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The design of instructional multimedia in e-Learning: A Media Richness Theory-based approach

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Abstract

The rapid development of computer and Internet technologies has made e-Learning become an important learning method. There has been a considerable increase in the needs for multimedia instructional material in e-Learning recently as such content has been shown to attract a learner's attention and interests. The multimedia content alone, however, does not necessarily result in significant positive learning performance and satisfaction. Moreover, it is expensive to design and develop multimedia instructional material. There is a lack of extant research to address the critical issue of how to develop effective multimedia instructional content that leads to desirable learning performance and satisfaction. The objective of our paper is to propose and empirically test a model that examines the impact of the fitness of instructional content and media on a learner's performance and satisfaction.

Our research finds that whether it is learning score as an objective measure or learning satisfaction as a subjective measure, the course unit with high uncertainty and equivocality in content needs high richness media representation. On the other hand, it is ineffective to use high richness media to promote learning performance.

Keywords: Multimedia instructional material design; e-Learning; Media richness theory

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1. Introduction

The rapid development of computer and Internet technologies has made e-Learning become an important learning method. One of the key characteristics of e-Learning is its capability to integrate different media, such as text, picture, audio, animation and video to create a multimedia instructional material, promoting the reading interests and willingness of the learner (Gillani & Relan, 1997; Vichuda, Ramamurthy, & Haseman, 2001). However, research has shown that the design of multimedia is costly (Dan, Feldman, & Serpanos, 1998; Dumont, 1996; Neumann, 1998) and multimedia does not have consistent effects on promoting learning performance. For instance, multimedia instructional material does not necessarily produces significant effect on understanding instructional content, although it does attract learner's attention more (Bartscha & Cobern, 2003; Najjar, 1998). Furthermore, some research shows that too much unnecessary multimedia elements in instructional material may distract learners and actually decrease learning performance (Bartscha & Cobern, 2003; Mayer et al., 2001; Park & Hopkins, 1993; Rieber, 1996; Sweller, van Merrienboer, & Paas, 1998). Researchers have argued that the media are not as important as the message itself, and believe that the positive effects of new media on learning performance shown in some research were mainly caused by Hawthorne effects[1] but not by the media, per se (Clark, 1985). Therefore, how to develop a cost-effective multimedia instructional material according to the properties of instructional content is emerging as an important issue of e-Learning. Unfortunately, there is a lack of extant literature to address this critical issue.

Based on the media richness theory, this research develops a research model and two major hypotheses to analyze the effect of fitness of instructional content and media on learning performance and satisfaction. We find that utilizing high richness multimedia materials for the course unit with high uncertainly and equivocality has positive effect on both learning score and learning satisfaction. Conversely, it is ineffective to use high richness media to promote learning performance for the course unit that can be stated clearly in regular text.

This paper is structured as follows. First, we review the media richness theory from which we develop our research model and hypotheses. Then, we describe an empirical study designed to test the hypotheses. Key research results are then presented. Finally, the implications of our findings are discussed and further research is suggested in concluding remarks.

2. Theoretical background and research model

2.1. Media richness theory

Media richness theory, originated from information processing theory, was developed by the organizational scientists Daft, Lengel, and Trevino (Daft & Lengel, 1984, 1986; Trevino, Lengel, & Daft, 1987). They argue that the communication efficiency between people is affected by the fitness of the media and the characteristics of the communication task. Media richness theory advances the notion that communication richness (or leanness) is an objective property of

[1] Hawthorne effects refer to the phenomenon where people change their behavior when they realize that they are being observed or studied.

communication media, and defines media richness as the ability to facilitate shared understanding within a time interval. Communication transactions that can overcome different frames of reference or clarify ambiguous issues to change understanding in a timely manner are considered rich. Communications that require a long time to enable understanding or that cannot overcome different perspectives are considered low in media richness. In other words, media richness refers to its capacity to facilitate shared meaning and understanding (Daft & Lengel, 1984). The richness of the media is based upon the following four criteria (Daft, Lengel, & Trevino, 1987).

Capacity for immediate feedback: The medium facilitates quick convergence on a common interpretation.
Capacity to transmit multiple cues: An array of cues, including physical presence, voice inflections, body gestures, words, numbers, and graphic symbols, facilitate conveyance of interpretation and meaning, rather than simply information or data.
Language variety: Numbers and formulas provide greater precision, but natural language conveys a broader set of concepts and ideas.
Capacity of the medium to have a personal focus: This refers either to the conveyance of emotions and feelings, or to the ability of the medium to be tailored to the specific needs and perspectives of the receiver.

