Relating E-Learning Effectiveness to Choice of Media for its Contents: A Quasi-Experimental Approach

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RELATING E-LEARNING EFFECTIVENESS TO CHOICE OF MEDIA FOR ITS CONTENTS: A QUASI-EXPERIMENTAL APPROACH

Lien entre l’efficacité de l’apprentissage électronique et le choix du média : une approche quasi-expérimentale

Research-in-Progress

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Abstract

Improved multimedia capabilities of information technology have resulted in increased interest in e-learning programs. Consequently, researchers and practitioners are investigating ways for design and development of effective e-learning programs. The prevailing tendency seems to be to use “richer” medium, in the progression from text to graphics to audio to video. It is not clear, however, if a “richer” medium always provides proportionately higher learning effectiveness. In this research-in-progress paper, we present a research model that the relationship between choice of media to present contents of an e-learning program and the program’s learning effectiveness is moderated by the learning domain of the program and the learning styles of learners. We then present a robust framework of quasi-experiments to fully test the research model, followed by encouraging results from three quasi-experiments as a prototype of the full framework. Lessons from the prototype are incorporated in the framework of quasi-experiments.

Keywords: E-learning, choice of media, learning domain, learning style, learning effectiveness, quasi-experiments

Résumé

Dans cette recherche en cours, nous présentons un modèle de recherche selon lequel la relation entre le choix du média pour présenter le contenu d’un programme d’apprentissage électronique et l’efficacité de l’apprentissage est modérée par le domaine d’apprentissage du programme et le style d’apprentissage des apprentis. Nous testons le modèle de recherche à l’aide d’une quasi-expérimentation.

Introduction

Significant improvements in information technology (IT) in accommodating multimedia contents have encouraged applications of IT in numerous activities, including for e-learning, also referred to as technology-mediated learning (TML) or computer-assisted instruction (CAI). As a result, how to design and develop effective e-learning programs has been of great interest to researchers and practitioners. Our study focuses on one of the important design decisions, namely selecting an appropriate medium to present the contents of an e-learning program, in particular for a self-learning program aimed at individual learners.

At the conceptual level, the academic discourse on the use of information technology for learning spans a wide spectrum from those who assert that media has no influence on learning effectiveness to those who believe that decisions made regarding media will have a major influence of learning effectiveness. Clark (1994) emphatically
stated that media will never influence learning effectiveness, but agreed that media choice may influence the cost or efficiency of learning. Kozma (1994 and 2000), on the other hand, advocated that technology, symbol systems and processing capabilities ought to be studied for their influence on learning effectiveness. A number of empirical studies have been conducted, albeit with contradictory results, addressing the effectiveness of media choice for e-learning programs for specific courses (Wisher and Curnow (1999), Passerini and Granger (2002), Jones (2002), Blank, et al (2002), Jones et al. (2005), Cybinski and Selvanathan (2005) and Luthans et al (2008)). The diametrically opposite views at the conceptual level and the contradictory results from empirical studies suggest the need for a deeper look at learning effectiveness of choice of media for contents, namely text, graphics, sound/audio and video.

We propose a research model, anchored in the results from current information systems (IS) research and learning research, that the relationship between media choice to present the contents of an e-learning program and the effectiveness of that program is moderated by the characteristics of the subject matter or learning domain and of the learner. The research question we are looking at is – in a self-learning program aimed at individual learners, does choosing a medium that allows for more data and more diverse set of cues and symbols always increase learning effectiveness?

