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The Relationships between Individual Differences and the Quality of Learning Outcomes in Web-Based Instruction

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Abstract

The use of web-based instruction is becoming widespread in higher education, however much remains to be learned about how different learners perceived such instructional programmes. The study presented in this paper evaluates students' learning performance and their experience in a web-based instructional programme, which was applied to teach students how to use HTML in Brunel University's Department of Information Systems and Computing. Sixty-one Masters students participated in this study. A number of interesting interactions were found. Students' task achievements were affected by the levels of their previous system experience. On the other hand, the Post-Test and Gain scores were positively influenced by their perceptions and attitudes toward the web-based instructional programme. The implications of these findings are discussed.

1. Introduction

As one of the most recent developments in learning technology, the web stands to offer significant innovation to the improvement of delivering instructional material. The value of such innovation does not only provide a new way for teaching and learning, but also allows instructors to do traditional things in new ways [1]. This is the probable reason as to there has been an increased growth in the use of the web for teaching and learning. In particular, many institutions in higher education have used the web to support university courses. However, the drawback is that the responsibility for designing learning paths through web-based instructional programmes becomes that of the students. Some students who lack independent learning skills may find it difficult to interact with web-based instruction programmes, so their learning achievement may be disrupted, limiting the outcome of their learning and reducing its effectiveness.

In order to understand the effectiveness of web-based instruction at an individual learner level, it is necessary to see how different people perceive web-based instruction. Therefore, empirical evaluation of learners' preferences becomes paramount because such evaluation can provide prescriptions for developing student-centred learning environments that can match with learners' particular needs. The purpose of this paper is to reflect the actual student experience of interacting with a web-based instruction programme to present prescriptions for the design of such programmes.

2. Web and Individual Differences

Today, many institutes in higher education apply web-based instruction to develop university courses. Web-based instruction utilises hypermedia techniques to provide students with freedom of navigation. Students can control their navigation paths that may help them to develop their own knowledge structure. The development of web-based instruction programmes provides students with many opportunities to explore, discover, and learn in theory according to their own information needs.

On the other hand, the freedom offered by web-based instruction may come with a price. Quintana (1996) states that while students gained the advantage of flexibility in time, pace, and distance with web-based instruction programmes, many students felt isolated, suffered from a lack of motivation, or lack of support, and found that the feedback provided was too limited and consequently dropped out of the course [15]. Hedberg and Corrent-Agostinho (2000) indicate that some students considered web-based instruction to be a difficult learning medium, showing their concern by asking for more incentives, more time, more structure, and more guidance [8]. These studies provide evidence that not all types of learners appreciate being given control over constructing their own knowledge structure. In particular, students who need more guidance through the learning process may meet an increased number of problems in using web-based instructional programmes. Therefore, research that examines the relationships between individual differences and web-based instruction has mushroomed in the past several years. Such differences include cognitive style [18, 4], gender differences [6, 5], system experience [16, 2], and domain knowledge [10].

However, some problems still exist in current studies. For example, most studies measure learning with either theoretical knowledge or practical tasks. Very few studies consider both theoretical knowledge and practical tasks. In addition, paucity of studies integrates the findings of learning outcome with those of perceptions and attitudes. Therefore, there is a need to provide empirical evidence to identify whether there is a close relationship between students' learning

outcome and perceptions to learning environments. The present study attempts to address these problems. The approaches to addressing these two problems in this study are: (a) students' learning outcomes are measured by both theoretical knowledge and practical tasks in a web-based instruction program; and (b) the interactions between students' learning outcomes and perceptions are explored.