According to the above four characteristics of communication media, Daft et al. (1987) classify the communication media used in daily life as, in order of decreasing richness, face-to-face, telephone, personal documents (e.g., letters or memos), impersonal unaddressed documents (e.g., reports, bulletins, etc.), and numeric reports (e.g., spreadsheets). Face-to-face is considered the richest medium because it provides immediate feedback. Face-to-face also provides multiple cues via body language and tone of voice, and message content is expressed in natural language. Telephone conversations rank below face-to-face as it allows verbal cues such as words, intonation, and silence, but cannot convey gestures and other visual cues. Personal documents are above impersonal unaddressed documents, while no-statement numerical reports rank as the leanest medium. After Daft et al. (1987), several researchers follow a similar approach to classify others media such as video, voice, pictures, text, email (Rice, 1992; Schmitz & Fulk, 1991; Trevino et al., 1987; Zmud, Lind, & Young, 1990). These classifications can serve as a reference for medium selection in different situations.

With regard to the characteristics of communication task, media richness theory states that the purpose of communication is to reduce uncertainty and equivocality in order to promote communication efficiency. Uncertainty is associated with the lack of information. Organization creates structures such as formal information systems, task forces, and liaison roles that facilitate the flow of information to reduce the uncertainty. The role of media in uncertainty reduction is its ability to transmit the sufficient amount of correct information. Equivocality is associated with negotiating meanings for ambiguous situations. To deal with equivocality, people in an organization must find structures that enable rapid information cycles among them so that meaning can emerge (Daft & Weick, 1984). The role of media in dealing with equivocality is to enable the processing of rich information. Different media differ in their ability to convey rich information (Daft et al., 1987).

It is found that a task's complexity and variety is proportional to the quantity of information needed to be processed in communication. The more complex or varied the task is, the more uncertain the communication content will be. Therefore, it needs more information to reduce

uncertainty to achieve a better decision (Daft & Macintosh, 1981; Tushman, 1978). On the other dimension, equivocal tasks tend to have more equivocal information. Both sides of the communication usually try to interpret those clues according to their own experiences. Owing to the differences of individual experiences, misunderstanding is prone to occur (Daft & Macintosh, 1981). To complicate the matter, it is difficult to interpret or represent the content in rules during communication (Daft & Weick, 1984). Therefore, the degree of the task content that can be interpreted or represented in rules is an important indicator of task uncertainty and has been called analyzability (Perrow, 1967). Analyzable task contains more rules and procedure and consequently contain more regular information. On the contrary, in the unanalyzable task, the content is usually more private, less clue, and more special and impromptu (Daft & Weick, 1984). When the content is unanalyzable, the information in it tends to be rough and fuzzy, and the precise coding system such as numerical report or rules will not be suitable in such kind of communication task (Daft & Macintosh, 1981). For low analyzable task, people need media with higher richness such as face-to-face, because in such situation fast feedback can clarify the questions arising in communication and the possibility to complete the task is higher (Randolph & Finch, 1977; Tushman, 1978; Van de Ven, Delbecq, & Koenig, 1976; Zmud et al., 1990).

McGrath and Hollingshead (1993) analyze the fitness of media and communication task characteristics in organizations to form a media-task corresponding matrix from the perspective of media richness theory. Their research shows that tasks with different levels of uncertainty and equivocality need a proper media in communication. Using high richness media for simple tasks may cause distraction or loss of focus, while for tasks with high level of uncertainty and equivocality using lean media can not convey the information efficiently and effectively and results in poor communication. In short, efficient and effective communication requires the matching of media richness with the task at hand.

In addition to studying the fitness between media and task characteristics, media richness theory has been widely applied in other issues such as the effects of media richness on task satisfaction, decision quality, and decision time (Kahai & Copper, 2003; Mennecke, Valacich, & Wheeler, 2000; Purdy & Nye, 2000; Rice, 1992), organization system design (Daft & Lengel, 1984, 1986), conflict management, marketing (Klein, 2003), and the prediction and explanation of the media selection and usage in organizations (Allen & Rodger, 1997; Daft et al., 1987; Markus, 1994; Whitfield, Lamont, & Sambamurthy, 1996). In sum, the media richness theory has been applied in a wide variety of issues with success in both theoretical analyses and empirical studies.

