The Influence of Cognitive Styles on the Design of Adaptive Web-based Learning Materials

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ABSTRACT

This research addresses the issues of adaptation and personalisation of the computer interface for Web-based learning materials taking into consideration key characteristics of learners and particularly their cognitive style.

The thesis examines main concerns driving learning towards individualisation. Different approaches to adaptation and personalisation are analysed, as are a range of adaptive systems. The need for further research regarding individual differences is identified; it is argued that cognitive styles should be allowed for in designing adaptive learning materials.

A comprehensive review of cognitive style classifications is presented, from which key defining attributes and advantageous instructional conditions are identified and a number of adaptive variables derived.

LEARNINT, a prototype based on these variables was developed and used in two experimental studies. Results show a relationship between Interface Affect and learning outcomes and also between the variables underpinning the interface style used and variation in user reactions and performance; however, little interaction is observed between these variables and cognitive style.

It is suggested that for most learners using Web-based learning materials performance may improve if they experience positive affect towards the interface; also, that the proposed variables stand as good candidates for providing adaptivity. A methodological approach is presented that extends the functionality of LEARNINT. The generic aspects of the research are further elaborated offering guidance on future directions for the design of adaptive Web-based learning materials.

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"Gratitude is the memory of the heart"

(Jean Baptise Massieu)

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LIST OF ABBREVIATIONS

AH	**A**daptive **H**ypermedia
AJAX	**A**synchronous **JA**vaScript and **X**ML
CAA	**C**omputer **A**ided **A**ssessment, **C**omputer-**A**ssisted **A**ssessment
CAI	**C**omputer **A**ided **I**nstruction
CAL	**C**omputer **A**ided **L**earning
CAT	**C**omputer **A**daptive **T**ests
CSA	**C**ognitive **S**tyles **A**nalysis test
CBL	**C**omputer **B**ased **L**earning
CBT	**C**omputer-**B**ased **T**est
CD ROM	**C**ompact **D**isc-**R**ead **O**nly **M**emory
CMC	**C**omputer **M**ediated **C**ommunications
DVD	**D**igital **V**ersatile **D**isc
HE	**H**igher **E**ducation
HTML	**H**yper**T**ext **M**arkup **L**anguage
ICT	**I**nformation and **C**ommunication **T**echnologies
IMS	**IMS** Global Learning Consortium
ITS	**I**ntelligent **T**utoring **S**ystem
IRT	**I**tem **R**esponse **T**heory
LCMS	**L**earning **C**ontent **M**anagement **S**ystems
LIPS	**Li**st **P**rocessor (programming language)
LO	**L**earning **O**bject
LOM	**L**earning **O**bject **M**etadata
LT	**L**earning **T**echnology
MLE	**M**anaged **L**earning **E**nvironments
SUS	**S**ystem **U**sability **S**cale
URL	**U**niform **R**esource **L**ocator
VICS & E-CSA-WA	**V**erbal-**I**mager **C**ognitive **S**tyle & **E**xtended **C**ognitive **S**tyle **A**nalysis **W**holist-**A**nalytic test
VLE	**V**irtual **L**earning **E**nvironments
WWW	**W**orld **W**ide **W**eb
Web	World Wide **Web**
XHTML	E**X**tensible **H**yper**T**ext **M**arkup **L**anguage
XML	E**X**tensible **M**arkup **L**anguage
XSP	E**X**tensible **S**erver **P**ages

LIST OF PUBLICATIONS

The following articles were published during my period of research. Certain material and concepts from these publications will necessarily be presented within the body of this work.

- Uruchurtu, E., Rist, R., MacKinnon, L. (2006) Interface Affect and Familiarity: Some Implications for Designing the Interaction. In Bryan-Kinns, N., Blandford, A., Curzon, P. & Nigay, L.(Eds.) People and Computers XX – Engage, proceedings of Proceedings of the *20th British HCI Group Annual Conference*. Queen Mary University of London, 11-15 September. London: Springer-Verlag, pp. 73-82.

- Uruchurtu E., MacKinnon L., Rist R. (2005) Designing the Learning Interface using Cognitive Styles. Proceedings of the *19th British HCI Group Annual Conference*, Vol. 2. Edinburgh, Scotland, 5-9 September.

- Uruchurtu E., MacKinnon L., Rist R. (2005) User Cognitive Style and Interface Design for Personal, Adaptive Learning. What to Model?. In Ardissono L., Brna P. and Mitrovic A. (Eds.) Proceedings of the *10th International Conference on User Modeling*. Edinburgh, Scotland, 24-29 July. Lecture Notes in Artificial Intelligence 3538. London: Springer-Verlag, pp. 154-163.

- Uruchurtu E., MacKinnon L., Rist R. (2004) Interface Design for Adaptive, Personal Learning Systems. Doctoral Consortium at the *18th British HCI Conference*. Leeds Metropolitan University, 6-10 September.