CHAPTER 5

EXTENDED EVALUATION OF LEARNINT

5.1 INTRODUCTION

Chapter 4 reported on an initial study carried out to evaluate the proposed approach for the development of adaptive interfaces for Web-based learning materials. Results showed no evident relationship between cognitive style and learning outcomes. However, a relationship was observed between Interface Affect, being the reaction of a student to the interface design, and the learning outcomes achieved through the use of that interface.

The limitations of the initial study were also discussed in the previous Chapter, indicating a clear need to conduct the experiment with a larger sample to verify the results. An extended evaluation was thus carried out, which is described in this Chapter. In this study, the concept of Interface Affect is explored further, and the case is argued in particular for investigating the learners' perceived familiarity with the style of the interface as a variable mediating Interface Affect. The research method is detailed in the following sections, indicating the changes made to the experimental design as a result of the experience gained from the initial evaluation. Results from the analysis of the data gathered are presented and discussed in detail.

5.2 THE CASE FOR AFFECT

The analysis of the data gathered during the initial evaluation of the LEARNINT prototype suggested a relationship between Interface Affect and the learning outcomes achieved by the participants. While Interface Affect was characterised as the reaction of a student to the style of the interface, there is a need to further explore the concept in order not just to explain the results from the data collected, but also to understand how user preferences interact with style during learning situations and what the implications are for the design of adaptive interfaces for Web-based learning materials.

Although emotions were, for a long time, considered undesirable for rational behaviour [Picard, 1997; LeDoux, 1998; Paiva, 2000; Picard et al., 2004], findings from a range of disciplines such as neuroscience, psychology and cognitive science advance our understanding of the human brain not only as a cognitive information processing system, but as a system in which affective functions and cognitive ones are interrelated [Martin & Briggs, 1986; Fijda, 1993; Picard, 1997; LeDoux, 1998; Norman, 2002; Picard et al., 2004; Ortony et al., 2005]. Accordingly, learning is increasingly understood as the result of a complex interaction of structures and processes, both internal and external to the learner, and having both cognitive and affective aspects [Martin & Briggs, 1986; Martinez & Bunderson, 2000; Picard et al., 2004].

The results observed in the initial evaluation of LEARNINT reflect this interaction between cognitive and affective factors since the design approach proposed for the development of adaptive interfaces is based on key cognitive characteristics of learners and an interaction has been observed between interface style, the expressed reactions and preferences of the participants and their learning performance. Therefore, the parameters that influence Interface Affect and their relationship with the learners' cognitive style and learning performance are factors that have to be explored further.

5.2.1 Emotional Experiences and Affect

It has been suggested that emotional experience is built up from a small set of basic emotional feelings including happiness, sadness, fear, anger and disgust [Oatley, 1992]. For Fijda [1993] this approach is unsatisfactory, particularly because the concepts used to label those elementary feeling qualities are semantically decomposable. He suggests that only affect proper – that is the experience of pleasantness or unpleasantness – is both un-analysable and specific for the affective experience.

Emotions arise from encounters with events that are perceived as relevant for the individual's current concerns. It is the notion of *affect* that gives emotions their non-cognitive character: affect is not experienced as a feeling of pleasantness; rather, the individual is aware of the pleasant or unpleasant nature of the emotion-eliciting event [Fijda, 1993]. Apart from affect, the appraisal of emotional events also includes a series of values on dimensions such as certainty-uncertainty, goal conduciveness, self-confidence, and controllability. In turn, this profile of values helps to differentiate types of emotions from one another.

Affect not only indicates the occurrence of a relevant event, it also signals the state of the individual's estimated coping ability. This component of the emotional experience is what Fijda [1993] calls *felt state of action readiness*, and refers to the readiness or un-readiness to enter into contact and to modify our relationship with the environment – e.g. moving toward, moving away, moving against, hyperactivation, hypoactivation. Different emotions tend to involve different kinds of action readiness and strong correlations have been observed between particular emotion concepts and specific kinds of action readiness, such as fear and avoidance, or joy and approach.

States of action readiness do not in the first place refer to inner feelings, but to sets of predictions of past and future appraisals and relational behaviours (e.g. in anger, likelihood of negative evaluation of the event, and/or future avoidance of the object), and of behaviour types that are likely to come forth (e.g. in anger, verbal aggression or physical assault if the confrontation persists) [Fijda, 1993]. Emotional experiences are, in this sense, objects of reflective judgements since past events help building a framework that influences the way individuals assess a particular situation, their affective reaction and their consequent behaviour.

These properties of emotions – affect, appraisal, state of action readiness and available coping resources – have then important behavioural and cognitive consequences, including motivation, general activation, perception, judgement, information retrieval and performance, among others.

5.2.2 Emotion, Cognition and Interaction

While the cognitive system interprets and makes sense of the world, the affective system assigns positive or negative valence to the environment. Affect and cognition are thus processing systems with different operating parameters [Norman, 2002]. Each system affects the other: affective states are driven by cognition, and cognition is influenced by affect.

It has been observed that affect induces different kinds of thinking. Positive affect broadens the thought processes towards greater creativity in problem solving and enhanced efficiency in decision making [Isen, 2000; Norman, 2002]. On the contrary, negative affect focuses the mind, leading to avoidant and defensive tendencies, closure to stimulation and selective attention [Fijda, 1993; Norman, 2002].

If the interaction between learners and Web-based learning materials produces an emotional reaction in the student, this response would then influence their thinking process and, ultimately, their learning performance. Furthermore, based on previous findings of the research, it is suggested that this learning performance is related to Interface Affect.

As stated above, affect signals our coping ability and subsequent response to the current environment; this judgement is based on the reference context built by each individual from previous experiences. Similarly, it has been observed in previous studies [Davis & Wiedenbeck, 2001] that different interfaces evoke different reference contexts, which in turn raise positive/negative affect towards the interaction.

Emotional reactions and individual cognitive factors are therefore intertwined during the interaction: the more different an interface is with respect to the reference context the user possesses, the more increased is the cognitive load, and thus the lower concentration on the task and higher attention on the interaction environment. Taken to the extreme, curiosity is overloaded – with too great a complexity and too much incongruence – which might lead to a sense of loss of control and lower motivation because challenge is perceived as greater than skills [Davis & Wiedenbeck, 2001]. Negative affect is therefore expected in this situation.

On the contrary, the evoked reference context might raise positive affect, then users can focus on the content at hand and not on the interaction environment and they may perform better. In turn, this increases self-confidence and ease of use perceptions. Ultimately "…all other things being equal, people will form an intention to use a software system to which they have a positive affect" [Davis & Wiedenbeck, 2001, p. 554].

