Impact of Cognitive-based Instructional Intervention on Learning Motivation: The Implementation of Student-made Glossary in a Programming-oriented Engineering Problem-solving Course and Its Impact on Learning Motivation

David Wenhao Huang
Hans Aagard
Heidi Diefes-Dux
Purdue University

Abstract

This article describes the purpose, development, and implementation of a cognitive-based instructional intervention and its impact on learning motivation. The study was conducted in a programming-based problem-solving course for first-year engineering students. The results suggest that the instructional intervention developed based on the hierarchical analysis of intellectual skills development and partial-to-whole learning task approach has significant correlation with the Satisfaction component of ARCS Motivational Design Model.

Introduction

Problems with current approaches to study of motivation

Motivation is a critical factor in learning (Linnenbrink & Pintrich, 2002) and many researchers have examined the subject from various perspectives (Gonzalez-Pienda, *et al*., 2002; Hancock, 2002; Cokley, *et al*., 2001). Three issues trouble current studies of learning motivation: the lack of a systematic approach, neglect of other aspects of learning, and the inability to separate different aspects of motivation.

The affective and complex nature of motivation makes it is difficult to study, resulting in many motivational studies that lack a systematic approach. This lack of sytematicity limits reproduction of the effect and makes application difficult in practical situations. A review of motivational studies based on various aspects of learning (e.g. cognitive, social, and attitudinal) reveals that there is no sound systematic approach applied to them; most are solely based on motivational theories (Harlen & Crick, 2004) and frameworks to establish a broad, inductive goal without identifying a motivational problem. Identifying the motivational problem can clarify the motivational analysis and intervention. For example, Bandura's Self-Regulation theory is well received in the learning motivation field and efforts are being made to identify the measurable variables affecting levels of Self-Regulation (Miller & Brickman, 2004). However, there is no suggestion as to how those variables or components can be practically applied to resolve specific problems.

In other words, one problem with learning motivation studies is a lack of linkage between theories and practical instructional practices. Many theorists have proposed theories on how people get motivated and what behaviors can be stimulated by motivation (Weiner, 1985; Ames, 1992; Anderman & Maehr, 1994; Bandura, 1997). However, educators are still in search of practical and applicable guidelines that would enable them to convert motivation-enhancing theories into practical instructional practices with confidence (Hancock, 2002).

Another problem with current studies of learning motivation is their narrow approach. Given the complexity of investigating and measuring learning motivation in any instructional setting, various aspects of learning should be considered when trying to address motivational issues holistically. Aspects ranging from internal factors like student learning styles to external factors like the learning environment and applied instructional strategies should be considered.

Finally, the other learning components, such as instructional strategies, along with affective components traditionally associated with motivation such as enthusiasm and understanding of content, need to be separated and their effects on each other evaluated. This poses the concern of how reliable and valid motivational studies are if multiple issues are addressed simultaneously. Because factors affecting learning do interact with each other, a confounding effect can occur. Motivation does not occur in a vacuum, and the effects other factors in learning have on motivation are traditionally neglected (Astleitner & Wiesner, 2004).

A Systematic Approach: Selection of the ARCS Model

In order for the results of motivational studies to be more practical in addressing known instructional

or learning problems, perhaps a problem-solving process should accompany the investigation process. A generic instructional design process whose components are found in many instructional design models (e.g. Dick, 1996; Smith & Ragan, 1993; Gentry, 1994, Gustafson & Branch, 1997) may be an appropriate tool. The ADDIE process is geared towards solving instructional problems in five general steps: (A) analysis of the instructional problem, (D) design and (D) development of the instructional intervention, (I) implementation of the intervention, and (E) evaluation of the outcome(s). These systematic steps can be applied to the investigation of learning motivation due to their generalizability.

