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Effect of Varied Types of Instructional Delivery Media and Messages for Engineering Education: an Experimental Study*

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In a Digital Signal Processing course, students received two different types of instructional delivery messages (online text only and text along with a simulation tool: MATLAB) via two different types of instructional delivery media (desktop PC and personal digital assistant (PDA)). An experimental study was designed to investigate the potential main effects and the interaction of these two independent variables: instructional delivery message and instructional delivery media. Results showed that students expressed a significantly higher intention to learn in a desktop PC environment than in a PDA environment ($F[1,21]=17.31$, $p < 0.05$). We also found that students who used a MATLAB simulation tool performed significantly better on an achievement test than those who did not use it ($F[1,21]=10.96$, $p < 0.05$).

Keywords: Mobile learning; digital filter design; instructional science; multimedia learning; e-learning

INTRODUCTION

ENGINEERING EDUCATION is rapidly evolving as the advancement of technological innovations accelerates. With the prevalence of Internet technologies, methods of instruction and learning are changing from a conventional approach (e.g. classroom lecture) to an e-learning environment. Recently, as mobile equipment (e.g. cell phones, PDAs, etc.) became widely accepted by the general population, instructional and learning technologies underwent another paradigm shift: from e-learning to m-learning (mobile learning) [1].

Due to the successful development of WAP (Wireless Application Protocol), GPRS (General Pocket Radio System) and Wi-Fi, researchers have started to pay attention to the impact of mobile systems on learning. Some significant findings are being manifested in the Wireless Andrew project in Carnegie Mellon University and the WELCOME (Wireless E-Learning and Communication Environment) project in Regensburg University [2].

Researchers claim that learners benefit from mobile learning technologies because they can access course materials and other course-related applications at any time and in any place [3, 4]. In addition, one finds that mobile learning technologies have a positive effect on pedagogical change, such as communication between instructors and students [5]. However, these observations lack evidence to support their claims, as Alamäki [6] alludes that there is no positive answer to the effect of WAP-assisted learning. Very few research studies explore whether the use of mobile learning technologies will result in student learning achievement, and this warrants further investigation.

This study explored the effect of various types of instructional messages (text only and text with a simulation tool: MATLAB) delivered via different types of instructional media (desktop PC and PDA) on engineering undergraduate students' learning achievement and attitude. Three research null hypotheses may be drawn as follows:

(1) No statistically significant differences in student test achievement, intention and satisfaction when they learn by using varied types of instructional media (desktop PC vs. PDA);
(2) No statistically significant differences in student test achievement, intention and satisfaction when they are presented with varied types of instructional messages (text only vs. text with a simulation tool: MATLAB)
(3) No statistically significant interaction in student test achievement, intention and satisfaction between the two studied independent variables: instructional media and instructional message.

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COURSE DESCRIPTION

Digital filter design is one of the most important topics in digital signal processing (DSP), a critical course in modern electronics/electrical engineering education. It can be applied to a variety of fields, such as communication, medicine, control, robotics and geophysics.

The content of the course covers the fundamentals of digital filter design, structures, design of Finite Impulse Response (FIR) and Infinite Impulse Response (IIR) filters, applications of digital filters and tests and feedback systems. The course is divided into three major parts as briefly described below:

Part I

Basic concepts of analogue and digital signals are introduced. In digital signal processing, an analogue signal is transited through an A/D translator. The main capability of the A/D translator is to transform an analogue signal into a digital signal, after which a D/A translator is used to convert the result of a digital signal into an analogue signal as its output.

Part II

The following theories in DSP are introduced: convolution, sampling theory, discrete Fourier transform and Z-transform. Then, basic principles and design methods of FIR filter and IIR filter follow. Several design examples are provided using MATLAB. For example, an experiment with filter architectures is conducted to convert coefficients from a direct form to a cascade form or a parallel form.

Part III

Based on the fundamental theories of FIR and IIR filters introduced in Part II, the most important characteristics of FIR filters are linear phase and position of zero, which are designed by Windows and frequency sample methods. Two main methods are introduced: impulse invariant and bilinear transform. Finally, notch filters, comb filters and all-pass filters are introduced. Results of the output wave are obtained with a users' interface designed by MATLAB.