When the interaction is for learning, an additional factor is that of learning strategies. Learning strategies are combinations of skills implemented when a situation is perceived as one demanding learning [Schmeck, 1988; Riding & Rayner, 1998]. Developing and applying learning strategies is an extended process driven by a tendency to seek cues for the purpose of achieving success [Diseth & Martinsen, 2003]. When faced with a learning situation, individuals will assess the learning setting and select the activities they consider best to cope with the learning task. Each student develops a repertoire of learning strategies based on the success or failure achieved by applying a given set of learning activities under certain conditions [Schmeck, 1988; Riding & Rayner, 1998].

All these concepts together suggest that certain elements of the interface style elicit a sense of familiarity with the learning environment. This judgement, being part of the emotional appraisal of the current situation, triggers an affective reaction towards the learning environment, which in turn impacts the kind of learning strategies each student puts in practice to cope with the learning task (Figure 5.1).

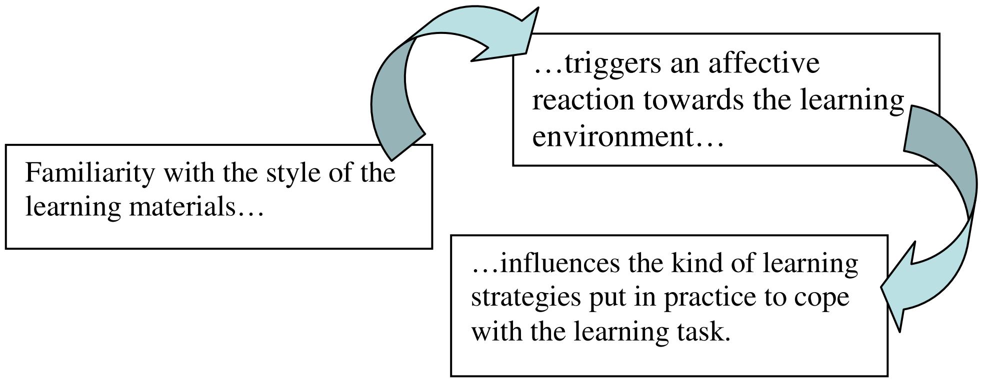

Figure 5.1: The possible connection between familiarity, Interface Affect and learning performance.

Given that a relationship has been observed between Interface Affect and learning performance, some issues that would require further attention in an extended evaluation of the LEARNINT prototype include the possibility of assessing the student's perceived familiarity with the style of the interface and the extent to which this sense of familiarity influences Interface Affect, as well as the possible interaction between these variables, the learners' performance and their cognitive style.

5.3 EXPERIMENTAL STUDY

During the initial evaluation study, LEARNINT was used to investigate the relationship between cognitive style and learning performance under different user interface conditions. As has been discussed, while the relationship between cognitive style and learning performance was not clearly identified, a connection was determined between the participants expressed reactions to the style of the interface and their learning performance. The concept of Interface Affect was put forward and it has been examined further in order to explain these results and understand their implications.

Since a clear need was established to conduct an extended evaluation to verify these results, a second experiment was carried out. A number of changes were deemed necessary in order not just to verify previous outcomes, but also incorporate the notion of Interface Affect and, importantly, overcome the limitations of the initial evaluation study. These changes are discussed in the following section.

5.3.1 Changes to the Experimental Design

The aim of the second experiment was to explore the relationship between cognitive styles, Interface Affect and learning performance under different interface conditions.

One of the major changes to the experimental design of this extended evaluation was to further investigate the notion of familiarity. Derived from the analysis presented in section 5.2 above, suggesting that Interface Affect seems to be mediated by the students' sense of familiarity with the interface style, it was considered important to investigate whether familiarity with the user interface influenced Interface Affect. Since no published, empirically developed measure of familiarity was available, it was necessary to determine a suitable scale -the process followed is detailed in a separate section below.

In addition, a more extensive profile of the participants was sought in this study, which could inform the research about their experience using different software environments and thus about their familiarity with different interface styles. Various items were therefore included in the general information questionnaire (Appendix C.2) in this direction.

Another change in the design of the experiment was carried out to overcome one of the limitations identified in the initial study, namely the risk of obtaining differences in results due to the sequence in which the interface styles and their content were presented. As detailed in section 3.6, LEARNINT comprises two extreme interfaces: the first design is *Imager* and *Wholist* (W/I) and the second style (A/V) is *Verbaliser* and *Analytic*. In the previous evaluation of this prototype, each interface style was related to a specific topic of the subject content; for this study, LEARNINT was extended and the two topics – "Combinational Circuit Design" and "Relational Circuit Design" – were available in both styles. As a result four possible combinations (treatments) were available for the experiment (Table 5.1).

It was expected that having these treatments available would later facilitate the analysis of the data obtained in order to determine whether systematic differences existed derived from the order in which the participants experienced interface styles or subject content. This in turn, would contribute to the validity of the experiment and its results (Hayes, 2000; Bryman, 2004).

Treatment	Task 1	Task 2
T1	W/I Interface Content: Combinational Circuit Design	A/V Interface Content: Relational Circuit Design
T2	A/V Interface Content: Combinational Circuit Design	W/I Interface Content: Relational Circuit Design
T3	W/I Interface Content: Relational Circuit Design	A/V Interface Content: Combinational Circuit Design
T4	A/V Interface Content: Relational Circuit Design	W/I Interface Content: Combinational Circuit Design

Table 5.1: Treatments used in the extended evaluation of LEARNINT.

The Evaluation Questionnaire was updated to include the items used to assess familiarity. Other changes included the exclusion of the usability scale used in the initial evaluation of LEARNINT – i.e. the SUS questionnaire, mainly because some of the questions identified to assess familiarity would overlap with the SUS to some extent. Another change was to move the set of questions regarding the user's general reactions to the beginning of the questionnaire in order to capture the initial thoughts of the participants just after they had finished using the system. It was expected that in this way Interface Affect would be captured more accurately. The evaluation questionnaire used in the extended evaluation of LEARNINT is presented in Appendix C.3.

Additional changes to the experimental design derived from the identified need to gather a larger sample of participants. It has been discussed that the possibility of generalising the results obtained from the initial evaluation of LEARNINT was limited because the small number of participants. For this extended evaluation a greater number of learners were sought. While over sixty postgraduate students participated in this experiment, it was not possible to test them individually (as was the case during the initial evaluation study); nor was it possible to have sessions a week apart from each other. Instead, the participants were tested in groups (according to the treatment to which they were allocated) and attended two sessions on two consecutive days.