A motivational model with practical instruments should be used along with a problem-solving process to address specific aspects of motivation that a broad instructional design model like ADDIE cannot. The ARCS model, a motivational design model (Keller, 1987a, b), provides both a theoretical framework and a tool for assessing motivational levels by following the steps of ADDIE. The ARCS model suggests that learning motivation is influenced by four components: Attention, Relevance, Confidence, and Satisfaction. By enhancing an individual component using specific motivational strategies and instructional methods, students' learning motivation can be improved. Keller (1987b) suggested a systematic approach to first identify motivational problems and then prescribe motivational strategies to solve them. A pre - motivational survey is needed to establish students' initial motivational level. Keller's (1993) Instructional Materials Motivational Survey (IMMS) was developed as a situated measuring instrument to gauge the learning motivation of specific instructional materials. From the survey, motivational strategies can be prescribed according to identified motivational objectives. A post-motivational survey should be conducted to examine the effectiveness of the motivational strategies applied.

Motivational Studies Focusing on Cognitive Information Processing

Another way to make motivational studies more widely applicable is to focus on the cognitive side of learning. Studies on the cognitive aspects of learning, including cognition development, have established a scientific methodology to empirically investigate the human learning process from an information processing viewpoint. This deductive approach makes the studies more replicable, the focus of research questions more clear, and the outcomes more reliable and easier to identify.

In addition to the measurable outcomes these scientific research designs can produce, various studies have suggested a possible relationship between cognitive information processing and learning motivation (Wolters, 2004; Chalupa, Chen, & Charles, 2001). For example, Malone and Lepper (1987) proposed four components to establish learning motivation, all derived from human mental cognition. The association between motivation and cognition is also supported by the Expectancy Theory (Vroom, 1964) and the Control Theory (Klein, 1989) in which the learner's goal setting behaviors and perceived control are emphasized. Astleitner and Wiesner (2004) further proposed an integrated model of multimedia learning and motivation that describes the relationship between memory capacity and resource management, and their effect on learning motivation.

From an instructional design viewpoint, the systematic process to approach motivational problems and the relationship between cognitive processing and motivation means it is possible to design and develop interventions for motivational problems based on a cognitively based instructional strategy.

Purpose of the Study

The purposes of this study are to examine the feasibility of adopting a systematic and instructional design-oriented research design for the investigation of learning motivation, and to investigate the relationship between a cognitively based intervention and learners' motivation. This study employed (1) a procedure to diagnose, analyze, and develop instructional interventions for better motivational outcomes, (2) a hierarchical analysis of intellectual skills to better understand the complexity of the subject's cognitive learning tasks, and (3) the cognitive load theory (Sweller, 1994) as the foundation for developing the intervention in response to the identified motivational problems.

Methodology

Setting and Participants

Our focus in this study was on how subjects used a computer-based tutorial called M-Tutor™. M-Tutor was designed to help students learn MATLAB® syntax. MATLAB® is a computational software package that integrates mathematical computing, visualization, and a powerful computer programming language to provide a flexible environment for technical computing (Mathworks, 2003).

In the Fall semester of 2002, first-year engineering students who enrolled in ENGR 106, Engineering Problem-Solving and Computer Tools, were instructed to use M-Tutor as their primary means of learning MATLAB syntax. This 2 credit-hour, required course is designed to develop first-year engineering students' abilities to solve engineering problems with appropriate computer tools. In order to accomplish the course objectives, the instructor needed to create an active learning environment in the lecture, which emphasizes fundamental engineering concepts and problem-solving strategies. However, the students needed to simultaneously learn to be efficient and effective users of computer tools and use those tools to solve engineering problems. The instructor struggled with devoting class time to simply telling students about computer tools and how they worked versus covering fundamental engineering concepts and how to use these computer tools to solve realistic problems. Thus the instructor adopted M-Tutor to help students learn MATLAB syntax outside of class. Students' motivation for using M-Tutor to learn MATLAB was the focus of this study.

Keller's ARCS Model of Motivational Design and Instructional Materials Motivational Survey (IMMS) were adopted as the theoretical framework of learning motivation as well as the basis for quantitative and qualitative data collection. The study employed the one group pre and post-tests design. Three surveys were implemented: Pre-motivational survey, post-motivational survey, and an additional survey on the use of student-made glossary. The treatment was having students complete instructor-guided glossary items. The last survey focused on the glossary itself was implemented in order to associate students' perception towards the use of the glossary with their learning motivation levels. The pre-motivational survey based on the ARCS Model indicated that students gave a relatively low rating on the Satisfaction component. Students' qualitative responses also suggested that they felt frustrated when using the computer-based tutorial. The main reason for that reaction is the lack of connection between isolated coding tasks and their application to engineering problems. Thus the motivational strategy was developed based on the pre-motivational survey with specific emphasis on the Satisfaction component of ARCS Model.