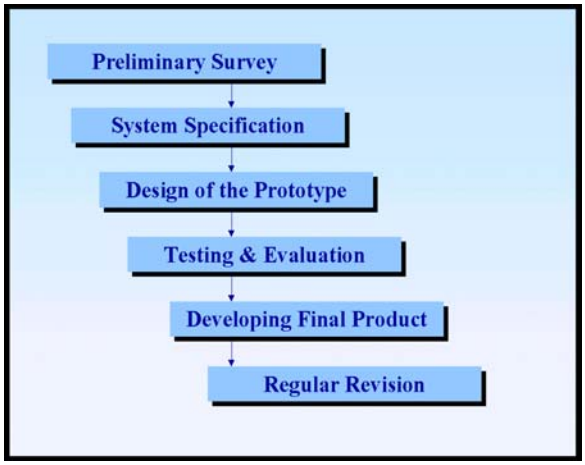

Figure 1: Development process

3. Curriculum Design

Curriculum design is a critical issue in the process of implementing web-based instruction. The sections below describe the approaches of the curriculum design in the development of web-based instruction, which include two important elements: creation of instructional material and assessment of learning outcome.

3.1 Creation of Instructional Material

3.1.1 Development Process

Instead of taking a technology-centred approach, the whole development process took a student-centred approach. In other words, the student was central to development process and continually gave input to the improvement of the web-based instructional programme. This approach was to make sure that the web-based instructional programme could meet with the students' particular needs.

As showed in Figure 1, the whole design process included six steps. The preliminary survey, which was the first and most important step, aimed to identify the students' understanding in this subject and to ensure that the level and presentation of the content were matched with their capabilities.

In order to reach this aim, a series of activities were conducted, including:

- Observation by sitting in the lecture was used to find students' difficulties in studying this subject;
- Informal discussion was conducted with the lecturers to ascertain their opinions of the students' capabilities;
- Comprehensive lecture notes and learning materials were collected and analysed in details;
- An in-depth study of other similar web-based instructional programmes in the relevant subject areas was conducted.

