The Effects of Technology-Mediated Instructional Strategies on Motivation, Performance, and Self-Directed Learning

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Abstract: The shift in education from an instructor-centered to a learner-centered focus requires learners to be self-directed and motivated. However, empirical data are lacking on how to positively effect self-directed learning. Further, the motivational needs of learners are often overlooked, and there is need for more literature examining both self-directed learning and motivation in technology-mediated learning environments. The purpose of this design experiment was to attempt to positively affect motivation, performance, and self-directed learning of undergraduate students enrolled in a tuition-free, public military school. A second purpose was to use new technologies to deliver these instructional strategies as supplementary course content. The subjects in this study were undergraduate students enrolled in a tuition-free, public military school in the Northeast United States. 784 students, representing approximately 20% of the population at the academy, were randomly divided into control and experimental groups for each of 16 instructors. Interventions were developed using Keller's ARCS model of motivation and delivered via PDA, web, and other technologies. The within-subjects research design used a mixed method approach involving both quantitative and qualitative data. Students completed four surveys to measure motivation and SDL. Course aggregate points were used to measure academic performance. The findings showed there were significant differences in motivation, academic performance, and proclivity to be self-directed learners of students who accessed the technology-mediated instructional strategies, suggesting that such motivational strategies should be incorporated into course instructional design.

Introduction

In the past century, the concept of distance learning has evolved from correspondence courses to instructional television to computer-based instruction to web-based learning. Today, the effort to put courses online is ubiquitous in education and training. Technology-mediated learning environments provide new opportunities for people to learn at their own convenience and pace. This shift in education from an instructor-centered to a learner-centered focus requires learners to be motivated and self-directed (Lee, 2000). However, empirical data are lacking on how to positively effect self-directed learning and satisfy the motivational needs of learners (J. Visser & Keller, 1990). Further, there is need for more literature examining motivation in technology-mediated learning environments.

Csikszentmihalyi, for example, spent over thirty years researching controlled experiments and case studies to investigate the importance of motivation and positive psychology (1990). His volumes of empirical evidence conclude that motivational issues are as important to learning as cognitive issues. Motivation has been found to be one of the most critical concerns in how and why people learn (Efklides, Kuhl, & Sorrentino, 2001; Keller, 1979). Keller (1999) notes that instructional designers are faced with even greater challenges in self-directed learning environments than with traditional learning, especially with regard to satisfying the motivational needs of learners.

Further, there has been some criticism about the quality of existing literature. Reeves (1995) analyzed decades of research studies in instructional technology (IT). He concluded that most studies in the field have problems including insufficient sample sizes, specification errors, lack of connection to theoretical foundations, meager treatment implementation, various measurement flaws, inaccurate statistical analyses, and futile discussions of results. The same author (Reeves, 2000, p. 4) said, "Given the poor quality of the inputs to research syntheses in the field of instructional technology, it is little wonder that the literature reviews and meta-analyses in IT yield disappointing results that provide practitioners with insufficient or confusing guidance." Similarly, Kulik and Kulik (1991) conducted an extensive literature review to examine the effectiveness of computer-based instruction. They argued that researchers conducting meta-analyses often reject more than 75 percent of published studies to include a small number that are worthy of additional analysis.

Thus, for researchers, the challenges include the need to pay particular attention to research design, development, and analyses. For instructional designers and educators, the challenges include the need to select the most appropriate instructional, technological, and motivational methods to improve learning. This study deals with some of these challenges.

Purpose/ Problem

Motivation is essential to learning and performance, particularly in technology-mediated environments where students must take an active role in their learning by being self-directed (Lee, 2000). However, empirical data are lacking on how to positively effect self-directed learning (SDL). Further, despite the importance of motivation to learning, J. Visser and Keller (1990) argue that the motivational needs of learners are often overlooked in educational research. To demonstrate this gap in the literature, L. Visser, Plomp, Arimault, and Kuiper (2002) examined the proceedings of the World Conferences of the International Council for Distance Education between 1988 and 1995. They found that less than one percent of the papers (only six of 801) focused on motivational issues. Consequently, more empirical research is necessary to examine motivation in technology-mediated learning environments.

