HARDWARE, SOFTWARE AND PEOPLEWARE

South African Institute of Computer Scientists and Information Technologists
Annual Conference
25 – 28 September 2001
Pretoria, South Africa

SAICSIT 2001

Edited by Karen Renaud, Paula Kotzé & Andries Barnard
University of South Africa, Pretoria
# Table of Contents

**Message from the SAICSIT President** ................................................................. iv
**Message from the Chairs** ........................................................................ vi
**Conference Organisation** ........................................................................ vii
**Referees** ........................................................................................................ viii

## Keynote Speakers

- **Cyber-economies and the Real World** .................................................... xi
  - Alan Dix
- **Computer-aided Instruction with Emphasis on Language Learning** ............ xiv
  - Lut Baten
- **Internet and Security Trends** ................................................................. xv
  - Arthur Goldstuck
- **The Future of Data Compression in E-technology** ..................................... xvi
  - Nigel Horspool
- **Strategic Planning for E-Commerce Systems: Towards an Inspirational Focus** .... xvii
  - Raymond Hackney

## Research Papers

### Human-Computer Interaction / Virtual Reality

- **The Development of a User Classification Model for a Multi-cultural Society** .... 1
  - M Streicher, J Wesson & A Calitz
- **Real-Time Facial Animation for Virtual Characters** ................................... 11
  - D Burford & E Blake
- **The Effects of Avatars on Co-presence in a Collaborative Virtual Environment** .... 19
  - J Casanueva & E Blake

### Education

- **Structured Mapping of Digital Learning Systems** ..................................... 29
  - E Cloete & L Miller

### Formal Methods

- **The specification of a multi-level marketing business** .............................. 35
  - A van der Poll & P Kotzé
- **Finite state computational morphology - the case of the Zulu noun** ............. 45
  - L Pretorius & S Bosch
- **Combining context provisions with graph grammar rewriting rules: the three-dimensional case** ................................................................. 54
  - A Barnard & E Ehlers

### Human-Computer Interaction / Web Usability

- **Web Site Readability and Navigation Techniques: An Empirical Study** .......... 64
  - P Licker, R Anderson, C Macintosh & A van Kets
- **Jiminy: Helping Users to Remember Their Passwords** ............................... 73
  - K Renaud & E Smith

### Information Security

- **Computer Security: Hacking Tendencies, Criteria and Solutions** .............. 81
  - M Botha & R von Solms
- **An access control architecture for XML documents in workflow environments** ... 88
  - R Botha & J Eloff
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Graphics and Ethics</strong></td>
<td>Model-based Segmentation of CT Images</td>
</tr>
<tr>
<td></td>
<td>O Marte &amp; P Marais</td>
</tr>
<tr>
<td></td>
<td>Towards Teaching Computer Ethics</td>
</tr>
<tr>
<td></td>
<td>C de Ridder, L Pretorius &amp; A Barnard</td>
</tr>
<tr>
<td><strong>Human-Computer Interaction / Mobile Devices</strong></td>
<td>Ubiquitous Computing and Cellular Handset Interfaces – are menus the best way forward?</td>
</tr>
<tr>
<td></td>
<td>G Marsden &amp; M Jones</td>
</tr>
<tr>
<td></td>
<td>A Comparison of the Interface Effect on the Use of Mobile Devices</td>
</tr>
<tr>
<td></td>
<td>J Franken, A Stander, Z Booley, Z Isaacs &amp; R Rose</td>
</tr>
<tr>
<td></td>
<td>The Effect of Colour, Luminance, Contrast, Icons, Forgiveness and Closure on ATM Interface Efficiency</td>
</tr>
<tr>
<td></td>
<td>A Stander, P van der Zee, &amp; Y Wang</td>
</tr>
<tr>
<td><strong>Object Orientation</strong></td>
<td>JavaCloak - Considering the Limitations of Proxies for Facilitating Java Runtime Specialisation</td>
</tr>
<tr>
<td></td>
<td>K Renaud</td>
</tr>
<tr>
<td><strong>Hardware</strong></td>
<td>Hierarchical Level of Detail Optimization for Constant Frame Rate Rendering</td>
</tr>
<tr>
<td></td>
<td>S Nirenstein, E-Blake, S Windberg &amp; A Mason</td>
</tr>
<tr>
<td></td>
<td>A Proposal for Dynamic Access Lists for TCP/IP Packet Filtering</td>
</tr>
<tr>
<td></td>
<td>S Hazelhurst</td>
</tr>
<tr>
<td><strong>Information Systems</strong></td>
<td>The Use of Technology to Support Group Decision-Making in South Africa</td>
</tr>
<tr>
<td></td>
<td>J Nash, D Gwilt, A Ludwig &amp; K Shaw</td>
</tr>
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<td></td>
<td>Creating high Performance I.S. Teams</td>
</tr>
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<td>D C Smith, M Becker, J Burns-Howell &amp; J Kyriakides</td>
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<tr>
<td></td>
<td>Issues Affecting the Adoption of Data Mining in South Africa</td>
</tr>
<tr>
<td></td>
<td>M Hart, E Barker-Goldie, K Davies &amp; A Theron</td>
</tr>
<tr>
<td><strong>Information Systems / Management</strong></td>
<td>Knowledge management: do we do what we preach?</td>
</tr>
<tr>
<td></td>
<td>M Handzic, C Van Toorn, &amp; P Parkin</td>
</tr>
<tr>
<td></td>
<td>Information Systems Strategic Planning and IS Function Performance:</td>
</tr>
<tr>
<td></td>
<td>An Empirical Study</td>
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<td>J Cohen</td>
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<tr>
<td><strong>Formal Methods</strong></td>
<td>Implication in three-valued logics of partial information</td>
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<td>A Britz</td>
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<td></td>
<td>P Lutu</td>
</tr>
</tbody>
</table>
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  C Dixie & J Wesson

