place in one situation or “state” is generally better remembered later in a similar situation or state, known as “state-dependent learning”. Such state can include environmental context, physical state, emotional state, and sensory modality (Myers, 2006). Research studies suggest that people perform better when state is congruent during learning and tests (M.S. Clark, Milberg & Ross, 1983; Marian & Neisser, 2000; Schramke & Bauer, 1997). While learners in this study didn’t report much difference in their learning behaviors between lab and real-life situations, it is still possible that the laboratory environment in this study could have led to a response bias in learner motivation or learning performance.

Interestingly, several participants reported that they would like to listen to music while learning online. As a type of sensory stimuli, music has been found to be of special influence on human emotion (Elliott 1995; Griffin 2006; Handel 1989; Menuhin & Davis, 1979). A body of research has also been conducted into the physiological, psychological and cognitive effects of background music on human beings. Through recent advances of biomedical technologies such as fMRI (functional magnetic resonance imaging) and PET (positron emission topography), neuroscientists have discovered that music is capable of inducing emotions, both unpleasant and pleasant emotions, with a fairly strong intensity (Koelsch 2005). The emotional arousal induced by music was also considered to have effects on learning and task performance. Davidson and Powell (1986) conducted experiments on the effects of background music in the science classroom and found an increase in task performance as a result. Cockerton, Moore and Norman (1997) found that background music facilitated cognitive test performance. More questions were completed and more answers were correct compared with the control condition of no music. In a more recent study on computer task performance (Phillips, 2004), it was found that participants in the Classical music condition performed better on the problem-solving task than those in the Punk music or No music conditions.

With recent advances in digital music technology and portable/personal music-playing devices, more people are listening to background music while doing their daily activities than ever before. The associations among music, emotion and learning or computer task performance pose implications for designing an online learning environment. Hallam, Price and Katsarou (2002) suggest that background music can be used to increase or maintain learner arousal levels for study purposes. It should be noted though that people respond to music differently. The constituents of the music itself (e.g., tempo, tonality, texture, volume, form and melodic range) may determine the arousal degree on the listener (Griffin 2006). The personality profile is an additional factor which must be taken into account. Extroverts are likely to desire relatively high levels of arousal and introverts have a lower threshold than extroverts in tolerating background music and noise (Cassidy and MacDonald, 2007). It would seem that less complex music would best fit for a learning environment full of mixed personalities (Griffin 2006). While not all learners will benefit directly from the background music, they may also benefit from the reduced distractions. As discussed above, most

participants in this study preferred to study in an environment free of distractions. Background music and the emotional influence of the online learning environment is a challenging but interesting direction in e-learning design and more future studies are needed in this area.

## **5.8 Motivation, Usability and Instructional Design and Technology**

Despite its well-recognized importance in learning and education, motivation had been the neglected “heart” of instructional technology (Keller, 1979, p.27), which was reflected by the little attention and coverage in literature and textbooks of educational technology and instructional design (Spitzer, 1996). Motivating learners is especially challenging in online learning or other settings where learners are at distance. “The attrition rate alone can be viewed as an indication of motivational problems.” (Keller, 1999, p. 43) Whilst many realize that course design is one of the factors that influence learner motivation (Cornell & Martin, 1997) and simply placing lecture content on Web pages makes no contribution to active learning (Bostock, 1997), few understand how to deal with motivation systematically.

Similar situations are faced by usability practices in the e-learning context. On the one hand, the importance of usability and its testing/evaluation process have been discussed in several e-learning design guides and books. Usability methods have also been applied in many newly-published e-learning design applications. On the other hand, current usability practices are still largely restricted to those measurements based on software use, which may not be able to reflect all facets of users’ learning experiences, and are criticized as not being able to fit the e-learning context (Notess, 2001; Squires & Preece, 1999). In addition, few instructional design models take the problems of the user interface design into account in their evaluation process (Nam & Smith-Jackson, 2007).

Results from this study demonstrated the benefits of integrating usability and motivational design process into the interface design of an online self-pace tutorial. The final design (UM) that involved both usability improvement and motivational design significantly improved learner motivation compared with the baseline interface (B). The study also revealed positive correlations between some usability and motivation measures. All of the above suggested the need for the incorporation of both usability and motivational approaches

in design of e-learning systems. The process for developing interface U and UM used in this study can be a good reference for future research to develop systematic design models that integrate the two processes.

This study was designed based upon the concept that if instruction itself cannot be easily revised, systematically designed online tutorial interface can help improve motivation. The interface designs in this study did not touch upon the main instructional configurations of the original tutorial, such as content, structure, organization, pictures, quizzes, course tests, etc. From a more holistic view of online tutorial design that includes not only the interface design, but also other aspects such as content, learning support and implementation, the design changes and improvements applied to only interface design in this study were very limited. While such treatment successfully improved learner motivation in this study, the design process in this study was only a supplementary approach. In fact, results from this study also suggested that other tutorial design aspects besides interface design have impacts on some learner motivation components (Section 4.1.5). Therefore, it is recommended that for developing a new online instructional material, factors related to all aspects of the tutorial are carefully considered. It is more beneficial to revise those aspects whenever feasible to include more interactive motivational tactics and strategies. The process of usability and motivational design should also be vigorously integrated into the entire instructional design process, from early learner analysis, to design, development, implementation and evaluation.

## **5.9 Design Recommendations and Implications**

### *5.9.1 Focus on attention*

Attention is one of the four motivation constructs in the ARCS model and is also a “prerequisite for learning” (Keller 1987a, p. 3). This study reveals that interface design can significantly affect learner attention in the self-paced online learning environment (see Section 4.1.3). A number of interface design factors or features are also considered to be associated with attention (see Section 4.1.5). These findings support previous research studies that suggested significant improvement of learner attention by applying ARCS-based motivational design to computer aided instruction (Song & Keller, 2001) or technology mediated instruction (Gabrielle, 2005).

As discussed in Section 5.2, attention getting and attention sustaining are both important for learning in the online environment. According to Keller (1987c), attention getting strategies can be summarized in three categories: perceptual arousal, inquiry arousal, and variability. Earlier research studies have proposed several attention strategies or tactics (Keller 1983, 1987c; Keller & Burkman, 1993; Keller & Suzuki 1988), but most of them are recommendations relating to the general design of instruction and cannot be directly applied to interface design. Based on the results and observations of this study, those strategies and tactics were re-examined and summarized. The strategies that are considered specifically relevant to interface design were selected and provided with design examples (Table 5.4). These are considered as general attention strategies recommended specifically for interface design of online self-paced tutorials. Detailed recommendations by interface design components will be discussed in the next section.

Cares must be taken when using the attention strategies listed in Table 5.4. First of all, these attention strategies are derived from only a fraction of the available motivation strategies. While these are the attention strategies that are considered most relevant to interface design, design decisions should not be based on only these strategies. Other tutorial design components besides interface design and the motivation strategies relevant to those components need to be considered as well. For example, using real-life examples, conflicting opinions or facts may also help to stimulate curiosity and attention. Sometimes these may work better than simply presenting a sudden sound or flashy object. Secondly, when applying motivation strategies, more is not always better. Too much motivation strategy use may distract learners from the actual instructional content. Especially for those learners who are already highly motivated, the motivational treatments may pose great distraction to them or even annoy them. Song and Keller (2001) developed a “motivationally adaptive” design that resulted in better performance than “motivationally saturated” design. Lastly, some of these attention strategies have conflicts with traditional usability guidelines. For example, variation of the interface presentation may help catch attention but violate the design guideline of consistency, which might lead to user confusion or other usability problems. Requiring the learner to move his/her mouse constantly may help keep him/her attentive, but it may also reduce efficiency. Compromising decisions need to be made in order to address these issues.

Table 5.4: Recommended Attention Strategies for Interface Design

<b>Selected Attention Strategies</b>	<b>Design Examples</b>	<b>Relevant Code from This Study</b> (see Table 4.4 & 4.5 for details)	<b>Strategies and Recommendations from Literature</b>
<b>Perceptual Arousal</b>			
Use novel and incongruous design elements or abrupt changes to catch attention.	-- Sounds -- Animations -- Videos -- Interesting pictures -- High-contrast color -- Large bolded fonts	Overall: color/style/appearance Text Appearance Graphics/Multimedia	Gain and maintain student attention by the use of novel, surprising, incongruous, or uncertain events in instruction. (Keller & Suzuki, 1988)
Make the layout of the page easy to perceive in order to maintain attention	-- Place the headings at top center -- Avoid crowded display -- Reduce prose text and use bullets and/or lists instead -- Use familiar fonts	Overall : easy-to-use Page Layout Paging/Scrolling Navigation	
Place eye-catching features as early as possible in the tutorial to create early interest	-- Use animated characters in the introduction section	Homepage Graphics/Multimedia	Create interest as early as possible to gain learner attention. (Keller & Burkman, 1993)
<b>Inquiry Arousal</b>			
Provide help and prompt learners to seek help or generate questions using screen features, in order to stimulate an attitude of inquiry.	--Use a flashing arrow or question mark to point to the links of supportive information -- Provide an open field in which to type or email questions	Overall: color/style/appearance	Stimulate information seeking behavior by posing, or having learner generate questions or a problem to solve. (Keller & Suzuki, 1988)
<b>Variability</b>			
Avoid monotonous layouts page after page. Vary the presentation of content to stimulate attention and curiosity.	-- Change the background colors for different sections -- Vary the position of texts and/or graphics on different pages	Overall: color/style/appearance Page Layout	Maintain student interest by varying the elements of instruction. (Keller & Suzuki, 1988)
Use interactive features and prompt mouse movements or clicks in order to stimulate and sustain attention.	-- Use an interactive game or quiz question that encourages the learner to move the mouse and click on different areas of the screen	Learning Support: Quiz Questions	

### 5.9.2 *Recommendations for interface design*

This study identified six sub-categories of interface design components (overall appearance, graphics/multimedia, navigation, page layout, text appearance, and paging/scrolling) that were associated with motivation components (see Section 4.2.3 Table 4.5). These associations provided practical implications for the design of self-paced online tutorials. Based on these six categories, 14 recommendations were proposed for interface design of online self-paced tutorials (Table 5.5). These recommendations are different from traditional usability guidelines in that each recommendation is targeted to one or more motivation components. Research evidences from this study and literature were also provided for references. It is hoped that designers adopting any of these recommendations would keep in mind what motivation components would be affected by implementing the design.

In Table 5.5, the first column of the table describes the design recommendations. The second column indicates the targeted motivation components of the recommendation. The third column shows the related codes and frequencies. The fourth column provides relevant sample quotes of learner comments from this study, which indicate learner preference or usability problems. The last column includes the related research findings and design recommendations from the literature.

Note that the design recommendations provided in Table 5.5 are some highlighted design considerations based on the limited results from this study. They are not a complete set of design guidelines and should not be taken as the single source of reference for design decisions. Interface design and motivation is still an emerging field of research. The recommended strategies here can be viewed as a preliminary step toward developing a comprehensive set of design guidelines. Some of the recommendations from this study are still very general. Further studies are required to explore and verify the associations between design and motivation, and develop detailed guidelines. The recommendations are intended specifically for online self-paced tutorials for learners 18 years or older. Care must be taken if recommendations are applied outside these bounds. Designers are also cautioned that design choices work in concert and a change in one aspect can impact other areas. To assess a particular design, usability testing and/or motivation evaluations are recommended. It is also important to consider the full range of target audience including age groups, Internet skills, prior experiences, etc.

Table 5.5: Recommendations for Interface Design of Online Self-paced Tutorials

<b>Design Recommendation</b>	<b>Target Motivation Components</b>	<b>Code [Freq]</b>	<b>Learner Comments from This Study (sample quotes)</b>	<b>Related Research Findings and Design Recommendations from Literature</b>	
<b>Overall Appearance</b>					
1	Use fresh and clean color scheme and overall style to create positive first impression. For long tutorials consisting of multiple sections, consider varying color and/or style between sections.	Attention Satisfaction	color/style/appearance [40]	The tutorial looked rather bland.  It caught my attention because it had a nice visual style.	Changes in the organization and presentation of content can stimulate the learner's attention and curiosity. (Keller & Burkman, 1993)
2	Make the overall design simple and easy-to-use, in order to maintain attention and increase satisfaction.	Attention Satisfaction	easy-to-use [25]	I was not looking forward to the tutorial, however as I was going through(,) the layout, design, and activities made it easy and enjoyable.	Make initial perception of courseware seem easy, rather than difficult, to read and use in order to gain and maintain attention and to build confidence. (Keller & Burkman, 1993)
3	Ensure the Web site looks professionally designed to increase credibility.	Attention Confidence	credibility/professionalism [3]	The tutorial did not look professional so I immediately questioned it's (its) credibility.	Optimize the credibility of information-oriented Web sites. (HHS & GSA, 2006) Learner confidence and efforts to succeed are increased in proportion to the perceived credibility of the source. (Keller & Burkman, 1993)
<b>Graphics/Multimedia</b>					
4	Use colorful pictures, graphics, animations or flash.	Attention Satisfaction	Graphics/Multimedia [73]	It caught my attention because it was colorful, included pictures, and had that guy with glasses that said some things.	Include graphics that make courseware easier to interpret and use in order to maintain learner attention and to build confidence. (Keller & Burkman, 1993) Animation attracts users' attention and facilitates quicker location of the flashed target item in tightly packed screen displays. (Hong, Thong & Tam, 2004)
5	Use animation only sparsely and meaningfully at key points of instruction, such as the very	Attention Mental Effort Satisfaction	Graphics/Multimedia [73]	Pictures say 1000 words and they are helpful in conveying the message.	Multimedia elements (such as video, animation, and audio) can easily capture the attention of users; therefore, it is important to have clear and useful

<b>Design Recommendation</b>	<b>Target Motivation Components</b>	<b>Code [Freq]</b>	<b>Learner Comments from This Study (sample quotes)</b>	<b>Related Research Findings and Design Recommendations from Literature</b>
beginning of the course or the middle of a long section.	Persistence		It was cute and helpful to my drive to have the "little guy" pop up mid way and say that I was half way there and to keep going. it made me laugh and broke up the feeling of having so far to go.	reasons for using multimedia to avoid unnecessarily distracting users. (HHS & GSA, 2006) Create interest as early as possible to gain learner attention. (Keller & Burkman, 1993)
<b>Navigation</b>				
6 Provide progress indicators to let learners know where they are and how far to go.	Satisfaction Persistence Mental Effort	provide feedback on user's location [18]	On the top of the page, I could see how far along I was, so I knew if I just went on a little further, I would be able to finish soon.	Feedback on users' location provides users with the information they need to understand where they are within the Web site, and for proceeding to the next activity. (HHS & GSA, 2006)
7 Always provide navigational options grouped in a consistent and easy to find place and let learners control the pace of learning.	Satisfaction Persistence Mental Effort Confidence	Navigation [39]	I never felt frustrated. I knew what buttons to click in order to continue the tutorial.  It supported my persistence by making it easy to navigate and understand.	Do not create or direct users into pages that have no navigational options. Clearly differentiate navigation elements from one another, but group and place them in a consistent and easy to find place on each page. (HHS & GSA, 2006) Include learner options to promote an internal sense of control on the part of the learner. Allow learners to go at their own pace to increase motivation and performance. (Keller & Burkman, 1993) Using techniques that offer personal control supports learner confidence. (Keller, 1987c)
8 Provide alternative ways of navigation when appropriate, e.g., a clickable status bar and a drop-down menu.	Satisfaction Persistence Mental Effort Confidence		Knowing my status (help with my persistence) and the site does that many ways with the progress bar on the top and progress counter at the bottom right.	