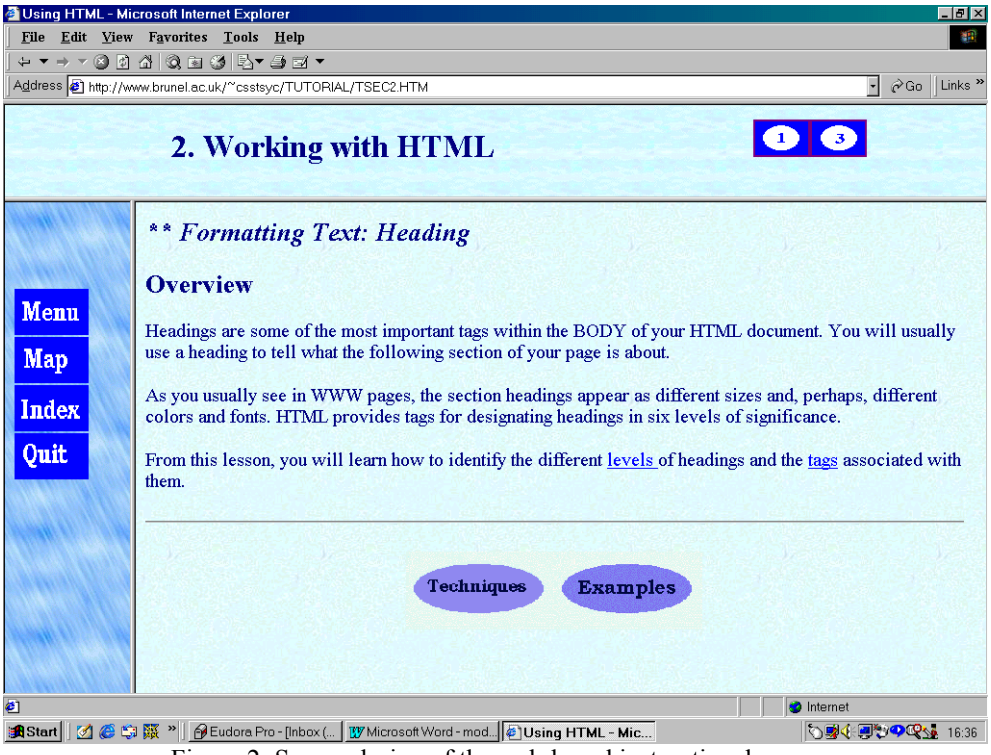

Figure 2: Screen design of the web-based instructional programme

Table 1: Three Types of Navigation Control

Control	Purposes	Tools
Sequence Control	To allow students to decide the sequence of subjects to be learned;	▪ *Subject Maps*: to show all topics and sub-topics in a hierarchical way; ▪ *Keyword Index*: to list keywords in an alphabetical way; ▪ *Back/Forward*: to see the page previously visited;
Content Control	To allow students to control the selection of the contents they wish to learn;	▪ *Section Buttons*: to choose three sections of the main content; ▪ *Main Menu:* to present main topics; ▪ *Hypertext Links*: to connect relevant concepts;
Display Control	To allow students to choose one of several display options that cover the same concept.	▪ *Display Options*: to include overview, examples, and detailed techniques, etc.

According to the results of the preliminary work, a system specification was developed and was employed to define the content, functionality and usability of the web-based instructional programme. A prototype was then designed based on the system specification and the students were invited to test and evaluate its function and contents. Their opinions were summarised and were used to implement the final product. It is important to note that implementing the final product is not the end of the development process. Revising the content on a regular basis is important because it can get students to re-visit the web-based instructional programme frequently.

3.1.2 Content Presentation

The subject matter of the web-based instructional programme was related to an introduction to using HTML. The programme began by giving an introduction to the learning objectives and explaining the available navigation approaches provided in the instructional programme. The contents were divided into three sections: (1) What is HTML? (2) Working with HTML, and (3) Relations with SGML and WWW. Section 2, which covers twelve sub-topics of HTML authoring, is the key element of the web-based instructional programme. Each sub-topic was further split into five parts, comprising (a) overview, (b) detailed techniques, (c) examples, (d) related skills, and (e) references. Information was presented in 82 pages using texts, tables, index, and maps. The contents of the web-based instructional programme were divided into seven hierarchical levels.

As shown in Figure 2, the screen was divided using frames. In the top frame was a title bar showing the section name being viewed and the other available section buttons. In the left frame were the Main Menu, Index, Map, and Quit buttons. The right frame displayed the main content for each section, including topic buttons and text-based hypertext links.

3.1.3 Navigation Control

The web-based instructional programme took advantage of non-linear learning and provided students with freedom of navigation. Topics and sub-topics could be studied in any order. In other words, students were allowed to decide their own navigational routes through the subject matter. Three types of navigation control were available in this programme as shown in Table 1.

3.2 Assessment of Learning Outcome

The objectives of the assessment were to examine the students' learning outcomes and the factors that affect these. Students are required to demonstrate their understanding of the fundamental technologies that underpin HTML authoring and to express their learning experience in using the web-based instructional programme. To achieve these objectives effectively, three types of the assessment were developed:

- Pre-Test and Post-test: to reflect students' theoretical knowledge;
- Practical Task: to reflect students' real skills of using HTML;
- Exit Questionnaire: to reflect students' learning experience.

3.2.1 Pre-Test and Post-Test

Examining students' theoretical knowledge was conducted by developing Pre-Test and Post-Test. Students were evaluated with a Pre-Test to examine their levels of prior HTML knowledge and with Post-Test to assess learning achievement. Both these tests were presented in paper-based formats and included 20 multiple-choice questions. There was only one right answer for each question. The formats of the questions were similar, with only the specific subject of the question being modified. The questions covered all three sections of the web-based instructional program from basic concepts to advance topics.

Students were allotted 20 minutes to answer each test and were not allowed to examine the content presented in the web-based instruction at the same time. Students' learning outcomes were assessed by:

- Post-Test Score: the sum of each student's score on the Post-Test, ranging from 0 to 20;
- Gain Score: score difference between the Pre-Test and the Post-Test in order to ascertain how much knowledge had been gained.