Designing a Scale to Assess Familiarity

Following the guidance for the development of questionnaires (e.g. Hinkin, 1999; Hayes, 2000; Bryman, 2004), an initial pool of questions relating to familiarity with the software interface was developed consulting the literature. Questions initially selected related to the extent to which the style of the interface reminded the users of software commonly used by them, also how difficult it was to understand the system and to work with it, and how confident the user felt while interacting with the system. The literature consulted included Shneiderman's [1998] Questionnaire for User Satisfaction, the Perceived Ease of Use questionnaire [Davis & Wiedenbeck, 2001], the Computer Attitude Scale [Gressard & Loyd, 1986] and the IT Learning Questionnaire [Masiello, 2005], among others. The initial pool of 25 questions was reviewed by a group of six PhD students and two lecturers from the Computer Science Department at Heriot-Watt University. The list was refined by eliminating items that the reviewers considered were not related to familiarity; an additional set of questions was also identified linked to perceptions of usefulness and ease of use rather than to familiarity. The two lists of questions derived from this heuristic evaluation were included in the questionnaire used for this evaluation of LEARNINT, comprising 5 items for a measure of Usefulness and Ease of Use and 8 items for the Familiarity scale.

The research method of the extended evaluation study, including the changes made to the experimental design, is detailed in the following section.

5.3.2 Research Method

In order to investigate the relationship between interface style, learners' cognitive style and Interface Affect as well as the influence of these variables in learning performance, an extended evaluation of the LEARNINT prototype was carried out. It was also expected that the study would provide some indication as to whether familiarity with the interface style relates to Interface Affect and/or to learning performance. Given this scenario, a number of hypotheses were stated:

H_0 Matching the interface style to the cognitive style of the user will not influence Interface Affect, nor improve learning performance.

H_1 Matching the style of the interface to the cognitive style of the user will increase familiarity and Interface Affect, which in turn will improve learning performance.

H_2 Increased familiarity with the interface style will increase Interface Affect, which in turn will improve learning performance.

H_3 Increased Interface Affect will improve learning performance.

Participants

A total of 63 MSc students from the School of Mathematical and Computer Sciences at Heriot-Watt University participated in this study. However, three sets of data were eliminated since the participants withdrew from the experiment. Therefore, the actual number of participants was 60 (Table 5.2): 11 women and 49 men; the average age was 26 years old (max = 45, min = 22).

Course Stated	Participants	Course Stated	Participants
MSc	1	MSc IT MM	3
MSc IT	8	MSc IT Mobile	1
MSc IT BIO	3	MSc IT Learning	2
MSc IT ES	6	MSc IMM	7
MSc IT SS	13	MSc DMIS	16

Table 5.2: Distribution of participants by course, $n = 60$.

In order to allocate the participants into the four available treatments (see Table 5.1), their names were organised in alphabetical order and evenly distributed to the groups. However, since participation in the experiment was voluntary the actual distribution of students varied between groups (Table 5.3).

Results from the General Information Questionnaire (Appendix C.2) indicate that 75% of the participants use computers for more than 24 hours per week (Figure 5.2) and that 46% spend more than 24 hour per week on the Internet (Figure 5.3).

Treatment	Participants
G1	11
G2	11
G3	21
G4	17

Table 5.3: Distribution of participants by treatment, n=60.

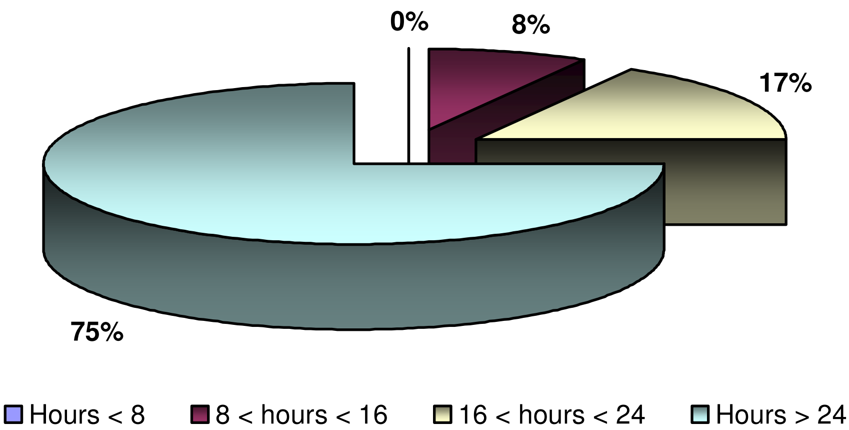

Figure 5.2: Time spent per week using computers.

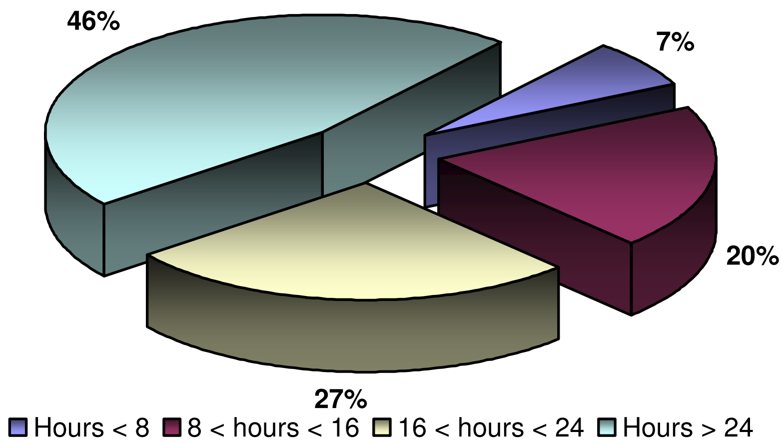

Figure 5.3: Time spent per week using the Internet.

In terms of the familiarity of the participants with specific software environments, the analysis of the data indicates that Windows is used *all the time* by 85% of the participants. Linux is used *occasionally* by 27% of the participants, whereas 63% of them *never* use Mac OS. MS Office suite is used *all the time* by 47% of the participants, while 37% and 27% of the participants use *some times* Adobe and Macromedia software respectively (Figure 5.4). Other software used on regular basis was mentioned, including Windows media player, Jbuilder, C++, and various Web browsers.

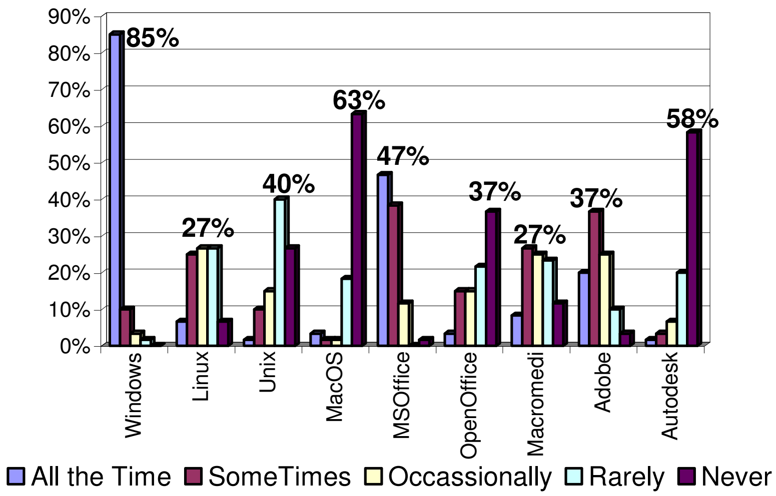

Figure 5.4: Software frequency of use.