<b>Design Recommendation</b>	<b>Target Motivation Components</b>	<b>Code [Freq]</b>	<b>Learner Comments from This Study (sample quotes)</b>	<b>Related Research Findings and Design Recommendations from Literature</b>	
<b>Page Layout</b>					
9	Avoid cluttered displays and design the layout to make the structure of the instructional text explicit.	Satisfaction Attention Mental Effort Persistence Relevance Confidence	Page Layout [38]	<p>The tutorial was good at showing the overall structure, which increased my persistence to finish the course.</p> <p>The layout was east to follow, so I didn't have to hunt for information.</p> <p>The layout was effect(ive) and logical which appealed to my need for clarity.</p> <p>It supported my confidence in that I felt it was easy for me to learn with the layout it had, ...</p>	<p>Create pages that are not considered cluttered by users. (HHS &amp; GSA, 2006)</p> <p>Layouts for courseware should be designed primarily to make the structure of the text explicit. Careful use of white space is an important tool for making the structure of instructional text explicit. (Keller &amp; Burkman, 1993)</p>
10	Place headings at top center.	Attention Satisfaction	heading/label [2]	<p>Caught my attention because ... the font was big, with a topic at the top, and a picture on the side.</p>	<p>Put the most important items at the top center of the Web page to facilitate users' find the information. (HHS &amp; GSA, 2006)</p> <p>Prominent titles and headings can make the structure of instruction explicit and improve learning from prose materials. (Keller &amp; Burkman, 1993)</p>
<b>Text Appearance</b>					
11	Use dark text on plain background to facilitate reading and maintain learner attention.	Attention Mental Effort	Text Appearance [32]	<p>The blue screen with the yellow and red text was actually kind of difficult to read.</p>	<p>When users are expected to rapidly read and understand prose text, use black text on a plain, high-contrast, non-patterned background. (HHS &amp; GSA, 2006)</p>
12	Use 8-10 words per line and at least 12-point familiar font make text easier to read and maintain attention.	Attention Mental Effort	Text Appearance [32]		<p>Use a familiar font to achieve the best possible reading speed. Use at least a 12-point font on all Web pages. (HHS &amp; GSA, 2006)</p> <p>Use a familiar typeface and size that follow standard typesetting conventions to maintain learner attention. Make each line around eight to ten words and 10- to 12- point type to make text easier to read, maintain</p>

<b>Design Recommendation</b>	<b>Target Motivation Components</b>	<b>Code [Freq]</b>	<b>Learner Comments from This Study (sample quotes)</b>	<b>Related Research Findings and Design Recommendations from Literature</b>
13 Use larger, bold or colored font for headings and keywords to attract attention.	Attention Mental Effort	Text Appearance [32]	Caught my attention because ... the font was big, ... Bolded and highlighted words that stick out to me so that I do not have to read entire paragraphs.	learner attention, and increase confidence. (Keller & Burkman, 1993) Use bold text only when it is important to draw the user's attention to a specific piece of information. (HHS & GSA, 2006)
<b>Paging/Scrolling</b>				
14 Break up information into smaller portions and reduce the need of scrolling.	Mental Effort Attention Persistence	Paging/Scrolling [18]	The tutorial was easy to follow with just enough information on each page which helps in learning each concept or term. It supported my persistence because each slide was relatively short so it feels like you're accomplishing something when you learn a slide.	If users' system response times are reasonably fast, use paging rather than scrolling. Scroll fewer screenfuls. (HHS & GSA, 2006) Use relatively short text segments to convey a less formidable image than long segments in order to maintain attention and to build confidence. (Keller & Burkman, 1993)

## 5.10 Limitations

This study recruited participants who were all college engineering students and most of them were juniors and seniors majoring in the same academic program. This relatively homogeneous group might have made it easier for the design of interface and selection of effective motivational strategies, but the results were hard to be generalized to a larger population with a wider range of age, education level, economic status and past experiences. In fact, a couple of latest studies have discussed the cross-cultural differences in online learning motivation (Clem, 2004; Lim 2004). Further research is needed to involve diverse learners especially those in the workplace with working experiences and study their motivational experiences with the online training tutorial.

This study used an existing online safety training tutorial as the baseline in the experiment. The format and design of the original tutorial limited the potential range of motivational strategies that could be applied. For example, after training, some participants commented on the lack of audios or videos for more motivational features. The experiment also constrained that the overall structure, picture use, quiz questions, and wording of instructional contents were kept constant across the three groups. Thus some important motivational strategies (Keller & Suzuki 1988), such as using familiar real-world examples, presenting explicit learning requirements and providing hands-on practices were not used. The limited strategy use may have contributed to the smaller variances in motivation among treatment groups. In addition, the *remembering* test was limited by the original course test, as the validity of the latter was unknown.

Motivation assessment was administered immediately after training by self-report methods. The reported perceived motivational level might have been different from participants' actual experience and might not reflect the possible long-term benefit (Keller & Suzuki, 2004) to the motivational enhancement. In addition, some items of the IMMS questionnaire used showed relatively low item reliability. As a result, one item (#26) was dropped and the Cronbach's alpha coefficient of Relevance subscale was increased to .71. Also the Confidence subscale had an  $\alpha$  value of .67, which was still below the recommended level of .70 (Nunnally, 1978). Some researchers also criticized the IMMS for its unstable

validity influenced by the instructional material used (Huang, Huang, Diefes-Dux & Imbrie, 2006).

This study used open-ended questions in the post-session questionnaire to collect learners' feedbacks regarding the tutorial design and the impacts on their motivation. This method provided valuable data that were successfully triangulated with the quantitative statistical analysis to answer some of the research questions. However, during the coding process of those responses, it was found that most of the learners' responses were rather short and general. Many learners mentioned the "design" or "content" or "tutorial", but few provided enough details into the exact aspects of design. Thus relatively little information regarding design features could be inferred from the responses. A possible reason for the lack of details is that the questionnaire consisted of ten questions, and participants were not able to spend much time on each question. While those questions were necessary for the purpose of this study to obtain the holistic view of motivation vs. tutorial design, future studies with more focused objectives could possibly consider reducing the number of questions or using alternative data collection method such as interview or focus group.

## 6 CONCLUSIONS

### 6.1 Usability, Motivation and Online Learning

In a self-paced online learning environment, a usable and motivating interface is desirable for learners; however, creating such an interface can be challenging for designers. Both motivation research and usability studies have endeavored to improve the design of online instruction and enhance learners' learning experience, from different perspectives. While a few discussions have been documented in literature involving motivation or usability concepts into one another (Shilwant & Haggarty, 2005; Zaharias, 2006), little empirical evidence is available to demonstrate how motivational design and/or usability improvements may affect learners' learning experience. Few studies have been conducted to show how motivation and usability methods may work together in computer-based learning environments, especially in the relatively new but rapidly growing field of online learning.

This study was the first that applied both motivational design and usability approaches into the design of self-paced online tutorials and examined the effects through experiments. The study addressed *how motivational design and usability improvement could affect learner motivation and learning performance in the self-paced online learning environment*. Results from this study filled the current lacunae in experimental data in the self-paced online learning environment, and demonstrated the benefits of usability engineering and the ARCS-based motivational design. The study also explored *the interrelationships between commonly-used usability measures and ARCS-based motivation measures*. The findings led to a new understanding of the associations between usability and learner motivation in online learning environments; and provide a basis for future studies to formally develop design guidelines and/or usability metrics in the e-learning context.

A three-group generalized randomized block design experiment was conducted with 72 college engineering students (mostly junior and senior undergraduate students) to evaluate an existing online safety training tutorial and two alternative designs. The methods and tools of usability and the ARCS-based motivational design model were used to develop the two alternative designs. Think-aloud methods, heuristic evaluation, subjective evaluation instruments, and open-ended questionnaires contributed to new knowledge related to usability and learner motivation in the self-paced online learning environment. Statistical

analysis, content analysis and the triangulation of qualitative data with quantitative data provided further insights of tutorial design and online learner motivation.

The experimental results suggested that usability improvement and motivational design, when applied together, can positively affect learner motivation in the self-paced online learning environment. In particular, significant difference in learners' *attention* was found between the group using the interface with both usability improvement and motivational design applied (UM) and the group using the baseline interface B (Section 4.1.3). Results supported previous research findings that suggested design effects on learner motivation in computer-assisted instruction (Song & Keller, 2001) and technology mediated learning (Gabrielle, 2005). It was also found that *interface design* was perceived as the most influential tutorial design factor that affects *attention*, among *content*, *learning support* and *implementation*.

A number of interface design components were identified as important factors for learner attention, such as overall appearance, graphics/multimedia, text appearance, and page layout. These interface design components, as well as some other components such as navigation and paging/scrolling, were also found to be relevant to other motivation components i.e., satisfaction, persistence and mental effort (Table 4.5). These results had implications for online tutorial interface design. Six attention-related strategies and 14 design recommendations were proposed (Section 5.7.2). Compared with other published usability guidelines and motivation strategies, the recommendations in this study provided a clearer connection between interface design and learner motivation.

As an exploratory investigation of the interrelationship between the three ISO-defined usability measures (effectiveness, efficiency, and satisfaction) and the four ARCS-based motivation measures (attention, relevance, confidence, and satisfaction), this study only found small to medium positive correlations between usability satisfaction and three motivation measures: Attention ( $r = .40$ ), Satisfaction ( $r = .30$ ), and Relevance ( $r = .25$ ). Effectiveness and efficiency were not found to be correlated with any of the four motivation measures. These correlation results suggested two important relationships between usability and motivation. First of all, usability and learner motivation are related in the online learning environment. Specifically, user satisfaction is related to multiple motivation components. This has implication to usability studies in the e-learning context. To improve user

satisfaction for an online learning application, learner motivation is an important factor that must be considered. Second, usability and motivational design are not equivalent or exchangeable approaches in e-learning design. Both are necessary for developing a good solution. By traditional usability methods alone, learner motivation components cannot be fully incorporated and some may be neglected such as *confidence*. Similarly, motivational design itself also cannot guarantee that the system is working in an effective and efficient way.

Results from this study suggested motivational differences between genders in the self-paced online learning environment. Females were more motivated than males in terms of the overall motivation score as well as each of the four subscales of *attention*, *relevance*, *confidence*, and *satisfaction*. The results supported prior research studies, which found that females studying online were more academically engaged and achieved better learning performance (Lim & Kim, 2002; Price, 2006). This gender difference serves as a reminder to the e-learning design community for the need to acknowledge both genders when designing an online learning application.

This study found no significant differences in learning performance among the three treatment groups using different interface designs. None of the usability or motivation measures was able to predict learning performance, either. These were contradictory with earlier research that suggested that motivation is either correlated with learning achievement scores (Keller 1987b; Pintrich & Schunk, 1996; Pintrich et al., 1993) or is a significant predictor of learning achievement (Sankaran & Bui 2001; Shih & Gamon, 2001; Waschull, 2005). The non-significant result of this study could be explained by the “selective learning” phenomenon, “ceiling effect” of the learning performance test, and the possible differences of effects that motivational design had on different levels of learning (see Section 5.3 for details).

Lastly, it was found in this study that the majority of participants would select a quiet place without distractions to do online learning activities, such as their own room or library or computer lab. Some also indicated that they would like to listen to background music while learning. Such factors were implicative for designing effective online learning environments.

From this research, instructional designers and usability professionals benefit from new understanding of learner motivation and usability in the self-paced online learning environment. Instructional designers have further data that confirm the effects of motivational design on learner motivation in online learning environments. This study also reveals that certain design elements have impacts on specific motivation components. Usability professionals benefit from additional knowledge to inform learner-centered usability practices in online learning. Learner motivation is an important factor that needs to be considered in usability practices. Interface design features affect learner motivation and learner motivation is closely associated with user satisfaction. The lists of attention strategies and design recommendations are informative for both instructional designers and usability professionals to select proper tactics or design features. It is hoped that this study will demonstrate the benefits of the integration of motivation and usability studies in the e-learning context. It is also hoped that online learners will gain an advantage with new tutorial designs that are easy-to-use, useful, engaging, enjoyable and inspiring for continuous learning.

## **6.2 Future Research**

Results from this study provide a launching point for many additional studies regarding usability and learner motivation in the self-paced online learning environment. The effects of usability improvement and motivational design on learner motivation found in this study need to be verified by additional empirical studies with a number of online tutorials and diverse learners. The tutorials should cover a wide range of topic areas with various levels of instructional objectives. The learners should include different age groups, cultures, background, experiences and socio-economic status.

Related to the effects of specific interface design features on learner motivation, this study highlighted a few general categories of design components such as overall appearance, graphic/multimedia, text appearance, navigation, etc. Future study should be directed to refine the understanding of the relationship between tutorial design and learner motivation. Each of the above categories needs to be further studied to find out how the relevant design features could contribute to the positive or negative impacts on learner motivation.

The design recommendations proposed from this study should be empirically verified. Guidelines with more details need to be developed. Existing motivational design strategies and tactics may also need to be re-examined for their targeted impacts on learner motivation. Some learner comments from this study suggested that some motivational design strategies may have impacts on some other motivation component besides what the strategy originally “intended” to affect. For example, animated character was designed to catch learners’ *attention*, but several learners commented that it also increased their *satisfaction*. For another example, some learners reported that the improvement of navigation and page layout, which were mainly designed to enhance their *confidence*, helped with their *persistence*. Further studies are required to explore and verify the effects of particular motivation strategies.

Established definitions and models of usability should be revisited for the online learning environment. Should motivation be included as an additional criterion besides effectiveness, efficiency, and satisfaction?

Related to instructional design and technology, how could current models be updated to include usability and motivation? Most usability, motivational design and instructional design models have similar phases such as analysis, design, development, and evaluation. Can those similar phases be combined? What is a practical way to incorporate needs and criteria from the three disciplines into a holistic model?

There is a wealth of opportunity for research into gender differences in the online learning environment. Why are females more motivated than males? Is it related to the learning strategies that they use? Or is it related to the type of learning tasks? What types of design features are preferred by females or males? How to design the online instruction to accommodate both genders? When assigning online students into groups or teams for instructional activities, what needs to be considered in order to balance the gender differences in motivation and encourage collaboration? Experimental studies may also consider using a factorial design experiment to compare the differences between males and females.

This study used self-reported methods for motivation assessment. Both standardized Likert-scale instruments and open-ended questionnaire were used. It remains somewhat undecided which type of method is better in terms of validity, reliability, sensitivity and feasibility for learners in the online environment. The standardized instruments had good

overall reliability, but the resulting score seemed not sensitive enough to detect the differences between treatment groups. The open-ended questionnaire provided valuable information regarding some specific design features, however, the responses were difficult to analyze and some were too general to be interpreted. Additional assessment methods need to be investigated for their feasibility to evaluate online learners. Objective measurements should be considered, such as tracking the number of drop-outs in an e-learning course. In practice, assessing motivation using multiple methods is recommended. When using open-ended questionnaires, reducing the length and number of questions may encourage more detailed responses. Other research methods such as semi-structured interview or focus group may also help to get details regarding learners' experience.

The assessment of motivation and learning performance in this study both evaluated short-term effects on learners, which were administered immediately after exposure to the tutorial. Future study should examine learning retention and long-term effect in motivation toward future learning.

The debate of media and learning is ongoing. Results from this study suggested interface design effects on learner motivation but not on learning performance, at least not in short term. It is still unclear whether certain interface design would have the "learning benefit" in a self-paced online learning environment. Future studies are needed in this area.

The animated character, or avatar, implemented in this study (Interface UM) received positive feedbacks from participants as being helpful to their attention, persistence and satisfaction. The animated character used in this study was a "male human". Some research studies showed gender differences in response to avatars. For example, Nowak and Rauh (2006) found that people preferred avatars that were both human and matched their own gender. Zambaka, Goolkasian and Hodges (2006) found that participants were more persuaded when the speaker was in an opposite gender. There were also evidences suggesting cultural differences in interpreting the facial expressions of an avatar (Koda & Ishida, 2006). Additional research is needed to study these differences in online learning environments.