3.2.2 Practical Task

Students were assigned to do a practical task, which involved constructing a web page using HTML in order to measure learning outcome on the real skills that they had learnt. The practical task entailed 10 key areas (e.g. creating hypertext links, changing background colours, formatting text, etc.). A printed task sheet that described the detailed features of the web page to be completed was given to the students, who were allowed to decide the order in which they attempted to complete the task activities on the sheet. They were also allowed to look at the content of the web-based instruction programme simultaneously.

One and a half hours were allocated for each student to complete the task. The starting time and the end time for each student were recorded. Students' task achievement was evaluated by:

- Task Score: a score consisting of summing items successfully completed, on a 0-10 scale;
- Task Time: the total time spent for completing the whole task activities.

3.2.3 Exit Questionnaire

The exit questionnaire was divided into two parts. The first part was the assessment of the web-based instructional programme, including (a) levels of understanding, (b) content description, (c) presentation and explanation, (d) functionality and usability, and (e) difficulties and problems. The second part contained information regarding biographical data of students and their experience with using computers, the Internet, and HTML.

The assessment contained three open-ended questions and 47 closed statements. The open-ended questions were related to students' opinions about the strengths and weaknesses of the web-based instructional programme and the barriers that they met. Students were requested to express their opinions in their own words. Enough space was provided for them to write down their opinions. Each closed statement could be classed as either in favour or not in favour of the programme. The numbers of statements in favour was almost equal to those statements not in favour (20 statements in favour and 27 statements not in favour), in an attempt to reduce bias in the questionnaire. All statements used a five-point Likert Scale consisting of: strongly agree, agree, neutral, disagree, to strongly disagree. Students' perceptions and attitudes were measured by

- Positive Perceptions: the sum of the scores for all favoured statements of the Exit Questionnaire;
- Negative Attitudes: the sum of the scores for all not-favoured statements of the Exit Questionnaire.

4. Student Experience

The section below presents the results of how individual differences influence student learning in the web-based instructional programme. The data obtained from Pre- and Post Tests, practical tasks, and exit questionnaires (closed questions) were used to conduct quantitative analyses to identify students' learning experience. Pearson's *r,* which is appropriate to analyse interval level data [21], was applied to find the correlatons between students' individual differences and their learning preferences. A significance level of $p < .05$ was adopted for the study. In addition, the mean scores are employed to describe the learning outcome for each individual group.

4.1 Overall Results

Table 2: The distribution of the participants

	Male (N=32)	**Female (N=29)**	**Total (N=61)**
Computer Experience			
None	0	0	0
Little	0	0	0
Average	9	11	20
Good	12	10	22
Excellent	10	9	19
Internet Experience			
None	0	0	0
Little	0	0	0
Average	12	10	22
Good	9	12	21
Excellent	10	8	18
HTML Authoring			
None	8	7	15
Little	9	11	20
Average	6	7	13
Good	8	5	13
Excellent	0	0	0

The participants (N=61) consisted of Masters' students at Brunel University's Department of Information Systems and Computing. Despite the fact that the participants were entirely self-selecting, in fact the sample is extremely evenly distributed in terms of gender, and system experience. They were 32 males and 29 females. The computer experience and Internet experience reported by the participants varied from average to excellence. Their familiarity with the subject content, *HTML authoring*, ranged from none to good (Table 2).

Table 3: Overall learning outcomes

	Post Test	Gain Score	Task Score	Task Time
Mean	10.4	7.7	6.5	46.5
SD	1.8	0.9	1.6	6.8

A majority of the students (78%) felt that the web-based instruction programme was useful and they liked the web treatment of the content. Their actual learning outcomes are described in Table 3.