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  T Nepal & D Petkov

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  B Potgieter

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More than 50 years have passed since the first electronic computer appeared in our society. In the intervening years technological development has been exponential. Over the last 20 years there has been a vast growth and pervasiveness of computing and information technology throughout the world. This has led into the expansion and consolidation of research into a diversity of new technologies and applications in diverse cultural environments. During this period huge strides have also been made in the development of computing devices. The processing speed of computers has increased thousand-fold and memory capacity from megabytes to gigabytes in the last decade alone. The Southern African region did not miss out on these developments.

It is hardly possible for such quantitative expansion not to bring a change in quality. Initially computers had been developed mainly for purposes such as automation for the improvement of processing, labour-reduction in production and automation control of machinery, with artificial intelligence, which made great strides in the 1980s, seen as the ultimate field to which computers could be applied. As we moved into the 1990s it was recognized that such an automation route was not the only direction in the improvement of computers. The expansion of processing power has enabled image data to be incorporated into computer systems, mainly for the purpose of improving human utilisation. For most computer technologies of the 1990s, including the Internet and virtual reality, automation was not the ultimate purpose. Humans were increasingly actively involved in the information-processing loop. This involvement has gradually increased as we move into the 21st century. Development of computer technology based not on automation, but on interaction, is now fully established.

The method of interaction has significantly changed as well. The expansion of computer ability means that the same function can be performed far more cheaply and on smaller computers than ever before. The advent of portable and mobile computers and pervasive computing devices is ample evidence of this. The need for users to be at the same location as a computer in order to reap the benefits of software installed on that computer is becoming an obsolete notion. Time and space are no longer constraints. One of the most discussed impacts of computing and information technology is communication and the easy accessibility of information. This changes the emphasis for research and development – issues such as cultural, political, and economic differences must, for example, be accommodated in ways that researchers have not previously considered. Our goal should be to enable users to benefit from technological advances, hence matching the skills, needs, and expectations of users of available technologies to their immense possibilities.
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Paula Kotzé  
SAICSIT President
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The papers published in this volume are conclusive evidence of the indefatigability and pertinacity of Computer Science and Information Systems academics and technologists in South Africa. We are proud to be part of such a prestigious and innovative group of people.

In conclusion, we would like to thank the conference chair, Prof Paula Kotze, for her support. We also specially thank Prof Derrick Kourie for his substantial contribution. Finally, to all of you, contributors, presenters, reviewers and organisers – a big thank you – without you this conference could not be successful.