As for the participants' experience with e-learning, data collected indicates that 37% of the participants use e-learning *occasionally,* and a great number of them *never* use Scholar –a virtual learning environment developed at Heriot-Watt University – WebCT or Blackboard (Figure 5.5). Nevertheless, some participants mentioned the use of other types of learning resources for learning, such as websites and CD-ROMs.

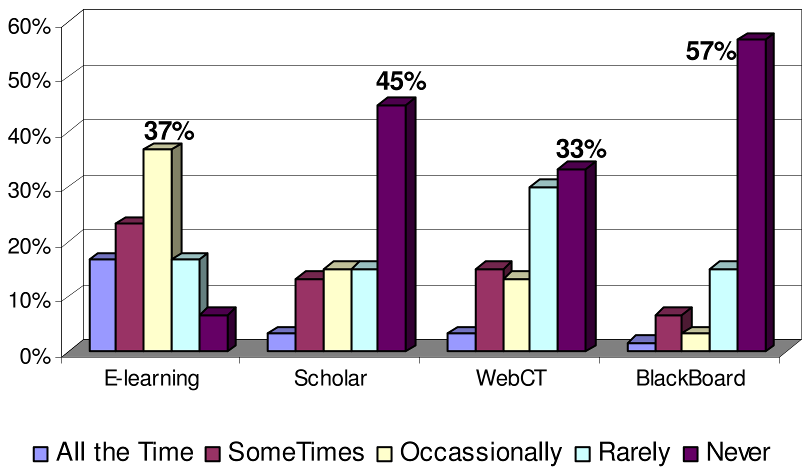

Figure 5.5: Participants' experience using e-learning.

The participants in this study seem to have a fairly positive attitude towards computers (mean=6.33, s.d. =2.75, α=.672), and also towards e-learning (mean=5.11, s.d. =2.30, α = .838). Cronbach's alpha coefficients were calculated for these measures showing acceptable internal consistency.

Finally, the participants rated their previous knowledge about "Circuit Design" using four categories: (A) No previous knowledge, (B) Basic knowledge about the subject, (C) Intermediate knowledge, or (D) Advanced knowledge. Results indicate that 20% of them did not have previous knowledge about the subject, while 38% rated themselves as having basic knowledge, 31% as having intermediate knowledge, and 12% as having advanced knowledge of the topic (Figure 5.6).

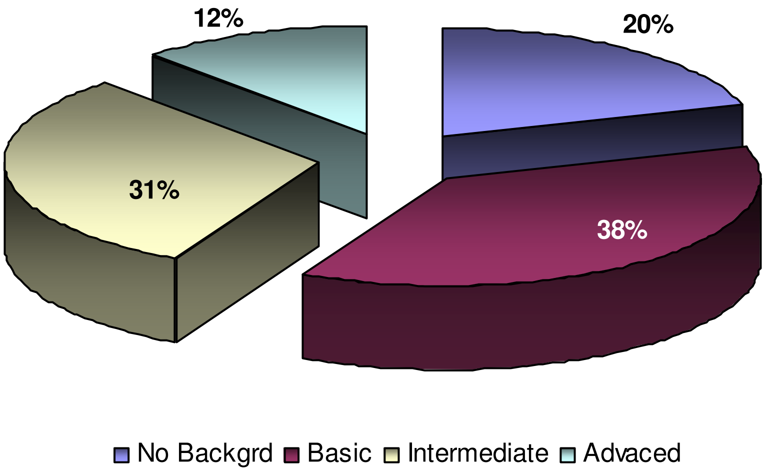

Figure 5.6: Participants' previous knowledge about "Circuit Design".

The information gathered through this initial questionnaire indicates that the majority of participants in this study spend more than 24 hours per week using computers, and that a large amount of this time is spent on the Internet. They are familiar with the Windows environment and more than half of them also know the UNIX environment. Students expressed a fairly positive attitude towards computers and towards e-learning, although they do not use e-learning on a regular basis. Finally, the majority of the participants indicated that their knowledge about "Circuit Design" was basic.

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 one of the two existing interface designs to study about one of the two topics available. Task 2 was defined as using the opposite interface design to study about the remaining topic. Therefore, four possible treatments were available as indicated in Table 5.1. Participants were randomly assigned to each treatment. Although the content of each topic allowed for a 30-minute work session, no time limit was established for using the application.

Measures and Instruments

Measures were set as Interface Affect, user perceptions about various aspects of the interface style, perceived familiarity with each interface style, and learning performance.

Data about Interface Affect, user perceptions and familiarity were collected by the user's responses to a questionnaire using a 9-point Likert type scale. 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]. The participants' cognitive style was assessed using the VICS and E-CSA-WA test.

The instruments used to collect the information for this evaluation are presented in Appendix C, including:

C.1 Consent Form

C.2 General Information Questionnaire

C.3 Evaluation Questionnaire

The assessment tests used for this extended evaluation of LEARNINT were the same as in the initial study; therefore, the examples of these instruments can be found in Appendixes A.4 and A.5.

All the sessions of the study took place in the Multimedia labs at the Computer Science Department. The equipment used has the following technical characteristics:

- Processor Inter Pentium 4
- 15" colour Monitor, 1024 x 768 pixels, 32 bit colour quality
- PS/2 compatible mouse
- Standard 101/102 keyboard
- Microsoft Windows XP, Professional Edition
- Internet Browser: Internet Explorer

Experimental Procedure

The participants attended two sessions on two consecutive days. In the first session the objective of the study and its procedure were explained, then each participant signed the participatory agreement and answered the General Information Questionnaire. Next they carried out task 1 and responded the evaluation questionnaire for the assigned interface design. Finally, they answered the assessment test for the content studied.

During the second session, participants carried out task 2, answered its evaluation questionnaire and responded to the assessment test for the corresponding topic. They finally carried out the VICS & E-CSA-WA test to determine their cognitive style.

5.3.3 Results

The questionnaire to evaluate the participants' perceptions after using each interface consisted of eight sections: (1) User reaction to the interface – i.e. Interface Affect, (2) Content, (3) Structure, (4) Mode of Presentation, (5) Navigation, (6) Layout, (7) Ease of use, and (9) Familiarity. The raw data gathered in this extended evaluation of LEARNINT is presented in Appendix D.

In order to ascertain the reliability of the Evaluation Questionnaire, Cronbach's coefficients were calculated for all sections (Table 5.4). Reliability of a measure refers to its consistency and is particularly important regarding multiple-item scales because it raises the issue of whether such a scale measures a single concept and whether its constituent items are internally consistent [Bryman 2004]. A widely used method for estimating the reliability of a scale is Cronbach's alpha coefficients, which vary between 0 and 1; the nearer the result is to 1 (and particularly over 0.8) the more reliable is the scale. Therefore, the coefficients presented in Table 5.4 indicate acceptable reliability for all the sub-scales of the Evaluation Questionnaire.