Maslow (1970) defines motivation as a psychological process where a behavior is directed toward a goal based on an individual's needs. Keller (1999) argues that although motivation is idiosyncratic, learner motivation can also be affected by external aspects. These factors include systematic instructional design of tactics and strategies intended to improve motivation and performance, as well as encouragement and support by instructors, tutors, or peers. Thus, it would seem feasible that after conducting a motivational analysis of learners, appropriate strategies could be developed to improve motivation, performance, and SDL.

There is both experimental and correlational support for the instructional methods presented in this study. Song (1998) used Keller's Attention, Relevance, Confidence, Satisfaction (ARCS) model of motivation to develop computer-based instruction for middle school students. One control and two experimental groups received different levels of motivation in the instruction. Song found significantly higher levels of attention, relevance, motivation, and effectiveness in the group that received motivationally adaptive instruction than in the control group. J. Visser (1990) studied the impact of strategies designed using Keller's ARCS model that were delivered to adult learners. His embedded single-case exploratory study concluded that motivational messages could enhance learning by motivating students to undertake SDL tasks outside the classroom. J. Visser and Keller (1990) further studied the efficacy of motivational messages with adult learners in Mozambique, also with positive results. L. Visser (1998) took the concept of motivational messages a step further to encourage learners to persist in correspondence courses. She found that learners who received the motivational messages had reduced dropout rates and increased satisfaction. L. Visser, Plomp, and Kuiper later (1999) used similar strategies using the ARCS model with distance learners. In all studies, motivational messages were generally found to improve learner motivation, retention, satisfaction, and performance.

The purpose of this design experiment was to attempt to positively affect motivation, performance, and self-directed learning of undergraduate students enrolled in a tuition-free, public military school. A second purpose was to use new technologies to efficiently deliver these instructional strategies as supplementary course content. Three questions were examined to achieve these purposes:

1. In applying the technology-mediated instructional strategies (TMIS) in the given instructional context, will a relationship exist between access to TMIS and academic performance as measured by course aggregate points (projects, homework, and examination grades throughout the semester)?
2. In applying the TMIS in the given instructional context, will a relationship exist between access to TMIS and proclivity to be self-directed as measured by the SDLRS instrument?
3. In applying the TMIS in the given instructional context, will a relationship exist between the access to TMIS and student motivation as measured by Keller's ARCS instruments (CIS and IMMS)?

Sample/ Population

The subjects in this study were undergraduate students enrolled in a tuition-free, public military school in the Northeast United States. 784 randomly selected students, representing approximately 20% of the population at the academy, agreed to participate in the study. The selected courses primarily consisted of freshmen and juniors in the graduating classes of 2003 and 2005. The courses were diverse in content (i.e. hard vs. soft sciences) to address the situational aspects of motivation.

Twelve courses were selected for the treatment and control, in a balanced design where each instructor had randomly assigned treatment sections and control sections. Within these courses, students in each section had identical syllabi and took identical examinations. Instructors were not informed of which sections were treatment and which were control.

Limitations of the Study

The most palpable limitation of the study was the homogeneity of the population. Prior studies in this publicly funded military academy reveal that the demographics of these cadets are not representative of traditional students (Hancock, 1991; Preczewski, 1997). For example, only 15% of cadets are female, all are unmarried with no children, and none are physically handicapped. The results are not likely generalizable beyond this context. However, this homogeneity also provides increased scientific control of the internal validity of the research.

Research Design

A mixed method approach involving both quantitative and qualitative components was employed in this study. Four surveys were used to measure motivation and self-directed learning: (1) the Course Interest Survey (CIS), developed by John Keller; (2) the Instructional Materials Motivation Survey (IMMS), developed by John Keller; (3) The Self-Directed Learning Readiness Scale (SDLRS), developed by Lucy Guglielmino, and; (4) The Self-Directed Learning (SDL) survey, developed for this study to track experimental group students' participation and perceptions of the strategies. The CIS, IMMS, and SDLRS were converted to web-based format and made available along with the SDL survey on the campus intranet. For all students in the study, academic performance (measured by course aggregate points including homework, projects, papers, and exams) was tracked throughout the semester, and extensive demographic data were also collected. See Figure 1 for the conceptual model.