The strategy for enhancing students' Satisfaction level is to provide students with more opportunities to gain a sense of accomplishment on course assignments by using M-Tutor™. Providing immediate feedback is also considered a crucial element for better motivational outcome. Thus the student-made glossary assignment was developed as the intervention to carry out the motivational strategy, which allows students to receive meaningful feedback as well as obtain a sense of accomplishment prior to solving application problems. The feeling of accomplishment is obtained by allowing students to go through smaller parts of the learning task (i.e. individual syntax as opposed to a chunk of coding). There are five columns on the glossary form: (1) syntax, (2) overview of the syntax, (3) student developed test case(s) based on instructor guidelines, (4) hand computations to predict results of test cases, and (5) MATLAB results. The complexity level of each column is increased by following the hierarchical analysis of intellectual skills (i.e. discrimination, concepts, and rules). By accomplishing the lower levels allows students to build a schema and tie the ideas together, so that when they are presented with a problem, they can relate the problem to their new schema.

Each glossary item was designed by the instructor according to immediate assignments since it helps students to better transfer newly acquired programming skills (composing with syntax) to application problems. Students were asked to complete the glossary before they worked on application problems.

Research Design

This study included all five steps of the generic instructional design process discussed earlier (i.e. ADDIE).

(1) The analysis of the pre-motivational survey and examining its data.
(2) The design of motivational intervention based on the pre-motivational data.
(3) The development of a motivational intervention based on previous relevant research and theories as well as subject matter experts' input.
(4) The implementation of the developed motivational intervention (instructional strategy) to the actual instructional setting.
(5) The evaluation of the motivational strategy by a post-motivational survey and an intervention-specific survey.

Development of Motivational Strategies and Data Processing

Pre- and Post-Motivational Survey and Data Analysis The first motivational survey was conducted in the week after the first M-Tutor assignment while the post-motivational survey was given after the implementation of intervention. The survey instrument collected students' Pre- and Post- reactions towards the

tutorial. Keller's IMMS survey was adapted in order to accommodate the computer-based study setting. It consisted of 36 rating questions (Cronbach's Alpha= 0.917). The Instructional Materials Motivational Survey (IMMS) (Keller, 1993) was developed based on the ARCS Model. The IMMS consists of 36 statements that are rated using Likert-type scales (1 = Not True; 5 = Very True). Each item is mapped to an individual ARCS component and provides a measure of the respondent's perception of that particular component. Quantitative data are composed of ratings from the IMMS. It is important to remember that responses to a Likert-type scale item generate categorical data that cannot be averaged to provide a mean response for an individual survey item. Therefore, the frequency with which students responded "Mostly True" and "Very True" on individual survey items were computed. For all items mapped to a particular ARCS component, the frequency with which students responded "Mostly True" (4) and "Very True" (5) was used to provide a single quantitative measure of that ARCS component. Qualitative data was also collected by open-ended questions attached to the survey. The main purpose of collecting qualitative data was to better identify design issues within each instructional component.

Studies indicate that the ARCS Model is applicable in the computer-based or web-based instructional environment (Keller,1999; Keller & Song,1999; Knowlton , Shellnut & Savage, 1999; Park & Hannifin, 1993) although it was originally designed for developing motivating instructional materials in traditional face-to-face, classroom settings. For this pilot study, the IMMS was modified to assess the motivational effectiveness of M-Tutor. Each survey item was revisited and, as needed, re-focused on the research question, which was to diagnose students' motivational level in using the tutorial as a learning tool, with the expectation that students would effectively learn MATLAB syntax and effectively use MATLAB as a tool for solving engineering problems.