2.2. Research model

From the above description on the media richness theory, the media richness can be interpreted as the ''pipe'' for the transmission of information. Pipes of different sizes come with different transmission capacities and are produced with different costs. Therefore, choosing the ''right pipe'' is vital to the design of an efficient delivery system. With regard to instruction, the aptness of representation for instructional material has the direct effects on learner's comprehension process, although learning is very much relevant to the individual's comprehension for the instructional material (Burns, Clift, & Duncan, 1990). From the perspective of media richness theory, the medium used in representing instructional material has its own usage cost and transmission capacity for information and thus needs to be selected carefully. An improper choice of the media

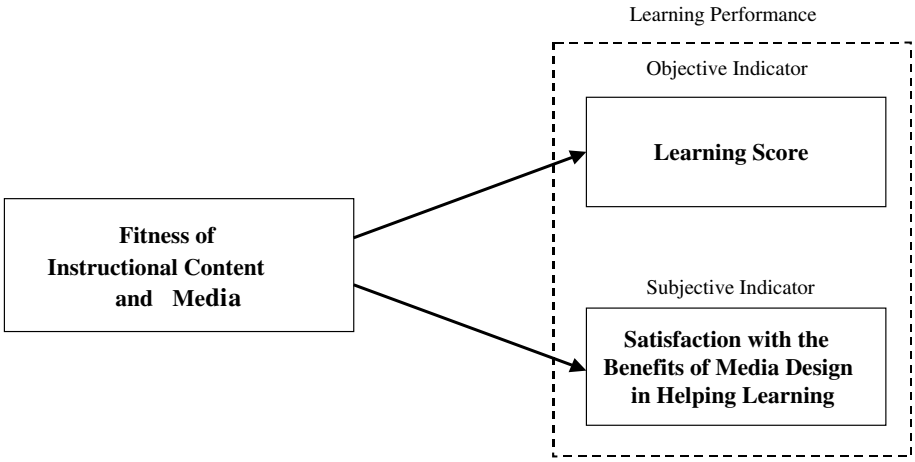

Fig. 1. Research model.

is not only unbeneficial to learning performance but also uneconomical. For example, it is expensive to use high richness media such as animation to present the instructional material with low level of uncertainty and equivocality. Moreover, too much unnecessary multimedia elements in instructional material will distract a learner's attention and have no significant positive effect on learning (Bartscha & Cobern, 2003; Gillani & Relan, 1997).

Based on the above analyses, we propose a research model and two major hypotheses relative to the design of multimedia instructional material in e-Learning as shown in Fig. 1. In our research model, learning performance is measured by an objective measure (score) and a subjective measure (learning satisfaction). Our two major hypotheses are stated as follows.

Hypothesis 1. The fitness of the media and instructional content has positive effect on learning score.

Hypothesis 2. The fitness of the media and instructional content has positive effect on learning satisfaction.

3. Methodology

3.1. Instructional material design

As described in Fig. 1, the independent variable of this model is the fitness between the instruction content and the media. We choose two different course units as the e-Learning material in our empirical study, which are the Chinese poem "The River Mechant's Wife" ("樂府詩—長干行")[2] from the course of Chinese Literature and the scheme of number system transformation from the course of Basic Computer Concept. To match these two course units to rich or lean media, we design four e-Learning instructional materials for four experiment groups to investigate the effect of the fitness of media and instructional content on learning performance.

[2] The English translation of this Chinese poem is provided in the Appendix.

The Chinese poem "The River Mechant's Wife" ("樂府詩—長干行") is the work of ancient Chinese poet Li Bai. It presents a romantic atmosphere and expresses warm feelings with exuberant imagination. The learning objective is to let students understand the rich meanings in the poem. Therefore, the instruction mainly contains detailed explanations about the poem. According to the response of the course teachers and students, they think that the poem is filled with imagination and abstract concept. This is why we choose it as a representation of high uncertainty and equivocality course unit because of its varied meaning and abstractive and non-logical content. Based on our research model, if the level of uncertainty and equivocality is high, the course unit needs a high richness media so that it will have significant positive effect on learning performance than one in low richness media. For the empirical test, two instructional materials of this course unit were designed in multimedia and text media for the experiment.

On the other hand, with regard to the course unit of Basic Computer Concepts, this research chooses the scheme of number system transformation as the instructional unit for the experiment, in which learners need to exercise the basic number and logic concept. The goal of instruction for number system transformation is to let students understand the principle of the transformation of different number systems. The instruction mainly contains some arithmetic operations and deductions, a typical representative of regular, sequential, and logical course unit. As the level of uncertainty and equivocality of this course unit is low, the media richness suggests that it need low media richness and the use of high richness media will therefore have no significant positive effect on learning performance. To test our hypotheses, we designed two instructional materials of this course unit in multimedia and text respectively for the experiment. Given the above design, our two major hypotheses are further expanded into the following.

Hypothesis 1-1. The use of high richness media in highly equivocal and uncertain course unit like Chinese poem "The River Mechant's Wife" ("樂府詩—長干行") has significant positive effect on learning score than the use of low richness media.

Hypothesis 1-2. The use of high richness media in the course unit with low equivocality and uncertainty like "the scheme of number system transformation" has no significant difference on learning score than the use of low richness media.

Hypothesis 2-1. The use of high richness media in highly equivocal and uncertain course unit like Chinese poem "The River Mechant's Wife" ("樂府詩—長干行") has significant positive effect on learning satisfaction than the use of low richness media.