The physical environment where learners would normally do online learning has implications for the design of virtual online learning environments. While the majority of participants in this study reported that they would prefer selecting a place "free of

distractions” to do online learning, the reality is, as indicated from the responses to the post-session questionnaire, that learners sometimes are not able to control or avoid those distractions, e.g., food, TV, email, instant messaging, cell phone calls, text messages, etc (Figure 4.8). Multi-tasking is also common nowadays among students. Some study suggested that students doing multiple tasks in classroom performed poorer on recall of lecture content compared with their non-multi-tasking counterparts (Hembrooke & Gay, 2003). It is also criticized that multi-tasking consumes time and energy on switching attention to multiple tasks and on making decisions of the switches (Adams, D., 2006). The design of future online learning may consider measures from two directions in order to accommodate multi-tasking: 1) Making the online tutorial more attractive and engaging so that students are willing to stay within the instructional content and are less likely to be distracted by other irrelevant tasks; 2) Allowing more learner-control of the learning process and making it easy for students to get back on track when switching from other tasks, e.g., making the tutorial self-paced, providing clear course structure or content map, offering automatic saving of session progress to resume later, etc.

When conducting studies of this area in the laboratory environment, efforts must be taken to make sure that the learners are comfortable and the environment can best simulate their actual experiences. Keeping each learner in a private room is desirable. Refreshments can be provided in the reception area. If the learning session is longer than an hour, easy finger food with no wrappings or pits can be provided at the learning desk, to minimize the distraction from learning. Even it is online learning, paper and pencil need to be provided for note taking. It is recommended to ask each learner their preferences before letting them start, so that their needs can be accommodated. This is also a good opportunity to let them know the “rules” or “no rules”. For instance, are they allowed to take a break as they wish, listen to music, receive cell phone calls, visit other website, or take notes using the notepad or other software on the computer?

Although studying online learner motivation can be challenging, the work is beneficial to solve real-life design problems of online learning applications. Most importantly, the result will help develop engaging, enjoyable and inspiring tutorials that benefit millions of online learners. Online learners can be at a distance with their face invisible and voice unheard, but their needs and frustrations are central to human factors professionals who care for them.

## REFERENCES

- Adams, D. (2006). Wireless laptops in the classroom (and the Sesame Street Syndrome). *Communications of the ACM*, 49(9), 25-27.
- Adams, S. J. (1963). Towards an understanding of inequity. *Journal of Abnormal and Social Psychology*, 67, 422-436.
- Alderfer, C. P. (1972). *Existence, relatedness, and growth*. New York: Free Press.
- Allen, E., & Seaman, J. (2006). Making the grade: Online education in the United States, 2006 [Electronic Version]. Retrieved 02-27-2006, from [http://www.sloan-c.org/publications/survey/pdf/making\\_the\\_grade.pdf](http://www.sloan-c.org/publications/survey/pdf/making_the_grade.pdf)
- Allen, M. (1994). Adventures with 'Robin Hood': Gender conflict on a first-year bulletin board. *Journal of Teaching Writing*, 13(1-2), 169-196.
- Anderson, L. W., & Krathwohl, D. R. (Eds.). (2000). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's Taxonomy of educational objectives*. New York: Longman.
- APA dictionary of psychology. (2006). Washington, DC: American Psychological Association.
- Ardito, C., Marsico, M. D., Lanzilotti, R., Levialdi, S., Roselli, T., Rossano, V., et al. (2004). *Usability of e-learning tools*. Paper presented at the Proceedings of the Working Conference on Advanced Visual Interfaces.
- ASTD. (2006). ASTD 2006 state of the industry report: executive summary [Electronic Version]. Retrieved 02-15-2007, from [http://www.astd.org/astd/research/research\\_reports](http://www.astd.org/astd/research/research_reports)
- Astleitner, H., & Hufnagl, M. (2003). The effects of situation-outcome-expectancies and of ARCS-strategies on self-regulated learning with Web-lectures. *Journal of Educational Multimedia and Hypermedia*, 12(4), 361-376.
- Astleitner, H., & Keller, J. M. (1995). A model for motivationally adaptive computer-assisted instruction. *Journal of Computing in Education*, 27(30), 270-280.
- Bach, P. M., & Lai, J. (2006). *Usability and learning in a speech-enabled reading tutor: a field study*. Paper presented at the CHI '06 Extended Abstracts on Human Factors in Computing Systems.
- Bandura, A. (1977a). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review*, 84(2), 191-215.
- Bandura, A. (1977b). *Social learning theory*. Englewood Cliffs, NJ: Prentice Hall.
- Bandura, A. (1994). Self-efficacy. In V. S. Ramachaudran (Ed.), *Encyclopedia of human behavior* (Vol. 4, pp. 71-81). New York: Academic Press.
- Barrett, E., & Lally, V. (1999). Gender differences in an on-line learning environment. *Journal of Computer Assisted Learning*, 15, 48-60.
- Bates, R., & Khasawneh, S. (2004). *A path analytic study of the determinants of college students' motivation to use online learning technologies*. Paper presented at the Academy of Human Resource Development International Conference (AHRD), Austin, TX. March 3-7, 2004. p.1075-1082. ED492503.
- Bohlin, R. M., Milheim, W. D., & Viechnicki, K. J. (1993). *Factor analyses of the instructional motivation needs of adult learners*. Paper presented at the Convention of Association for Educational Communications and Technology sponsored by the Research and Theory Division (15th), January 13-17, New Orleans, LA.
- Boling, E., & Frick, T. W. (1997). Holistic rapid prototyping for Web design: Early usability testing is essential. In B. H. Khan (Ed.), *Web-based instruction* (pp. 319-328). Englewood Cliffs, NJ: Educational Technology Publications.
- Bonk, C. J. (2002). Online training in an online world. *USDLA Journal*, 16(3).

- Bordens, K. S., & Abbott, B. B. (1996). *Research design and methods: A process approach* (3rd ed.). Mountain View, CA: Mayfield.
- Bostock, S. J. (1997). Designing Web-based instruction for active learning. In B. H. Khan (Ed.), *Web-based instruction* (pp. 225-230). Englewood Cliffs, NJ: Educational Technology Publications.
- Bouffard, T., Boisvert, J., & Vezeau, C. (1995). The impact of goal orientation on self-regulation and performance among college students. *The British Journal of Educational Psychology*, *65*, 317-329.
- Brainard, S. G., & Carlin, L. (1997). A longitudinal study of undergraduate women in engineering and science. In *Proceedings of the Frontiers in Education Conference, 1997*, 134-143.
- Brophy, J. E. (1983). Conceptualizing student motivation. *Educational Psychologist*, *18*(3), 200-215.
- Brown, K. G. (2005). A field study of employee e-learning activity and outcomes. *Human Resource Development Quarterly*, *16*(4), 465.
- Cassidy, G., & MacDonald, R. A. R. (2007). The effect of background music and background noise on the task performance of introverts and extraverts. *Psychology of Music*, *35*(3), 517-537.
- ChanLin, L.-J. (1994). *A case for assessing motivation from learning a computer-assisted instruction*. Report. Fu-Jen University, Taiwan. ED376803.
- Chiu, C.-M., Hsu, M.-H., Sun, S.-Y., Lin, T.-C., & Sun, P.-C. (2005). Usability, quality, value and e-learning continuance decisions. *Computers & Education*, *45*(4), 399-416.
- Chyung, S. Y. (2000). Systematic and systemic approaches to reducing attrition rates in online higher education. *American Journal of Distance Education*, *15*(3), 36-49.
- Clark, C. S., Dobbins, G. H., & Ladd, R. T. (1993). Exploratory field study of training motivation: Influence of involvement, credibility, and transfer climate. *Group & Organization Management*, *18*(3), 292.
- Clark, M. S., Milberg, S., & Ross, J. (1983). Arousal cues, arousal-related material in memory: Implications for understanding effects of mood on memory. *Journal of Verbal Learning and Verbal Behavior*, *22*, 633-649.
- Clark, R. E. (2001). Media are "mere vehicles". In R. E. Clark (Ed.), *Learning from media: Arguments, analysis and evidence*. Greenwich, CT: Information Age Publishing.
- Clem, F. A. (2004). *Culture and motivation in online learning environments*. Paper presented at the Association for Educational Communications and Technology, 27th. ED485100.
- CLO. (2006). 2006 Business intelligence industry report: executive summary [Electronic Version]. *Chief Learning Officer*. Retrieved 10-30-2006, from [http://www.clomedia.com/docs/CO\\_Biir2006\\_Summary\\_A.pdf](http://www.clomedia.com/docs/CO_Biir2006_Summary_A.pdf)
- Cockerton, T., Moore, S., & Norman, D. (1997). Cognitive test performance and background music. *Perceptual and Motor Skills*, *85*, 1435-1438.
- Colquitt, J. A., LePine, J. A., & Noe, R. A. (2000). Toward an integrative theory of training motivation: A meta-analytic path analysis of 20 years of research. *Journal of Applied Psychology*, *85*(5), 678-707.
- Cornell, R., & Martin, B. L. (1997). The role of motivation in Web-based instruction. In B. H. Khan (Ed.), *Web-based instruction* (pp. 93-100). Englewood Cliffs, NJ: Educational Technology Publications.
- Cousineau, T. M., Franko, D. L., Ciccazzo, M., Goldstein, M., & Rosenthal, E. (2006). Web-based nutrition education for college students: Is it feasible? *Evaluation and Program Planning*, *29*(1), 23-33.
- Dabbagh, N., & Kitsantas, A. (2004). Supporting self-regulation in student-centered Web-based learning environments. *International Journal on E-Learning*, *3*(1), 40-47.
- Dan, S. C., & Amanuel, G. T. (2005). Individual and contextual influences on multiple dimensions of training effectiveness. *Journal of European Industrial Training*, *29*(8/9), 604-626.
- Davidson, C. W., & Powell, L. A. (1986). The effects of easy-listening background music on the on-task-performance of fifth-grade children. *Journal of Educational Research*, *80*(1), 29-33.

- Dawn, S. C., Dennis, P. B., Kacmar, K. M., Patrick, M. W., & Gary, C. M. (2000). Training motivation in organizations: An analysis of individual-level antecedents. *Journal of Managerial Issues*, 12(3), 271-287.
- Dick, W., Carey, J. O., & Carey, L. (2005). *The systematic design of instruction* (6 ed.). Boston: Allyn & Bacon.
- Dillon, A., & Zhu, E. (1997). Designing Web-based instruction: A human-computer interaction perspective. In B. H. Khan (Ed.), *Web-based instruction*. Englewood Cliffs, NJ: Educational Technology Publications.
- Donald, J. G. (1999). Motivation for higher-order learning. In M. Theall (Ed.), *Motivation from within: approaches for encouraging faculty and students to excel* (pp. 27-36). San Francisco: Jossey-Bass.
- Duffy, V. G. (2000). *Toward online virtual safety training in the manufacturing and service industries*. Paper presented at the IEA2000/HFES2000, Proceedings of the XIVth Triennial Congress of the International Ergonomics Association and the 44th Annual Meeting of the Human Factors and Ergonomics Society. San Diego, CA. July 30-August 4, 2000. p.341-344.
- Duncan, T. G., & McKeachie, W. J. (2005). The making of the Motivated Strategies for Learning Questionnaire. *Educational Psychologist*, 40(2), 117-128.
- Eccles, J. S. (1983). Expectancies, values, and academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motives* (pp. 75-146). San Francisco: Freeman.
- Eccles, J. S., & Wigfield, A. (1995). In the Mind of the Actor: The Structure of Adolescents' Achievement Task Values and Expectancy-Related Beliefs. *Personality And Social Psychology Bulletin*, 21(3), 215-225.
- Elliott, D. J. (1995). *Music matters: A new philosophy of music education*. New York: Oxford University Press.
- Ettinger, A., Holton, V., & Blass, E. (2006). E-learner experiences: what is the future for e-learning? *Industrial and Commercial Training*, 38(4), 208-212.
- Evans, C., & Sabry, K. (2003). Evaluation of the interactivity of Web-based learning systems: principles and process. *Innovations in Education and Teaching International*, 40(1), 89-99.
- Feldstein, M. (2002). What is "usable" e-learning? *eLearn*, 2002(9), 2.
- Feldstein, M., & Neal, L. (2006). Designing usable, self-paced e-learning courses: a practical guide *eLearn Magazine* 2006(8), 1.
- Gabrielle, D. M. (2005). *The effects of technology-mediated instructional strategies on motivation, performance, and self-directed learning*. (Doctoral dissertation, Florida State University, 2005)
- Gemino, A., Parker, D., & Kutzschan, A. O. (2005). Investigating coherence and multimedia effects of a technology-mediated collaborative environment. *Journal of Management Information Systems*, 22(3), 97-121.
- Gibbs, G., & Simpson, C. (2005). Conditions under which assessment supports students learning. *Learning and Teaching in Higher Education*(1), 3-31.
- Goodman Research Group, Inc. (2002). A comprehensive evaluation of women in engineering programs. Retrieved June 3, 2002, from <http://www.grginc.com>.
- Goldstein, I. L., & Ford, J. K. (2002). *Training in organizations: needs assessment, development, and evaluation* (4 ed.). Belmont, CA: Wadsworth Group.
- Griffin, M. (2006). *Background Music and the Learning Environment: Borrowing from other Disciplines*. (Master's thesis, University of Adelaide, 2006). ED498430.
- Hallam, S., Price, J., & Katsarou, G. (2002). The effects of background music on primary school pupils' task performance. *Educational Studies*, 28(2), 111-122.
- Hamid, A. A. (2001). E-learning: Is it the "e" or the learning that matters? *Internet and Higher Education*, 4(3-4), 311-316.
- Handel, S. (1989). *Listening. An Introduction to the perception of auditory events*. Cambridge, MA: The MIT Press.

- Hembrooke, H., & Gay, G. (2003). The laptop and the lecture: The effects of multitasking in learning environments. *Journal of Computing in Higher Education*, 15(1).
- Herman, P., & Gomez, L. (2006). *Motivation in project-based classrooms: new measures better coupled to students' experiences*. Paper presented at the 7th International Conference on Learning Sciences, Bloomington, Indiana. 250-256.
- Herzberg, F. (1966). *Work and the nature of man*. Cleveland: World Publishing.
- HHS, & GSA. (2006). *Research-based Web design and usability guidelines*. U.S. Department of Health and Human Services (HHS), U.S. General Services Administration (GSA) <http://usability.gov/pdfs/guidelines.html>.
- Hillman, D. C., Willis, D. J., & Gunawardena, C. N. (1994). Learner-interface interaction in distance education: An extension of contemporary models and strategies for practitioners. *The American Journal of Distance Education*, 8(2), 31-42.
- Hodges, C. B. (2004). Designing to motivate: motivational techniques to incorporate in e-Learning experiences. *The Journal of Interactive Online Learning*, 2(3), 1-7.
- Hogge, J., & Sherlock, G. (2005). *Arrive online - A web based road safety and injury prevention resource*. Paper presented at the Road Safety Research, Policing and Education Conference 2005.
- Hong, W., Thong, J. Y. L., & Tam, K.-Y. (2004). Does animation attract online users' attention? The effects of flash on information search performance and perceptions *Information Systems Research*, 15(1), 60-86.
- Hornbaek, K. (2006). Current practice in measuring usability: Challenges to usability studies and research. *International Journal of Human-Computer Studies*, 64(2), 79-102.
- Horton, W. (2000). *Designing Web-Based Training*. New York: John Wiley & Sons.
- Hoskins, S. L., & van Hooff, J. C. (2005). Motivation and ability: Which students use online learning and what influence does it have on their achievement? *British Journal of Educational Technology*, 36(2), 177-192.
- Huang, W., Diefes-Dux, H., Imbrie, P. K., Daku, B., & Kallimani, J. G. (2004). *Learning motivation evaluation for a computer-based instructional tutorial using ARCS model of motivational design*. Paper presented at the 34th ASEE/IEEE Frontiers in Education Conference. Savannah, GA, October 20-23.
- Huang, W., Huang, W., Diefes-Dux, H., & Imbrie, P. K. (2006). A preliminary validation of Attention, Relevance, Confidence and Satisfaction model-based Instructional Material Motivational Survey in a computer-based tutorial setting. *British Journal of Educational Technology*, 37(2), 243-259.
- Inglehart, M. R., & Brown, D. R. (1987). *Gender differences in values and their impact on academic achievement*. Paper presented at the Annual Meeting of the International Society of Political Psychology (10th, San Francisco, CA). ED287134.
- Irizarry, R. (2002). Self-efficacy & motivation effects on online psychology student retention. *USDLA Journal*, 16(12).
- ISO 9241-11. (1998). *Ergonomic requirements for office work with visual display terminals (VDTs) -- Part 11: Guidance on usability*: International Organization for Standardization.
- ISO 13407. (1999). *Human centred design processes for interactive systems*: International Organization for Standardization.
- ISO/IEC 25062. (2006). *2006 Common Industry Format (CIF) for usability test reports*: International Organization for Standardization/International Electrotechnical Commission.
- Jarvela, S., & Niemivirta, M. (1999). The changes in learning theory and the topicality of the recent research on motivation. *Research Dialogue in Learning and Instruction*, 1, 57-65.
- Johnson, K. A., & Ruppe, J. (2002). A job safety program for construction workers designed to reduce the potential for occupational injury using tool box training sessions and computer-assisted biofeedback stress management techniques *International Journal of Occupational Safety and Ergonomics*, 8(3), 321-329.