Enjoy the Conference!
Karen Renaud & Andries Barnard

¹ This taken almost verbatim from Professor Derrick Kourie’s SACLEA 2001 paper titled: “The Benefits of Bad Teaching”.
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Janet Wesson – University of Port Elizabeth
Referees

Molla Alemayehu  Klarissa Engelbrecht  Pecka Pihlajasaaari
Trish Alexander  David Forsyth  Nelisha Pillay
Adi Attar  John Galletly
Bob Baber  Vashti Galpin
Andries Barnard  Wayne Goddard
John Barrow  Alexandre Hardy
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Gordon Blair  Johannes Heidema
Arina Britz  Tersia Hörne
Andy Bytheway  Chris Johnson
André Calitz  Bob Jolliffe
Charmain Cilliers  Paula Kotzé
Elsabe Cloete  Derrick Kourie
Gordon Cooper  Les Labuschagne
Richard Cooper  Paul Licker
Annemieke Craig  Philip Machanick
Thad Crews  Anthony Maeder
Quintin Cutts  David Manlove
Michael Dales  Gary Marsden
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Alan Dix  Elsa Naudé
Dunlop Mark  Martin Olivier
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# Table of Contents

- **Message from the SAICSIT President** ................................................ iv
- **Message from the Chairs** ................................................................... vi
- **Conference Organisation** ................................................................... vii
- **Referees** ............................................................................................. viii

## Keynote Speakers

- **Cyber-economies and the Real World** ................................................ xi
  - Alan Dix
- **Computer-aided Instruction with Emphasis on Language Learning** ........ xiv
  - Lut Baten
- **Internet and Security Trends** ............................................................... xv
  - Arthur Goldstuck
- **The Future of Data Compression in E-technology** ................................ xvi
  - Nigel Horspool
- **Strategic Planning for E-Commerce Systems: Towards an Inspirational Focus**  xvii
  - Raymond Hackney

## Research Papers

### Human-Computer Interaction / Virtual Reality
- **The Development of a User Classification Model for a Multi-cultural Society** ...... 1
  - M Streicher, J Wesson & A Calitz
- **Real-Time Facial Animation for Virtual Characters** ..................................... 11
  - D Burford & E Blake
- **The Effects of Avatars on Co-presence in a Collaborative Virtual Environment** .... 19
  - J Casanueva & E Blake

### Education
- **Structured Mapping of Digital Learning Systems** ..................................... 29
  - E Cloete & L Miller

### Formal Methods
- **The specification of a multi-level marketing business** .................................. 35
  - A van der Poll & P Kotzé
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  - L Pretorius & S Bosch
- **Combining context provisions with graph grammar rewriting rules: the three-dimensional case** ................................................................. 54
  - A Barnard & E Ehlers

### Human-Computer Interaction / Web Usability
- **Web Site Readability and Navigation Techniques: An Empirical Study** .......... 64
  - P Licker, R Anderson, C Macintosh & A van Kets
- **Jiminy: Helping Users to Remember Their Passwords** ................................ 73
  - K Renaud & E Smith

### Information Security
- **Computer Security: Hacking Tendencies, Criteria and Solutions** ................. 81
  - M Botha & R von Solms
- **An access control architecture for XML documents in workflow environments** .... 88
  - R Botha & J Eloff
Graphics and Ethics
Model-based Segmentation of CT Images .......................................................... 96
O Marte & P Marais
Towards Teaching Computer Ethics ................................................................. 102
C de Ridder, L Pretorius & A Barnard

Human-Computer Interaction / Mobile Devices
Ubiquitous Computing and Cellular Handset Interfaces – are menus the best way forward? ........................................................................................................... 111
G Marsden & M Jones
A Comparison of the Interface Effect on the Use of Mobile Devices .................. 120
J Franken, A Stander, Z Booley, Z Isaacs & R Rose
The Effect of Colour, Luminance, Contrast, Icons, Forgiveness and Closure on ATM Interface Efficiency ................................................................. 129
A Stander, P van der Zee, & Y Wang

Object Orientation
JavaCloak - Considering the Limitations of Proxies for Facilitating Java Runtime Specialisation ................................................................. 139
K Renaud

Hardware
Hierarchical Level of Detail Optimization for Constant Frame Rate Rendering .......... 147
S Nirenstein, E Blake, S Windberg & A Mason
A Proposal for Dynamic Access Lists for TCP/IP Packet Filtering .................... 156
S Hazelhurst

Information Systems
The Use of Technology to Support Group Decision-Making in South Africa .......... 165
J Nash, D Gwilt, A Ludwig & K Shaw
Creating high Performance I.S. Teams ............................................................... 172
D C Smith, M Becker, J Burns-Howell & J Kyriakides
Issues Affecting the Adoption of Data Mining in South Africa ........................... 182
M Hart, E Barker-Goldie, K Davies & A Theron

Information Systems / Management
Knowledge management: do we do what we preach? ........................................ 191
M Handzic, C Van Toorn, & P Parkin
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J Cohen

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  P Machanick & Z Patel

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Keynote Abstracts
Pure cyber-economies of information goods traded within virtual space have their own dynamics similar in some ways to physical goods, but in other ways more fundamental as the products of cyber-space may transform the space itself. However, the most radical effect of e-commerce for ordinary consumers may be its transformation of the real world of physical goods in real shops. A theoretical view of information society and the informational role of money stretching from 40,000BC to the present day backs up this analysis.