Hypothesis 2-2. The use of high richness media in the course unit with low equivocality and uncertainty like "the scheme of number system transformation" has no significant difference on learning satisfaction than the use of low richness media.

To ensure that the experiment correctly reflects the effect of fitness of media and instructional content on learning, we only varied the media used in the above e-Learning instructional material design while holding all other variables constant. That is, the instructional materials in two different types of media are "informationally equivalent."[3] The rich media e-Learning instructional

[3] We gratefully acknowledge one anonymous reviewer pointing out this term.

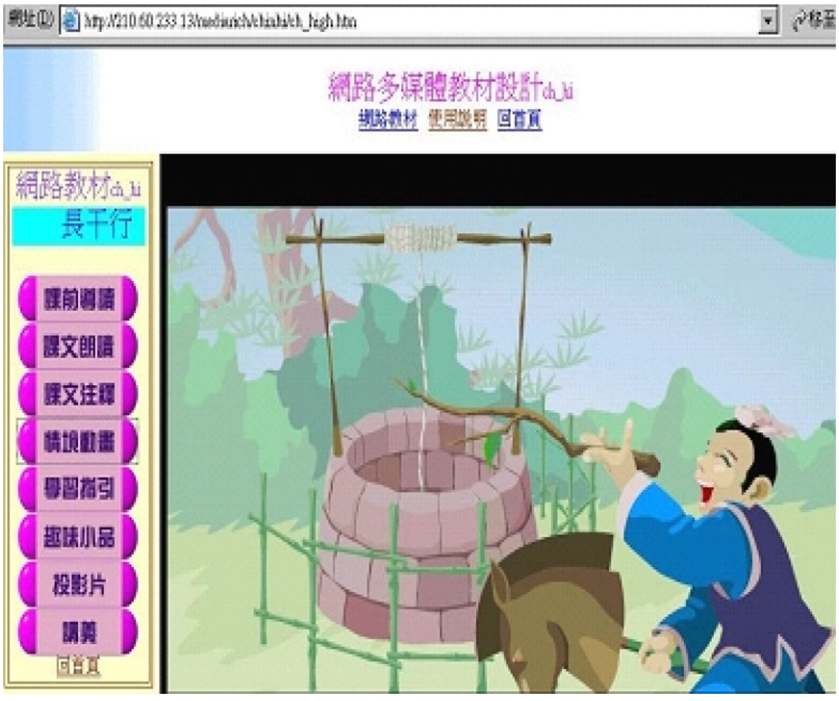

Fig. 2. The Chinese Poem "The River Merchant's Wife" in high richness media.

material was presented with animation of Macromedia Flash and lean media e-Learning instructional material was presented with text.

According to the meanings of the poem, we designed the rich media presentation into a scenario-based animation using Macromedia Flash shown in Fig. 2. There were sounds, images, and music in the animation and students could understand the content of the course unit through the animation. With regard to lean media presentation, we presented the Chinese poem "The River Mechant's Wife" in text as shown in Fig. 3.

The course unit for number system transformation was designed in the same way. The design of rich media representation is shown in Fig. 4 and the design of the lean one is shown in Fig. 5.

3.2. Experiment design and participants

Two one-factor between-groups designs were employed for matching these two course units to rich and lean media respectively. A total of four experiment groups were conducted including a number system transformation with high media richness media, a number system transformation with low media richness media, a Chinese poem "The River Mechant's Wife" with high media richness media, and a Chinese poem "The River Mechant's Wife" with low richness media (hereafter referred to as Number-High, Number-Low, Poem-High and Poem-Low, respectively). A total of 240 Level-1 students from a national senior high school in Taiwan were invited to join the experiments and were randomly divided into four experiment groups. Candidates of this experiment were those who had not studied these two course units before, and all the students