In addition, Part II and Part III contain several simulation experiments, seven of them in Part II:

(1) convolution;
(2) sampling theory;
(3) discrete Fourier transform;
(4) Z-Transform;
(5) FIR filter;
(6) IIR filter;
(7) filter architectures transform.

Part III contains eight simulation experiments:

(1) linear phase method;
(2) frequency sample method;
(3) Windows method;
(4) impulse invariant method;
(5) bilinear transform method;
(6) notch filter;
(7) comb filter;
(8) all-pass filter.

All the simulation experiments are conducted using MATLAB.

METHODS

Participants

Twenty-eight undergraduate students on a digital signal processing course were recruited from the Electronic Engineering Department, National Kaohsiung University of Applied Sciences (KUAS), Taiwan. Twenty-five of them (89%) completed the experiment; three (11%) dropped out during it. Of those who completed the experiment, twenty-two (88%) were male; three (12%) were female. Their age range was 21–23.

Instructional materials

One instructional unit in the course, Introduction to Digital Filter, was used for the experiment. It covered Finite Impulse Response Filter (FIR) and Infinite Impulse Response Filter (IIR).

Independent/dependent variables

Two independent variables were studied:

(1) instructional media (desktop PC and PDA);
(2) instructional message (text only and text with a simulation tool: MATLAB).

Three dependent variables were measured:

(1) a knowledge achievement test;
(2) intention to use instructional media;
(3) satisfaction toward learning environments.

A knowledge test was given when students had finished the assigned experimental treatments. A questionnaire was designed to measure two student-affective constructs:

(1) intention to use instructional media;
(2) satisfaction toward the assigned instructional message.

The two affective constructs were measured by a seven-point Likert scale. To guarantee the validity of the two dependent measures, the test items and the questionnaire were reviewed by subject matter experts.

Research design

The research design of the study was a 2×2 randomized post-test design. Multivariate Analysis of Variance (MANOVA) was performed to analyse the collected data. The main effects and the potential interaction of the two independent variables were examined.