- Kalyuga, S., Ayres, P., Chandler, P., & Sweller, J. (2003). The expertise reversal effect. *Educational Psychologist, 38*(1), 23-31.
- Karsenti, T., & Thibert, G. (1994). *The influence of gender differences on within-term changes in junior-college student motivation*. Paper presented at the Annual Meeting and Exhibit of the American Educational Research Association (New Orleans, LA). ED373837.
- Keller, J. M. (1979). Motivation and instructional design: a theoretical perspective. *Journal of Instructional Development, 2*(4), 26-34.
- Keller, J. M. (1983). Motivational design of instruction. In C. M. Reigeluth (Ed.), *Instructional-design theories and models: an overview of their current status* (pp. 383-434). Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.
- Keller, J. M. (1987a). Development and use of the ARCS model of motivational design. *Journal of Instructional Development, 10*(3), 2-10.
- Keller, J. M. (1987b). Development of two measures of learner motivation. Florida State University. Unpublished manuscript.
- Keller, J. M. (1987c). Strategies for stimulating the motivation to learn. *Performance and Instruction, 26*(8), 1-7.
- Keller, J. M. (1987d). The systematic process of motivational design. *Performance and Instruction, 26*(9), 1-8.
- Keller, J. M. (1999). Using the ARCS motivational process in computer-based instruction and distance education. In M. Theall (Ed.), *Motivation from within: approaches for encouraging faculty and students to excel* (pp. 39-47). San Francisco: Jossey-Bass.
- Keller, J. M. (2007). Motivation and performance. In R. A. Reiser & J. V. Dempsey (Eds.), *Trends and issues in instructional design and technology* (2 ed., pp. 82-92). Upper Saddle River, NJ: Pearson Education.
- Keller, J. M., & Burkman, E. (1993). Motivation principles. In M. Fleming & W. H. Levie (Eds.), *Instructional message design: principles from the behavioral and cognitive sciences*. Englewood Cliffs, NJ: Educational Technology Press.
- Keller, J. M., & Kopp, T. W. (1987). Application of the ARCS model of motivational design. In C. M. Reigeluth (Ed.), *Instructional theories in action: Lessons illustrating selected theories and models*. Hillsdale, NJ: Lawrence Earlbaum Associates.
- Keller, J. M., & Suzuki, K. (1988). Use of the ARCS motivational model in courseware design. In D. H. Jonassen (Ed.), *Instructional designs for microcomputer courseware* (pp. 401-434). Hillsdale, NJ: Lawrence Erlbaum Associates, Publisers.
- Keller, J. M., & Suzuki, K. (2004). Learner motivation and e-Learning design: a multinationally validated process. *Journal of Educational Media, 29*(3), 229-239.
- Kim, K.-J. (2004). *Motivational influences in self-directed online learning environments: A qualitative case study*. Paper presented at Association for Educational Communications and Technology, 27th, Chicago, IL. ED485041.
- Kim, K.-J., & Bonk, C. J. (2005). Surveying the future of workplace e-learning: the rise of blending, interactivity, and authentic learning. *eLearn Magazine, 2005*(6).
- Kincaid, J. P., Donovan, J., & Pettitt, B. (2003). Simulation techniques for training emergency response. *International Journal of Emergency Management, 1*(3), 238-246.
- Klein, H. J., Noe, R. A., & Wang, C. (2006). Motivation to learning and course outcomes: The impact of delivery mode, learning goal orientation, and perceived barriers and enablers. *Personnel Psychology, 59*(3), 665-702.
- Koda, T., & Ishida, T. (2006). Cross-cultural study of avatar expression interpretations. In *Proceedings of the 2005 Symposium on Applications and the Internet (SAINT'06)*. 207-220
- Koelsch, S. (2005). Investigating emotion with music. Neuroscientific approaches. *Annals of the New York Academy of Sciences, 1060*(1), 412-418.

- Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: University of Cambridge Press
- Lewis, J. R. (1995). IBM computer usability satisfaction questionnaire: psychometric evaluation and instructions for use. *International Journal of Human-Computer Interaction*, 7(1), 57-78.
- Liebel, G. (2006). Focusing on user motivation by usability testing with goals and tasks [Electronic Version]. Retrieved 10-20-2006, from <http://usability.about.com/od/usabilitytestingtips/qt/utgoals.htm>
- Lim, D. H. (2004). Cross cultural differences in online learning motivation. *Educational Media International*, 41(2), 163-175.
- Lim, D. H., & Kim, H. (2002). Motivation and learner characteristics affecting online learning and learning application. *Journal of Educational Technology Systems*, 31(4), 423-439.
- Locke, E. A. (1968). Towards a theory of task motivation and incentives. *Organizational Behavior and Human Performance*, 3, 157-189.
- Locke, E. A., & Latham, G. P. (1990). *A theory of goal setting and task performance*. Englewood Cliffs, NJ: Prentice-Hall.
- Lohr, L. L. (2000). Designing the instructional interface. *Computers in Human Behavior*, 16(2), 161-182.
- Lohr, L. L., & Eikleberry, C. (2001). Learner-centered usability: tools for creating a learner-friendly instructional environment. *Performance Improvement*, 40(4), 24-27.
- Main, R. G. (1993). Integrating motivation into the instructional design process. *Educational Technology*, 33(12), 37-41.
- Marian, V., & Neisser, U. (2000). Language-dependent recall of autobiographical memories. *Journal of Experimental Psychology: General*, 129(3), 361-368.
- Martinez, M. (2003). High attrition rates in e-learning: challenges, predictors, and solutions. *The e-learning developers' journal*, July 14, 2-9.
- Maslow, A. H. (1954). *Motivation and personality*. New York: Harper & Row.
- McManus, T. F. (2000). Individualizing instruction in a Web-based hypermedia learning environment: nonlinearity, advance organizers, and self-regulated learners. *Journal of Interactive Learning Research*, 11(3), 219-251.
- Mehlenbacher, B. (2002). Assessing the usability of on-line instructional materials. In R. S. Anderson, J. F. Bauer & B. W. Speck (Eds.), *Assessment strategies for the on-line class: from theory to practice*. San Francisco: Jossey-Bass.
- Menuhin, Y., & Davis, C. W. (1979). *The Music of Man*. New York: Simon & Schuster Inc.
- Meyen, E. L., Aust, R. J., Bui, Y. N., Ramp, E., & Smith, S. J. (2002). The online academy formative evaluation approach to evaluating online instruction. *Internet and Higher Education*, 5(2), 89-108.
- Mills, L. (1999). HazCom training goes hi-tech. *Safety and Health* 159(5), 50-59.
- Miltiadou, M., & Savenye, W. C. (2003). Applying social cognitive constructs of motivation to enhance student success in online distance education. *Educational Technology Review*, 11(1), 78-95
- Moore, M. G. (1989). Three types of interaction. *The American Journal of Distance Education*, 3(2), 1-6.
- Nahm, E.-S. (2005). Development and testing usability of theory-based, hip fracture prevention online learning modules. *Geriatric Nursing*, 26(6), 352-353.
- Nam, C. S., & Smith-Jackson, T. L. (2007). Web-based learning environment: A theory-based design process for development and evaluation. *Journal of Information Technology Education*, 6, 23-43.
- National Center for Educational Statistics. (2000). *Entry and persistence of women and minorities in college science and engineering education*. NCES 2000-601, by G. Huang, N. Taddese, E. Walter, & S. S. Peng. Washington, DC: Author.
- Neal, L., & Miller, D. (2005). The basics of e-learning: an excerpt from handbook of human factors in web design. *eLearn*, 2005(8), 2.

- Nielsen, J. (1993). *Usability engineering*. Cambridge, MA: Academic Press.
- Notess, M. (2001). Usability, user experience, and learner experience. *eLearn*, 2001(8), 3.
- Nowak, K. L., & Rauh, C. (2006). The influence of the avatar on online perceptions of anthropomorphism, androgyny, credibility, homophily, and attraction. *Journal of Computer-Mediated Communication*, 11, 153-178.
- Nunnally, J. C. (1978). *Psychometric theory* (2nd ed.). New York: McGraw-Hill.
- Paas, F. (1992). Training strategies for attaining transfer of problem-solving skill in statistics: A cognitive load approach. *Journal of Educational Psychology*, 84, 429-434.
- Pan, B., Gay, G., Saylor, J., Hembrooke, H., & Henderson, D. (2004). *Usability, learning, and subjective experience: user evaluation of K-MODDL in an undergraduate class*. Paper presented at the 4th ACM/IEEE-CS Joint Conference on Digital Libraries.
- Parlangeli, O., Marchigiani, E., & Bagnara, S. (1999). Multimedia systems in distance education: effects of usability on learning. *Interacting with Computers*, 12, 37-49.
- Patronis, M. (2005). Motivational constructs in an online learning environment in a UAE university [Electronic Version]. Retrieved 10-28-2006, from <http://www.admc.hct.ac.ae/emel2005/people/patronis/MP%20Paper2005.doc>
- Paulsen, M. B., & Feldman, K. A. (1999). Student motivation and epistemological beliefs. In M. Theall (Ed.), *Motivation from within: approaches for encouraging faculty and students to excel* (pp. 17-26). San Francisco: Jossey-Bass.
- Pavolka, R., Mount, V., Neymeyr, A., & Rhodes, C. (2005, November 6-9). *From waterfall to rapid prototyping: Supporting enterprise-wide adoption of the oncourse collaboration and learning (CL) environment at Indiana University*. Paper presented at the SIGUCCS'05, Monterey, California, USA.
- Perrin, D. G. (2005). Creative online learning environments. *International Journal of Instructional Technology & Distance Learning*, 2(4), 33-50.
- Phillips, C. (2004). Does background music impact computer task performance? [Electronic Version]. *Usability News*, 6, 1. Retrieved July 25, 2008, from <http://psychology.wichita.edu/surl/usabilitynews/61/music.asp>
- Phyllis, T. (2001). The relationship of training motivation to participation in training and development. *Journal of Occupational and Organizational Psychology*, 74(5), 599-621.
- Pintrich, P. R. (2000). The role of goal orientation in self-regulated learning. In M. Boekaerts, P. R. Pintrich & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 452-502). San Diego, CA: Academic Press.
- Pintrich, P. R., & Schunk, D. H. (1996). *Motivation in education: theory, research, and applications*. Englewood Cliffs, NJ: Prentice-Hall.
- Pintrich, P. R., Smith, D., A.F., Garcia, T., & McKeachie, W. J. (1993). Reliability and predictive validity of the Motivated Strategies for Learning Questionnaire (MSLQ). *Educational and Psychological Measurement*, 53(4), 801-813.
- Pintrich, P. R., Smith, D. A. F., Garcia, T., & McKeachie, W. J. (1991). *A manual for the use of the Motivated Strategies for Learning Questionnaire (MSLQ)*. The University of Michigan. (Technical Report No. 91-B-004)
- Porter, L. W., & Lawler, E. E. (1968). *Managerial attitudes and performance*. Homewood, IL: Irwin.
- Price, L. (2006). Gender differences and similarities in online courses: challenging stereotypical views of women. *Journal of Computer Assisted Learning*, 22, 349-359.
- Reeves, T. C., Benson, L., Elliott, D., Grant, M., Holschuh, D., Kim, B., et al. (2002). *Usability and instructional design heuristics for e-learning evaluation*. Paper presented at the World Conference on Educational Multimedia, Hypermedia & Telecommunications (ED-MEDIA 2002).
- Rotter, J. B. (1954). *Social learning and clinical psychology*. New York: Prentice-Hall.

- Rotter, J. B. (1966). Generalized expectancies for internal versus external control of reinforcement. *Psychological Monographs*, 80(1), 1-28.
- Rucker, N. P. (2003). Efficacy of Web-based training for office ergonomics. In *Ergonomics in the Digital Age. Proceedings of the XVth Triennial Congress of the International Ergonomics Association and the 7th Joint Conference of the Ergonomics Society of Korea and the Japan Ergonomics Society* (Vol. 5, pp. 4-4). Seoul, Korea, August 24-29, 2003.
- Rumpradit, C. (1999). An evaluation of the effect of user interface elements and user learning styles on user performance, confidence, and satisfaction on the world wide web. *Dissertation Abstracts International Section A: Humanities and Social Sciences*, 60(1).
- Ryu, Y. S. (2005). *Development of usability questionnaires for electronic mobile products and decision making methods*. (Doctoral dissertation. Virginia Polytechnic Institute and State University).
- Sankaran, S. R., & Bui, T. (2001). Impact of learning strategies and motivation on performance: A study in Web-based instruction. *Journal of Instructional Psychology*, 28(3), 191-198.
- Schmidt, J. T., & Werner, C. H. (2007). Designing online instruction for success: Future oriented motivation and self-regulation. *Electronic Journal of e-Learning*, 5(1), 69-78.
- Schramke, C. J., & Bauer, R. M. (1997). State-dependent learning in older and younger adults. *Psychology and Aging*, 12(2), 255-262.
- Schunk, D. H. (1991). Self-efficacy and academic motivation. *Educational Psychologist*, 26(3&4), 207-231.
- Schunk, D. H., Pintrich, P. R., & Meece, J. L. (2008). *Motivation in education* (3rd ed.). Upper Saddle River, NJ: Merrill Prentice Hall.
- Segall, N., Doolen, T. L., & Porter, J. D. (2005). A usability comparison of PDA-based quizzes and paper-and-pencil quizzes. *Computers & Education*, 45(4), 417-432.
- Selfe, C., & Selfe, R. (1994). The politics of the interface: Power and its exercise in electronic contact zones. *College Composition and Communication*, 45, 480-504.
- Semmar, Y. (2006). *Adult learners and academic achievement: The roles of self-efficacy, self-regulation, and motivation*. University of Qatar. ED491441.
- Shackel, B. (1991). Usability - context, framework, design and evaluation. In B. Shackel & S. Richardson (Eds.), *Human factors for informatics usability* (pp. 21-38). Cambridge: Cambridge University Press.
- Sheller, S. L., & Ruffner, J. W. (2003). Computer-based (and Web-based) training solutions for meeting cockpit avionics training needs. In R. Jensen. (Ed.), *Proceedings of the 12th International Symposium on Aviation Psychology*. Dayton, Ohio, USA, April 14-17, 2003.
- Shih, C.-C., & Gamon, J. (2001). Web-based learning: relationships among student motivation, attitudes, learning styles, and achievement. *Journal of Agricultural Education*, 42(4), 12-20.
- Shilwant, S., & Haggarty, A. (2005). Usability testing for e-learning [Electronic Version]. *Chief Learning Officer*. Retrieved 10-20-2006, from [http://www.clomedia.com/content/templates/clo\\_article.asp?articleid=1049](http://www.clomedia.com/content/templates/clo_article.asp?articleid=1049)
- Shrout, P. E., & Fleiss, J. L. (1979). Intraclass correlations: Uses in assessing rater reliability. *Psychological Bulletin* 86, 420-427.
- Sloman, M. (2002). *The e-learning revolution: how technology is driving a new training paradigm*. New York, NY: AMACOM.
- Small, R. V., & Arnone, M. P. (1999). Assessing the motivational quality of Websites. In M. Khosrowpour (Ed.), *Managing Information Technology Resources in Organizations in the Next Millennium (1999 Information Resources Management Association IRMA International Conference)* (pp. 1000-1003). Hershey, PA: IDEA Group Publishing.
- Small, R. V., & Arnone, M. P. (2004). Website Motivational Analysis Checklist (WebMAC) Professional (v. 2.0) [Electronic Version]. Retrieved 08-30-2006, from <http://digital-literacy.syr.edu/resources/webmac.shtml>