	Interface Affect	Content	Structure	Mode of Presentation	Navigation	Layout	Ease of Use	Familiarity
α	0.832	0.849	0.923	0.930	0.960	0.864	0.900	0.822
Items	4	4	4	11	4	4	5	8

Table 5.4: Reliability coefficients for each sub-scale of the Evaluation Questionnaire.

In addition to the reliability coefficients, it was considered important to determine the extent to which the items included in each sub-scale were related to each other. Given that Factor Analysis is a technique concerned with establishing the soundness of the items that form a scale by examining the extent to which they seem to be measuring the same concept [Bryman & Cramer 1997], this technique was applied to the Evaluation Questionnaire.

Factor Analysis works by analysing the variance shared by scores of peoples on three or more items and grouping these into unrelated factors [Bryman & Cramer 1997]. The method employed for analysing the data collected in the extended evaluation of LEARNINT was Factor Analysis with varimax rotation. The solution obtained was a 7-factor structure as shown in Table 5.5.

The factors obtained closely correspond to the sub-scales used in the questionnaire. The first factor includes all the questions related to the mode of presentation of the learning content, a question about perceived ease of use, and a question relating to the interface layout –however, these two questions also exhibits a significant cross-loading with the second factor. The second factor comprises the remaining questions relating to the layout of the interface and all the questions about its structure, suggesting that these concepts are not separated components of the participants' evaluation. The next factor includes precisely the four questions about navigation means in the system. The fourth component incorporates most of the questions relating to familiarity with the style of the interface and a couple of questions from the ease of use sub-scale, which clearly reflects the strong relationship between these concepts as mentioned in section 5.3.1 where the process of defining the familiarity scale was explained. The next factor consists of the fourth questions enquiring about the content of the system. The sixth and seventh factors include just one question each about ease of use and familiarity respectively.

As shown in Table 5.6, the factors obtained from the rotated factor analysis account for more than 73% of the variance from the participants' evaluation of the interfaces.

	Component						
	1	2	3	4	5	6	7
PresentationH	0.841	0.013	-0.069	-0.036	0.166	0.162	0.144
PresentationK	0.771	0.128	0.070	0.277	0.164	-0.252	-0.004
PresentationI	0.770	0.162	0.262	0.109	0.108	0.008	-0.035
PresentationJ	0.763	0.259	0.310	0.095	0.186	-0.064	-0.078
PresentationG	0.753	-0.112	-0.058	-0.107	0.188	0.121	0.310
PresentationE	0.728	0.287	0.181	-0.149	0.124	0.280	0.089
PresentationA	0.643	0.235	0.112	-0.074	0.130	0.436	0.130
PresentationD	0.615	0.381	0.179	0.029	0.091	0.289	-0.031
LayoutB	0.596	0.411	0.288	0.047	0.084	0.106	-0.031
PresentationB	0.549	0.454	0.101	-0.042	0.194	0.457	-0.143
PresentationC	0.547	0.476	-0.008	-0.010	0.126	0.445	-0.076
PresentationF	0.523	0.325	0.353	0.055	-0.041	-0.070	0.407
EouC	0.473	0.447	0.073	0.146	0.288	0.411	0.303
StructureD	0.157	0.754	0.250	0.182	0.327	0.101	0.142
StructureA	0.171	0.745	0.186	0.308	0.192	0.101	0.134
LayoutA	0.226	0.717	0.296	0.373	0.011	-0.053	0.068
StructureC	0.197	0.707	0.107	0.187	0.423	0.091	0.022
StructureB	0.147	0.637	0.191	0.055	0.442	0.259	0.190
EouE	0.268	0.576	0.174	0.208	0.084	0.318	0.459
LayoutC	0.359	0.560	0.359	0.346	0.009	0.044	0.029
LayoutD	0.358	0.542	0.266	0.195	0.027	-0.018	0.372
FamiliarC	0.397	0.481	0.048	0.251	0.349	0.294	0.234
NavigationB	0.106	0.152	0.910	0.131	0.090	0.034	0.088
NavigationD	0.165	0.196	0.866	0.281	0.119	0.091	0.123
NavigationC	0.132	0.181	0.851	0.281	0.128	0.090	0.099
NavigationA	0.154	0.237	0.846	0.205	0.056	0.072	0.027
FamiliarE	-0.033	0.085	0.193	0.710	0.112	-0.042	0.094
FamiliarB	-0.111	0.166	0.021	0.676	-0.037	-0.117	-0.028
FamiliarG	0.009	0.088	0.250	0.664	-0.113	0.094	-0.024
FamiliarD	0.207	0.341	0.144	0.555	0.225	0.235	0.189
FamiliarA	-0.128	0.238	0.109	0.525	0.198	0.038	0.341
EouA	0.251	0.238	0.403	0.523	0.177	0.447	0.091
FamiliarF	0.165	0.064	0.404	0.493	0.151	0.230	0.075
EouD	0.259	0.300	0.341	0.469	0.059	0.325	0.287
ContentB	0.297	0.218	0.167	0.083	0.822	-0.079	-0.077
ContentA	0.171	0.039	0.052	0.031	0.766	-0.049	0.226
ContentC	0.103	0.326	0.024	0.060	0.732	0.219	-0.099
ContentD	0.268	0.212	0.193	0.066	0.686	0.420	0.037
EouB	0.181	0.113	0.403	0.463	0.147	0.561	0.104
FamiliarH	0.105	0.372	0.267	0.339	0.075	0.051	0.672

Table 5.5: Factor analysis. Extraction method: Principal Component Analysis. Rotation method: varimax with Kaiser normalisation.

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	16.832	42.080	42.080	7.024	17.559	17.559
2	4.454	11.135	53.215	5.893	14.733	32.292
3	2.497	6.242	59.457	4.838	12.096	44.389
4	1.798	4.494	63.951	4.021	10.051	54.440
5	1.416	3.539	67.491	3.482	8.704	63.144
6	1.285	3.212	70.703	2.355	5.887	69.031
7	1.073	2.682	73.385	1.742	4.354	73.385

Table 5.6: Factor analysis, variance explained.

Descriptive statistics (mean and standard deviation) were calculated for all the sections of the Evaluation Questionnaire and are presented in Table 5.7. Given that 9 was the most positive agreement in terms of user satisfaction, it can be observed that the evaluation was positive towards both interfaces. Further analysis of these results included determining correlation coefficients between the sub-scales of the questionnaire. Considering that correlation coefficients indicate the strength and the direction of the relationship between pairs of variables [Bryman & Cramer 1997].

