CHAPTER 4

THE INITIAL EVALUATION OF LEARNINT

4.1 INTRODUCTION

In Chapter 3, the cognitive style construct was characterised as the stable approach of each individual to organising and representing information. Following the methodological approach outlined at the beginning of this research, a series of key defining attributes of cognitive styles were extracted and instructional conditions that capitalize on such attributes identified. Based on both the key characteristics of cognitive styles and their advantageous instructional conditions, adaptive variables were proposed as a framework for the development of adaptive interfaces for Web-based learning materials. A learning application (LEARNINT) developed as a case study to assess some of the variables previously identified, was also introduced.

This Chapter reports on an initial study carried out to gather evidence to support the proposed approach using LEARNINT as a test vehicle. The research method is presented in detail and its results, showing that individual differences influence the way learners react to and perform under different interface conditions, are discussed in detail.

4.2 RESEARCH METHOD

In order to enquire whether matching the interface design to the cognitive style of the user can facilitate learning performance an experiment was conducted using LEARNINT as a test vehicle. The hypothesis was stated as follows:

H_1 Matching the interface's style to the user's cognitive style will improve learning efficiency

LEARNINT comprises two extremely different interfaces. The first interface is highly *Imager* and *Wholist* (W/I) and covers the topic "Combinational Circuit Design". The second interface (A/V) is highly *Verbaliser* and *Analytic* and its learning content relates to the topic "Relational Circuit Design" (a detailed description of the interfaces is provided in section 3.6). In both cases learning material allows for a 30-minute session.

4.2.1 Participants

The evaluation involved the participation of 28 volunteers, from which three withdrew from the study and their data was therefore not included in the analysis of the results. The actual sample consisted then of 25 students: 9 women and 16 men, the average age was 30.4 years (max = 42, min = 21).

With just one exception, all the participants were postgraduate students, 14 in computer science or IT, and the rest in different disciplines such as mathematics, economics, energy, marine resources and chemistry. Participants reported their previous knowledge on "Circuit Design" using one of the four categories shown in Table 4.1.

Categories	Description	No. of participants
A	No previous knowledge	8
B	Limited previous knowledge	8
C	Average previous knowledge	8
D	Extensive previous knowledge	1

Table 4.1: Categories used by the participants to self-classify their previous knowledge about Circuit Design.

4.2.2 Tasks

The tasks carried out by the participants involved using LEARNINT to study the topics covered by the interfaces. Task 1 was defined as using the W/I interface to study "Combinational Circuit Design", and Task 2 as using the A/V interface to study "Relational Circuit Design". Although each interface was designed for a 30-minute session, no time limit was established.

4.2.3 Measures and Instruments

Measures were set as user satisfaction and perceived usability on each interface, performance on each topic, and individual cognitive style. User satisfaction was measured by the users' responses to a modified-Shneiderman questionnaire [Shneiderman, 1998]. For measuring usability, the System Usability Scale (**SUS**) develop by John Brooke [1996] was used. Learning performance was registered in terms of information recall as measured by a test for each topic comprising 6 multiple-choice questions with degrees of confidence – based on the MICE system [Adeboye &

Culwin, 2003], degrees of confidence were used as an attempt to eliminate the confounding factor derived from the students' approach to answering multiple choice questions (i.e. to determine to what extent the answer was a guess). The scale used to mark the tests is presented in Table 4.2. The individual cognitive style of each participant was assessed using the VICS & E-CSA-WA test [Peterson, 2003].

| Degrees of confidence | Marks given when the answer was | |
	Correct	Incorrect
Very Confident	3	-2
Slightly confident	2	-1
No confident	1	0

Table 4.2: Scale used to mark the assessment tests.

The instruments used to collect the information for this study are included in Appendix A, including:

A.1 Consent Form

A.2 General Information questionnaire

A.3 Evaluation questionnaire – which includes the SUS scale as its final section

A.4 Combinational Circuit Design – Assessment tests

A.5 Relational Circuit Design – Assessment test

All the sessions of the study took place in the *Human Cognition Laboratory* at the Computer Science Department. The lab comprises three computers with the following technical characteristics:

- Processor Intel Pentium 4, 1.80GHz

- 15" Colour Monitor, 1024 x 768 pixels, 32 bit colour quality

- PS/2 compatible Mouse

- Standard 101/102 Keyboard

- Microsoft Windows XP, Professional Edition V. 2002

- Internet Browser: Internet Explorer V. 6.0

4.2.4 Experimental Procedure

Participants attended a total of three sessions, one week apart from each other. Times and dates were allocated according to their availability and in most cases they were tested individually.

In the first session the objective and the procedure of the study were explained and each participant signed the participatory agreement and filled in the general information questionnaire. Then they carried out Task 1 and answered the evaluation questionnaire for the W/I interface.