The talk will be based around a 16th-century Venetian Monk, Mrs Goggins at the electronic village shop and a Birmingham prostitute. Three real and virtual people who have shaped my vision of what will be, what may be, and what might be if we make it so.

Focus

As this is a keynote I'm taking the liberty of giving a very personal look at some of the issues that will shape all our lives over the coming decade. This is based partly on my academic background, but also from experience being involved in two venture capital funded Internet start-ups, aQtive and vfridge.

I aim to give you a slightly different view of the role of the growing cyber-economy. This will be partly

- descriptive – what things are like
- predictive – what things will happen.

But also it will be about

- possibilities – what may happen
- potentiality – what could happen if we choose to make it so.

Academic work, like the world, is full of interlocking themes. This talk is no exception. However I will draw out two main threads:

The informational role of money

Clearly money has a principal role as a token of value. However, it has a secondary role in exchange of information. When I pay for a tin of beans, the coins don't just have an equivalent value, but also, by being involved in the transaction, say "Alan wants some beans". The success of the market economy is based entirely on these information flows of 'who wants what where and when' driving the 'hidden hand' of optimal supply. As electronic information increasingly takes this role, it is not surprising that businesses are having to restructure themselves radically.

The real economy and the cyber-economy

I believe that the most radical changes of e-commerce will be in the High Street or Mall, not that these will wither, giving way to pure electronic shopping, but instead they will be transformed as the supply and business information infrastructure become oriented to more individual and on-demand delivery. landing hoax, argues that the location was really Norton Air Force Base in San Bernardino, CA.
People

The talk will be structured around three real and virtual people, a 16th-century Venetian Monk, Mrs Goggins at the electronic village shop and a Birmingham prostitute, who have in different ways shaped my vision of what will be, what may be, and what might be if we make it so.

I encountered Fra Mauro, the Venetian monk, because he was a map maker and maps are one of the sources we can use to explore our understanding of real space and so influence our design of cyberspace. However, Fra Mauro also lived at one of the turning points of history between the second and third of the four ages of information:

• **The age of proximity**: starting around 40,000 years ago, when the main means of information exchange and control was through direct physical contact or at most line of sight

• **The age of empires**: starting around 4,000 years ago, when the growth of the great empires allowed information and control to be exercised at a distance – the beginnings of cyberspace

• **The age of money**: starting around 400 years ago, when the rise of the merchant classes changed the main means of control from carnage to coinage, and money began to be the information flow that drove the development of market economies in the 19th and 20th century

• **The age of information**: starting around 40 years ago, when telecommunications and computing have become the principal means of information flow and control

And possibly we have just seen the dawn of a fifth age, from around 4 years ago, an age of global information. In taking a look at the pure cyber-economy of information and communication goods, we may take a quick foray into market ecology and market engineering – how to understand the interconnections within the Internet marketplace and design products to exploit and transform them.

Mrs Goggins is the village postmistress in Postman Pat. Across the UK, and I'd guess also in other countries, village shops and small neighbourhood shops in towns and cities have been closing down, unable to cope with the pressure from large out-of-town superstores. As well as the personal loss to the shop-owners, there is a social loss, as they often represent the heart of the community and especially serve the needs of the 'transport poor'. However considering the future of these, and the possibility of the electronic village shop (a real place!) we can see how the business transformations engendered by cyber-economies may give Mrs Goggins a new role as the community information scientist navigating the e-shopping web and being a point of personalisation to an already more individualised delivery infrastructure. In looking at these issues we will consider the way diversity density (the number of different things in a given area) changes as one moves through a traditional supply chain compared with the new information-rich structures.

Finally a Birmingham prostitute teaches us about the effect of the information society on ordinary people. Yes, AIDS is driven as much by poverty as by HIV – what alternatives are on offer for those who walk the streets? In first world economies IT has eroded many traditional jobs of the unskilled and semi-skilled female workforce. However, there is potential for the transformation of business supply chains to offer more individualised goods: shoes for each foot in different sizes and clothes that really fit. As well as improving the consumer experience, just-in-time final assembly of consumer goods may open up new job opportunities in light manufacturing and textiles. Furthermore, the effects of information on the production side of the supply chain may allow more direct matching of local producers to local consumers countering some of the centralisation due to the limited information capacity of money. If this happens we will see environmental gains through localised transportation of goods and social gains as jobs are spread more uniformly.