- Small, R. V., & Arnone, M. P. (2006). Awesome Web sites: How to find and use them [Electronic Version]. *American Library Association*. Retrieved 06-20-2007, from <http://www.ala.org/ala/aasl/aaslpubsandjournals/kqweb/kqarchives/volume30/301Small.cfm>
- Somers, J. A. (2005). Educational uses of the Internet and the Web. In B. Webber (Ed.), *Handbook of human factors in Web design* (pp. 441-453). Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.
- Song, S. H. (2000). Research issues of motivation in Web-based instruction. *Quarterly Review of Distance Education, 1*(3), 225-229.
- Song, S. H., & Keller, J. M. (2001). Effectiveness of motivationally adaptive computer-assisted instruction on the dynamic aspects of motivation. *Educational Technology Research and Development, 49*(2), 5-22.
- Sonwalkar, N. (2002). A new methodology for evaluation: The pedagogical rating of online courses. *Syllabus, 15*(6), 18-21.
- Spiros, R. K. (2003). *Individual differences in motivation during distance training: The influence of goal orientation and self-efficacy on learning outcomes*. Unpublished Ph.D. dissertation, The George Washington University, Washington, D.C., United States
- Spitzer, D. R. (1996). Motivation: the neglected factor in instructional design. *Educational Technology, 36*(3), 45-49.
- Squires, D., & Preece, J. (1999). Predicting quality in educational software: evaluating for learning, usability and the synergy between them. *Interacting with Computers, 11*(5), 467-483.
- Steers, R. M., Mowday, R. T., & Shaprio, D. L. (2004). The future of work motivation theory. *Academy of Management. The Academy of Management Review, 29*(3), 379.
- Stevens, D. D., & Levi, A. J. (2004). *Introduction to rubrics: An assessment tool to save grading time, convey effective feedback and promote student learning*. Sterling, VA: Stylus Publishing
- Stoney, S., & Oliver, R. (1999). Can higher order thinking & cognitive engagement be enhanced with multimedia? [Electronic Version]. *Interactive Multimedia Electronic Journal of Computer-Enhanced Learning, 1*(2). Retrieved 06-27-2008, from <http://www.imej.wfu.edu/articles/1999/2/07/index.asp>
- Stoney, S., & Wild, M. (1998). Motivation and interface design: maximizing learning opportunities. *Journal of Computer Assisted Learning, 14*, 40-50.
- Storey, M.-A., Phillips, B., Maczewski, M., & Wang, M. (2002). Evaluating the usability of Web-based learning tools. *Educational Technology & Society, 5*(3), 91-100.
- Suchman, L. A. (1987). *Plans and situated actions: The problem of human-machine communication*. Cambridge: Cambridge Press.
- Sullivan, P. (1999). Gender and the online classroom. *Teaching English in the Two-Year College, 26*, 361-371.
- Sullivan, P. (2001). Gender differences and the online classroom: Male and female college students evaluate their experiences. *Community College Journal of Research and Practice, 25*, 805-818.
- Tai, W.-T. (2006). Effects of training framing, general self-efficacy and training motivation on trainees' training effectiveness. *Personnel Review, 35*(1), 51-65.
- Tallent-Runnels, M. K., Lan, W. Y., Fryer, W., Thomas, J. A., Cooper, S., & Wang, K. (2005). The relationship between problems with technology and graduate students' evaluations of online teaching. *The Internet and Higher Education, 8*(2), 167-174.
- Tao, Y.-H., Guo, S.-M., & Lu, Y.-H. (2006). The design and the formative evaluation of a Web-based course for simulation analysis experiences. *Computers and Education, 47*(4), 414-432.
- Tsai, W.-C., & Tai, W.-T. (2003). Perceived importance as a mediator of the relationship between training assignment and training motivation. *Personnel Review, 32*(1/2), 151-163.
- UPA. (2007). Definitions of usability [Electronic Version]. *Usability Professionals' Association*. Retrieved 07-06-2007, from [http://www.upassoc.org/usability\\_resources/about\\_usability/definitions.html](http://www.upassoc.org/usability_resources/about_usability/definitions.html)
- Visser, L. (1999). Development research applied to improve motivation in distance education. In *Proceedings of Selected Research and Development Papers Presented at the National Convention of the Association*

- for *Educational Communications and Technology [AECT] (21st)* (pp. 403-411). Houston, Texas, February 10-14, 1999.
- Vogt, C. M., Hocevar, D., & Hagedorn, L. S. (2007). A social cognitive construct validation: Determining women's and men's success in engineering programs. *The Journal of Higher Education* 78(3), 337-364.
- Vrasidas, C. (2004). Issues of pedagogy and design in e-learning systems. In *Proceedings of the 2004 ACM Symposium on Applied Computing*. Nicosia, Cyprus: ACM Press.
- Vroom, V. H. (1964). *Work and motivation*. New York: Wiley.
- Waschull, S. B. (2005). Predicting Success in Online Psychology Courses: Self-Discipline and Motivation. *Teaching of Psychology*, 32(3), 190-192.
- Weiner, B. (1974). *Achievement motivation and attribution theory*. Morristown, NJ.: General Learning Press
- Wlodkowski, R. J. (1982). *Motivation*. Washington, D.C.: National Education Association.
- Wlodkowski, R. J. (1985). *Enhancing adult motivation to learn : a guide to improving instruction and increasing learner achievement* San Francisco, CA: Jossey-Bass Publishers.
- Wlodkowski, R. J. (1999a). *Enhancing adult motivation to learn: a comprehensive guide for teaching all adults*. (2 ed.). San Francisco, CA: Jossey-Bass Publishers.
- Wlodkowski, R. J. (1999b). Motivation and diversity: A framework for teaching. *New Directions for Teaching and Learning*(78), 7-16.
- Wojahn, P. (1994). Computer mediated communication: The great equalizer between men and women? . *Technical Communication: Journal of the Society for Technical Communication Research*, 41(4), 747-752.
- Wolfe, J. (1999). Why do women feel ignored?: Gender differences in computer-mediated classroom interactions. *Computer and Composition*, 16(1), 153-166.
- Xie, K., Debacker, T. K., & Ferguson, C. (2006). Extending the traditional classroom through online discussion: The role of student motivation. *Journal of Educational Computing Research*, 34(1), 67-89.
- Zaharias, P. (2004). Usability and e-learning: the road towards integration. *eLearn*, 2004(6), 4.
- Zaharias, P. (2006). *A usability evaluation method for e-learning: focus on motivation to learn*. Paper presented at the CHI '06 extended abstracts on Human Factors in computing systems.
- Zanbaka, C., Goolkasian, P., & Hodges, L. F. (2006). Can a virtual cat persuade you? The role of gender and realism in speaker persuasiveness. In *Proceedings of CHI 2006, ACM Press (2006)*. 1153-1162.
- Zumbach, J., & Reimann, P. (1999). Combining computer supported collaborative argumentation and problem-based learning: an approach for designing online learning environments [Electronic Version]. Retrieved 10-28-2006, from <http://d3e.open.ac.uk/cscl99/Zumbach/Zumbach-paper.html>

## **APPENDICES**

Appendix A— IRB Approval

Appendix B— Pilot Study Surveys

Appendix C— Usability Evaluation Checklist

Appendix D— Remembering Test

Appendix E—Applying Test

Appendix F— Benchmark Tasks of Usability Testing

Appendix G— Participant Recruitment Flyer and Email

Appendix H— Pre-session Questionnaire

Appendix I— Informed Consent Form

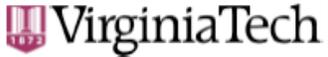
Appendix J— Post-session Questionnaire

Appendix K— Permission Letter to Reprint Screen Shots

Appendix L— Sample Screenshots of Interface B, U, and UM

## Appendix A— IRB Approval

### A.1 IRB Approval of Pilot Study



Office of Research Compliance  
Carmen T. Green, IRB Administrator  
2000 Kraft Drive, Suite 2000 (0497)  
Blacksburg, Virginia 24061  
540/231-4358 Fax 540/231-0959  
e-mail [ctgreen@vt.edu](mailto:ctgreen@vt.edu)  
[www.irb.vt.edu](http://www.irb.vt.edu)  
FWA00000572/ expires 1/20/2010  
IRB # Is IRB00000667

DATE: June 21, 2007

#### MEMORANDUM

TO: Tonya L. Smith-Jackson  
Ying Hu

FROM: Carmen Green 

SUBJECT: IRB Exempt Approval: "Experiencing Online Training: Usability and Learner Motivation", IRB # 07-329

I have reviewed your request to the IRB for exemption for the above referenced project. I concur that the research falls within the exempt status. Approval is granted effective as of June 21, 2007.

As an investigator of human subjects, your responsibilities include the following:

1. Report promptly proposed changes in previously approved human subject research activities to the IRB, including changes to your study forms, procedures and investigators, regardless of how minor. The proposed changes must not be initiated without IRB review and approval, except where necessary to eliminate apparent immediate hazards to the subjects.
2. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

cc: File  
Department Reviewer: Thurmon E. Lockhart  
T. Coalson 0118

*Invent the Future*

VIRGINIA POLYTECHNIC INSTITUTE UNIVERSITY AND STATE UNIVERSITY  
*An equal opportunity, affirmative action institution*

A.2 IRB Approval of Main Study



Office of Research Compliance  
Institutional Review Board  
2000 Kraft Drive, Suite 2000 (0497)  
Blacksburg, Virginia 24061  
540/231-4991 Fax 540/231-0959  
e-mail moored@vt.edu  
www.irb.vt.edu

FWA0000572/ expires 1/20/2010  
IRB # 16 IRB00000667

DATE: October 1, 2007

MEMORANDUM

TO: Tonya L. Smith-Jackson  
Ying Hu

Approval date: 10/1/2007  
Continuing Review Due Date: 9/16/2008  
Expiration Date: 9/30/2008

FROM: David M. Moore 

SUBJECT: **IRB Expedited Approval:** "Motivation, Usability and Their Interrelationships in the Self-paced Online Learning Environment", IRB # 07-473

This memo is regarding the above-mentioned protocol. The proposed research is eligible for expedited review according to the specifications authorized by 45 CFR 46.110 and 21 CFR 56.110. As Chair of the Virginia Tech Institutional Review Board, I have granted approval to the study for a period of 12 months, effective October 1, 2007.

As an investigator of human subjects, your responsibilities include the following:

1. Report promptly proposed changes in previously approved human subject research activities to the IRB, including changes to your study forms, procedures and investigators, regardless of how minor. The proposed changes must not be initiated without IRB review and approval, except where necessary to eliminate apparent immediate hazards to the subjects.
2. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.
3. Report promptly to the IRB of the study's closing (i.e., data collecting and data analysis complete at Virginia Tech). If the study is to continue past the expiration date (listed above), investigators must submit a request for continuing review prior to the continuing review due date (listed above). It is the researcher's responsibility to obtain re-approval from the IRB before the study's expiration date.
4. If re-approval is not obtained (unless the study has been reported to the IRB as closed) prior to the expiration date, all activities involving human subjects and data analysis must cease immediately, except where necessary to eliminate apparent immediate hazards to the subjects.

**Important:**

If you are conducting **federally funded non-exempt research**, this approval letter must state that the IRB has compared the OSP grant application and IRB application and found the documents to be consistent. Otherwise, this approval letter is invalid for OSP to release funds. Visit our website at <http://www.irb.vt.edu/pages/newstudy.htm#OSP> for further information.

cc: File

Department Reviewer: Thurmon E. Lockhart  
T. Coalson 0118

*Invent the Future*

VIRGINIA POLYTECHNIC INSTITUTE UNIVERSITY AND STATE UNIVERSITY  
*An equal opportunity, affirmative action institution*

### A.3 IRB Approval of Main Study-Amendment



Office of Research Compliance  
Institutional Review Board  
2000 Kraft Drive, Suite 2000 (0497)  
Blacksburg, Virginia 24061  
540/231-4991 Fax 540/231-0959  
e-mail moored@vt.edu  
www.irb.vt.edu  
FWA00000572/ expires 1/20/2010  
IRB # 16 IRB00000667

DATE: October 12, 2007

MEMORANDUM

TO: Tonya L. Smith-Jackson  
Ying Hu

FROM: David M. Moore 

Approval date: 10/1/2007  
Continuing Review Due Date: 9/16/2008  
Expiration Date: 9/30/2008

SUBJECT: **IRB Amendment 1 Approval:** "Motivation, Usability and Their Interrelationships in the Self-paced Online Learning Environment", IRB # 07-473

This memo is regarding the above referenced protocol which was previously granted approval by the IRB on October 1, 2007. You subsequently requested permission to amend your IRB application. Since the requested amendment is nonsubstantive in nature, I, as Chair of the Virginia Tech Institutional Review Board, have granted approval for requested protocol amendment, effective as of October 12, 2007. The anniversary date will remain the same as the original approval date.

As an investigator of human subjects, your responsibilities include the following:

1. Report promptly proposed changes in previously approved human subject research activities to the IRB, including changes to your study forms, procedures and investigators, regardless of how minor. The proposed changes must not be initiated without IRB review and approval, except where necessary to eliminate apparent immediate hazards to the subjects.
2. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.
3. Report promptly to the IRB of the study's closing (i.e., data collecting and data analysis complete at Virginia Tech). If the study is to continue past the expiration date (listed above), investigators must submit a request for continuing review prior to the continuing review due date (listed above). It is the researcher's responsibility to obtain re-approval from the IRB before the study's expiration date.
4. If re-approval is not obtained (unless the study has been reported to the IRB as closed) prior to the expiration date, all activities involving human subjects and data analysis must cease immediately, except where necessary to eliminate apparent immediate hazards to the subjects.

cc: File  
Department Reviewer: Thurmon E. Lockhart  
T. Coalson 0118

*Invent the Future*

VIRGINIA POLYTECHNIC INSTITUTE UNIVERSITY AND STATE UNIVERSITY  
An equal opportunity, affirmative action institution

## Appendix B— Pilot Study Surveys

### **Online Training Survey #1:**

**1. Age group**

<18                      18-20                      21-25                      26-30                      31-40                      41+

**2. Gender**

Female                      Male

**3. Academic Classification**

Freshman Sophomore                      Junior                      Senior                      Graduate student

**4. Are you comfortable using computers?**

Yes                      No

**5. Are you comfortable using the Internet?**

Yes                      No

**6. How frequently do you use the Internet?**

Daily                      Weekly                      Monthly                      Rarely

**7. Have you experienced any of the following online learning activities? Check all that apply.**

- No, I never had any online learning experience. → Skip to question # 11.
- Read a research article online.
- Search course/research related information online.
- Access course related information/documents from a course management system, e.g. Blackboard.
- Complete a self-paced learning/training tutorial, e.g., element K.
- Have a real-time class session online through a synchronous system
- Complete an online non-credit course (90% or above of the course content are delivered online).
- Complete an online credit course (90% or above of the course content are delivered online).
- Complete an online academic program and earn a degree.
- Other \_\_\_\_\_

**8. Overall, I think my online learning experience so far is**

Boring									Interesting
1	2	3	4	5	6	7	8	9	
Waste of time									Worthwhile
1	2	3	4	5	6	7	8	9	

**9. According to your own experience, what's the BEST thing about learning online?**

**10. According to your own experience, what's the WORST thing about learning online?**

**11. What would qualify a good online course? Check 3 that are most valuable to you.**

- Improve my learning
- Improve my instructors' teaching
- Improve student-to-instructor communication
- Improve instructor-to-student communication
- Improve my communication with my classmates
- Help manage course activities
- Efficiency (saves time)
- Allows for prompt feedback
- Help communicate complex concepts
- Others \_\_\_\_\_

12. What would qualify a good online self-paced tutorial? List 3 things that are most valuable to you:

13. How would you rate your knowledge on Back Safety?

Novice  
1      2      3      4      5      6      7      8      9  
Expert

What do you expect to learn from this short online training tutorial on Back Safety?