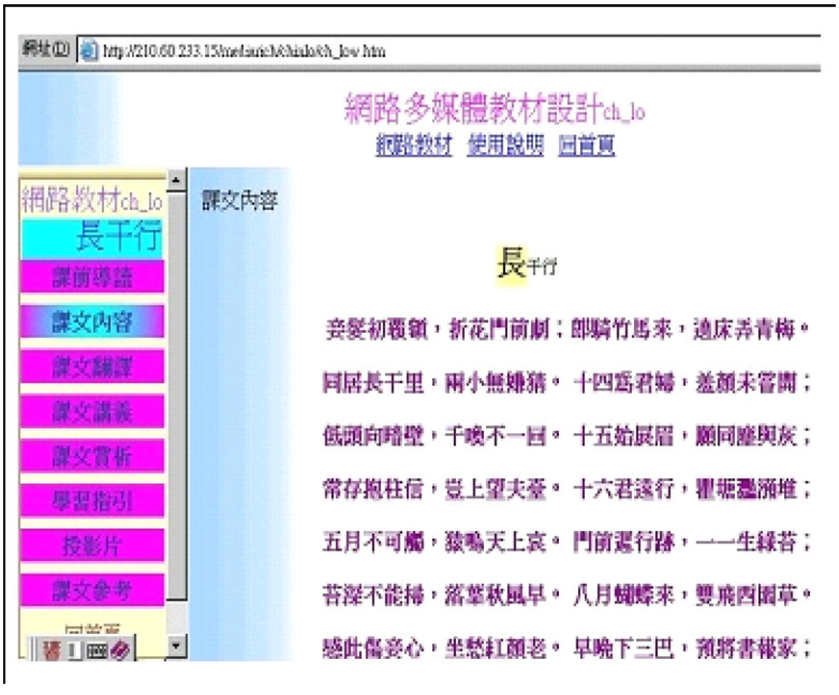

Fig. 3. Chinese Poem "The River Merchant's Wife" in low richness media.

Fig. 4. Number system transformation in high richness media.

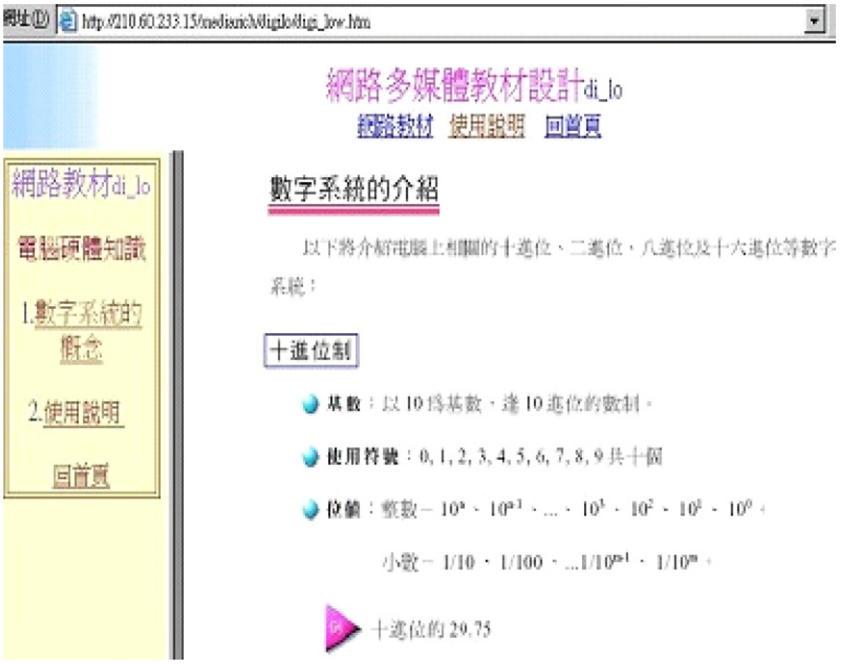

Fig. 5. Number system transformation in low richness media.

of this school had the similar background as they were admitted to the school with homogeneous performance in the same entrance examination. The two course units used in the experiments were also the learning course units those Level-1 students were slated to learn according to the school schedule. Hence, the experiment error that might result from the inconsistent subjects and the lack of sufficient motivation should be inconsequential.

3.3. Measurements

The dependent variables of this research model are learning score and learning satisfaction. The instruments of the learning score include the comprehensive test sheets designed for the two course units. Each test sheet was designed by two senior subject teachers with at least 10 years of teaching experience and refined by university professors. The test sheet for Chinese poem "The River Mechant's Wife" has 10 multiple-choice tasks and five exegesis tasks. The total score is 100. The test sheet of the number system transformation has 15 multiple-choice tasks and the total score is also 100. The final score for each test sheet was the average marks of scorings by two teachers and the scores were immune to the experiment conditions.

Since the learning satisfaction dependent variable is to measure the learner's satisfaction with the benefits of the media design in helping learning, we adapt the usefulness instrument developed and tested by Davis (1989) to measure this construct. The usefulness instrument has been used and validated in a wide range of studies and it has been shown to have high reliability and validity. A pretest for the instrument was administered to 32 students to ensure the validity of this measure. After the pretest, five items rated on a scale varying from one being "strongly disagree" to seven

Table 1
Items in learning satisfaction instrument

1. Using this presentation design in my e-Learning would make it easier to learn
2. Using this presentation design in my e-Learning would increase my understanding
3. Using this presentation design in my e-Learning would enable me to accomplish learning more quickly
4. Using this presentation design would improve my learning performance
5. I would find this presentation design useful in my e-Learning

being "strongly agree" (i.e., 7-point Likert scale) used to measure the learning satisfaction are shown in Table 1. The learning satisfaction construct satisfies the criteria of reliability with the coefficient of reliability (Cronbach α) at 0.77, exceeding the standard high water mark of 0.7.