The second session started with the assessment test for the content studied in Task 1, followed by completion of Task 2, to end by answering the corresponding evaluation questionnaire for the A/V interface.

In the last session the participants answered the assessment test corresponding to Task 2, and carried out the VICS & E-CSA-WA test.

4.3 RESULTS

The analysis of the results from the VICS & E-CSA-WA test shows that the participants in this study have a *Verbaliser-Imager* ratio between 0.826 and 1.819, which suggests an *Imager* style preference.

Verbaliser – Imager ratio:
$n=$ 25
mean= 1.109
s.d. = .279
max= 1.819
min= .826

The results corresponding to the *Wholist-Analytic* ratio show that the participants in this study have a position between 0.973 and 1.790, which suggest a tendency towards an *Analytic* preference.

Wholist – Analytic ratio:
$n=$ 25
mean= 1.348
s.d. = .249
max= 1.790
min= .973

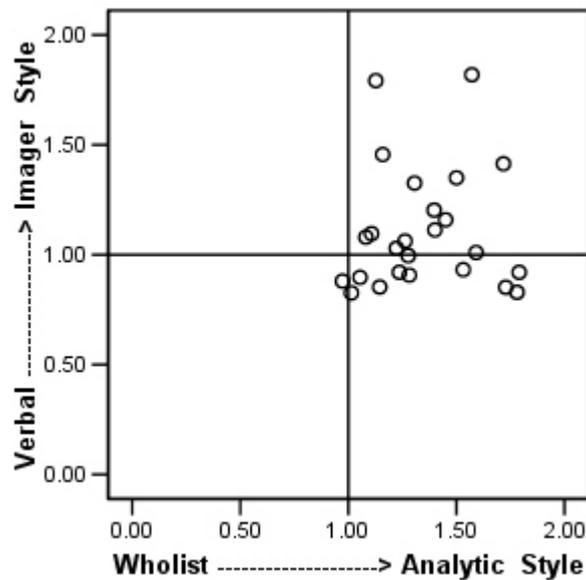The distribution of the participants' cognitive style is shown in Figure 4.1.

Figure 4.1: Distribution of the participants according to their cognitive style.
1 Individual of *Wholist-Verbaliser* style,
10 *Analytic-Verbaliser*, and 14 *Analytic-Imagers.*

The user satisfaction questionnaire was organised into 5 sections relating to perceived complexity of the Content, Navigation structure, Mode of presentation (textual vs. graphic content), Layout and User Reactions. The final section of the questionnaire was the SUS scale to obtain a global view of subjective assessment of usability. Results obtained from this questionnaire are shown in Table 4.3 for the W/I interface, and in Table 4.4 for the A/V one.

	Content	Navigation	Mode of Presentation	Layout	User Reactions	SUS
mean=	6.5	7.1	7.2	7.1	6.8	78.8%
s.d.=	1.8	1.9	1.7	1.9	1.4	12.6%
max=	8.6	9.0	8.8	8.9	8.5	97.5%
min=	4.0	3.7	4.8	4.1	4.0	50.0%

Table 4.3: Evaluation of the W/I Interface, *n*=25.

	Content	Navigation	Mode of Presentation	Layout	User Reactions	SUS
mean=	6.5	8.3	7.2	7.1	6.5	76.2%
s.d.=	2.0	1.1	2.0	2.1	1.9	17.1%
max=	8.6	9.0	8.8	9.0	8.5	100%
min=	3.2	5.3	3.9	3.7	2.5	40%

Table 4.4: Evaluation of the A/V Interface, $n = 25$.

Considering that the Likert type scale used consisted of nine possible values, where 9 was the most positive agreement in terms of user satisfaction, it can be observed that user perceptions were mainly positive towards both interfaces. In particular, user reactions were more favourable to the W/I interface with a mean value of 6.8, compared to 6.5 for the A/V interface.

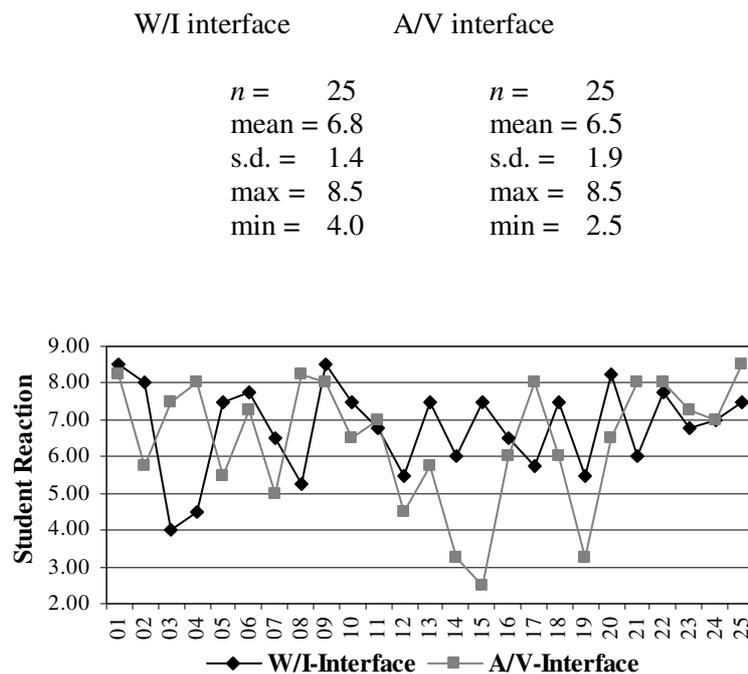In terms of individual preferences, most of the participants had a preferred interface as shown in Figure 4.2:

W/I interface   A/V interface

$n =$ 25 $n =$ 25
mean = 6.8   mean = 6.5
s.d. =   1.4   s.d. =   1.9
max =   8.5   max =   8.5
min =   4.0   min =   2.5

Figure 4.2: Participants' reactions under different interface conditions.

General performance was also different for each topic/interface:

Assessment Topic1, W/I interface   Assessment Topic2, A/V interface

$n =$ 25 $n =$ 25
mean = 52%   mean = 42.82%
s.d. =   .369   s.d. =   .400
max =   100%   max =   100%
min =   -5.56%   min =   -22.22%

78

This is a key result from this study, since it demonstrates both a difference in user reaction to the interfaces (*Interface Affect*) and differences in performance are then also observed: 21 participants performed differently between the two interfaces, and of these 15 (71%) demonstrated an improved performance in their preferred interface (Figure 4.3).
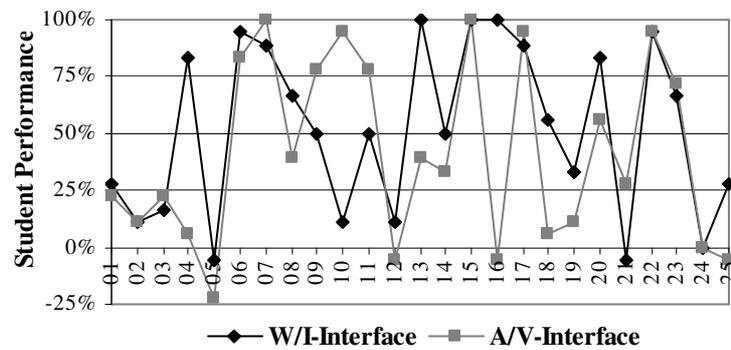

Figure 4.3: Individual performance.

Further analysis of the data collected failed to demonstrate any significant relationship between cognitive style and performance, or between cognitive style and the participants' expressed preferences. This additional analysis included, for example, comparing:

- The position of the participants on each cognitive style dimension (i.e. *Wholist-Analytic* and *Imager-Verbaliser*) against their expressed reactions towards each interface style

- The position of the participants on each cognitive style dimension against their learning performance regarding each topic (i.e. "Combinational Circuit Design" and "Relational Circuit Design")

- The position of the participants on each cognitive style dimension against their learning performance on their preferred interface style.

No simple relationship between the participants' cognitive style and their reaction was observed, nor was there a direct relation regarding the individuals' cognitive style and learning performance.

The raw data obtained from the study are included in Appendix B.

4.4 DISCUSSION

Considering that this study had a relatively small sample, the results cannot be deemed to be statistically significant. However, the results obtained give some indications as to whether matching the interface design to the learners' cognitive style improves learning efficiency.

It was speculated that the limited effects observed in earlier studies were due to the fact that single experimental conditions had been used, as has been the case for research evaluating the effects of mode of presentation [Wei, 2001; Brown, 2006], medium of delivery [Riding & Grimley, 1999], or Hypertext structure [Graff, 2003]. Conversely, the design of LEARNINT took into account several key characteristics derived from extensive previous research in the field of cognitive styles. Nonetheless, no simple relationship was observed between cognitive style and interface design preference or learning performance.

As it was expected, learners responded differently to each experimental condition, reflecting their expressed preferences towards the interfaces used: 24 out of 25 participants expressed a preference for either the W/I interface or the A/V one. Differences were also observed in the learning performance of the participants, 21 performing differently between the two interfaces, 15 (71%) of these performed better in their preferred interface. This suggests that students perform better in the interface they react most positively to.

The findings from this study imply that performance of individuals is superior in certain interface conditions. The question remains then as to why cognitive style does not relate to the users' reactions and/or to their performance given different interface designs?