THANK YOU FOR COMPLETING SURVEY #1.  
PLEASE REFER TO YOUR EMAIL DIRECTION TO PROCEED.

**Online Training Survey #2:**

Time taken to finish the TUTORIAL: \_\_\_\_\_ minutes.

Time taken to finish the TEST: \_\_\_\_\_ minutes.

Overall, I found this tutorial to be:

Boring								Interesting
1	2	3	4	5	6	7	8	9
Waste of time								Worthwhile
1	2	3	4	5	6	7	8	9

Which of the following best describes your experience when learning the tutorial?

- I exactly followed the order presented by the tutorial. I never skipped pages nor went back.
- I basically followed the order and kept going forward. I skipped a few pages or went back only occasionally.
- Whenever possible, I skipped some pages to see what's going on later. If I found the information on previous pages necessary, I went back.
- I first quickly looked through all the material and then went back again to selectively read those pages that I am most interested in.
- I kept jumping back and forth without a particular reason.
- Other. Please describe yourself: \_\_\_\_\_  
\_\_\_\_\_

How many times did you attempt the test? \_\_\_\_\_ times.

Do you think the test score best reflects your learning from this tutorial? Why or why not?

Other than the required tutorial, did you browse through any pages or other tutorials on the same Website? Why or why not?

I found the appearance of the Web pages to be:

Boring								Eye-catching
1	2	3	4	5	6	7	8	9

I found the content of this tutorial to be:

Not useful at all								Very Useful
1	2	3	4	5	6	7	8	9

I found the test of this tutorial to be:

Very easy								Very difficult
1	2	3	4	5	6	7	8	9

**In studying the tutorial, I invested:**

Very low mental effort

1

2

3

4

5

6

7

Very high mental effort

8

9

**List two BEST things of this tutorial (including the test).**

**List two WORST things of this tutorial (including the test).**

**Would you recommend this Website to your friends, colleagues or family members? Why or why not?**

**Do you have any suggestions for redesigning this tutorial? Feel free to apply any Human Factors knowledge that you have learned in class 😊**

**Anything else you want to let us know regarding the tutorials, tests, questionnaires, etc. ?**

**Thank you very much for completing this survey and taking time to participate this study. Your valuable feedbacks will help us improve the design of online tutorials.**

**Please feel free to contact Ying Hu ([huying@vt.edu](mailto:huying@vt.edu)) if you have any questions or comments.**

## Appendix C— Usability Evaluation Checklist

Assign each guideline a problem severity rating as follows:

- n/a = Not applicable
- 0 = I don't agree that this is a usability problem at all
- 1 = Cosmetic problem only: need not be fixed unless extra time is available on project
- 2 = Minor usability problem: fixing this should be given low priority
- 3 = Major usability problem: important to fix, so should be given high priority
- 4 = Usability catastrophe: imperative to fix this before product can be released

		Rating	Example Problem/ Comment
<b>Chapter 2—Optimizing the User Experience</b>			
2:01	Do Not Display Unsolicited Windows or Graphics		
2:02	Increase Web Site Credibility		
2:03	Standardize Task Sequences		
2:04	Reduce the User's Workload		
2:05	Design for Working Memory Limitations		
2:06	Minimize Page Download Time		
2:07	Warn of 'Time Outs'		
2:08	Display Information in a Directly Usable Format		
2:09	Format information for Reading and Printing		
2:10	Provide Feedback When Users Must Wait		
2:11	Inform Users of Long Download Times		
2:12	Develop Pages that Will Print Properly		
2:13	Do Not Require Users to Multitask While Reading		
2:14	Use Users' Terminology in Help Documentation		
2:15	Provide Printing Options		
2:16	Provide Assistance to Users		
<b>Chapter 5—The Homepage</b>			
5:01	Enable Access to the Homepage		
5:02	Show All Major Options on the Homepage		
5:03	Create a Positive First Impression of Your Site		
5:04	Communicate the Web Site's Value and Purpose		
5:05	Limit Prose Text on the Homepage		

5:06	Ensure the Homepage Looks like a Homepage		
5:07	Limit Homepage Length		
5:08	Announce Changes to a Web Site		
5:09	Attend to Homepage Panel Width		
<b>Chapter 6—Page Layout</b>			
6:01	Avoid Cluttered Displays		
6:02	Place Important Items Consistently		
6:03	Place Important Items at Top Center		
6:04	Structure for Easy Comparison		
6:05	Establish Level of Importance		
6:06	Optimize Display Density		
6:07	Align Items on a Page		
6:08	Use Fluid Layouts		
6:09	Avoid Scroll Stoppers		
6:10	Set Appropriate Page Lengths		
6:11	Use Moderate White Space		
6:12	Choose Appropriate Line Lengths		
6:13	Use Frames when Functions Must Remain Accessible		
<b>Chapter 7—Navigation</b>			
7:01	Provide Navigational Options		
7:02	Differentiate and Group Navigation Elements		
7:03	Use a Clickable 'List of Contents' on Long Pages		
7:04	Provide Feedback on User's Location		
7:05	Place Primary Navigation Menus in the Left Panel		
7:06	Use Descriptive Tab Labels		
7:07	Present Tabs Effectively		
7:08	Keep Navigation-Only Pages Short		
7:09	Use Appropriate Menu Types		
7:10	Use Site Maps		
7:11	Use 'Glosses' to Assist Navigation		
7:12	Breadcrumb Navigation		
<b>Chapter 8—Scrolling and Paging</b>			
8:01	Eliminate Horizontal Scrolling		
8:02	Facilitate Rapid Scrolling While Reading		
8:03	Use Scrolling Pages for Reading Comprehension		
8:04	Use Paging Rather Than Scrolling		
8:05	Scroll Fewer Screenfuls		
<b>Chapter 9—Headings, Titles, and Labels</b>			
9:01	Use Clear Category Labels		

9:02	Provide Descriptive Page Titles		
9:03	Use Descriptive Headings Liberally		
9:04	Use Unique and Descriptive Headings		
9:05	Highlight Critical Data		
9:06	Use Descriptive Row and Column Headings		
9:07	Use Headings in the Appropriate HTML Order		
9:08	Provide Users with Good Ways to Reduce Options		
<b>Chapter 10—Links</b>			
10:01	Use Meaningful Link Labels		
10:02	Link to Related Content		
10:03	Match Link Names with Their Destination Pages		
10:04	Avoid Misleading Cues to Click		
10:05	Repeat Important Links		
10:06	Use Text for Links		
10:07	Designate Used Links		
10:08	Provide Consistent Clickability Cues		
10:09	Ensure that Embedded Links are Descriptive		
10:10	Use 'Pointing-and-Clicking'		
10:11	Use Appropriate Text Link Lengths		
10:12	Indicate Internal vs. External Links		
10:13	Clarify Clickable Regions of Images		
10:14	Link to Supportive Information		
<b>Chapter 11—Text Appearance</b>			
11:01	Use Black Text on Plain,High Contrast Backgrounds		
11:02	Format Common Items Consistently		
11:03	Use Mixed-Case for Prose Text		
11:04	Ensure Visual Consistency		
11:05	Use Bold Text Sparingly		
11:06	Use Attention-Attracting Features when Appropriate		
11:07	Use Familiar Fonts		
11:08	Use at Least 12-Point Font		
11:09	Color-Coding and Instructions		
11:10	Emphasize Importance		
11:11	Highlighting Information		
<b>Chapter 12—Lists</b>			
12:01	Order Elements to Maximize User Performance		
12:02	Place Important Items at Top of the List		
12:03	Format Lists to Ease Scanning		
12:04	Display Related Items in Lists		
12:05	Introduce Each List		
12:06	Use Static Menus		
12:07	Start Numbered Items at One		
12:08	Use Appropriate List Style		
12:09	Capitalize First Letter of First Word in Lists		

<b>Chapter 14—Graphics, Images, and Multimedia</b>			
14:01	Use Simple Background Images		
14:02	Label Clickable Images		
14:03	Ensure that Images Do Not Slow Downloads		
14:04	Use Video, Animation, and Audio Meaningfully		
14:05	Include Logos		
14:06	Graphics Should Not Look like Banner Ads		
14:07	Limit Large Images Above the Fold		
14:08	Ensure Web Site Images Convey Intended Messages		
14:09	Limit the Use of Images		
14:10	Include Actual Data with Data Graphics		
14:11	Display Monitoring Information Graphically		
14:12	Introduce Animation		
14:13	Emulate Real-World Objects		
14:14	Use Thumbnail Images to Preview Larger Images		
14:15	Use Images to Facilitate Learning		
14:16	Using Photographs of People		
<b>Chapter 15—Writing Web Content</b>			
15:01	Make Action Sequences Clear		
15:02	Avoid Jargon		
15:03	Use Familiar Words		
15:04	Define Acronyms and Abbreviations		
15:05	Use Abbreviations Sparingly		
15:06	Use Mixed Case with Prose		
15:07	Limit the Number of Words and Sentences		
15:08	Limit Prose Text on Navigation Pages		
15:09	Use Active Voice		
15:10	Write Instructions in the Affirmative		
15:11	Make First Sentences Descriptive		
<b>Chapter 16—Content Organization</b>			
16:01	Organize Information Clearly		
16:02	Facilitate Scanning		
16:03	Ensure that Necessary Information is Displayed		
16:04	Group Related Elements		
16:05	Minimize the Number of Clicks or Pages		
16:06	Design Quantitative Content for Quick Understanding		
16:07	Display Only Necessary Information		
16:08	Format Information for Multiple Audiences		
16:09	Use Color for Grouping		

## Appendix D— Remembering Test

### Test A\_Remembering Test (40pts)

The following questions were used in the course test. Actual question orders were randomized.

Correct responses are **bolded**.

**1. Which of the followings is true about material labels? (4 pts)**

- a. All information concerning the hazardous materials you work with can be found on container labels.
- b. Only very hazardous materials must be labeled.
- c. Hazard classes on labels are represented by numbers.
- d. Commercial labels must include the product name; a warning statement, message or symbol; and manufacturers' name and address.**

**2. Which of the following statements is NOT true? (4 pts)**

- a. As an employee, you have a "Right to Know" about the hazardous materials used in your organization.
- b. Material Safety Data Sheets are available for ALL of the hazardous materials present in your work area.
- c. You should use an MSDS whenever you need additional information about a hazardous material that is not included on the product label.
- d. Material Safety Data Sheets (MSDSs) should only be referred to when detailed information is needed on very hazardous material.**

**3. The higher the number on a rating scale, the more dangerous the substance. (2 pts)**

- a. True**
- b. False

**4. Material Safety Data Sheets (MSDSs) contain the following information (check all that apply): (3pts)**

- a. Emergency First Aid Procedures**
- b. Carcinogenic Factors**
- c. Contact Information**
- d. Routes of Body Entry**
- e. Control Measures (personal protective equipment)**
- f. Safe-Handling Procedures**

**5. What are the most common types of physical hazards? Check all that apply. (2pts)**

- a. fire**
- b. explosion**
- c. chemical reactivity**
- d. combustibles

**6. Liquid combustibles ignite more easily than do liquid flammables. (2pts)**

- a. True
- b. False**

**7. Which of the following material classes should use an Explosive symbol? (2pts)**

- a. Pyrophoric
- b. Flammables
- c. Water Reactives**
- d. Combustibles

**8. Which of the following material classes should use a Flaming "O" symbol? (2pts) (check all that apply):**

- a. Organic Peroxides**
- b. Oxidizers**
- c. Pyrophoric
- d. Acids

**9. The gas in a gas cylinder is stored below normal pressure. (2pts)**

- a. True
- b. False**

**10. TWA is the average amount of a chemical a person can be exposed to over 24 hours. (2pts)**

- a. True
- b. False**

**11. Chronic effects occur immediately or soon after you come in contact with them. (2pts)**

- a. True
- b. False**

**12. Which of the followings is true? (4pts)**

- a. Dose is the only factor that determines how a substance might affect your health.
- b. Ingestion is the most common route of exposure in industrial application.
- c. The three ways a chemical can enter the body are ingestion, skin absorption, and inhalation.**
- d. Pure water is not toxic at any dose.

**13. Which of the following is NOT a health hazard? (3pts)**

- a. Primary Irritant
- b. Pyrophoric**
- c. Organ Specific Hazard
- d. Sensitizers
- e. Corrosives

**14. The symbol on the right is used to identify: (2pts)**

- a. Corrosives
- b. Radioactive Materials
- c. Explosives
- d. Biological Materials**



**15. What protective measures will insure that safe exposure limits are not exceeded? Check all that apply. (4pts)**

- a. Product Substitution**
- b. Engineering Controls**
- c. Training**
- d. Personal Monitoring**
- e. Environmental Monitoring**
- f. Personal Monitoring**
- g. Safe Work Practices**
- h. Communication**

## Appendix E— Applying Test

### Test B\_Applying Test (35pts)

1. Does the label below contain all of the OSHA required information for a commercial label? If yes, list what is the OSHA required information. If not, explain what is missing. (5 pts)

**TOLUENE SULPHONIC ACID 70%, LIQUID**

**RISK PHRASE(S)**  
Highly irritating to skin, eyes, and nose

**HEALTH HAZARD DATA:**  
Strong Acid: Treat as per sulphuric acid

**EFFECTS OF OVEREXPOSURE, ACUTE OVEREXPOSURE:** Skin and eye

**PRECAUTIONARY MEASURES**

**SPECIFIC PERSONAL PROTECTIVE EQUIPMENT**

**EYE:** Face shield and goggles  
**GLOVES:** Rubber  
**OTHER CLOTHING AND EQUIPMENT:** Rubber apron, rubber boots

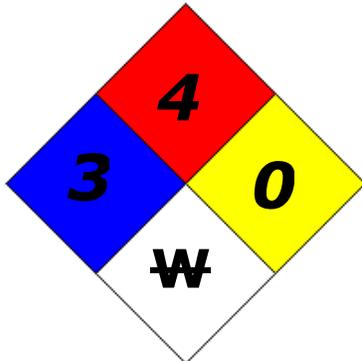
**FIRST AID MEASURES:**  
**EYES:** Flush with copious quantities of water for 15 minutes. Consult physician  
**SKIN:** Flush with water as per sulphuric acid  
**Ingestion:** Treat as per sulphuric acid. Consult physician.


#### RUBRIC:

Level of Achievement	Judgment (2 pts)	Knowledge Comprehension (3 pts)
<b>Excellent</b>	(2 pts) Answer "No"	(3 pts) Correctly point out that "Manufacturer's info is missing."
<b>Needs Improvement</b>	U/A	(1 pt) List some correct requirements.
<b>Unacceptable</b>	(0 pts) Answer "Yes" or no answer	(0 pts) Doesn't list any correct requirements or no answer.

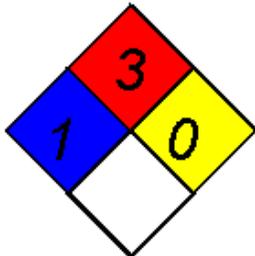
2. What hazard information can be read from the following label? (10pts)



**RUBRIC:**

Level of Achievement	Class Name (4 pts)	Color Match (3 pts)	Interpretation (3 pts)
<b>Excellent</b>	(4 pts) Flammability Health Reactivity Water reactive	(3 pts) Flammability--Red Health-- Blue Reactivity-- Yellow Water reactive-- White	(3 pts) Flammability-- Ignites at a very low degree (73 degrees Fahrenheit) Health--Extreme danger Reactivity--Stable
<b>Good</b>	(3 pts) Three correct names	(2 pts) Correctly match 2 pairs	(2 pts) Two correct interpretations
<b>Needs Improvement</b>	(1-2 pts) 1-2 correct names	(1 pts) Correctly match 1 pair	(1 pts) One correct interpretations
<b>Unacceptable</b>	(0 pts) Incorrect or no answer	(0 pts) Incorrect or no answer	(0 pts) Incorrect or no answer

3. You have spilled a bottle of chemical on the floor. The label of the bottle is shown below. How do you clean it up safely? Where can you find the information you need? (5pts)

	<p><u>Acetone</u> Chemical Name</p> <p><u>Fisher</u>                      <u>2-12-98</u> Manufacturer                      Date</p>
--	---

**RUBRIC:**

Level of Achievement	Use of Information (5 pts)
<b>Excellent</b>	(5 pts) Find the MSDS and follow the "safe-handling procedures".
<b>Needs Improvement</b>	(3 pt) Doesn't answer MSDS, but gives some appropriate ways of handling indicating correct interpretation of the label, e.g., avoid heat (flammable 3), open window/ventilation/wear glove (slightly hazard 1).
<b>Unacceptable</b>	(0 pts) Incorrect handling procedures or no answer.