3.4. Experiment procedure

Our experiments proceeded in accordance with the schedule of the subject school. The four experiment groups were tested in computer rooms with similar equipment. The instruction system allocation in computer servers had been carefully tuned to assure a good network performance during the experiment. Before proceeding with the experiment, the students received a short briefing on how to use the e-Learning system and the rules they should follow. For example, each student worked alone and no questioning and discussing were allowed during the process. After that, students logged into the system and received e-Learning instruction according to their respective assigned group. Students were given headphones so as not to be distracted by sounds from other computers.

All students were advised to complete their e-Learning in 50 min. Students worked through the program at similar pace as the multimedia content was delivered to the students' computers through video streaming. Video streaming also made reviewing the content not possible. When all the students finished in the given time, a test was conducted to measure the learning performance received from the instruction. Finally, a questionnaire was given to the students to assess their subjective satisfaction for using the instructional presentation design.

4. Research results

To test the hypotheses regarding the effects of the fitness of instructional content and media on score and satisfaction, we conducted two one-way analyses of variance (ANOVA). In the first ANOVA, Hypotheses 1-1 and 2-1 were tested, while Hypothesis 1-2 and 2-2 were tested in the second ANOVA. These two ANOVA analyses are described in details as follow.

4.1. The test for Hypotheses 1-1 and 2-1

In the ANOVA results shown in Tables 2 and 3, there exists significant effects of the fitness of the instructional content Chinese poem "The River Mechant's Wife" and media on learning score ($F_{1,115} = 36.01$, $p < 0.001$) and on learning satisfaction ($F_{1,115} = 10.36$, $p < 0.0017$). The results of the experiment support Hypothesis 1-1 as evidenced from the learning score difference between

Table 2
ANOVA analysis of Chinese poem for the effect of fitness on learning score

Dependent variable: Learning score	Course unit: Chinese poem				
Source	df	Sum of squares	Mean square	*F*-value	Pr > *F*
Model	1	2434.289	2434.289	36.01	<0.001
Error	115	7774.036	67.600		
Total	116	10208.325			

Grouping	Means	Number of subjects
Chinese poem (樂府詩長干行) in rich media	78.864	59
Chinese poem (樂府詩長干行) in lean media	69.741	58

Table 3
ANOVA analysis of Chinese poem for the effect of fitness on learning satisfaction

Dependent variable: Learning satisfaction	Course unit: Chinese poem				
Source	df	Sum of squares	Mean square	*F*-value	Pr > *F*
Model	1	3.129	3.129	10.36	<0.0017
Error	115	34.724	0.302		
Total	116	37.853			

Grouping	Means	Number of subjects
Chinese poem (樂府詩長干行) in rich media	3.631	59
Chinese poem (樂府詩長干行) in lean media	3.003	58

means shown in Table 2. That is, the use of high richness media in equivocal and uncertain course like Chinese poem "The River Mechant's Wife" ("樂府詩—長干行") has significant positive effect on learning score than the use of low richness media. Further, the satisfaction difference between means shown in Table 3 also indicates that the results of the experiment support Hypothesis 2-1. The use of high richness media in equivocal and uncertain course like Chinese poem "The River Mechant's Wife" "樂府詩—長干行" has significant positive effect on learning satisfaction than the use of low richness media.

4.2. The test for Hypotheses 1-2 and 2-2

The results of the second ANOVA show that the use of high richness media in number system transformation, a low equivocal and uncertain course unit, has no significant difference on learn-

Table 4
ANOVA analysis of Number System for the effect of fitness on learning score

Dependent variable: Learning score					
Source	df	Sum of squares	Mean square	*F*-value	Significance
Model	1	26.901	26.901	0.62	0.432
Error	111	4796.107	43.208		
Total	112	4823.008			

Table 5
ANOVA analysis of Number System for the effect of fitness on learning satisfaction

Dependent variable: Learning satisfaction					
Source	df	Sum of squares	Mean square	*F*-value	Significance
Model	1	0.005	0.005	0.02	0.876
Error	111	21.804	0.196		
Total	112	21.809			

ing score ($F_{1,111} = 0.62$, $P = 0.432$) and learning satisfaction ($F_{1,111} = 0.02$, $P = 0.876$) as reported in Tables 4 and 5 respectively. The results support Hypotheses 1-2 and 2-2.