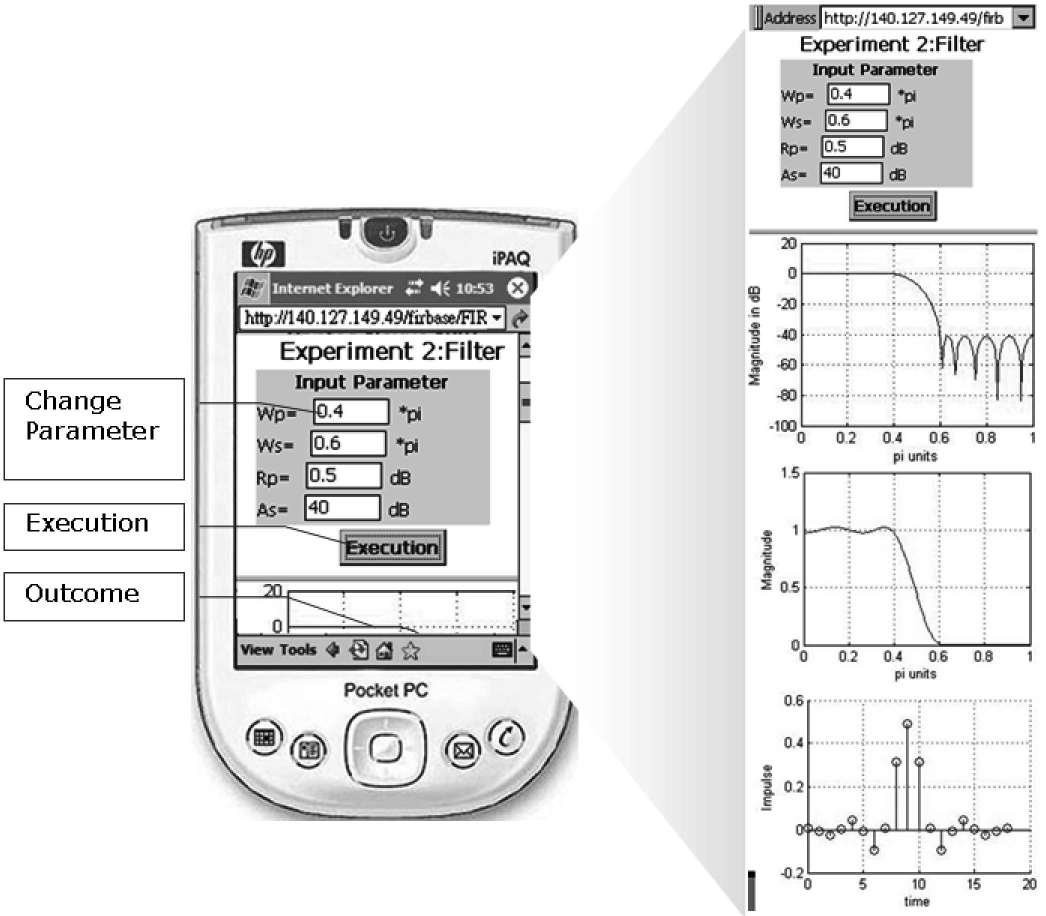

Fig. 1. Treatment 1. Mobile PDA plus text materials with a simulation tool.

Instructional treatments

According to the research design, four instructional treatments were created:

(1) mobile PDA plus text materials with a simulation tool;
(2) mobile PDA plus text-only materials;
(3) desktop PC plus text materials with a simulation tool;
(4) desktop PC plus text-only materials.

A brief description of the four instructional treatments follows.

Treatment 1: mobile PDA plus text materials with a simulation tool. In this treatment, a unit of interactive simulation materials was developed using MATLAB and posted to the Internet through HTML and a web server. Participants could access the materials and learn through a mobile PDA anywhere on campus. This service was supported by a wireless LAN. Given the PDA screen, the participants needed to input parameters and scrolled in order to view a waveform output. This instructional treatment allowed users to change parameters to observe variations of waveforms (Fig. 1).

*Treatment 2: mobile PDA plus text-only materials***.** This treatment entailed the presentation of text-only materials on a HTML web page. Participants could learn anywhere on campus using a mobile PDA by means of a scrolling browser. Given the PDA screen, the participants needed to scroll in order to view the instructional materials (Fig. 2).

Treatment 3: desktop PC plus text materials with a simulation tool. Similar to Treatment 1, this treatment used MATLAB to develop interactive simulation materials posted to a website through HTML and a web server. Participants could only access the instructional materials using a desktop PC installed in a computer lab. This instructional treatment allowed users to change parameters to observe variations of waveforms (Fig. 3).

*Treatment 4: desktop PC plus text-only materials***.** Similar to Treatment 2, this treatment entailed the presentation of text-only materials on an HTML web page. However, participants could only access the instructional materials by using the scrolling browser of a desktop PC installed in a computer lab (Fig. 4).

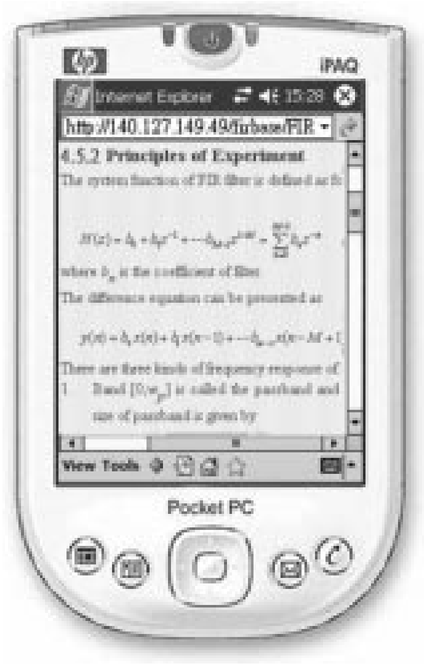

Fig. 2. Treatment 2. Mobile PDA plus text-only materials.

Experimental procedures

To avoid a sampling bias, all participants were randomly assigned into four groups. Before conducting the experiment, researchers explained its purpose to students and demonstrated how to use varied types of instructional media. To reduce interruptions among different treatment groups, the Mobile PDA groups and the desktop PC groups were in separate rooms (Fig. 5). After being assigned their locations, the participants were presented with their instructional treatments located in a remote server. To control experimental environments consistently, students in each experimental group were given 30 minutes to study the materials. After this, the participants were first asked to take a knowledge test and then fill out questionnaires on their intention and satisfaction with learning devices.