Theoretical Background

A number of Information Systems (IS) research papers, focused on the use of information technology for learning, has proposed very insightful theories and frameworks. Alavi and Leidner (2001) call for greater depth and breadth of research in TML. They suggest potential research avenues that require explicit consideration of relationships among technology capabilities, instructional strategy, psychological processes and contextual factors involved in learning. Leidner and Jarvenpaa (1995) provide a theoretical foundation for using information technology to improve learning processes by providing a framework for fit between technologies for different electronic classroom types with learning models. Piccoli et al. (2001) proposed a research framework for investigating effectiveness of web-based virtual learning environments that combined technology, learning models, learners, instructors, and contents. They also presented a preliminary assessment of effectiveness of Web-based virtual learning environment for one course in basic IT skills training. Holsapple and Lee-Post (2006) provide constructs for intermediate learning outcomes and also net benefits, including expected grades. Arbaugh and Rau (2007) considered the effects of subject matter, course structure, participant behavior and media variety on perceived learning and satisfaction. Wan et al. (2007) identified four primary inputs for e-learning programs, namely student, instructor, instructional design and information technology. All these papers correctly call for combining consideration of subject matter, learners, instructional design, instructor, learning environment and information technology.

Subject matter (or learning domain): Another set of IS research papers has focused on analyzing the characteristics of subject matter, or learning domain, that may influence effectiveness of e-learning programs. Hornik et al. (2008) conceptualize the difference across learning domains in terms of those with high paradigm development (e.g. computer science) and those with low paradigm development (e.g. sociology). They also used different learning objectives (levels) based on Bloom’s (1956) taxonomy (for cognitive domain only) as a moderating factor. They reported that student outcomes (i.e. grades and satisfaction) in an e-learning environment are higher for introductory courses in disciplines with low paradigm development than for introductory courses with high paradigm development. They also report that, conversely, student outcomes were higher for advanced courses with high paradigm development compared to advanced courses with low paradigm development. Arbaugh (2005a) categorized subject-matter based on whether or not Ph.D. is offered in the subject and hypothesized that e-learning in subjects for which Ph.D.s are offered will have higher grades, higher student perceived learning and greater student satisfaction than subjects in which Ph.D.s are typically not offered. Since the data did not support his hypothesis, he concluded that the focus should be on course level rather than on the discipline of the course. A course is still be too broad because it may consist of a heterogeneous set of topics and learning objectives. Bloom et al. (1971) state that a course, or a learning program, needs to be broken down into a series of steps or units to be learned in some sequence or structure. This would be similar to work break down structure in project planning/management. Given the IS research results published so far, the focus of our research is a well-bounded learning unit that is homogeneous in terms of contents and learning objectives.

included motivation and self-efficacy. Characteristics related to technology, such as comfort, attitude, anxiety, previous experience, and self-efficacy would influence the effectiveness of an e-learning program based on the multimedia technology used to deliver the program. Prior knowledge, motivation, and academic ability would be related to the specific topic of the e-learning program. Schniederjans and Kim (2005) analyzed characteristics of learners in an MIS course in terms of extraversion, emotional stability, agreeableness, conscientiousness, and openness to experience. They reported that learners with all these characteristics, except extraversion, affected the learning outcome (grade) positively. These studies did not address whether all those learner characteristics would influence the relative effectiveness of a media choice for presentation of contents compared to other media choices for a given topic and a delivery technology.

Three theories of learning also provide a strong theoretical background for incorporating in our study the characteristics of learning domains and learners. Perception, insight and meaning are key contributors to learning in the Cognitivist Theory of Learning (Merriam and Caffarella, 1999). According to that theory, learning is a cognitive phenomenon where a learner interprets the data acquired through the senses and gives meaning to that data. The Socio-Cultural Learning Theory (Merriam and Caffarella, 1999) posits that people learn from observing others and then visualize self-generated consequences. For something to be learned, it must be modeled and symbols from such models must be amenable templates for the learner to self-generate the appropriate experience. The Constructivist Theory of Learning (Jonassen, et al 1999, Merriam and Caffarella, 1999) posits that learning is a process of helping learners construct their own meaning from experiences by providing them those experiences first hand and guiding the meaning making process. According to this theory, knowledge about the topic of learning has to be conveyed to the learner, but the actual learning will depend upon the learner’s ability or preferences to construct that knowledge within him or her. These three learning theories point out that outcome of a learning program depends on its match with the capability or preferences of who is learning (a learner), and the use of symbols or models that are appropriate for what is being learned (domain of learning).