5. Discussions, limitations, future work and conclusions

5.1. Discussion

There has been a considerable increase in the needs for multimedia instructional material in e-Learning recently as such content has been shown to attract a learner's attention and interests. The multimedia content alone, however, does not necessarily result in significant positive learning performance and satisfaction. Moreover, it is expensive to design and develop multimedia instructional material, although the rapid progress of computer and Internet technologies makes such endeavor possible. Unfortunately, there is a lack of extant research to address the critical issue of how to develop effective multimedia instructional content that leads to desirable learning performance and satisfaction. The objective of our paper is to propose and empirically test a model that examines the impact of the fitness of instructional content and media on a learner's performance and satisfaction. A major longstanding difficulty in the design of multimedia content for e-Learning has been the lack of knowledge regarding the relationship between instructional media and learning content. A main contribution of this research is to fill the void of understanding this relationship by applying a well established media richness theory.

Our research finds that whether it is learning score as an objective measure or learning satisfaction as a subjective measure, the course unit with high uncertainty and equivocality in content needs high richness media representation. On the other hand, it is ineffective to use high richness media to promote learning performance for the course unit with low uncertainty and equivocality that can be stated clearly in regular text. No negative effect was observed in this case mostly because the instructional materials in both the low and high richness media are "informationally equivalent." That is, no excess unnecessary multimedia content was present in the course unit with low uncertainty and equivocality.

5.2. Limitations and future work

Several limitations and future research directions can be drawn from this study. First, a pre-test should be used to assess students' initial level of knowledge and possible motivation to learn the contents of our experiment. Fortunately, the subjects of our experiments had similar background and homogeneous performance in the entrance examination. Those students in our experiments

arguably had similar initial level of knowledge and motivation for the learning contents. Second, future research should provide useful guidelines and framework for e-Learning teachers and multimedia courseware designers to assess the appropriate level of media richness needed for the course units under consideration. Third, based on findings from this research, we believe that developing suitable instruments for different learning groups such as elementary students, university students, or low achievement students is a worthy extension of this research. Other moderator variables such as learning style, age, and individual differences should be investigated in future work.

5.3. Conclusion

The media richness theory, albeit well known in the organizational and MIS related literature, surprisingly has never been considered in the instructional media design domain. This study is among the first to apply and test media richness theory regarding the effectiveness of multimedia instructional material design. In particular, this study shows that the use of rich media in e-Learning should fit the characteristics of the course unit under consideration. This paper also points to a potentially very interesting direction in improving the rationale for multimedia instructional materials.

Appendix. English translation of Li Bai's Chinese poem "The River Mechant's Wife" by Ezra Pound (1885–1972)

THE RIVER-MERCHANT'S WIFE
While my hair was still cut straight across my forehead
I played about the front gate, pulling flowers.
You came by on bamboo stilts, playing horse,
You walked about my seat, playing with blue plums.
And we went on living in the village of Chokan:
Two small people, without dislike or suspicion.
At fourteen I married My Lord you.
I never laughed, being bashful.
Lowering my head, I looked at the wall.
Called to, a thousand times, I never looked back.

At fifteen I stopped scowling,
I desired my dust to be mingled with yours
Forever and forever and forever.
Why should I climb the look out?

At sixteen you departed,
You went into far Ku-to-en, by the river of swirling eddies,
And you have been gone five months.
The monkeys make sorrowful noise overhead.

(*continued on next page*)

Appendix (*Continued*)

You dragged your feet when you went out.
By the gate now, the moss is grown, the different mosses,
Too deep to clear them away!
The leaves fall early this autumn, in wind.
The paired butterflies are already yellow with August
Over the grass in the West garden;
They hurt me. I grow older.
If you are coming down through the narrows of the river Kiang,
Please let me know beforehand,
And I will come out to meet you
As far as Cho-fu-Sa.

References

Allen, D. G., & Rodger, W. G. (1997). Vertical and lateral information processing: The effect of gender, employee classification level and media richness on communication and work outcomes. *Human Relations, 50*(10), 1239–1260.

Bartscha, R. A., & Cobern, K. M. (2003). Effectiveness of PowerPoint presentations in lectures. *Computers & Education, 41*, 77–86.

Burns, J., Clift, J., & Duncan, J. (1990). Understanding of understanding: Implications for learning and teaching. *British Journal of Educational Psychology*(61), 276–289.

Clark, R. (1985). Evidence for confounding in computer-based instruction studies: Analyzing the meta-analyses. *Educational Communication and Technology Journal, 33*(4), 249–262.

Daft, R. L., & Lengel, R. H. (1984). Information richness: A new approach to managerial behavior and organization design. In B. Staw, & L. L. Cummings (Eds.), *Research in Organizational Behavior* (pp. 191–233), vol. 6.

Daft, R. L., & Lengel, R. H. (1986). Organizational information requirements, media richness and structural design. *Management Science*(32:5), 554–571.

Daft, R. L., Lengel, R. H., & Trevino, L. K. (1987). Message equivocality, media selection, and manager performance: Implications for information systems. *MIS Quarterly*(11:3), 355–366.