RESULTS

Descriptive statistics

A statistical summary for all dependent measures was demonstrated in Table I.

Results of the multivariate analysis of variance (MANOVA)

Table 2 shows the effect of interaction between learning device and instructional message. The value of Wilks' Lambda was 0.832, which was not significant at the p-value of 0.05. Therefore, Null hypothesis 3 should be retained. No significant interaction was found between those two studied variables.

However, a significant effect of the learning device was found (Lambda $(3,19) = 0.449$, $p < 0.05$). A second significant effect of instructional message was also found (Lambda $(3,19) = 0.218$, $p < 0.05$).

The univariate analysis of variance resulted in an F-ratio that was used to determine whether variations in the performance on the dependent measures existed. Three major findings followed and are shown in Table 3.

Finding 1: main effect of instructional media

As seen in Table 3, analysis of dependent variables shows that the significant main effect of the

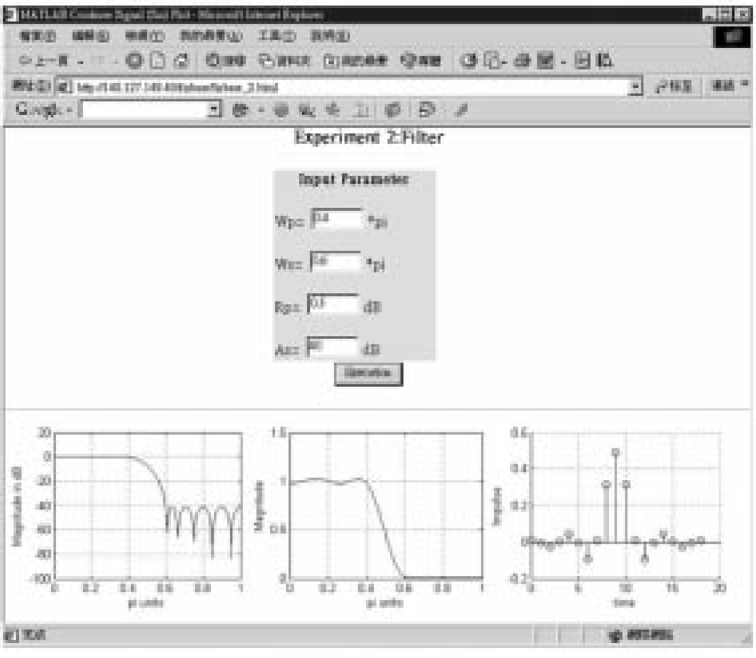

Fig. 3. Treatment 3. Desktop PC plus text materials with a simulation tool.

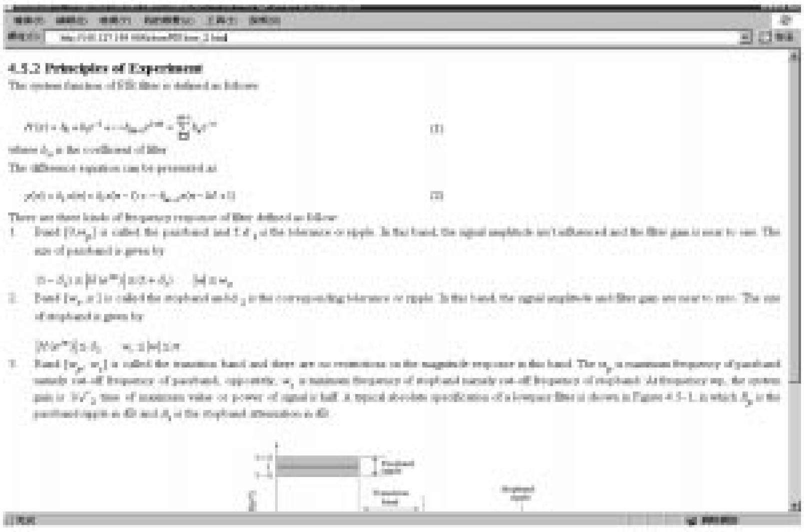

Fig. 4. Treatment 4. Desktop PC plus text-only materials.