Figure 1: Conceptual Model

Design of Technology-Mediated Instructional Strategies

Each TMIS consisted of three basic components (see Figure 2): (1) motivational messages at the beginning and end of each strategy; (2) supplementary instructional content, and; (3) the SDL survey to track participation and perceptions.

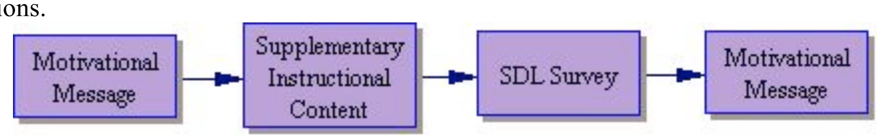

Figure 2: Systematic Design of Technology-Mediated Instructional Strategies

Keller's ARCS model of motivational design includes a ten-step procedure for instructional designers to develop motivational systems. The procedure was used for the design and development of TMIS in the present study and includes the following 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
10. Evaluate and revise.

Most of the strategies were interactive instructional content provided for PDAs, on the Internet or academy intranet, or on CD-ROM. All technology-based content was provided in at least two formats (i.e. PDA and web) to ensure accessibility. See Table 1 for examples of ARCS components incorporated in the TMIS.

Instructional Content	Technology	ARCS Components
Instructional Resources	Web, streamed video, PDA	A, R, C, S
Self-Assessment	Intranet	C
Skill Briefs	PDA	A, R
Social Interaction	Threaded Discussion, IRC, Email	R, C, S
Mentor Support	Email	C

Table 1: Examples of ARCS Components Incorporated in TMIS

Figure 3 presents an example of a portion of a TMIS provided for PE210, Introduction to Wellness. ARCS components are seen throughout the design. The end of the content (not shown) supplies additional information which relates to cadets in their everyday lives and is intended to help students master course objectives. Figure 4 shows an example of the motivational messages portion of TMIS annotated with ARCS components.

Figure 3: Example of Instructional Content Portion of TMIS

Hello again EN 102 Cadets,

Congratulations to all of you who participated in or supported the rigorous Sandhurst competition over the weekend! I also hope you did great on your last WPR. Thanks to all of you who have responded to the strategies so far (again, if you haven't, it's never too late). Most of you said you found the last strategy helpful, but as expected, some of you said you had too many other obligations to spend much time with the strategy. Based on your input, we are working to improve the strategies to try to make them as beneficial to learning the course material as possible.

You have been working on the challenging assignment of using your West Point experiences to produce a video that draws from *the Odyssey*. While not directly related to your video production, Strategy 6 should help you with your upcoming writing assignments, including HWE5. The strategy is provided in both web-based and PDA-based formats. Please give us your honest opinion on this supplementary material no later than COB 8 May. *Remember that even if you choose not to access the strategy, you should complete the brief questionnaire.* We would also strongly encourage you to provide your comments in the additional space provided on the web-based questionnaire.

1. Access **Strategy 6**: <> which is a study guide for the writing process. If you would like to add the web site to your PDA, click here to automatically add it to your existing AvantGo channels <>. Hint: when using your PDA on pages with lots of text, use the search function to quickly find what you need. Next, visit <> which is a study guide about writing correctly. To add the site to your PDA, click here to add it to your existing AvantGo account: <>.

2. Complete the brief online questionnaire: <> and please provide comments to give us the most beneficial feedback.

Thanks...and don't hesitate to contact me or CPT Corbett if you have any questions or if you need any assistance. Good luck on your HWE5!

Take care.

Gabrielle

Attention- Text has good blend of colors and is easy to read.

Relevance - addressed to specific students in their own language.

Relevance - relates to their everyday lives.

Satisfaction- lets the students know that their feedback is being heard and that they are making a difference in the content they receive.

Relevance - letting students know that you are connecting what they have been working on to what they need to know for their next assignments.

Confidence - providing alternate forms of instructional content; both PDA and web.

Confidence- making the instructional content portion of the TMIS easily accessible and instructions on how to access the TMIS clear.