4.2 Tasks vs. Tests

As indicated in Section 3, students needed to be assessed by both practical task and paper-based tests. It is important to note that both task and tests were markedly different. The distinctions between both of them are similar to those between open-book examination and closed-book examination. The practical task was completed in "open book" examination style, with the students building their Web pages being guided by the task sheet. The practical task could be completed successfully without necessarily recourse to memory, by applying knowledge read from the screen at the particular time it was needed. On the other hand, the Post-Test, which was a multiple choice factual test, entailed recalling knowledge from memory, and completed after learning using the web-based instructional programme, looked like a closed-book examination. These differences can also be associated with those between *procedural knowledge* and *declarative knowledge*. Derry (1990) distinguishes between these two, procedural being "knowledge how", and declarative being "knowledge that" [3]. Procedural refers to knowledge of how to do things, while declarative refers to knowledge about the world and its properties [13]. Practical tasks refer to procedure knowledge of how to use HTML, while paper-based tests refer to declarative knowledge about the properties of HTML.

Table 4 Task Score and Prior Knowledge

Task Score		Internet Experience	HTML Authoring
Excellent	Mean	8.2	N/A
	SD	1.9	N/A
Good	Mean	6.9	8.4
	SD	1.6	1.8
Average	Mean	4.3	7.2
	SD	0.7	1.3
Little	Mean	N/A	6.0
	SD	N/A	0.7
None	Mean	N/A	4.2
	SD	N/A	0.3
Significance		**r=.4400 p=.006**	**r=.3459 p=.036**

Significant Pearson's correlations showed the students' task scores were affected by the levels of their previous Internet experience and HTML authoring (Table 4). On the other hand, the Post-Test and Gain scores were positively influenced by their perceptions and attitudes toward the web-based instructional programme (Table 5). In other words, students who had more positive perceptions toward the web-based instructional programme could obtain better Post-test and Gain scores than those who had more negative attitudes toward the programme.

Table 5: Perceptions/attitudes & learning outcomes

	Post Test	Gain Score	Task Score	Task Time
Positive Perceptions	**r=.4052 p=.013**	**r=.4601 p=.004**	r=.2979 p=.073	r=.0856 p=.614
Negative Attitudes	r=-.0877 p=.606	r=-.1254 p=.460	r=.0548 p=.751	r=.3053 p=.066

It implied that performance on the practical task of applying procedural knowledge could be promoted by prior system experience in using Internet and HTML authoring, but it would not be affected by the matching or mismatching of instruction with students' preferences. Conversely, the ability to recall declarative knowledge appears to have been mainly facilitated by matching instructional presentation with learners' preferences, but it is not influenced by prior system experience of using Internet and HTML authoring.

4.3 Gender Differences

Table 6: Gender Differences in Learning Outcomes

	Post Test	Gain Score	Task Score	Task Time
Female				
Means	12.4	9.3	4.5	35 .5
SD	1.9	1.1	0.6	3.8
Male				
Means	8.5	6.2	8.6	56.4
SD	0.8	0.7	1.8	7.8
Significance	**r=.3519 p=.004**	**r=-.2889 p=.020**	**r=-.3374 p=.006**	**r=.3413 p=.005**

The students' learning outcomes showed some interesting findings with regard to gender differences. Female students performed better than male students in the Post-Test. Conversely, male students outperformed female students in the practical task (Table 6). As indicated in Section 4.2, the differences between the Post-Test and practical task can be related with those between *declarative knowledge* and *procedural knowledge*. It implies that female students are better at acquiring declarative knowledge, rather than procedural knowledge. Conversely, male students are

skilled in gaining procedural knowledge, instead of declarative knowledge.

For learning attitudes, male students were patient in completing the task. On the other hand, female students felt nervous doing the tasks and some of them (N = 10) gave up doing the task in the middle stage. In addition, female students needed more guidance than male students. Female students tended to ask for instruction from the tutor, instead of trying to correct errors by themselves. These findings are in line with previous studies, which found that males showed more interest in using and learning about computers while females reported fear of using computers and feeling helpless around them [17, 9]. For this phenomenon, educators should help female students to build their confidence in facing the challenge of using computers, instead of giving too detailed instructions. In addition, educational settings should ensure that instructional programmes developed should not place any students at a disadvantage due to their gender differences [14].