instructional media variable on the measure of intention is (F[1,21]=17.31, $p < 0.05$). For the knowledge test and the satisfaction measure, no significant differences were found among students (F[1,21]=1.83; F[1,21]=.45, $p > 0.05$). Thus, one might conclude that Null hypothesis 1 on instructional media should be rejected. A significant difference was found for the variable of instructional media. Specifically, students expressed a significantly higher intention to learn in a desktop PC environment than in a PDA environment.

Finding 2: Main effect of instructional message

Significant differences existed in both the knowledge test (F(1,21)= 10.96, $p < 0.05$) and intention measure (F(1,21)= 41.86, $p < 0.05$). Therefore, one might conclude that Null hypothesis 2 on instructional message should be rejected. Significant differences were found for the variable. Specifically, students who used a MATLAB simulation tool performed significantly better in their knowledge test than those who did not use it. In addition, students who used the simulation tool

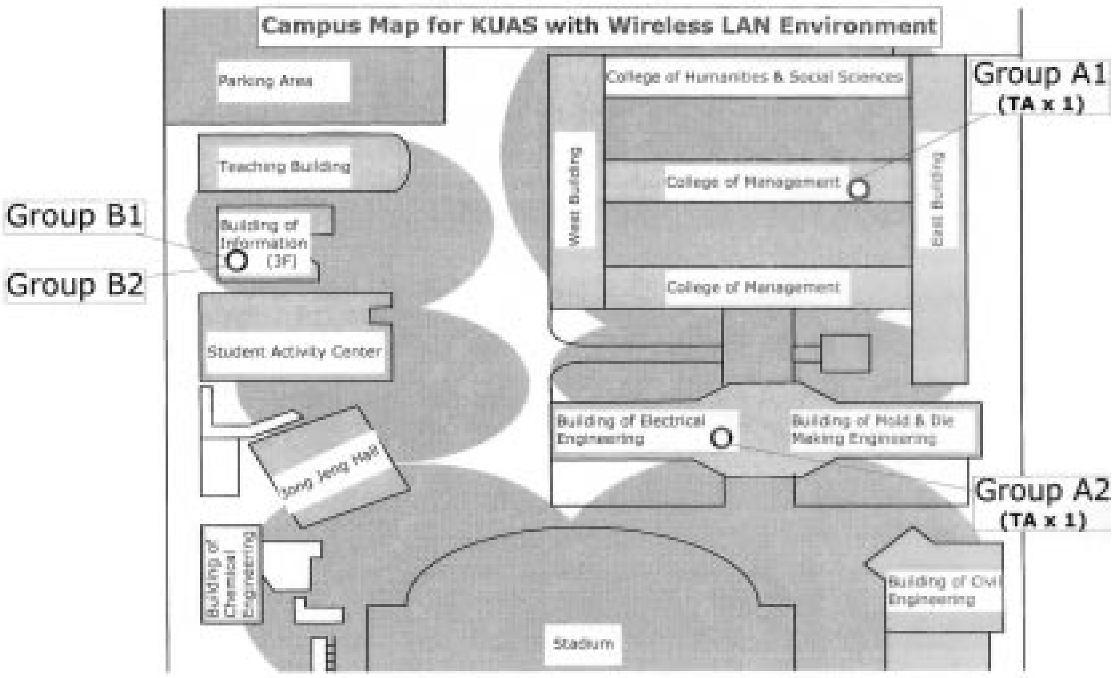

Fig. 5. Group arrangement at KUAS.

Table 1. Treatment means and standard deviations of all dependent measures.

	PDA		Desktop PC	
Dependent measures	Text only M/SD*	Text + simulation M/SD	Text only M/SD	Text + simulation M/SD
Knowledge Test	60.29/17.26	75.67/5.57	66.00/16.00	86.80/8.90
Intention	3.36/0.69	5.42/0.49	4.86/0.48	6.10/0.89
Satisfaction	3.50/1.25	4.46/0.58	4.32/0.97	4.05/0.97

* M: Mean; SD: Standard Deviation

Table 2. Multivariate tests.