4. Acetone (a highly toxic chemical) is known as an active ingredient in nail polish remover. In a painting shop, a heavy-duty degreaser containing acetone is used in the preparation of metal prior to painting. As the manager of the painting shop, what measures will you take to safeguard workers' health and physical safety? Briefly describe these measures and explain how each measure may affect workers' hazard potential for working with acetone. (15pts)

**RUBRIC:**

<b>Level of Achievement</b>	<b>Knowledge Comprehension (4 pts)</b>	<b>Application (8 pts)</b>	<b>Reasoning (3 pts)</b>
<b>Excellent</b>	(4 pts) --List 4+ types of protective/controlling measures*.	(8 pts) --Describe concrete procedures of each measure. --Explain the expected effects on hazard potential in this case scenario.	(3 pts) --Demonstrate the use of relevant knowledge to support the answer, such as the relationship between dose and toxicity. -- Clear and logical writing.
<b>Good</b>	(3 pts) --List 3 types of protective/controlling measures.	(6 pts) -- Describe procedures of each measure generally. --Mention some of the effects on hazard potential, but not as thorough as above.	(2 pts) --Provide some support for the answer, but no clear connection to relevant knowledge from this course. --Good writing.
<b>Needs Improvement</b>	(1-2 pts) --List only 1 or 2 types of protective/controlling measures.	(2-4 pts) --Describe the measures very briefly. --Does not explain the effects on hazard potential in this case scenario.	(1 pt) -- Does not provide relevant support of answer. -- Acceptable writing.
<b>Unacceptable</b>	(0 pts) --List no correct measure or no answer	(0 pts) --Does not describe each measure or no answer	(0 pts) -- Does not provide relevant support of answer. -- Poor writing.

\*Applicable protective measures:

- Product Substitution
- Engineering Controls
- Safe Work Practices
- Personal Protective Equipment
- Training and Communication
- Environmental Monitoring
- Personal Monitoring

## Appendix F— Benchmark Tasks of Usability Testing

### TASK#1

You just heard about the Free-Training.com website. You want to look for a safety training course on Hazard Communication. Start from the homepage, find the course you need and check out what the course is about.

When you find the information, please read it out aloud.

### TASK#2

You have a question regarding the Hazard Communication course. You want to reach the customer service or site facilitator. Start from the Hazard Communication course menu, find the information you need.

When you find the information, write it down below:

### TASK#3

Under the health hazard section, find the slide that talks about acute and chronic health hazard. Start from the course menu page.

When you are done, just say  
I GOT IT!

### TASK#4

You now have 30 minutes free time and you want to know if you can use it for the Hazard Communication course or part of it. Start from the Hazard Communication course menu page, try to make a quick estimate in 2 minutes as how long it will take for each of the sections.

Write down the estimated time in front of each of the sections below:

- \_\_\_\_\_ Introduction
- \_\_\_\_\_ Labeling
- \_\_\_\_\_ MSDSs
- \_\_\_\_\_ Physical Hazards
- \_\_\_\_\_ Health Hazards
- \_\_\_\_\_ Protective Measures

### TASK#5

You are interested to learn how to properly use pesticides, but such a course is not offered by this Free-Training.com website. You want to see if you can find any useful links from this website. Start from Homepage, find the information you need.

When you are done, just say  
I GOT IT!

## Appendix G— Participant Recruitment Flyer and Email

**Want to Learn More about *Hazard Communication* ?**

- **Call for participants**
  - Time: ~2 hours (Oct 15-31, to be scheduled)
  - Place: ACE Lab (Whittemore 530)
- **What you will get**
  - OSHA compliance safety knowledge
  - A free assessment of your motivated strategies for learning
  - Partial fulfillment of course requirement or extra credits
- **What you need to do**
  - A usability testing session
  - Complete the Hazard Communication online training tutorial + 2 learning assessment tests
  - A few questionnaires

**Your participation is VOLUNTARY.**  
More details about scheduling will be announced later.

For additional information, please contact  
**Ying Hu**  
[huying@vt.edu](mailto:huying@vt.edu)

Hello, ISE xxxx students,

We are conducting a research study on designing online training. We would like to hear your opinions about an online safety training tutorial on Hazard Communication. This would be a nice complementary learning material to your coursework, and can be used as partial fulfillment of your course requirements or earn extra credits.

This study will take place in the ACE lab in Whittemore 530. You will be asked to do a few computer tasks and learn the Hazard Communication tutorial using a desktop computer in the lab. You will also complete two tests to assess your learning and a few questionnaires. The whole process, including learning the tutorial, will take about two hours.

Your participation is VOLUNTARY, and all your responses are strictly confidential. Your PERFORMANCE during the study is NOT RELATED TO YOUR GRADE in the class. You will earn corresponding course credits by PARTICIPATION of this study. Depending on your class policy, you may be asked to complete additional coursework outside of this study.

--You must be 18 years old or older in order to participate.

--You DO NOT need to have any prior knowledge or experience in Hazard Communication to participate in this study.

If you are interested in participating, please contact Ms. Ying Hu at [huying@vt.edu](mailto:huying@vt.edu) to obtain your participant ID and further details. Feel free to contact the same person if you have any questions.

## Appendix H— Pre-session Questionnaire

Thank you for being interested in the online safety training study. In this survey, please take a few minutes to tell us a little more about yourself and your online learning experiences. Your feedbacks are important to us so that we can design online learning materials that better meet the needs of learners like you!

If you have any questions, please feel free to contact Ying Hu at [huying@vt.edu](mailto:huying@vt.edu).

*Your answers are anonymous and confidential.*

**Participant No.** \_\_\_\_\_  
(the 3-digit number you received in your email)

**1. Age** \_\_\_\_\_

**2. Gender**

Female                      Male

**3. Academic Classification**

Freshman              Sophomore              Junior                      Senior                      Graduate student

**4. Do you need any special accommodation to use the computers in a computer lab?**

No                                      Yes Please explain \_\_\_\_\_

**5. Are you comfortable using the Internet?**

Yes                                      No

**6. How frequently do you use the Internet?**

Daily                      Weekly                      Monthly                      Rarely

**7. Have you experienced any of the following online learning activities? Check all that apply.**

- No, I never had any online learning experience. → Skip to question # 9.
- Read a research article or book online.
- Search course or research related information online.
- Access course related information or documents from a course management system, e.g. Blackboard.
- Post messages to online course-related discussion groups.
- Complete an asynchronous online tutorial, e.g., a self-paced learning tutorial through element K.
- Have a live/synchronous online class session, e.g., virtual classroom or Web conferencing.
- Complete a semester-long (or equivalent) online asynchronous course (90% or above of the course content are delivered online asynchronously).
- Complete a semester-long (or equivalent) online synchronous course (90% or above of the course content are delivered online synchronously).
- Complete a semester-long (or equivalent) online blended course that contains both synchronous and asynchronous sessions.
- Complete an online academic program that consists of a number of courses and earn a degree or certificate.
- Other online learning experiences: \_\_\_\_\_

**8. Overall, I think my online learning experience so far is**

Boring									Interesting
1	2	3	4	5	6	7	8	9	
Waste of time									Worthwhile
1	2	3	4	5	6	7	8	9	

**9. Do you have any previous experiences in Occupational Safety, OSHA Safety Regulation, Hazard Communication, or related field? (Such as job, internship/co-op, research projects, courses, trainings, workshop, etc.) Please briefly describe your experiences.**

**10. How would you rate your knowledge on Hazard Communication?**

Novice  
1      2      3      4      5      6      7      8      9  
Expert

**11. In this study, you will take a Hazard Communication online course for about one hour. What do you expect to learn from this course?**

**THANK YOU FOR COMPLETING THIS SURVEY.**

**Please refer to your email direction to proceed.**

If you have any questions, feel free to contact Ying Hu at [huying@vt.edu](mailto:huying@vt.edu).

# Appendix I— Informed Consent Form

## Informed Consent for Participants in Research Projects Involving Human Subjects

Title of Project: Use and Design of Online Learning Tutorials  
Principal Investigator: Tonya L. Smith-Jackson  
Co-Investigator: Ying Hu

### I. PURPOSE OF PROJECT

The purpose of this study is to examine how people learn in a self-paced online learning environment and to identify any problems with design.

### II. INFORMATION

In this project, you will complete an online safety training course using a desktop computer in the laboratory. In some sessions, the computer screen will be recorded and you will be audiotaped to support data collection.

### III. PROCEDURES

You will be asked to read, sign and fill out on approved informed consent document. After informed consent, the moderator (the person leading this study) will show you the Website containing the training courses. You will be asked to do a few simple tasks on the Website and the moderator will ask you some questions while you are doing the tasks. The moderator will describe detailed instructions for each task. After the tasks, you will be asked to complete a questionnaire on usability.

Next, you will learn the training course by yourself. There is no time limit and you can learn your own way. After finishing the course, you will be asked to do two learning assessment tests on what you have just learned. In the end you will be asked to complete some questionnaires to tell us about you and your opinions of the online tutorial you just used.

Total time is expected to last for about 1 1/2 – 2 hours.

### IV. RISKS

Participation in this project does not place you at more than minimal risk of harm.

### V. BENEFITS

You will be compensated for your participation, and you will be given information to contact the principal investigator to get information about the outcomes of the study. You will also benefit from knowing that you have participated in worthwhile research that has immediate and positive applications.

### VI. CONFIDENTIALITY

The information gained in this research project will be kept strictly confidential. At no time will the researchers release the results of the study to anyone other than individuals working on the project without your written consent.

*VT IRB – This document is valid from 1 October 2007 – 30 September 2008*

You will be identified by a 3 digit study code. Data will be stored securely and will be made available only in the context of research publications and discussion. No reference will be made in oral or written reports that could link you to the data nor will you ever be identified as a participant in the project.

We will use digitized portions of the screen recordings and audios of the experimental sessions. The recordings and the audio may be used to present specific issues requiring design attention. If you feel uncomfortable with the display of your voice to other groups, please indicate on the last page.

**VII. COMPENSATION**

You will be compensated course credits for participation in this research.

**VIII. FREEDOM TO WITHDRAW**

You are free to withdraw from this study at any time without penalty.

**IX. APPROVAL**

This research project has been approved, as required, by the Institutional Review Board for Research Involving Human Subjects at Virginia Polytechnic Institute and State University and by the Department of Industrial and Systems Engineering. (IRB 07-473)

**X. PARTICIPANT'S RESPONSIBILITIES**

It is very important that you keep the activities and information discussed confidential, since others will be participating in this research.

**XI. QUESTIONS**

If you have questions, or do not understand information on this form, please feel free to ask them now

**PARTICIPANT'S PERMISSION**

I have read and understand the Informed Consent and conditions of this project. I have had all questions answered. I hereby acknowledge the above and give my voluntary consent for participation in this project.

If I participate, I may withdraw at any time without penalty.

Signature \_\_\_\_\_

Date \_\_\_\_\_

**PARTICIPANT'S PERMISSION TO USE EXCERPTS FROM AUDIOTAPED SESSIONS**

I have read and understand the manner in which audiotapes will be used for subsequent presentation of information related to this study. I understand that my voice will be presented as relevant to understanding how people use online learning tutorials. I grant permission to researchers to present this information as necessary in the manner described on this form.

Signature \_\_\_\_\_

Date \_\_\_\_\_

I DO NOT grant permission to researchers to present this information as necessary in the manner described on this form. I DO NOT want any recordings of voices of me to be used for presentation purposes.

Signature \_\_\_\_\_

Date \_\_\_\_\_

**CONTACT**

If you have questions at any time about the project or the procedures, you may contact

Ying Hu  
Investigator

231-8293 / [huying@vt.edu](mailto:huying@vt.edu)  
Telephone/E-mail

Tonya L. Smith-Jackson  
Faculty Advisor

231-4119 / [smithjack@vt.edu](mailto:smithjack@vt.edu)  
Telephone/E-mail

Thurmon E. Lockhart  
Departmental Reviewer

231-9088 / [lockhart@vt.edu](mailto:lockhart@vt.edu)  
Telephone/E-mail

If you feel you have not been treated according to the descriptions in this form, or your rights as a participant have been violated during the course of this project, you may contact

David M. Moore, PhD  
Chair, Virginia Tech Institutional Review Board  
for the protection of Human Subjects  
Office of Research Compliance  
2000 Kraft Drive, Suite 2000 (0497)  
Blacksburg, VA 24060

540-231-4991 / [moored@vt.edu](mailto:moored@vt.edu)  
Telephone/E-mail

## Appendix J— Post-session Questionnaire

Thanks very much again for participating in the online safety training study! Before you leave, we would like to hear about your comments or suggestions regarding the online course you just learned. Your feedbacks are important to us so that we can design online learning materials that better meet the needs of learners like you!

The following questions will ask for your opinions regarding the *tutorial* you just used. When answering those questions, **please think about your answers in relation to the various aspects of the tutorial such as its design, content, built-in activities, layout, feedback, etc.**

Tips: If you feel that some of your answers apply to more than one question, please feel free to copy and paste your answers to each applicable question. It will give us better understanding of your responses. Thanks.

1. Please describe how the *tutorial* did or did not catch your attention?
2. Please describe how the *tutorial* did or did not relate to your interests or needs?
3. Please describe how the *tutorial* did or did not support your confidence in learning?
4. Please describe how the *tutorial* did or did not support your persistence of completing the course?
5. In your opinion, what aspects of the *tutorial* make it an effective or ineffective learning tool?
6. In your opinion, what aspects of the *tutorial* make it an efficient or inefficient learning tool?
7. Please describe your overall satisfaction with this tutorial in terms of its design, content, built-in activities, layout, feedback, etc.
8. Are you interested in taking a similar online safety training course later on your own? Example topics include *Back Safety, Personal Protection Equipment, Forklift Safety and Operation, and Hearing Conservation*.  
Not interested at all                      Not Sure                      Very Interested  
1                      2                      3                      4                      5                      6                      7                      8                      9  
Why or why not?
9. Describe the place where you normally do the work for a self-paced online course.
10. If you were to learn the *tutorial* in the environment that you described above, what would you do differently from what you did today in the lab, if at all?

Is there anything else you want to let us know about this study?

**Thank you VERY MUCH again for completing this survey and taking time to participate this study. Your valuable feedbacks will help us improve the design of online tutorials.**

Please feel free to contact Ying Hu ([huying@vt.edu](mailto:huying@vt.edu)) if you have any questions or comments.

-----  
Note: The following question was asked at the end of the Mental Effort Scale.

**Please explain what costs or saves your (mental) effort in terms of the tutorial design, content, built-in activities, layout, feedback, etc.**

## Appendix K— Permission Letter to Reprint Screen Shots

July 25, 2008

Philip McGee  
Coordinator of the Masters Program  
Human Resource Development, Clemson University  
225 South Pleasantburg Drive  
P.O. Box 5616  
Greenville, SC 29606-5616  
Office Tel: (864) 250-6710  
Fax: (864) 250-8889  
pmcgee@clemson.edu

Dear Dr. Philip McGee:

I am completing a doctoral dissertation at Virginia Tech entitled "Motivation, Usability and Their Interrelationships in the Self-paced Online Learning Environment". I would like your permission to reprint in my dissertation some screenshots and content excerpts from the free-training.com Websites including the following:

- Screenshot of the homepage of the free-training.com website.
- Screenshots of the Hazard Communication course, including course menu page, content slides, quiz questions and course test.
- Content excerpts from the Hazard Communication course presented in different interface designs and learning tests, including contents from course menu page, content slides, quiz questions and course test.