However, some of the more hopeful signs are very much in the area of potential. They may happen, but only if we choose to make it so.
More …

The slides for this talk and links to materials on analytic techniques such as diversity density and market ecology will be at: http://www.hcibook.com/alan/papers/SAICSIT2001/

Read about Fra Mauro in:


I talk about Fra Mauro and the four ages of information in:


  http://www.hcibook.com/alan/papers/Graz2001/

For more on the understanding of maps and cyberspace:


  http://www.hcibook.com/alan/papers/CVE2000/


Postman Pat’s official site is at:

  http://www.postmanpat.co.uk/

but only works if you have Flash!
Teacher trainees of foreign language learning (FLL) are on average still 'digibetes'. The highest score on a simple test was 63%. So are many kids in secondary school. For both parties success with information and communication technology (ICT) is achievable on condition of integrated use at a personalized level. Schools have an extra mission to provide for computer literacy and transfer, especially via the Internet as this medium is a freely available network of resources. Both pupils and trainees will build confidence for future undertakings in IT if it is experienced as a success story during their training. *WebSiteStories* is an example of such a positive experience. *WebSiteStories* is a project in which the foreign language trainees were asked to participate in an on-line interdisciplinary project, using four different languages, and three schools of three different language communities, with computers as the obvious tool for communication.

The project works along a procedure of five steps that can be extrapolated to other fields as well. Autonomy in learning, communication with peers but especially respect of the learner's own input are the cornerstones in this approach. Learning, also online, deals with attitude, motivation, and comprehensible input. The trainees could work autonomously, being coached, however. They were given doable tasks, were personally challenged and teamed up to further explore. The same type of sustainment was carried over to the pupils in the classroom. In *WebSiteStories* the trainees are strongly present in the pupils' activities. In an earlier project, *InStap!Nederlands*, we had found out that ICT works well with a study contract integrated in group activities for foreign language learning. This contract is in fact teacher driven. The teacher makes up the sequence of tasks from which the learner can choose. ICT should help the teacher in doing what she is best at: making a good sequence of well-designed tasks.

However, we can go a step further: the learner also needs to make choices. At the KULeuven, *guided selfstudy* is now being promoted. Guidance is very important in self-study. It should rather be bottom-up than top-down. At university, especially with graduate students of economics, computer literacy is not a problem anymore. Hence, action research (English IV, portfolio) was set up in a course of Business English for graduate students of economics to further analyse the actual learner's approach to guidance.

Hence, the question of computer-aided language learning (CALL) could be narrowed down to whether students can be guided into autonomously developing their own tools for mentoring? Do they find adequate tools? How do they use them? Can they also assess themselves? Can the portfolio be integrated in curricula? And ICT? Does it also serve for reflection on the gained expertise and personal input? These learning skills are necessary in lifelong learning.

The year 2001, the year of foreign languages in Europe, strongly promotes language learning in a learner centred way. The Socrates, Leonardo and Lingua programs sponsor all kinds of initiatives at various levels and of differing aims. The slogan is: *Your mother tongue + 2, Learn the language of your neighbour*. *Portfolio* is being promoted as a passport and a tool, which is online available. The user can tailor the *Portfolio* to his own achievements.

Administratively spoken and policy wise ICT plays a role. We still have some way to go in online assessment and accreditation. Having acquired a language by self-study, ICT could be of great help to the learners to market themselves, especially if the personal portfolio is certified and usable at a global level.
Internet and security: trends into the 21st century

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Abstract

How has the Internet changed the way we do business, and what does that mean for the security of business information? How much are companies spending on information security, and how well are they protected? Do they build trusted relationships with their clients? How they undermine trust through neglecting security. A look at the trends that shape security. And where the hackers await...
The Future of Data Compression in E-Technology

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Extended Abstract

Anyone who uses the Internet should already be very familiar with uses of data compression. The acronyms and cryptic names for compressed file formats include Zip files for arbitrary data, JAR files for Java programs and libraries, TIFF files for black and white images, JPEG and GIF files for colour images, MP3 files for audio clips, Quicktime and MPEG for video clips ... the list of special file formats seems endless. Data compression is ubiquitous.

However, advances in technology have given us staggering growth in disk storage capacities and an equally amazing growth in the speed and bandwidth of the internet. Disk storage and computer communications are improving in performance at even faster rates than Moore's Law predicts for CPUs. If we extrapolate to the near future when ordinary PCs will have terabytes of very affordable storage and be capable of transferring data at gigabits per second over the Internet, why should we bother compressing data at all?