Interface		Interface Affect	Content	Structure	Mode of Presentation	Navigation	Layout	Ease of Use	Familiarity
W/I	mean	5.83	5.67	5.77	6.68	6.64	5.87	6.50	6.15
	s.d.	1.51	1.78	1.80	1.41	2.12	1.84	1.66	1.29
A/V	mean	5.83	5.78	6.65	6.37	7.82	6.73	6.99	7.10
	s.d.	1.60	1.75	1.47	1.50	0.84	1.41	1.48	1.13

Table 5.7: User evaluation of the interfaces used.

From Table 5.8 it can be observed that correlations between all the sub-scales in the Evaluation Questionnaire are significant. This suggests that the different concepts being investigated through the use of the questionnaire closely interact to produce the results observed. It was also observed that when the results are analysed in terms of each interface style, correlations between Interface Affect and the rest of the variables are significant, as are between familiarity and the remaining variables of the Evaluation Questionnaire (Table 5.9).

	Interface Affect	Content	Structure	Mode of Presentation	Navigation	Layout	Ease Of Use
Interface Affect	1						
Content	0.619	1					
Structure	0.617	0.562	1				
Presentation	0.699	0.515	0.580	1			
Navigation	0.416	0.348	0.537	0.387	1		
Layout	0.630	0.445	0.699	0.697	0.625	1	
Ease of Use	0.617	0.535	0.745	0.683	0.614	0.734	1
Familiarity	0.432	0.429	0.656	0.419	0.599	0.616	0.739

Table 5.8: Correlation coefficients between sub-scales.
All correlations are significant at the 0.01 level (2-tailed).

	A/V Interface Style		W/I Interface Style	
	Interface Affect	**Familiarity**	**Interface Affect**	**Familiarity**
Interface Affect	1		1	
Content	0.632	0.489	0.607	0.409
Structure	0.616	0.538	0.672	0.692
Presentation	0.646	0.540	0.766	0.458
Navigation	0.357	0.609	0.544	0.555
Layout	0.536	0.579	0.760	0.578
Ease of Use	0.593	0.758	0.660	0.729
Familiarity	0.460	1	0.469	1

Table 5.9: Correlation coefficients by interface style.
All correlations are significant at the 0.01 level (2-tailed).

While Interface Affect for each of the designs of the system is about the same (see Table 5.7), individual results show that most of the participants (58 out of 60) had a preferred interface (Figure 5.7), which suggests a difference in user reactions to the interfaces – i.e. individual Interface Affect.

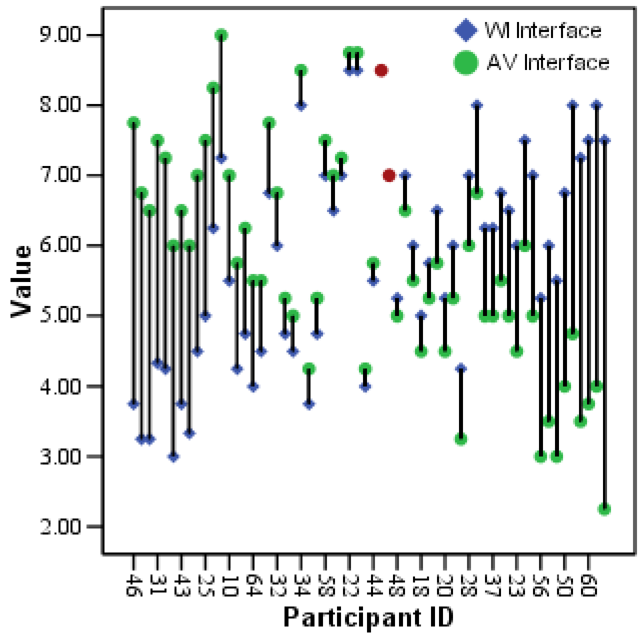

Figure 5.7: Differences in Interface Affect as expressed by the participants. Just two out of the sixty participants did not have a preferred interface.

Differences in performance were also observed: 52 participants performed differently between the two interfaces, and 31 of them (~60%) performed better in their preferred interface. Considering that participants were allocated to four different experimental treatments (see Table 5.3 for further details), it was considered convenient to analyse variance among these treatments in order to determine whether differences between distributions of results were statistically significant –i.e. to explore whether the treatment to which participants were allocated influenced their performance.

F test is a test for analysing variance by comparing means of three or more unrelated samples, and therefore was deemed as appropriate given the four different treatments used for this extended evaluation of LEARNINT. Two important concepts for analysing variance using the F test are *between* groups and *within* groups differences. Groups of people who have been assigned to different experimental conditions are known as unrelated samples or *between* subjects design [Bryman & Cramer 1997] – which is the case of the experimental design used for this evaluation of LEARNINT. When comparing the way people in the same treatment have responded to a particular experimental condition then differences *within* groups are being analysed.

Essentially, F test compares an estimate of the between groups variance with an estimate of the within groups variance by dividing the former with the later (Bryman & Cramer 1997). If the between groups variance is considerably larger than within groups variance, the value of the F ratio will be higher, implying that differences between treatments are unlikely to be due to chance [Bryman & Cramer 1997]. Results from the F test indicate that there were no systematic differences in learning performance across groups for the "Combinational Circuit Design" topic, which suggests that differences were not due to the treatment to which the participants were allocated (Table 5.10). However, significant differences were observed in learning performance between treatments for the "Relational Circuit Design" topic, which may be explained in terms of the difficulty of the topic ("Relational Circuit Design" is a more advanced topic than "Combinational Circuit Design") and also in terms of the previous knowledge of the participants. As can be seen from table 5.11, with just one exception (a participant that did not stated his/her previous knowledge about "Circuit Design"), learning performance was higher in the "Combinational Circuit Design" topic, and results were also better for those students with more advanced knowledge.

Total Points in Assessment Test		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Combinational Circuit Design	Between Groups	2.469	3	0.823	0.019	0.996
	Within Groups	2,457.181	56	43.878		
	Total	2,459.650	59			
Relational Circuit Design	Between Groups	270.254	3	90.085	2.344	0.083
	Within Groups	2,152.329	56	38.434		
	Total	2,422.583	59			

Table 5.10: Analysis of variance in learning performance between the different treatments to which the participants were allocated, *n*= 60, factor = treatment.

Previous Knowledge	**Points in Assessment Test (mean)**	
	Combinational Circuit Design	**Relational Circuit Design**
Not stated	12.00	17.00
No Previous Knowledge	6.00	5.33
Basic	8.59	8.45
Intermediate	11.33	10.78
Advanced	14.57	10.57

Table 5.11: Performance of the participants according to their previous knowledge about "Circuit Design".

The results obtained from the cognitive style test show that the participants in this study have a *Verbaliser-Imager* style between 0.89 and 2.0 suggesting an imager style preference (*n*=60, mean=1.304, s.d.=0.297). Their *Wholist-Analytic* style was between 0.77 and 1.85, showing an analytic preference (*n*=60, mean=1.099, s.d. =0.217). The distribution of the participants according to their cognitive style is shown in Figure 5.8.