The requested permission extends to any future revisions and editions of my dissertation, including non-exclusive world rights in all languages, and to the prospective publication of my dissertation by UMI Company. These rights will in no way restrict republication of the material in any other form by you or by others authorized by you. Your signing of this letter will also confirm that you own the copyright to the above-described material.

If these arrangements meet with your approval, please sign this letter where indicated below and return it to me in the enclosed return envelope. Thank you very much for assistance!

Sincerely,



Ying Hu  
2708 Lake Shore Dr. Apt 309  
Saint Joseph, MI, 49085  
(269)519-4370  
huying@vt.edu

PERMISSION GRANTED FOR THE USE REQUESTED ABOVE:

Instructional Designs, Inc

By:



Philip McGee

Title:

PRESIDENT

Date:

Aug 4, 2008

## Appendix L— Sample Screenshots of Interface B, U and UM

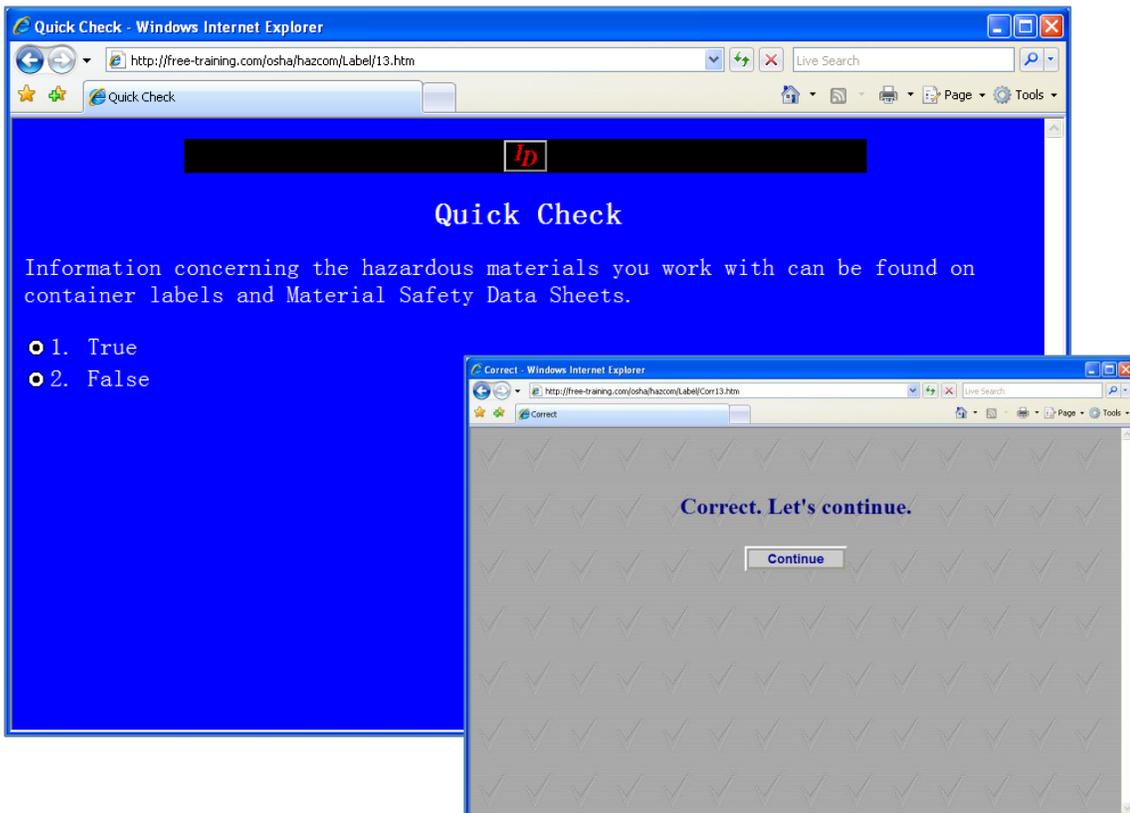
### Interface B—Homepage



## Interface B—Content Slide



## Interface B—Quiz Question



## Interface U—Homepage

**FREE TRAINING**  
www.free-training.com

[HOME](#)   [TRAINING PROGRAMS](#)   [TRAINING MANAGER](#)   [CONTACT US](#)

**What's New!**  
Listen to Randy Rowett, radio personality and safety expert comments concerning our site on Ridge Radio. [Listen](#)

**Instructional Designs, Inc.**  
Check out [Instructional Design Website](#) that features links and some cool resources that will help you as an instructional designer and distance trainer/educator.

**External Links**  
[OTHER FREE TRAINING SITES](#)

**Welcome** to the next step in Internet training. Training that is absolutely FREE!

If you are a trainee or student  
[TRAINING PROGRAMS](#)

- Each program located on this site is fully functional and complete in its content.
- These are not watered down demos or mere introductions to the topics covered.
- These are complete programs made possible by the companies and organizations who sponsor this site.

If you are a training manager  
[TRAINING MANAGER'S PAGE](#)

- Your free password to access the resource pages.
- Direct links to OSHA
- Complete course documentation
- "Hands-on" exercise guides
- Automatically e-mail trainee scores to your e-mail address
- It's all FREE!

Disclaimer: While every effort has been made to insure the accuracy and validity of the information presented by this site, Instructional Designs, Inc., site sponsors, advisors or third party providers may not be held liable for any special, incidental, consequential, indirect or similar damages due to the loss of data, loss of business profits, business interruption or any other reason. By using this site, you are assuming full responsibility for any and all consequences.

**CLEMSON UNIVERSITY**  
Earn your master's degree in HRD from Clemson University

AltaVista **BabelFish**  
To translate this page, click a flag!

Click on a flag to translate our site into the language of your choice using BabelFish!

Last update: Thursday, September, 27, 2007      This site developed and maintained by © 2007 Instructional Designs, Inc.

## Interface U—Course Menu Page

**FREE TRAINING**  
www.free-training.com

[HOME](#)   [TRAINING PROGRAMS](#)   [TRAINING MANAGER](#)   [CONTACT US](#)

**What's New!**  
Listen to Randy Rowett, radio personality and safety expert comments concerning our site on Ridge Radio. [Listen](#)

**Instructional Designs, Inc.**  
Check out [Instructional Design Website](#) that features links and some cool resources that will help you as an instructional designer and distance trainer/educator.

**External Links**  
[OTHER FREE TRAINING SITES](#)

**HAZARD COMMUNICATION COURSE MENU**

Click on one of the following modules: (A new window will pop up.)

- [Introduction](#)
- [Labeling](#)
- [Material Safety Data Sheets \(MSDs\)](#)
- [Physical Hazards](#)
- [Health Hazards](#)
- [Protective Measures](#)
- [Course Test](#)

**CLEMSON UNIVERSITY**  
Earn your master's degree in HRD from Clemson University

AltaVista **BabelFish**  
To translate this page, click a flag!

Click on a flag to translate our site into the language of your choice using BabelFish!

Last update: Thursday, September, 27, 2007      This site developed and maintained by © 2007 Instructional Designs, Inc.

## Interface U—Navigation

The screenshot shows a web browser window titled "Basic Label Information - Windows Internet Explorer". The address bar contains the URL "http://filebox.vt.edu/users/huying/pub/Training/HazCom\_CD/2/start.html". The page has a blue header with the word "Labeling" and a progress indicator showing "5/18 Basic Label Information". The main content area is titled "Basic Label Information" and contains the text: "OSHA requires that the following information be included on ALL labels:" followed by a list of requirements. A context menu is open over the text, listing various topics such as "The first step", "What do I need to know", "Where to find the information you need", "Quick Check #1", "Basic Label Information", "Commercial Labels", "Quick Check #2", "Key words", "Plant labels", "Chemical name", "Hazard class", "Quick Check #3", "Health hazards", "Flammability hazards", "Reactivity", "Special hazards", "Quick Check #4", and "End of section". The "Basic Label Information" option is highlighted. At the bottom of the page, there is a "POSITION: 5/18" indicator and "PREV" and "NEXT" navigation buttons.

## Interface U—Quiz Question

The screenshot shows a web browser window titled "Quick Check #1 - Windows Internet Explorer". The address bar contains the URL "http://filebox.vt.edu/users/huying/pub/Training/HazCom\_CD/2/start.html". The page has a blue header with the word "Labeling" and a progress indicator showing "4/18 Quick Check #1". The main content area is titled "Quick Check" and contains the text: "This question will not be scored. Your answer will not be recorded." followed by the question: "Only very hazardous materials must be labeled." Below the question, there are two radio button options: "True" and "False". The "False" option is selected. A green box with the text "Correct" and a blue link "Click here to proceed" is overlaid on the page. At the bottom of the page, there is a "POSITION: 4/18" indicator and "PREV" and "NEXT" navigation buttons.

## Interface UM – Course Menu Page

Free Training - Windows Internet Explorer  
http://filebox.vt.edu/users/huying/pub/Training3/

FREE TRAINING  
www.free-training.com

HOME TRAINING PROGRAMS TRAINING MANAGER CONTACT US

**What's New!**  
Listen to Randy Rowett, radio personality and safety expert comments concerning our site on Ridge Radio. [Listen](#)

**Instructional Designs, Inc.**  
Check out [Instructional Design Website](#) that features links and some cool resources that will help you as an instructional designer and distance trainer/educator.

**External Links**  
[OTHER FREE TRAINING SITES](#)

**HAZARD COMMUNICATION COURSE MENU**  
Click on one of the following modules: (A new window will pop up.)

- **Introduction**  
Your Right to Know and the scope and content of the course.
- **Labeling**  
The various labels used to identify hazardous materials.
- **Material Safety Data Sheets(MSDSs)**  
The use of Material Safety Data Sheets.
- **Physical Hazards**  
The various types of Physical Hazards and what you need to know to use these materials safely.
- **Health Hazards**  
The various types of Health Hazards and what you need to know to use these materials safely.
- **Protective Measures**  
The numerous ways that you can safeguard your health and physical safety when using hazardous materials.
- **Course Test**  
Self-test questions of this Hazard Communication Course.

**CLEMSON UNIVERSITY**  
Earn your master's degree in HRD from Clemson University

AltaVista **Babel Fish**  
To translate this page, click a flag!

Click on a flag to translate our site into the language of your choice using BabelFish!!

Last update: Thursday, September, 27, 2007  
This site developed and maintained by © 2007 Instructional Designs, Inc.

## Interface UM – Animated Character

Routes of exposure - Windows Internet Explorer  
http://filebox.vt.edu/users/huying/pub/Training3/HazCom\_CD/5/start.html

Health Hazards

CONTENTS  
HELP  
ABOUT

Ask A Question

15/30 Routes of exposure

**Routes of Exposure**

It's important to remember that hazardous materials present a health hazard only when they come into contact with the body. Chemicals can enter the body in **three** ways:

1. Inhalation
2. Skin absorption
3. Ingestion

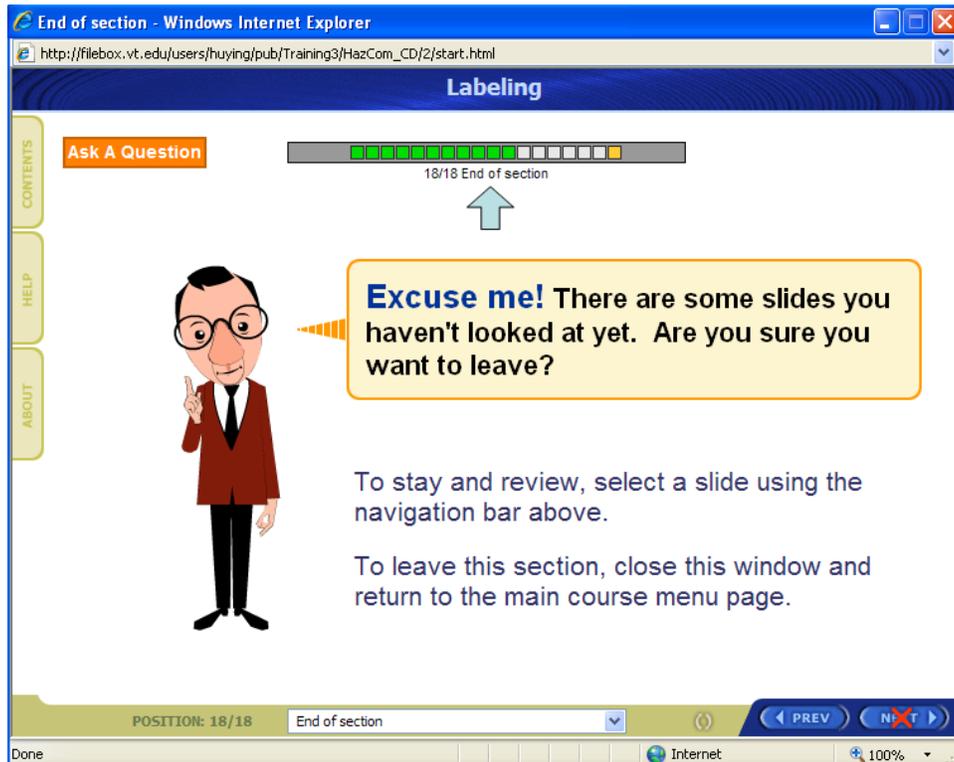
**Hey!** You are already halfway through this section. **Keep on going!**

POST Routes of exposure

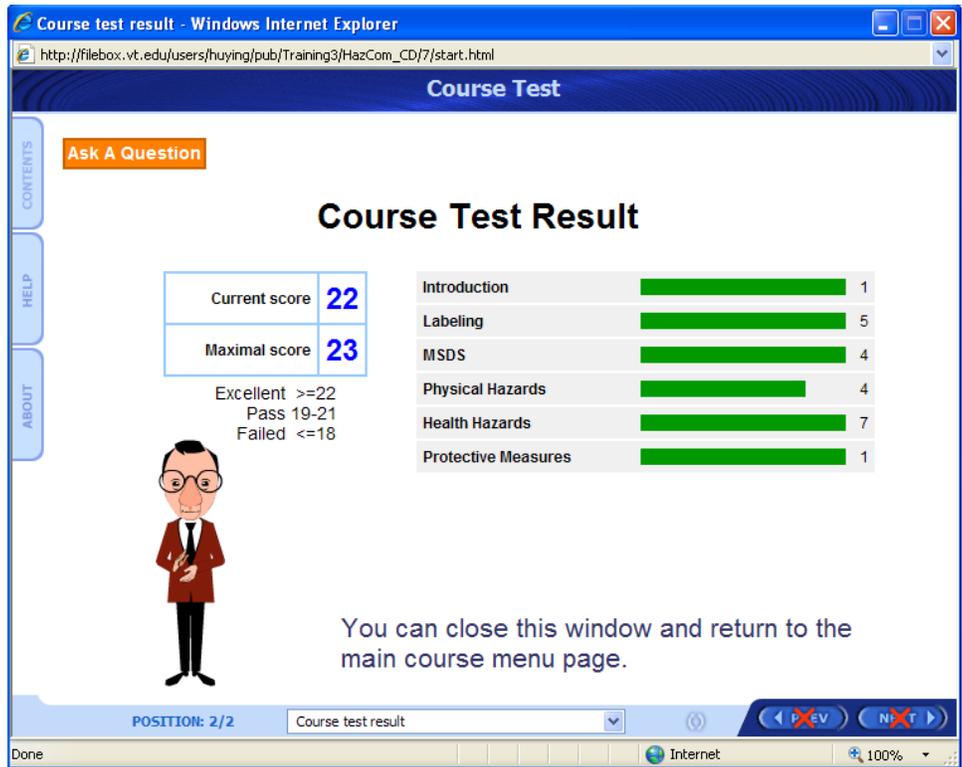
## Interface UM – Section End Congratulation



## Interface UM – Uncompleted Section



**Interface UM – Course Test Feedback**



**Interface UM – Ask A Question**