Design, Development, Implementation, and Evaluation of Motivational Strategies After the pre-motivational survey, we analyzed the quantitative as well qualitative data to determine which aspect of motivation to address. A coding system (Table 1) was developed for analyzing qualitative data based on design principles of multimedia courseware (Szabo & Kanuka,1998; Evans & Edwards,1999; Coscarelli & Shrock, 2000). The instructional coding system categorizes qualitative responses from each mapped ARCS Model open-ended question into various instructional components. The instructional components involved were coded as interface design, content, learning support, and implementation. Each qualitative response could be coded in one or more categories. The research direction was visited repeatedly during the development of the coding system to insure the validity of items (Coscarelli & Shrock, 2000).

By triangulating the quantitative and qualitative data, valuable information can be gained. First, the research team can identify which instructional component(s) are most influential on students' motivational levels. Second, the research team can map the instructional components of the tutorial (interface, content, learning support, and implementation) to the ARCS Model components (Attention, Relevance, Confidence, and Satisfaction).

Also to explicitly evaluate the instructional intervention, a ten-question survey was developed to measure students' reactions towards the intervention independently of its effectiveness in enhancing their motivational level. (Cronbach's Alpha =0.926, N=957).

Table 1. *EXAMPLES OF CODES AND INTERPRETATIONS*

Instructional Component Code	**Keyword Examples**
Interface Design	Text, graphs, navigational system, interactivity menu
Content	Relevance, easiness and difficulty of information
Learning Support	Textbook, assistance, Help session, feedback, exercises
Implementation	Course structure, technical infrastructure

Results

Pre-motivational survey analysis

Table 2 indicates that students initially provided the least of amount of positive response towards the Satisfaction component of ARCS model based on the frequencies of "Mostly True" and "Very True" that were selected for each component. Additionally, the qualitative data suggested a considerable amount of students did not perceive using the tutorial as a satisfactory experience. Therefore the objective, based on the pre- analysis, was to increase students' satisfaction level towards the tutorial with a feasible instructional intervention.

TABLE 2. *Comparison of frequencies of "Very True" selected by participants among ARCS components*

Pre-Motivational Survey	Attention	Relevance	Confidence	Satisfaction
Frequency of response indicating "Mostly True" and "Very True" combined	2692	3568	2749	711

Identifying Motivational Strategies

The qualitative data analysis from the pre-motivational survey indicated that the main issue influencing students' motivation was the transfer between learning programming syntax and using the syntax in problem-solving scenarios. The problem of transferability is common in abstract cognitive skill instruction such as programming or mathematics. Quilici and Mayer (2002) conducted a study on the transferability of statistical skills to word problems, which suggests the transfer of knowledge can be facilitated by providing systematic and frequent training. Renkl *et al*. (2002) also suggests that by providing problem-solving examples with gradually increasing levels of difficulty students were able to develop complete problem-solving skills by themselves. The low ratings on the Satisfaction component provided further support for designing corresponding motivational strategies. In order to enhance the Satisfaction level, students should have more opportunities to receive feedback and have feelings of accomplishment by exercising newly-learned knowledge (Keller, 1987b). As a result, a student-made glossary was developed (Table 3), which allowed students to define and practice MATLAB syntax prior to being given engineering problems to solve.

TABLE 3. *Example of student-made glossary*

MATLAB Syntax	**Overview of Syntax**	**Test Case(s)**	**Expected Result for Each Test Case**	**MATLAB Command Used for Each Test Case and Result**
who	**Description:** Displays a list of all the variables available in the workspace. **Input Arguments:** none **General Format:** >> who	Enter these MATLAB commands: >> C = 0 >> x = 3 >> who	Lists the variables C and x (and anything else previously created) as being available in the workspace	As given under Test Cases. **Result:** Your variables are: C x
save	**Description:** Saves all results, or specified results, to a MAT file **Input Arguments:** filename and specific variables (optional) **General Format:** >>save filename >>save filename var1	1. Create three variables. 2. Save all of the variables you've created in a filename called **vars_all**. 3. Save two of the three variables you	Saves variables to a MAT file Where are the files saved? Give the exact path name. To the current directory which should be **h:/My**	X = 1 Y = 2 Z = 3 save vars_all save vars_two X Y

MATLAB Syntax	Overview of Syntax	Test Case(s)	Expected Result for Each Test Case	MATLAB Command Used for Each Test Case and Result
	var2 ...	created in a filename called **vars_two**.	**Documents/m-tutor**	