Relevance- using the name of their instructor and reiterating that you are working together to help them master the objectives.

Relevance - talking their talk. HWE5 means homework assignment number 5.

Figure 4: Example of Motivational Message Portion of TMIS

In order to respect student time constraints, the TMIS were delivered no more than six times per course. Student feedback allowed the instructional designer to use formative evaluation to improve the TMIS and document the changes throughout the process (see Figure 5). Customary of design experiments, the interventions are replicable beyond this study. The instructional content is specific to a course, though the TMIS can be re-used and modified as needed in subsequent semesters. The modifications are facilitated with the use of technology.

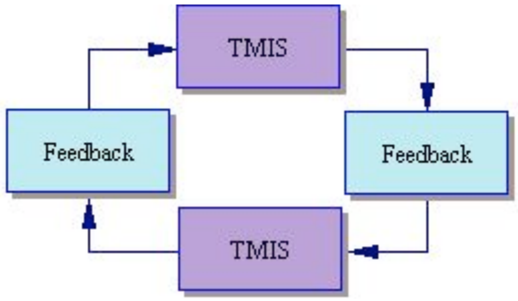

Figure 5: Formative Evaluation in TMIS Design Experiment

Procedures

The researcher met with academy department heads and course directors for input about the most appropriate courses to include. Course directors and department administrators selected instructors who reflected the diversity of all faculty including civilians and military officers. The researcher emailed all selected instructors to share information on their role in the study and request all course instructional materials so TMIS could be developed. A project website was developed to keep instructors informed. See Table 2 for a summary of the subsequent procedures and timeline.

	Control	Treatment
1. Visit classrooms in beginning of semester.	All	All
2. Email participants to thank them for participation.	All	All
3. Administer SDLRS pretest 2 weeks into study.	100 randomly selected	100 randomly selected
4. Administer CIS 4 weeks into semester.	All	All
5. Distribute TMIS a maximum of 6 times during semester.		All
6. Administer IMMS 2-4 times throughout semester.	All	All
7. Administer SDLRS posttest 2 weeks from end of semester to same students who took the pretest.	100 randomly selected	100 randomly selected
8. Collect performance data throughout semester.	All	All

Table 2: Summary of Procedures and Timeline

After communicating with instructors, the researcher visited all 48 classrooms to discuss the study and obtain signed informed consent forms. To prevent subject bias, the word "self-directed learning" was not used. A mock script was provided to instructors to ensure that students received the same information. Instructors encouraged participation by assuring students that the strategies would be brief, pre-approved by instructors, and designed to help them master course objectives. Students were assured that their participation was voluntary and confidential. All participating students signed informed consent forms before the study began.

An email message was sent to all participants thanking them for their participation. The SDLRS instrument was converted to web-based format and made available on the campus intranet. The SDLRS was called the Learning Preference Assessment to prevent subject bias. In the beginning of the semester, a random sample of 106 treatment group and 106 control group subjects received an email message directing them to complete the SDLRS. The rationale for limiting the number of students was the cost of the instrument. In the last two weeks of the semester, the same selected participants were asked to complete the SDLRS, providing a pretest/ posttest measure. It was assumed that four months between the tests was a sufficient interval to prevent test-retest issues. Some cadets were resigned from the academy before the end of the semester or did not complete the posttest, yielding 91 control and 104 treatment group students.

Treatment group students received TMIS via email. Each TMIS included motivational messages, a link to supplementary instructional content, and a link to the SDL survey. The SDL survey tracked participation and time on task, as well as open-ended questions for feedback about the TMIS. Control group participants did not complete the SDL survey since they did not receive the strategies.

Control and treatment group participants completed the online IMMS and CIS to quantify situational measures of motivation. The CIS was administered to all participants in the first two weeks of the study to measure their interest in each course. Email messages were sent to control group participants asking them to consider instructional materials related to specific course objectives to complete the IMMS. Email messages were sent to treatment group participants asking them to complete the IMMS to give their perceptions of the same instructional materials *and* associated TMIS.

Academic performance was measured for all participants by course aggregate points (examination, homework, projects, and other grades), except for EN302 students who were graded with pass/fail.