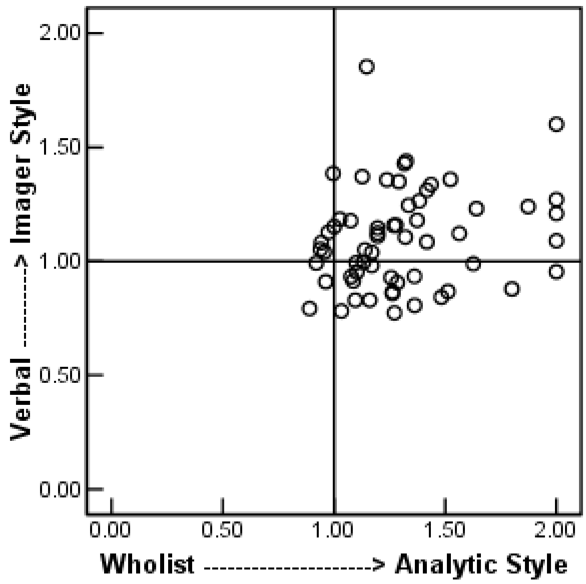

Figure 5.8: Distribution of the participants according to their cognitive style. 30 scored as *Analytic-Imagers* and 21 as *Analytic-Verbalisers*.

Further analysis of the data collected included comparing:

- The position of the participants on each cognitive style dimension (i.e. *Wholist-Analytic* and *Imager-Verbaliser*) against their Interface Affect
- The position of the participants on each cognitive style dimension against their learning performance regarding each topic
- The position of the participants on each cognitive style dimension against familiarity with each interface style.
- The position of the participants on each cognitive style dimension against their learning performance on their preferred interface style.
- The position of the participants on each cognitive style dimension against familiarity with their preferred interface style.

Significant results from these analyses are presented in Table 5.12, which presents the summary of the main correlations obtained between the users' Interface Affect, familiarity and performance in their preferred interface; it also compares these to the students' cognitive style dimensions. Significant relationships are observed between Interface Affect and familiarity, between Interface Affect and performance, and between familiarity and performance. The users' *Wholist-Analytic* cognitive style is significantly correlated with familiarity, while the *Verbaliser-Imager* dimension does not seem to be related to the rest of the variables.

	Interface Affect	**Performance in Preferred Interface**	**Familiarity in Preferred Interface**	**WA Dimension of Cognitive Style**	**VI Dimension of Cognitive Style**
Interface Affect	1				
Performance	0.364**	1			
Familiarity	0.510**	0.375**	1		
WA Dimension	0.265	0.310	0.342**	1	
VI Dimension	0.125	0.039	-0.032	0.202	1

Table 5.12: Correlation between main variables; ** indicates that the correlation is significant at the 0.01 level.

The relationship between the participants' familiarity and Interface Affect in their preferred interface is shown in Figure 5.9.

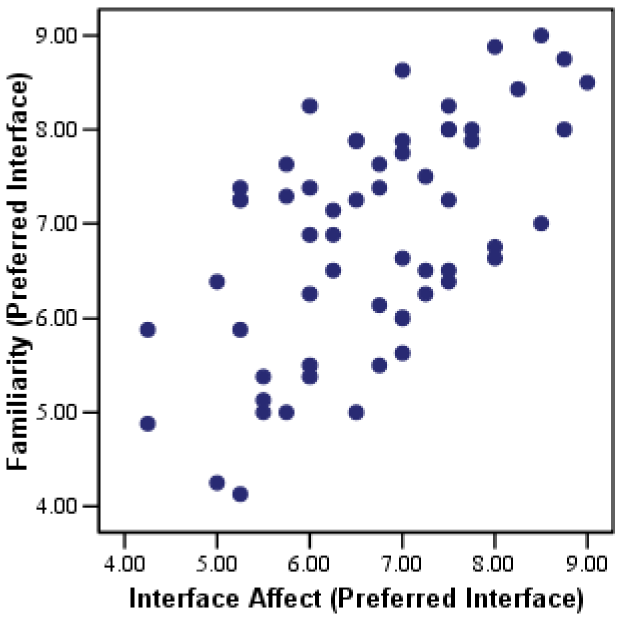

Figure 5.9: Interface Affect and familiarity scatterplot. A significant correlation was observed between users' Interface Affect in their preferred interface and the perceived familiarity with that interface style.

To further understand the possible relationships between the different variables analysed and how they influenced the results observed in terms of Interface Affect and Learning performance, a multivariate analysis was carried out.

Multivariate analysis is concerned with a number of approaches to the examination of relationships when more than two variables are involved. It is particularly useful when a survey has been employed – and where a number of potentially confounding factors may exist – because it helps to discount alternative explanations [Bryman & Cramer 1997]. In particular, multiple regression is widely used for conducting multivariate analysis when more than three variables are involved. Regression coefficients estimate the amount of change that occurs in the dependent variable for each unit of change in the independent variables. Regression coefficients are thus helpful to express the unique contribution of the various independent variables to the changes observed in the concept chosen as the independent variable [Bryman & Cramer 1997].

For the result obtained in this extended evaluation of LEARNINT, Multivariate analysis was carried out using linear regression with the stepwise method. The results observed when Interface Affect was defined as the dependent variable are presented in Table 5.13, and those corresponding to learning performance in Table 5.14.

Number of steps in the Model:	3
R:	0.780
R^2:	0.608
Adjusted R Square:	0.598
Std. Error of the Estimate:	0.99056

Variables	**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**	**Collinearity Statistics**	
	B	**Std. Error**	**Beta**			**Tolerance**	**VIF**
(Constant)	0.168	0.442		0.379	0.705		
Presentation	0.458	0.080	0.431	5.728	0.000	0.613	1.631
Content	0.238	0.067	0.267	3.569	0.001	0.620	1.612
Structure	0.208	0.073	0.225	2.850	0.005	0.555	1.801

Table 5.13: Multiple regression. Dependent variable: Interface Affect.

Number of steps in the Model:	2
R:	0.636
R^2:	0.405
Adjusted R Square:	0.394
Std. Error of the Estimate:	5.003

Variables	**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**	**Collinearity Statistics**	
	B	**Std. Error**	**Beta**			**Tolerance**	**VIF**
(Constant)	-6.438	1.892		-3.403	0.001		
Content	1.527	0.325	0.416	4.702	0.000	0.668	1.498
Structure	1.133	0.336	0.298	3.374	0.001	0.668	1.498

Table 5.14: Multiple regression. Dependent variable: learning performance.

In Tables 5.13 and 5.14 R^2 is the multiple coefficient of determination for the collective effect of all of the independent variables and represents a measure of how well the different concepts being investigated explain the changes observed in terms of Interface Affect and Learning performance [Bryman & Cramer 1997].