While it is often foolish to predict the future, I confidently predict that we will never have sufficient data storage attached our computers and connection speeds will never be fast enough. As costs continue to decrease, and as speeds and capacities continue to increase, people will continue to find ingenious new services to deliver by computer. Even the simple and much promised service of video-on-demand requires prodigious network capacity — a single video stream with DVD quality requires a data rate of about 750 kbps.

Effective compression methods for still images, video and audio are all based on models of human perception. They achieve good compression by discarding information if the model predicts that the human will not notice the difference. Faster computers will permit more sophisticated perceptual models to be used and consequently we can expect to see incrementally better compression methods come into common use. However, no big breakthroughs should be expected for current forms of data.

What about new file formats to support new kinds of data? Will we have holographic image data to provide more realistic visual pictures? Or olfactory data? Or sensory data to stimulate the nerve endings of the wearer of a special suit? All these, and much more, are possibilities when computers become cheap enough and powerful enough. And all these new data formats will require new data compression techniques. It will be an exciting future for everyone.
Strategic Planning of E-Commerce Systems: An Inspirational Focus

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Extended Abstract

The essential argument for this talk, based upon both theoretical constructs and empirical evidence, is to make observations for analysing strategic planning for e-commerce systems (SPECS). These notions has been developed from previous research which considered the nature of SPECS and its contribution to business transformation generally. The opportunity is now taken to map the main characteristics currently found in SPECS business models onto a classification framework. The value of this approach is to identify the ‘evolutionary’ aspects of e-commerce systems which are strategically managed to enable a more e-customer focussed relationship. It is argued that this provides the recognition of the critical importance of the inspirational opportunities which organisations need to achieve to formulate and implement successful e-business strategies.

In 1996, about 35,000 US companies had a web site, 8000 were taking orders and 5000 settling credit card payments and this figure is of course rising by the hour (Gupta, 1996; Hoffinan et al, 1996, 1996a, 1996b). Early information systems planning models are commonly noted to be highly prescriptive and too detailed for the demands of dynamic business environments (Dutta & Evard, 1999; Turban et al, 1999; Pant & Ravichandran, 2001). Clearly, business systems in the last decade have changed significantly with a need for more flexibility and responsiveness to customer requirements (Zwass, 1996; Shaw et al, 1997).

There is a critical need to capture the views of the key stakeholders in the analysis (mainly customers) and thus provide an holistic representation of the organisation as a whole. As Stacey (1993) observes, '......shared mental models determine how managers together construct their perceptions of reality and therefore what they agree to attend to'. An earlier summary of trends in thinking towards strategy formulation in this respect is provided by Wittington (1993). It is useful to map the latent characteristics and requirements of SPECS models within this framework. It is therefore possible to identify some of the most common aspects of approaches to strategy which could be exploited. The classical segment relates to the rational views found in the early literature; the systemic segment represents the political influences found in social systems, the processual segment relates to the need to accommodate strategy formulation to a changing environment and the evolutionary segment considers the ‘fatalistic’ view of the changeable market place. Clearly, the opportunity for an organisation to position itself within this ‘evolutionary’ segment acknowledges the reality of a dynamic and highly competitive market place where customer value and responsiveness are paramount. SPECS requires, therefore, an alternative paradigm which may urge organisations to think differently from conventional formal leadership, restructuring and reengineering approaches. It is recognised that the context in which most approaches to SPECS are applied is complex and currently have significant limitations overall – what is needed is a little inspiration (perhaps from Oscar?)

References


xvii


Research Papers

and

Abstracts of Electronic Papers
The Development of a User Classification Model for a Multi-cultural Society

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\textbf{Abstract:} During the last ten years, a number of computerised testing systems have been developed without considering the users' level of computer proficiency. Students at the University of Port Elizabeth come from a diverse background, both in home language and population group. The level of computer expertise of these students is diverse, and this may influence the test scores they obtain in computerised tests. In this study, various factors were found to be significant indicators of performance on computer-based tasks. These factors include previous computer and software experience, attitude towards computers, self-perceived ability to work with computers, contact with technology, gender, and home language. This paper discusses the development of a user classification model to classify students into three user groups, namely novice, intermediate and expert. Two methods were used for classification. The first followed a quantitative approach to user modeling and required users to perform simple computer-based tasks. The second method was qualitative in nature and used a questionnaire to assess the factors that were found to be significant indicators of performance in human-computer interaction. The hypothesis is that a user classification model can be developed for the first year student population at the University of Port Elizabeth.