4.4 Prior Knowledge

Through analysing the students' prior knowledge, one thing seems evident. For doing the practical task, students who had greater experience of using Internet or HTML authoring seemed able to look for relevant information in an efficient way. Conversely, students who were lacking prior knowledge of the subject content needed more time to complete the task by using the web-based instructional programme (Table 7). It seemed that student's existing knowledge did influence their interaction with the web-based instructional programme. These findings arguably supported results from previous studies [18, 7] which found there was a positive relationship between learner control and prior knowledge.

Table 7: Prior Knowledge and Task Time

Task Time		**Internet Experience**	**HTML Authoring**
Excellent	Mean	39.2	N/A
	SD	5.5	N/A
Good	Mean	44.5	31.4
	SD	6.1	3.2
Average	Mean	54.4	41.9
	SD	8.1	4.3
Little	Mean	N/A	50.5
	SD	N/A	5.9
None	Mean	N/A	61.2
	SD	N/A	7.3
Significance		**r=-.2690 p=.030**	**r=.2834 p=.022**

Expert learners who had an adequate amount of prior knowledge on the subject felt familiar with the interface and the contents of the web-based instructional programme so they were confident about being more active when navigating the web-based instructional system. On the other hand, novice learners might not be aware of the best order to read the material or what the most important information was. Therefore, it is important to provide novice learners with an initial phase of orientation relating to both interface and domain contents [12]. One of the ways is to provide visual paths, which can be displayed by means of cues to indicate how far students are along a path or by giving some conceptual description for the possible sequences. The alternative way is to providing good labels for the pages. Labels that clearly indicate the role of a particular page may help novices successfully to decide the appropriate coherent path [11].

4.5 Learning by Doing

In this web-based instruction programme, students were asked to do a practical task (i.e. designing a web page with HTML). A significant number of students (44%) reported that doing the task was a useful way of helping their learning in the web-based instructional programme though they felt pressured by the whole process of doing the task. They thought that the task activities could help them set the focus and recall what they had learnt. From these 44% of students, 52% of them could obtain the Post-Test scores above the average (= 10.4) and 63% of them demonstrated more positive perceptions to the web-based instructional programme. These results implied that "learning by doing" could assist some students to set their effective learning strategies. As indicated by Smith and Parks (1997), tasks serve to simulate "goal directed" browsing in such a way that learning performance can be enhanced [20].

On the other hand, a few of them (30%) reported that doing the task hindered their learning. They found that they lost other important information that they needed to learn because they were concentrating on doing the task. From these 30% of students, 58% of them obtained the Post-Test scores below the average and 54% of them showed more negative attitudes toward the web-based instructional programme. This raises some interesting questions for further studies to consider (a) whether task activities can facilitate promoting students' learning performance in a web-based instructional programme; and (b) what the relationships are between students' attitudes and their learning patterns as reflected in a web-based instructional programme with/without setting tasks.

5. Conclusions

The aforementioned findings provide evidence that web-based instructional programmes may not be suitable for all learners as an instructional methodology. Instructors must be aware of individual differences such as gender and levels of prior knowledge possessed. Some learners, e.g. novice learners, may need greater support and guidance from the instructors, while others may be able to follow web-based instructional programmes relatively independently. Thus, instructors should not assume that every student would benefit equally from web-based instructional programmes in

educational settings. There remains the need for guidance to ensure that all learners attain their learning potential.

Implementing web-based instructional programmes is a complex process composed of interactions among students, instructional content, and the features of web-based instructional programmes. It is important for educational settings to have a good plan in advance. Instructors should remain cautious about making a sweeping decision to convert entire curricula onto web-based instructional programmes. The goals of such a process should be weighed against the potential problems (e.g. alienating certain learners). To avoid alienating a certain group, instructors should continue to incorporate a number of different teaching strategies into their lectures. In addition, this transition requires time for the student and time in the classroom to acquaint the students with web-based instructional programmes. This is especially the case for students who have difficulties in independent learning; there is a need to let them have longer time for this shift. With this issue in mind, such innovation in teaching and learning will be more meaningful and valuable.

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