In the case of Interface Affect, a model was obtained in three steps and includes *presentation*, *content* and *structure*, standardised coefficients are 0.431, 0.267 and 0.225 respectively, with R^2=0.608, which indicates that 60.8% of the variance in Interface Affect is explained by *presentation*, *content* and *structure*. As for learning performance, the model was obtained in two steps and comprises *content* and *structure* as main predictors, standardised coefficients are 0.416 and 0.298 respectively, with R^2=0.405, this suggests that 40.5% of the variance observed in learning performance is explained by *content* and *structure*.

The order of the variables included in the models produced using the stepwise procedure is determined by the contribution of each variable to the explained variance of the dependent variable. This suggests that mode of presentation, content and structure of the learning materials are the more influential variables in terms of Interface Affect, while content and structure highly determine differences in learning performance. Nevertheless, it can be noted that R^2 accounts for low levels of variance in both cases, implying that the identified variables account for roughly 60% and 40% of the variance in terms of Interface Affect and learning performance respectively.

5.3.4 Discussion

The analysis of the information gathered through the General Information Questionnaire suggests that the participants in this study are fairly homogeneous: most of them spend more than 24 hours per week using computers; they are more familiar with Microsoft Windows and its interface and interaction style than with other types of software; and they do not use e-learning on regular basis, although their attitudes towards e-learning and towards computers are essentially positive. Nevertheless, 27 of them expressed a more positive affect towards the W/I interface style and 31 towards the A/V style. With the exception of the participants' previous knowledge about the content of the system, no significant correlations are observed between the variables accounted for using this questionnaire and the results obtained in terms of Interface Affect or learning performance. Therefore, it can be presumed that either these variables do not impact the interaction between students and Web-based learning materials under different interface conditions, or that the instrument used for measuring them was not appropriate.

In terms of the Evaluation Questionnaire used in the study, alpha coefficients were calculated showing acceptable reliability for all the sub-scales included. Its Factor analysis produced a 7-factor solution that strongly relates to the structure of the questionnaire; differences were observed in terms of layout and structure, which seem to belong to the same component rather than being separate aspects of the evaluation. Some statements, such as questions 26, 30 and 40, appear to be redundant for evaluating the interfaces presented and may be eliminated from the questionnaire in a more refined version of the instrument. Overall, the acceptable internal consistency of the Evaluation Questionnaire supports the results obtained from its analysis.

Examining the relationships between the variables being studied, results indicate that Interface Affect significantly correlated with the users' perceptions in terms of content, structure, mode of presentation, navigation, layout and ease of use. Familiarity with the style of the interface highly correlated with Interface Affect and learning performance, especially when the results from the students' preferred interface are analysed. However, factor analysis and regression of the results show that familiarity is not statistically decisive for the variations observed in terms of Interface Affect or learning performance. While there is the possibility that the scale designed to measure familiarity is not appropriate, the evidence obtained in this study cannot support the argument about the influence of familiarity on the Interface Affect expressed by the participants.

Results also indicate that learning performance significantly correlates with the style of the interface in terms of mode of presentation, navigation, layout and ease of use. However, the regression carried out indicates that content and structure of the learning materials are the variables that for the most part contribute to the explained variance of learning performance; this seems to corroborate the moderating effects of prior knowledge upon learning outcomes, and also findings from previous research in that individuals engage differently not just with the learning setting, but also with different types of content depending on the mental tasks involved and their own aptitudes [Jonassen & Grabowski, 1993].

As was observed in the preliminary evaluation of LEARNINT, the majority of the students expressed different affect towards the interfaces used, 58 out of 60 participants expressed a more positive affect to either the W/I style or the A/V one. Differences were also observed in terms of the learning performance of the participants, 52 students performed differently between the two interfaces, and 31 of them performed better in their preferred interface. This again suggests that students may perform better in the interface to which they have a more positive affect.

As for the participants' cognitive style, results obtained from the VICS & E-CSA-WA test suggest an *Imager* style preference in the *Verbaliser – Imager* dimension, and an *Analytic* preference in the *Wholist-Analytic* dimension. The two styles in combination show that 30 students were *Analytic-Imagers* and 21 *Analytic-Verbalisers*. Given that the distribution of cognitive styles observed in this study is consistent with the scores observed in the previous evaluation of LEARNINT, it seems that the cognitive style test is informing the research about certain aspects of the style of postgraduate computer science students which may have not been fully acknowledged in this study.

While the scores observed in *Wholist-Analytic* dimension fairly correlate with the preferences expressed by the participants and their learning performance in the A/V interface, according to the other statistical tests carried out none of the dimensions of cognitive style sufficiently influences Interface Affect or learning performance as to be considered a significant variable.

Taking into account the results obtained from the analysis of the information gathered in this evaluation, there is evidence to support hypothesis three (H_3) in that increased Interface Affect will improve learning performance.

5.4 SUMMARY

This Chapter puts forward that learning is increasingly understood as the result of a complex interaction including affective as well as cognitive factors. The concept of affect is explored further and its importance for assigning a positive or negative value to emotional events is highlighted, as is its effect for informing the individuals about their coping ability with the current environment. In turn, it is argued, this judgement is based on the reference context built by each individual from previous experiences.

Previous research is referred to suggesting that different interfaces evoke different reference contexts which bring positive or negative affect to the interaction between students and computer-based learning materials. It is proposed that Interface Affect, used here to refer to the reaction of a student to the interface design of Web-based learning materials, is highly influenced by the familiarity experienced by the learner with the style of the interface.

This Chapter then describes the extended evaluation of LEARNINT, carried out to corroborate the results obtained from the preliminary evaluation of the application, aiming at investigating the extent to which cognitive style and Interface Affect influence learning performance under different interface conditions.

The results of this study suggest certain influence of the *Wholist-Analytic* dimension of cognitive style in the Interface Affect expressed by the participants, but it is limited to the evaluation of the A/V interface. When both dimensions of cognitive style are analysed in combination, the distribution of the participants' style corresponds to the distribution observed in the initial evaluation of LEARNINT. These results seem to imply that there are some aspects about the cognitive style of postgraduate computer science students that have not been fully acknowledged in this study. Nevertheless, evidence obtained in this and the previous study is not sufficient to support the argument that cognitive style influences learning performance.

The analysis of the data suggests that interface style does have an impact on the Interface Affect expressed by the participants, which in turn have an impact on the student's learning performance. It was observed that 31 participants scored higher on the topic presented in their preferred interface, supporting previous research [Norman, 2002; Isen, 2000] which maintains that performance of individuals is superior when interface learning conditions lead to positive moods. This may be extended to include the interface style of Web-based learning materials.

Further implications of the findings from this study suggest that the design approach underpinning the interface styles used accounted for differences in users' reactions and performance. Therefore, the adaptive variables suggested in this research stand as good candidates for providing adaptivity and eventually personal interfaces for Web-based learning materials, which corresponds to objective eight (O8) of the research. A methodological approach for implementing these is discussed in the next Chapter.