\textbf{Keywords:} Human-computer interaction; user modeling; user characteristics; user profiling; user interface design; computer-based testing.

\textbf{Computing Review Categories:} H.5.2, K.3.1

\section{1. Introduction}

An ongoing research project at the University of Port Elizabeth (UPE) resulted in various selection models and methods for the placement of first year computer science students. Earlier selection models made use of matriculation results and the subjects used as predictors were Mathematics, the average of Science, Accountancy and Biology, and the student's First Language\textsuperscript{1}. Recent models consist of school marks and scores obtained from a series of pencil-and-paper and computerised tests.

Computerised testing systems currently in use by the university do not take the students' capabilities to work with user interfaces into account. The student population at UPE is very diverse, both in culture and language. Presenting the same test user interface to all the students may discriminate against students having low levels of computer literacy, and can introduce construct-irrelevant variance into test scores.

This paper presents the development of a user classification model for the first year student population at UPE. The first section of this paper provides an overview of user characteristics and classification techniques employed by other researchers. The current situation of concern at UPE is discussed thereafter. Two instruments were used in the development of the user classification model. These instruments, the methodology used and the results are described. Following the research, a framework for user classification is suggested and recommendations for further research are provided.

\section{2. User Modeling}

\subsection{2.1 What is user modeling?}

Computer-based systems have evolved without much sensitivity to the capabilities and limitations of the user\textsuperscript{5}. Interface design would be greatly simplified if all users belonged to a homogeneous user population – a user population having the same capabilities and skills. However, users' capabilities and skills have important implications for human-computer interaction (HCI) performance, and specifically, for interface design. Users are far from identical and tend to have tremendous individual differences. Understanding the nature of these individual differences is important in order to accommodate them in interface design\textsuperscript{3}.

Shneiderman\textsuperscript{14} states that all designs should begin with an understanding of the intended users, including profiles of their age, gender, physical abilities, education, cultural or ethnic background, training, motivation, goals and personality. Often, several groups of users interact with a system, and the number of
design alternatives for the system is then multiplied. Individual differences can play a large role in determining whether humans can use a computer to perform a task effectively. Performance differences of the order 20:1 are not uncommon for certain computer-based tasks [5]. Thus, improved ways of dealing with individual differences among users could yield sizable gains in productivity, and consequently, make computer-based tasks available to more people.

Since the user's knowledge and skills have important implications for human-computer performance, designers must attempt to classify users into well-defined groups [15]. Different users are the happiest or achieve the most sufficient interaction at different points in the dimensions of interface options, depending on their background and personal preferences. However, most interactive systems do not have the necessary knowledge about their users. A solution to this problem is for interactive systems to employ a user classification scheme. The purpose of a user classification scheme is thus to identify groups of users who are sufficiently close in background and preferences, that there is a single point in the space of interface options that will give them all an acceptable level of interface performance [12].

2.2 Existing models

Two fundamental approaches have been adopted in user classification schemes [12]. The first and earlier approach, concentrates on the classification of the user's tasks on the occupational level. Examples of categories in this approach are Pre-System, Interactive, Programmer and System Expert users [4]. However, in this approach, task categorisations generally fail, or are hard to implement, mainly because of the large number of potential tasks that may exist within a system.

The second and more recent approach to user categorisation concentrates on the user's expertise and experience with a system. This approach to user classification has in turn employed two methods of classification. The first method categorises users according to their subjective ratings of experience and expertise. This type of user modeling technique attempts to develop a model of the user by asking the user a number of questions regarding the user's experience and knowledge. These categories of users are generally defined by factors such as the user's previous experience, the time spent with computer systems and also computer knowledge.

For the second method, users' interactions with interfaces are monitored and logged, typically without the users' knowledge. Users are then categorised according to their performance on the interface. This approach can provide an efficient model of the user's experience with an application or the user's level of computer experience, or both [8]. An advantage of this method is that it overrides questioning and any negative effect due to questioning is minimised in this manner. However, this approach may not always be viable. For example, an occasional user, responding to many questions (that may provide important information necessary to develop a user classification model), may far outweigh the benefits that the model provides during the user's interaction with the system.

Different user characteristics have different impacts on computer-based task performance. The most important of these is the amount of previous computer experience [3, 8, 13]. Various aptitudes (which includes spatial and reasoning abilities, achievement in mathematics and science and also verbal aptitudes) were also found to have significant impacts on HCI [5]. Age can be a powerful indicator of how much difficulty users have in learning new systems. Egan states that as the complexity of a task increases, the effect of age tends to be larger. Gender [7] and computer anxiety [11] were also found to be significant in predicting computer achievement.