**Media choice:** For e-learning in particular, the more recent Cognitive Theory of Multimedia Learning (Mayer 2001) provides further theoretical foundation for the research model in our study. This theory is premised on three principles. (1) The dual channel principle is that humans possess separate information processing channels for visually presented data and auditorily presented data, and then integrate the results from both the channels. That suggests that providing data through both channels will lead to better results than through only one channel in conveying the data. (2) The second principle, however, is that humans have limited capacity to process data from each channel. This implies that there may be a threshold for the amount of data pushed through the two channels that can be of use to a learner, and above that threshold there may be no marginal addition to information being transferred to the learner. (3) The third principle in this theory is that humans actively process both the images they see and what they hear to create a coherent mental model of the subject. This theory suggests that although learning can be more effective by choosing media for presentation of contents that use both the channels, i.e. auditory and visual, it is worth investigating if there is a threshold above which learning may not be more effective and could be counter-productive. Our research model is aimed to investigate exactly that.

IS research papers have also looked issues related to media for e-learning. The notion of media variety (Arbaugh, 2005b, Arbaugh and Rau, 2005), media appropriateness (Tscheridou et al., 2008), and media choice (Irner and Bordia, 2003) have all been used to explain variations in e-learning effectiveness. Arbaugh (2005) reports that using a variety of media for online MBA courses increased student perceived learning but not student satisfaction with delivery medium. These studies focused on the choice of delivery technology rather than media choice for contents, e.g. text, graphics, sound and video.

Another stream of IS research has focused on the use of multi-media technologies for two highly important tasks in any business, namely organizational communications and managerial decision making. Daft and Lengel (1986, 1987) proposed the Media Richness Theory (MRT) which defines richness of a medium as its ability to reduce uncertainty and equivocality of information in order to achieve acceptable level of performance. Their result was that richness of media increases from numeric documents to impersonal documents to personal letter to telephone conversation to face-to-face meetings. MRT proposes that matching the richness of media to the needs of the task will improve performance of that task. The notion of “richness” of a medium for a task is certainly very appealing, but other studies have been published since then which refute the applicability of Media Richness Theory, primarily because it deals only with fitness between multimedia technologies and task, and does not factor in the characteristics of the individual performing those tasks (Trevino et al (1990), El-Shinnawy and Markus (1992, 1998), Dennis and Kinney (1998), Carlson and Davis (1998), Campbell (2006), Sun and Cheng (2007)).
**Learning effectiveness:** Different research papers have used different combinations of measures of effectiveness related to learning process and to learning outcomes. Arbaugh and Rau (2007) looked at perceived student learning; satisfaction with course delivery medium. Hornik et al. (2008) looked at withdrawal rates, grades in course, student satisfaction. Jones et al. (2005) looked at pre- and post- test scores. Palvia and Palvia (2007) looked at pre- and post- test scores in computing literacy and satisfaction with e-learning. Arbaugh (2005b) looked at student perceived learning and student satisfaction with e-learning. Holsapple and Lee-Post (2006) looked at user satisfaction with e-learning, user perceptions of net benefits of e-learning. Schniederjans and Kim (2005) looked at test exam score. Arbaugh (2005a) looked at course grade, perceptual data on perceived learning and perceived delivery medium satisfaction. Gagne and Merrill (1992) suggest nine instructional events relevant to effective learning. While their model is very useful in defining the process of learning, we have focused our study on the outcome of learning. Sharda et al (2004) addressed the issue of e-learning effectiveness by tapping the theoretical foundations of learning (Bloom, 1956). Their approach helps us understand the different learning outcomes associated with the different learning domains, namely cognitive, affective and psychomotor domains. While it is important to study impact on the learning process, we are interested in looking at the learning outcomes.

As explained above, IS research has studied extensively subsets of different pieces of the e-learning puzzle. Our research model is focused on the interactions between these pieces, namely subject matter or learning domain, learner characteristics, media choice and effectiveness of learning outcome.

**Research Model**

Figure 1 contains the schematic for our research model showing the hypothesized relationship between the choice of media for contents and learning effectiveness, moderated by the learning domain and learner characteristics.