Implementation of Motivational Strategy: The Student-Made Glossary

The student-made glossary was implemented as a homework assignment towards the end of the semester. The glossary items came from the last M-Tutor learning unit assigned and included syntax needed to complete problem-solving assignments for the remainder of the semester. Students were asked to fill out all four columns as the first part of the assignment. Later the commands seen in the glossary were applied to other homework problems. The columns conform to Renkl's idea (Renkl, *et al.,* 2002) of increasing difficulty. In the first column, the student describes the programming syntax in terms of how and why to use it. In the next column, the student must generate a small sample case using the syntax. In the next two columns, the student generates an answer without the computer, then feeds their sample code into the MATLAB program and records its response.

Post-Motivational Survey Data Analysis

The same instrument (IMMS) used in the pre-motivational survey was administrated to conduct the post-motivational survey to make a valid comparison, as shown in Table 4.

A one-way ANOVA was applied to data analysis to investigate the significance of variance between pre- and post-motivational surveys as the result of implementing the motivational intervention, that is, the student-made glossary.

The analysis indicated that the use of the glossary significantly lowered students' satisfaction as shown in Table 4 based on the aforementioned frequency method, which contradicts our hypothesis that the satisfaction level would increase when students were provided with opportunities to practice newly acquired skills and to gain meaningful feedback. Possible reasons contributing to the result will be addressed in the Discussion section.

TABLE 4. *One-way ANOVA on students' satisfaction towards M-Tutor between Pre- and Post-motivational surveys*

	Pre Mean	Post Mean	F	Significance level
N= 957	0.75	0.57	10.717	0.001

Post-Motivational Survey and Glossary Survey

The purpose of implementing the glossary survey (Cronbach's Alpha= 0.926) was to collect data on students' reactions to using it as a supplementary learning tool and its relation to students' satisfaction level on the post-motivational survey. To thoroughly evaluate the implemented motivational strategy (i.e. student-made glossary), it is important to measure students' initial reaction towards the glossary as the first level of evaluation (Kirkpatrick, 1998). Interestingly the linear regression analysis suggests there is a significant relationship between students' reactions towards the glossary and the post-satisfaction response frequencies as shown in Table 5. Students' reactions towards the glossary, which was developed based on the different levels of intellectual skill hierarchical analysis, had a statistically significant relationship with students' post-satisfaction level as defined by Keller's ARCS Model.

TABLE 5. *Linear regression analysis between students' reaction towards glossary and Post-satisfaction responses frequencies*

Y=aX+b	Coefficient	t statistic	P value	R Square
a(Glossary Reaction)	0.1103	9.2985	9.42E-20	0.083

The study suggests that the cognitively based instructional intervention (i.e. student-made glossary) is influential on the variance of students' Satisfaction level in a computer-based instructional setting, though the

effect is considered negative towards students' overall motivational gain. Further discussion will explore the underlying reasons as to how the construction of their problem-solving schema affects students' perceived motivational levels during the development of higher cognitive skills.
As the result of evaluation for the implemented intervention, the significant linear regression relationship between students' positive reaction to glossary and their post-satisfaction level suggests, interestingly, the possibility of other factors affecting the motivational gain induced by the glossary, which also will be discussed in the next section.

Discussion

Traditionally motivational studies have not been conducted very systematically, perhaps due to the complex nature of motivation and the difficulty in measuring it. This study uses a generic systematic model, ADDIE, often used in instructional design, with the following steps: analysis, design, development, implementation, and evaluation. The ADDIE model is general enough to approach most problems, including motivation. The appearance of each component of ADDIE in most of the accepted instructional design models today is a sign of its theoretical grounding.

This study focused primarily on the Satisfaction component after the pre-motivational survey, and showed significant change after the intervention. Students felt less satisfied towards M-Tutor after the use of the glossary. However, the regressive relationship between students' positive reaction to the glossary (i.e. how they like the intervention) and their post-satisfaction level suggests otherwise. Before we delve into the reasons as to why the loss of motivational gain, it is necessary to first to understand the function of student-made glossary and how it is compatible with Keller's definition of the Satisfaction component. Keller breaks Satisfaction up into three parts: natural consequences, positive consequences, and equity (Keller, 1987).