Data Analysis

Table 3 represents the hypotheses, instruments, and data analysis procedures used to test the hypotheses.

Hypotheses	SDL	SDLRS	IMMS	CIS	Variables	Stat Test
H_{A1}: Treatment group students who used TMIS have significantly higher levels of academic performance (measured by course aggregate points including homework, projects, papers, and examinations) than control group students taught by traditional methods.	Usage				IND= Access to TMIS, instructor, course DEP= Academic Performance	General Linear Model, Resampling for WPPWE examination (P/F)
H_{A2}: The change in the mean pretest and posttest SDLRS score of treatment students with access to TMIS is significantly higher than the change in the mean pretest and posttest score of control group students taught by traditional methods.	Usage	Total Score (pretest/ posttest)			IND= Access to TMIS DEP= Δ SDLRS score	t-test, Wilcoxon Rank Sum test
H_{A3}: Treatment group students with access to TMIS have significantly higher mean vector scores for CIS and IMMS than control group students taught by traditional methods.	Usage		A,R,C,S, Total Score	A,R,C,S, Total Score	IND= Access to TMIS DEP= CIS score, IMMS score	Hotelling's *T*-squared test, MANOVA

SDL = Post-Strategy Self Directed Learning; SDLRS = Self-Directed Learning Readiness Scale; IMMS = Instructional Materials Motivation Survey; CIS = Course Interest Survey

Findings

Quantitative research findings indicated that there were significant differences in academic performance (p=.0045) between those students who accessed the technology-mediated instructional strategies and those who did not access the strategies. There were also significant differences in motivation as measured by the Course Interest Survey (p=.009) and the Instructional Materials Motivation Survey (p= less than .0001). Further, as hypothesized, the change in SDLRS scores was significantly greater for treatment group students than for control group students. There was a significant difference (p=.004) between the two groups, with control group cadets dropping by 3.3 points and treatment group cadets increasing SDLRS scores by 2.82 points.

Qualitative data showed that cadets felt the technology-mediated instructional strategies benefited their learning experience. For example, cadet comments included:

- "The tutorial was concise and quick to read... to the point and quick--just what cadets need."
- Seeing pictures to tie with the things we have heard about and were suppose to think about helped a lot. It made it more interesting."
- "The PDA is very helpful because you can always access your work and it has some interesting readings on it."
- "I am really enjoying the online discussions. In class, discussions are happening in real time, so a lot of very random thoughts are tossed out. However, on the web you have more time to think and contemplate what you are going to say before you say it. This ensures that the level of conversation stays in the intelligent realm."
- "WOW!!! about sums it up. The link to the tutor pages was awesome. They had so much information that I had to go back a few different times this weekend just to see all that was there. This is good stuff, just like all that has been coming our way in order to help prepare us to be successful for the lessons and WPRs (exams)."
- "I really appreciated all of the extra study material all year, and I think that it should be made accessible and encouraged for all classes of basic chemistry."
- "The questions give the reader an idea of what to look for and also causes the reader to think more in depth on a subject or event he might have overlooked."
- "I enjoy the threaded discussions better than just writing out a journal entry. It helps to get different perspectives on the material from classmates as opposed to only hearing the instructor's side of the work."
- "It was fun!!! Made learning more interactive."

Qualitative data were very insightful as to how beneficial cadets perceived the strategies. Most were highly positive, though a handful of comments were negative, particularly with regard to frustration about using the technologies. Whenever a cadet made comments on the SDL questionnaire about problems with the technologies, the researcher contacted the cadet to help resolve the issue. Most problems were able to be resolved through email or phone dialogue, though a few cadets needed to bring their PDAs in to have the researcher fix them. Aside from that, many comments included wanting more interactivity and making the learning experience more fun.

Conclusions

This study revealed that systematically designed technology-mediated instructional strategies can be effective means of improving motivation, performance, and self-directed learning of students. Further, Keller's ARCS model is an effective method of developing such strategies and addressing the motivational needs of learners. Likewise, new technologies including PDAs can be efficient and effective means of delivering instructional content. Additional research is needed to show the effects of specific strategies on motivation and to test the instructional methods presented in this study with different populations.

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