Although several other factors need to be taken into account, it seems that individual orientation to learning significantly interacts with cognitive style. While cognitive style is considered a fixed core characteristic of an individual, researchers also argue that individual strategies are developed to deal with learning material which is not initially compatible with their cognitive style [Schmeck, 1988; Riding & Rayner 1998]. Individual learning strategies are understood as orientations displayed by learners to implement specific sequences of procedures for accomplishing learning that are based on their skills. Schmeck [1988] argues that cognitive style and learning orientation interact dynamically in a developmental way as style influences approach and approach determines the learning outcome, which in time may change style. Riding & Rayner

[1998] emphasise the stability of style, but also recognise that several different strategies of learning may be adopted as a response to environmental demands. Moreover, Diseth & Martinsen [2003] suggest that learning strategies are driven by a tendency to seek environmental cues for the purpose of achieving success, and that this seeking of cues may be related to the student's previous experience in terms of familiarity with the learning environment and earlier success in such a learning context.

Furthermore, the sample in this study was limited in the distribution of individual cognitive styles. As shown before, 24 participants were of *Analytic* style, and from these 14 of *Imager* style, which might not be truly representative of the student population. Peterson [2003] in her research observed a *Verbaliser - Imager* style ratio between .8 and 1.0 and a *Wholist - Analytic* ratio between .97 and 1.25 from samples of university students.

While the observed distribution of cognitive styles may be seen as a limitation of this evaluation study, some issues have to be noted. Firstly, the assessment of cognitive style was left for the final session of the experimental procedure to avoid influencing the participants' reaction and evaluation of the different interfaces in the system. For the same reason there was no sampling in advance. Secondly, it was expected that the unitary combinations of the cognitive style dimensions used for the design of the interfaces, i.e. *Wholist-Imager* (W/I) and *Analytic-Verbaliser* (A/V), would allow for the interaction between interface style and the learner's style in either dimension, which was not the case in this study. Finally, based on the extensive research carried out by Peterson and her colleagues with hundreds of university students, there were not grounds to expect such a tendency towards a particular style among the participants as was the case in this experiment. On the other hand, the tendency observed among the participants in this study may be informing the research about the particular cognitive style of engineering and science students.

An additional issue that has to be discussed refers to the order in which interface styles and subject content were experienced by the participants in this study. Each interface style currently available in LEARNINT relates to a specific topic of the "Computer Hardware" subject:

- Wholist-Imager (W/I) interface → "Combinational Circuit Design" (Topic 1)

- Analytic-Verbaliser (A/V) interface → "Relational Circuit Design" (Topic 2)

81

According to the experimental design, all the participants used the W/I interface first to study about Topic 1, and afterwards they used the A/V interface to study about Topic 2. There is therefore, the possibility that differences in the results observed have been influenced either by the order in which the users experienced the user interface styles, or by the order in which they studied the subject content.

On the whole, a number of limitations in this evaluation study have to be noted:

- Small sample of participants, which restricts the possibility of generalising the results observed.

- Limited distribution of cognitive styles among participants.

- Risk of differences in the results due to the sequence in which the interface styles and their content were presented.

Taking all these factors into account there is clearly a need to conduct this experiment with a larger sample to verify the results. However, since our results mirror those achieved by previous studies on the relationship between cognitive style and learning performance, there is also a clear need to formally identify those parameters which influence Interface Affect and their relationship with learning performance.

4.5 SUMMARY

This Chapter describes the initial study carried out to evaluate the impact of key characteristics of individual cognitive style on learning performance under different interface conditions. A small sample of students from Heriot-Watt University participated in the experiment, using LEARNINT as a test vehicle. The majority of them expressed a preference for one of the interfaces of the system. Differences were also observed in terms of learning performance: most of the participants performed better in their preferred interface, which suggests that students perform better in the interface they react most positively to. Conversely, the evidence from this study, supported by previous research projects, suggests little or no impact of cognitive style in learning performance.

While the initial hypothesis of the evaluation was disproved by the outcomes of the data analysis, the results also indicate that interface style does have an impact on learners' preferences, which in turn have an impact on their learning performance. These findings imply that certain features of the interface design and ultimately the adaptive behaviour

of a learning system can be matched to the learner's characteristics and preferences to facilitate more effective learning and enhance the learning experience. These findings inform the proposed approach for the design of adaptive interfaces for Web-based learning materials, and satisfy objective eight (O8) of the research to an extent.

Since a relationship is determined between **Interface Affect**, being the reaction of a student to the style of an interface, and the learning outcomes achieved through the use of that interface, the objective nine (O9) of the research has been achieved to a certain degree in that further variables influencing the interaction between learners and different interface designs for Web-based learning materials have been identified.

Findings from this evaluation have important implications for the design approach proposed for the development of adaptive interfaces for Web-based learning materials as individuals would seem to benefit from using adaptive learning environments. However, given the limitations of the study discussed in this Chapter, further work has been carried out with a greater number of participants and considering additional issues such as the influence of familiarity in Interface Affect. The results of the extended evaluation are discussed in the next Chapter.