It could be that either positive consequences or equity relate to this study. The design and development of student-made glossary, however, focused on natural consequences mainly because it can give students a meaningful way to transfer the information they have learned. The student-made glossary is a cognitive advance organizer that addresses that aspect of satisfaction by helping student create a glossary of terms, leading them from knowing what the term is to practicing how to use it. The organizer categorizes students' knowledge, then provides a way for students to use it in a meaningful way in context and therefore meeting the "natural consequences" requirement of satisfaction.

Given the pedagogically-sound theoretical foundation and rationale of designing and developing the student-made glossary derived from either cognitive loading theory (e.g. worked example) (Sweller, 1994) or the ARCS motivational design model (Keller, 1987a,b), the negative effect on motivational gain induced by the glossary raises issues not only associated with the developmental portion of instructional intervention, but redirects our attention to the overall research design, especially in the implementation part of the study.

The pre-motivational survey was administered in the first quarter of the semester while the instructional intervention (i.e. student-made glossary) was not in place until the last quarter due to time needed for the pre-motivational survey data analysis and the design and development of the glossary. This temporal gap is typical in the developmental research (Richey& Nelson, 1996). Additionally the study was conducted simultaneously with the progression of the course. Therefore it is very likely that the glossary is not the cause of the motivational loss. Various factors such as course structure, complexity of learning tasks, interaction between teaching staff (i.e. professors and teaching assistants) and students, and the utilization of M-Tutor could have influenced students' motivation levels. It is questionable whether the student-made glossary could overcome the interactions among the aforementioned factors in terms of students' motivational gain or loss. In order to better measure any instructional intervention's effectiveness especially on perceived motivation, a more controlled study setting (e.g. smaller sample size) with a much shorter time gap between pre- and post-motivational surveys needs to be applied.

Conclusion

This study presents the concept and feasibility of using a generic instructional design process (ADDIE model) to motivational evaluation. It also demonstrates the use of the ARCS Model of Motivational Design for analysis and evaluation of students' learning motivation when using an existing computer-based tutorial. Triangulation of quantitative and qualitative data provided insight on the impact of instructional components on students' learning motivation as represented by four motivational components, which is also helpful for future revision of the computer-based tutorial. Finally the issue of effective implementation of an instructional intervention for motivational studies poses important considerations when migrating from the realm of

developmental research to a more replicable research design.

References

Ames C., (1992). Classroom: Goals, structures, and student motivation, *Journal of Educational Psychology,* 84, 261-71.

Anderman, E., M.,& Maehr M., L., (1994). Motivation and schooling in the middle grades, *Review of Educational Research*, 64, 287-309.

Astleitner, H.& Wiesner, C. (2004). An integrated model of multimedia learning and motivation. *Journal of Educational Multimedia and Hypermedia*, 13(1), 3-21.

Bandura, A.(1997), *Self-efficacy: The exercise of control,* New York: Freeman,.

Chalupa M., Chen, C.,& Charles, T. (2001). An analysis of college students' motivation and learning strategies in computer courses: A cognitive view. *The Delta Pi Epsilon Journal.* 43(4), 185-99.

Cokley, K.O., Bernard, N., Cunningham, D. & Motoike, J. (2001). A psychometric investigation of the academic motivation scale using an United States sample. *Measurement and Evaluation in Counseling and Development*, 34(2), 109-19.

Dick, W. (1996). The Dick and Carey model: Will it survive the decade? *Educational Technology Research and Development*, 44(3), 55-63.

Evans C., and Edwards M., (1999). Navigational interface design for multimedia courseware, *Journal of Educational Multimedia and Hypermedia*, 8(2),74-151.

Gentry C., G.,(1994) *Introduction to instructional development: Process and technique.* Belmont, CA: Wadsworth Publishing Company.

Gonzalez-Pienda, J.A., Nunez, J.C., Gonzalez-Pumariega, S., Alvarez, L., Roces, C. & Garcia, M. (2002). A structural equation model of parental involvement, motivational and aptitudinal characteristics, and academic achievement. *Journal of Experimental Education,* 70(3), 257-87.