![Figure 1. Research Model](image-url)

Media choices available to present contents of an e-learning program are text, graphics, audio/sound, and video. The amount of data and diversity of cues and symbols that can be conveyed through each of these media choices is very different, and that increases from text to graphics to audio/sound to video. Within video, there are two major practical alternatives for learning that provide very different opportunities for cues and symbols. The first is talking head where the video of the instructor or expert is shown talking about the subject. The second is full-motion video or animation that illustrates specifics of the topic in video format. Face-to-face instruction is not a comparable alternative media choice in our study because it has the capability for immediate feedback or interaction between an instructor and a learner but which is not available in self-learning programs. Therefore, the progression of choices of media in the research model, from low to high, consists of text (T), text plus graphics (TG), text plus graphics and audio/sound (TGS), text plus graphics and talking heads (TGTH), and full-motion video or animation (TGVA).

The IS literature, mentioned above, has studied subject matter at the level of a program, discipline or a course, and used different characteristics of the contents. The unit of observation in our research model is a learning unit that is tightly bound to a specific topic. Thus a course may consist of a number of learning units. To operationalize learning domain of such a learning unit, we have chosen Bloom’s taxonomy (Bloom et al, 1956) because it is well accepted in the learning community. That taxonomy defines three categories of domains of learning. The cognitive domain involves acquiring knowledge and development of intellectual skills. The affective domain includes learning about feelings, values and attitudes. The psychomotor domain includes learning about physical movements, coordination and use of motor-skills. The taxonomy further subdivides these domains at a micro level, but we have included in our study only the broader categorization of learning domains, namely cognitive, affective and psychomotor.
Learning Domain as moderating factors

Different choices of media for e-learning provide different sets of cues and symbols needed for different learning domains. Psychomotor domain of learning from Bloom’s taxonomy, that involves physical movement and motor-skills, will require models and symbols that can be conveyed through video, particularly full-motion video or animation, compared to all other choices of media including talking heads. Therefore, we expect the learning effectiveness to increase monotonically for psychomotor domain of learning as the choice of media is changed along the progression from T to TGVA. Cognitive domain of learning, on the other hand, deals with intellectual skills, and hence does not necessarily need cues and symbols available in video. Robert and Dennis (2005) have argued that as the number of cues (relevant or irrelevant) increases, the learner’s ability to filter out the irrelevant cues decreases. It is quite possible that too many cues and symbols available in video may detract from acquiring intellectual skills. Therefore, we expect that the learning effectiveness for cognitive domain will increase from T to TGS but decrease for TGTH and TGVA. The affective domain of learning is far more sensitive to social presence and while e-learning is not as effective as real presence, it could mitigate against a total lack of physical presence though effectively using sound and video. Luthans et al. (2008) report that using web-based online training intervention (including video and animation clips) increased development of positive psychological capital (of hope, self-efficacy, optimism and resiliency which falls in the affective domain of Bloom’s taxonomy) compared to a control group that did not have that online intervention. Therefore, we expect the learning effectiveness for affective domain to increase as the media choice is changed from T to TGVA. Hence we hypothesize that:

H1: The learning domain influences the relationship between choice of media for contents and learning effectiveness.

Learning Style as a moderating factor

According to Kolb and Kolb (2005), individuals with a diverging learning style tend to acquire as much information as possible from external sources. The diverse set of cues and symbols possible in the higher end of the media choice would fit the needs of such learners very well in providing additional information and perspectives.
Therefore, we expect learning effectiveness for learners with diverging learning style to increase monotonically along the progression of media choices from T to TGVA. On the other hand, individuals with converging learning styles want limited information and prefer to process it on their own (Kolb and Kolb, 2005). Therefore, they may find the additional cues and symbols from higher end of the media choice to be distracting, and less effective than some of the lower end of the media choices. Hence, we expect learning effectiveness for learners with converging learning styles to increase monotonically from T to TGS but decrease for TGTH and TGVA. Learners with accommodating learning style prefer hands-on experience and involve themselves in new and challenging experiences (Kolb and Kolb (2005)). Furthermore, learners with assimilating learning style prefer to gather wide range of information but are more interested in ideas and abstract concepts (Kolb and Kolb (2005)). Consequently, the need for diverse set of cues and symbols for these two learning styles is less than that for diverging style but more than that for converging style. Hence we hypothesize that:

**H2**: The learning style influences the relationship between choice of media for contents and learning effectiveness.

**The interaction of Learning Domain and Learning Style as a moderating factor**

All the three learning theories mentioned earlier posit that appropriate symbols and models are needed for a learning domain, and all those symbols and models must match the ways learners interpret the data, self-generate the experience, and give meaning to the data. Therefore, the combination of learning domain and learning style will influence the relationship between media choice and its learning effectiveness. Since psychomotor domain of learning involves physical movement and motor skills, we expect learning effectiveness to increase monotonically when choice of media is changed from T to TGVA for all learning styles. However, for cognitive domain, which by itself does not need cues and symbols available from the higher end of the media choices, different learning styles will influence learning effectiveness when media choice is changed from T to TGVA. We expect learners with diverging learning style, because they generally prefer to gather more information, to show monotonically increasing learning effectiveness along the progression of media choices from T to TGVA for cognitive domain. We also expect that learners with converging learning style will show monotonically increasing learning effectiveness for media choice from T to TGS but decrease for TGTH and TGVA for cognitive domain. Learners with other two learning styles, namely accommodating and assimilating, will show an intermediate profile for cognitive domain. Since the affective domain requires social presence, which sound and video provide, we expect the learning effectiveness for affective domain to increase as the media choice is changed from T to TGVA for all learning styles. Hence we hypothesize that:

**H3**: The interaction of learning domain and learning style influences the relationship between choice of media for contents and learning effectiveness.

**Research Method**

We will identify a learning unit for a topic in each of the three learning domains, and conduct one quasi-experiment for each of those three topics in one of the five choices of media. In each quasi-experiment, we will collect data on the learning style of each participant, and replicate the quasi-experiment as needed until we have statistically sufficient number of participants from each of the four learning styles. Thus, we will have 15 quasi-experiments, and each will be conducted in the O X O mode, as described below.

The initial observation (O) will collect data items through a survey instrument at the beginning of each quasi-experiment. These data will include demographic variables such as participants’ expectations of the efficiency, effectiveness, cognitive overload associated with the media choice for contents, experience or knowledge of the topic, motivation, familiarity with media, cognitive interest and emotional interest. In addition, participants will be administered the learning style (LSI3) survey in this phase, as well as a pre-test on the topic.

The intervention (X) will provide the participants with an e-learning program for one topic from a learning domain in one media choice from T to TGVA: in a set of text-only slides covering the topic (T); in a set of slides that contain graphics and bulleted text covering the topic (TG); a set slides that contain graphics and bulleted text with voice annotations for each slide that explain the text and the associated graphics (TGS); a set slides that contain graphics and bulleted text along with a video of the instructor speaking about each slide explaining the text and the associated graphics (TGTH); and full-motion video or animation that illustrates the contents of the topic, as distinct from showing video of only the instructor (TGVA). Participants will be instructed that they will have a limited
amount of time, such as one week, to go through the online material. Throughout the intervention, we will keep track of and collect data regarding how many times the material was accessed and for how long.

The subsequent observation (O) will consist of collecting the scores from a post-test that the participants will take one week after the intervention. In addition, participants will report on the efficiency, effectiveness and cognitive overload associated with the self-learning program through a self-reported survey.

The data from the 15 quasi-experiments will be compiled for the following analyses using ANOVA: For hypotheses 1, LE = f(MC, LD, MC*LD); for hypotheses 2, LE = f(MC, LS, MC*LS); and for hypotheses 3, LE = f(MC, LD, LS, MC*LD*LS), where LE is learning effectiveness, MC is media choice (MC), LD is learning domain (LD), LB is learning style (LS). The analysis will also be carried out using the control variables associated with learners, learning environment and instructional design, and the results will be shown graphically along with the ANOVA output.