Daft, R. L., & Macintosh, N. B. (1981). A tentative exploration into the amount of equivocality of information processing in organizational work units. *Administrative Science Quarterly, 26*, 207–224.

Daft, R. L., & Weick, K. (1984). Toward a model of organizations as interpretations systems. *Academy of Management Review*(9), 284–295.

Dan, A., Feldman, S. I., & Serpanos, D. N. (1998). Evolution and challenges in multimedia. *IBM Journal of Research and Development*(42:2), 177–184.

Davis, F. D. (1989). Perceive usefulness, perceived of ease of use, and end user acceptance of information technology. *MIS Quarterly*(13:3), 319–340.

Dumont, R. A. (1996). Teaching and learning in cyberspace. *IEEE Transactions on Professional Communication*(39:4), 192–204.

Gillani, B. B., & Relan, A. (1997). Incorporating interactivity and multimedia into web-based instruction. In B. H. Khan (Ed.), *Web-based instruction* (pp. 231–237). Englewood Cliff, NJ: Educational Technology Pub..

Kahai, S. S., & Copper, R. B. (2003). Exploring the core concepts of media richness theory: The impact of cue multiplicity and feedback immediacy on decision quality. *Journal of Management Information Systems, 20*(1), 263–284.

Klein, L. R. (2003). Creating virtual product experiences: The role of telepresence. *Journal of Interactive Marketing, 17*(1), 41–55.

Markus, M. (1994). Electronic mail as the medium of managerial choice. *Organization Science, 5*(4), 502–527.

Mayer, R. E. et al. (2001). Cognitive constraints on multimedia learning: When presenting more material results in less understanding. *Journal of Educational Psychology, 93*(1), 187–198.

McGrath, J. E., & Hollingshead, A. B. (1993). Putting the "Group" back in group support systems: Some theoretical issues about the dynamic process in groups with technological enhancements. In L. M. Jessup, & J. S. Valacich (Eds.), *Group support systems: New perspectives* (pp. 76–96).

Mennecke, B. E., Valacich, J. S., & Wheeler, B. C. (2000). The effects of media and task on user performance: A test of the task-media fit hypothesis. *Group Decision and Negotiation*(9:6), 507–529.

Najjar, L. J. (1998). Principles of educational multimedia user interface design. *Human Factors, 40*(2), 311–323.

Neumann, P. G. (1998). Risks of e-Education. *Communications of the ACM*(41:10), 136.

Park, O., & Hopkins, R. (1993). Instructional conditions for using dynamic visual displays: A review. *Instructional Science, 21*, 427–449.

Perrow, C. (1967). A framework for the comparative analysis of organizations. *American Sociological Review, 32*(2), 194–208.

Purdy, J. M., & Nye, P. (2000). The impact of communication media on negotiation outcomes. *International Journal of Conflict Management*(11:2), 162–187.

Randolph, W. A., & Finch, F. E. (1977). The relationship between organization technology and the direction and frequency dimensions of task communications. *Human Relations, 30*(12), 1131–1145.

Rice, R. E. (1992). Task analyzability, use of new media, and effectiveness: A multi-site exploration of media richness. *Organization Science, 3*, 475–500.

Rieber, L. P. (1996). Animation as a distractor to learning. *International Journal of Instructional Media, 23*, 53–57.

Schmitz, J., & Fulk, J. (1991). Organizational colleagues, information richness, and electronic mail: A test of the social influence model of technology use. *Communication Research, 18*, 487–523.

Sweller, J., van Merrienboer, J. J. G., & Paas, F. G. W. C. (1998). Cognitive architecture and instructional design. *Educational Psychological Review, 10*(3), 251–296.

Trevino, L. K., Lengel, R. K., & Daft, R. L. (1987). Media symbolism, media richness and media choice in organizations. *Communication Research, 14*(5), 553–574.

Tushman, M. L. (1978). Technical communication in R&D laboratories: The impact of project work characteristics. *Academy of Management Journal, 21*(4), 624–645.

Van de Ven, A., Delbecq, A., & Koenig, R. (1976). Determinants of coordination modes within organizations. *American Sociological Review, 41*, 322–338.

Vichuda, K., Ramamurthy, K., & Haseman, W. D. (2001). User attitude as a mediator of learning performance improvement in an interactive multimedia environment. *International Journal of Human–Computer Studies, 54*(4), 541–583.

Whitfield, J., Lamont, B., & Sambamurthy, V. (1996). The effects of organization design on medium richness in multinational enterprises. *Management Communication Quarterly, 10*(2), 209–226.

Zmud, R. W., Lind, M. R., & Young, F. W. (1990). An attribute space for organizational communication channels. *Information Systems Research, 1*(4), 440–457.