Gustafson K., L., and Branch, R., M.,(1997). *Survey of instructional development models, third edition,* Syracuse, NY: ERIC Clearinghouse on Information and Technology,

Hancock, D.R. (2002). Influencing postsecondary students' motivation to learn in the classroom. *College Teaching.* 50(2), 63-66.

Harlen, W. & Crick, R. D. (2004). Testing and motivation for learning, *Assessment in Education: Principles,Policy & Practice*, 10(2), p169-207.

Keller, J.M. (1987a). Strategies for stimulating the motivation to learn. *Performance and Instruction Journal.* 26(8). 1-7.

Keller, J.M. (1987b). The systematic process of motivational design. *Performance and Instruction Journal.* 26(9/10). 1-8.

Keller, J.M. (1993). *Instructional Material Motivational Survey.* Unpublished manuscript.

Keller J., M., and Song S., H., (1999). The ARCS Model for Developing Motivationally-Adaptive Computer Assisted Instruction", *Proceeding of Selected Research and Development Papers Presented at the National Convention of the Association for Educational Communications and Technology (AECT)*.

Kirkpatrick, D.L. (1998). *Another look at evaluating training programs.* Alexandria, VA: American Society for Training & Development.

Klein, H.J.(1989). An integrated control theory model of work motivation. *Academy of Management Review*, 14: 150-172.

Knowlton A., Shellnut B., and Savage T.,(1999). Applying the ARCS Model to the design and development of computer-based modules for manufacturing engineering courses, *Educational Technology Research & Development*, 47(2).

Linnenbrink, E.A. & Pintrich, P.R. (2002). Motivation as an enabler for academic success. *School Psychology Review*, 31(3), 313-27.

Malone, T.W., & Lepper, M.R. (1987). Making learning fun. A taxonomy of intrinsic mo tivations foe learning. In R.E. Snow & M.J. Farr (Eds.), *Aptitude, learning, and instruction. Volume 3: Conative and affective process analyses* (pp.223-253). Hillsdale, NJ: Lawrence Erlbaum.

MathWorks (2003), *MATLAB®*, http://www.mathworks.com/, 2003.

Messner W., Tilbury D., (1999). *Control Tutorials for MATLAB ® and Simulink ®: A Web-Based Approach,* Prentice Hall, http://www.engin.umich.edu/group/ctm/index.html .

Miller, R.B. & Brickman, S.J.(2004). A Model of Future-Oriented Motivation and Self-Regulation, *Educational Psychology Review*, 16 (1), 9-33.

Park I., and Hannifin M., J. (1993). Empirically-based guidelines for the design of interactive multimedia,

Educational Technology Research & Development, 41(3), 63-85.
Quilici, J.H. & Mayer, R.E. (2002). Teaching students to recognize structural similarities between statistics word problems. *Applied Cognitive Psychology.* 16, 325-342.
Renkl, A., Atkinson, R.K., Maier, U.H., & Staley, R. (2002). From example study to problem solving: Smooth transitions help learning. *The Journal of Experimental Education.* 70(4), 293-315.
Richey, R. C., & Nelson, W. A. (1996). Developmental research. In D.H. Jonassen (Ed.) *Handbook of research for educational communications and technology* (pp. 1213-1245).New York: Macmillan.
Sigmon K., 1993. *MATLAB Tutorial,* University of Florida, Retrieved from http://www.gg.utah.edu/gg_computer_seminar/matlab/matlab.html,.
Smith, P. L., & Ragan, T. J. (1993). *Instructional design.* New York: Macmillan
Sweller, J. (1994). Cognitive load theory, learning difficulty and instructional design. *Learning and Instruction*4: 295-312
Szabo M., and Kanuka H. (1998). Effects of violating screen design principles of balance, utility, and focus on recall learning, study time, and completion Rates, *Journal of Educational Multimedia and Hypermedia,* 8 (1), 23-42.
Vroom, V. (1964). *Work and motivation*. New York: Wiley.
Weiner, B. (1985). An attributional theory of achievement motivation and emotion. *Psychology Review*, 92, 548-73.
Wolters, C. A. (2004) Advancing achievement goal theory: Using goal structures and goal orientations to predict students' motivation, cognition, and achievement. *Journal of Educational Psychology*; 96(2), 236-50.