Results from Prototype

We have conducted three quasi-experiments, as a prototype, on the topic of General Linear Models (GLM) from the cognitive learning domain. We chose three sections of the same course taught by the same instructor in the same semester to carry out three quasi-experiments. A total of 70 students in the three sections were pursuing the same MBA program at three different locations in the same metro area. Therefore, each section could be considered as an independent sample from the same population. Students were provided the learning material on GLM using the Blackboard course management system. Since we had access to only three sections, e-learning materials were provided for three media choices only – TG, TGS and TGVA. For the TGVA media choice for contents, the graphics in specific slides were animated to highlight the relationship between the total sum of squared deviations around the mean, the explained variation and the unexplained variation was animated. Results from those prototype quasi-experiments are shown graphically in Figure 2 and the ANOVA results in Table 1.

![Figure 2](image.png)  
Figure 2. Results from prototype quasi-experiments

<table>
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<th>F Ratio</th>
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<table>
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<th>DF</th>
<th>F Ratio</th>
<th>Prob &gt; F</th>
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<td>2</td>
<td>2.36</td>
<td>0.1040</td>
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</tbody>
</table>

Figure 2 shows empirical support for our rationale for Hypothesis 1 for cognitive domain. The increase in learning effectiveness for GLM (in the cognitive domain) increases when the choice of media is changed from TG to TGS, but remains the same when changing from TGS to TGVA. In other words, adding sound annotations to slides containing text and graphics resulted in an increase in learning effectiveness, but none for further addition of animation. It so happened that the number of participants were adequate with only two of the four learning styles—Accommodating and Diverging. Nevertheless, the results show that Hypothesis 2 was supported for those two learning styles namely, that diverging style showed monotonic increase in effectiveness from TG to TGS to TGVA but decreases from TGS to TGVA for accommodating style.

Implications and Limitations

We expect the results from our study to be useful to instructional designers and also to directors/administrators of e-learning programs. Instructional designers for a course would determine the learning domain of each learning unit in that course. If the course is meant for learners in general, i.e. no target audience, then the instructional designer can use the results from our work to choose a medium that provides the most learning effectiveness for the learning domain of each learning unit. If the course/program is targeted, say to specific discipline, it would be possible to determine the predominant learning style of such target discipline that have been reported (Kolb 1999, Kolb and Kolb 2005), or a sample of the target audience could be surveyed to determine the learning style(s) of the target.
audience. Then results from our work can be used to choose a medium that provides the most learning effectiveness for the combination of learning domain for each learning unit and the learning style(s) of the target audience.

The cost of design and development of a learning unit increases substantially as the choice of medium is changed from T to TGVA. Directors and administrators can compare the incremental costs with incremental learning effectiveness to choose appropriate media for a learning unit. It is quite possible that our results may show only a marginal increase in learning effectiveness from one media choice to the next for a specific learning domain and learning style(s), then the director/administrator of that e-learning program can compare the “value” of that marginal increase in effectiveness with increased cost of the higher choice of media to choose appropriate medium for each learning unit.

As stated in the introduction, our work is focused on self-learning programs aimed at individuals. Therefore, the results cannot be directly applicable in e-learning programs that blend TML with instructor-led teaching, and for e-learning programs that are aimed at groups requiring collaborations among the learners. We aim to control for other variables that may also influence learning effectiveness. Our analysis will show if any of them are better predictors of learning effectiveness than media choice moderated by learning domain and learning style. We do plan to capture data on learning process improvements but our focus is on learning outcomes. Hence, our results may not be useful if the aim of an e-learning program is improvements in learning process.

Future Work

We are encouraged by the results from the prototype quasi-experiments that we are on the right track. We also learned from the prototype that we need to collect additional data to act as statistical controls which we have included in our research framework. We plan to embark on the 15 quasi-experiments as per the framework described in this paper for learning units in appropriate courses or learning programs in different universities and organizations. We are in the process of securing needed resources, and have begun discussions with potential collaborators to carry out these quasi-experiments. We certainly welcome comments and criticisms on this research-in-progress paper.

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