Effect	Wilks' Lambda	F	P
LD (PDA v.s. PC)	0.449	7.78	0.001*
IM (Text v.s. Text with Simulation)	0.218	22.70	0.000*
LD *IM	0.832	1.28	0.311

* Significant at 0.05 level; LD: Learning device; IM: Instructional message

Table 3 Tests of between-subjects effects.

Source	Degrees of Freedom	Sum of Squares	F-ratio	p-value
Knowledge Test				
LD	1	330.90	1.83	0.19
IM	1	1981.17	10.96	0.003*
LD *IM	1	45.01	0.249	0.623
Error	21	3795.56		
Intention				
LD	1	7.11	17.31	0.000*
IM	1	17.19	41.86	0.000*
LD *IM	1	1.022	2.49	0.13
Error	21	8.623		
Satisfaction				
LD	1	0.442	0.454	0.508
IM	1	0.864	0.887	0.357
LD *IM	1	2.318	2.381	0.138
Error	21	0.973		

* Significant at 0.05 level; LD: Learning device; IM: Instructional message

expressed a significantly higher intention to learn than those who did not.

Finding 3: interaction

Statistical results showed no significant interaction between the two studied independent variables: instructional media and instructional message for all three dependent measures. The absence of this interaction implied that the difference in students' dependent measures was not significant, whether students used the simulation tool or not. Therefore, one might conclude that Null hypothesis 3 should be retained.

CONCLUSION

This study explored the effects of various types of instructional media and instructional message on undergraduate students majoring in electronic engineering. Statistical data collected from a total of twenty-five students simply yielded preliminary results. A future study should be considered to enhance the generalizability of the current research by increasing sample size.

Results showed that the interaction between two studied independent variables (instructional media and instructional message) was not significant. Therefore, a further investigation for main effects of the independent variables should follow [7].

With instructional media, a significant difference was found between the two groups. The desktop PC group expressed a significantly stronger intention to learn than those in a PDA environment, while the two groups were not significantly different in the knowledge and satisfaction tests.

Even though mobile instructional media, such as PDAs, could provide learners with more flexibility to learn anywhere and at any time, student learning achievement shown by a knowledge test did not exhibit significant differences between the two groups. The result suggested that students' learning performance seemed not to be influenced by the instructional media per se. This finding was consistent with Dillon and Gabbard's results [8] from a meta-analysis research, namely that many media comparison studies had shown no differences in learning achievement. However, an interesting finding was that students preferred to learn in a desktop PC environment rather than a PDA environment. A reasonable inference was that desktop PCs provided a bigger display screen, which might make it easier for students to read technical course content.

With instructional message, the two groups exhibited significant differences in the knowledge test and the intention measure. Specifically, students who used a MATLAB simulation tool performed significantly better in a knowledge test and also expressed a significantly higher intention to learn than the text-only group.

This finding was consistent with Carter's [9] that interactive multimedia contents enhanced student learning. The topic of digital filter design involved student understanding in complicated mathematical equations. The use of such a MATLAB simulation tool indeed helped boost student learning performance. In addition, the study found that the design of multimedia content was more attractive to learners, thus enhancing their intention to learn. Davies [10] found a similar result.

According to the findings of the study, future research should continue to investigate the impact of mobile technologies along with different instructional strategies on engineering students' learning achievement, covering such topics as facts, concepts, comprehension, problem-solving and critical-thinking skills. Additionally, future studies should consider human factors in a mobile learning environment, such as learners' individual differences, learning styles, preferences in learning visual/audio materials, field dependence/independence, etc. Many of the independent variables associated with the study of aptitude-treatment interactions should be taken into account in the design of mobile-based instruction.

While mobile technologies may be manipulated to influence engineering students' learning positively, particular attention must be given to guidelines derived from mobile-based instruction and experimental methodology, as well as consideration of learner characteristics and learning styles. Only by initiating a systematic programme of investigation where independent variables are judiciously manipulated to determine their relative effectiveness and efficiency of facilitating specifically designated learning objectives will the true potential inherent in mobile learning be realized.

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