3. Current situation

The profile of the student population at UPE has changed dramatically over the past few years. The current student population is very diverse, both in language and population groups (See Figures 1 and 2). Consequently, diversities in the student population have rooted diversities in terms of educational standard and technological expertise.

![Figure 1: Student enrolment by population group.](image-url)
The university has identified various aptitude tests that can be used for the selection and placement of first year students. However a number of these tests are still pencil-and-paper based, and at some time in the near future, these tests will have to be computerised.

Changing the mode of delivering tests from pencil-and-paper format to a computerised format holds many promises. Improvement plans for computerised testing in the future includes tailoring item administration to examinee’s ability levels, creating new item types (which will allow for constructed responses), enabling examinees to control the pace of assessment, adding pictures and graphics to conceptualise items, allowing flexible scheduling and reporting scores faster [6].

However, certain risks are inherent in changing the delivery mode of tests from pen-and-paper format to computerised format [2]. Perhaps the greatest danger is that computerising aptitude tests could reduce the validity of measurement. If students are required to use a computer when taking a test, their score might reflect not only their ability tested, but also their level of computer proficiency. Construct-irrelevance variance could be introduced into the measure and test score interpretations could be confused with the student’s ability to use a computer.

Lee [10] conducted a study to investigate the effect of past computer experience on computerised aptitude test performance on college students. She found that past computer experience significantly affected performance on computerised tests. Students with the same aptitude may not perform equally well on computerised tests. These findings emphasise the need to consider human factors when using computers in testing. Lee also suggests that until the effects of interacting with a computer are more clearly defined, it should be advisable (if not necessary) to allow examinees to choose the mode by which to complete the test.

The existing computerised testing systems used by UPE do not take the students’ level of computer expertise into account. Presenting students with different levels of computer expertise and capabilities, with the same testing system interface might significantly affect the performance of students with lower levels of expertise.

It was therefore decided to develop a user classification model to categorise students into different student groups, each group representing a different level of ability to work with computer interfaces. These groups may then be presented with different interfaces to perform the test. In this way, the negative effect of using a computer for aptitude testing may be minimised, if not eliminated.

4. Research

4.1 Research Instruments

Two instruments were used in this study. The first, a tutorial (namely the Interactive Learner) developed by Van Wyngaard [16], was used to quantitatively model and categorise users. The second instrument, a user profile questionnaire, was compiled and used in a qualitative approach to user modeling. The questionnaire assesses the user’s self-perceived ability to work with computers, attitudes towards computers, previous experience with computers and contact with other and related technology.

4.1.1 Interactive Learner

The purpose of the Interactive Learner (IAL) tutorial was threefold. Firstly, it is intended to teach prospective students basic skills needed to complete computerised aptitude tests. These skills include the use of the typing and cursor section of the keyboard; moving and clicking of the mouse; the use of buttons, radio buttons and check boxes and dragging and dropping objects on the screen. Secondly, it monitors the user’s interaction with the computer and records statistics regarding the user’s interaction on a screen level. This includes the total time spent on each screen, number of times visited, number of key presses, number of mouse clicks and the distance the mouse has moved on the screen. Finally, it evaluates the skill level of users at the end.

Van Wyngaard did not use a complex model to evaluate user expertise. Users receive a “skill rating” equivalent to the number of correct
responses obtained in the tasks presented in the tutorial. The users were grouped into three groups, namely novice (scores ranging from 0 to 33%), intermediate (34% to 77%) and expert (78% to 100%). However, this user categorisation is potentially unsound and consequently not used or investigated in this study.

IAL consists of 39 screens following a sequential order. Four different screen types are found in the tutorial. The first type is referred to as “General” screens and is mainly used for the title screens and for general feedback. The second type of screen is an “Information” screen. These screens are used to “teach” and provide instructions to the user about the tutorial’s subject area. These screens require no interaction from the user, except for navigation forwards or backwards in the tutorial. The third type of screens, namely “Exercise” screens is used to provide the user with the opportunity to exercise what has been taught on the “Information” screens. No time limit is set on exercises and users are allowed to do an exercise more than once. The fourth type of screens, namely “Questions” is used at the end of the tutorial to present tasks that the user needs to complete. Each question has an associated time limit and users are allowed to attempt a question once only.

4.1.2 Questionnaire

Various factors were identified from literature as significant in a user model. A questionnaire (Appendix A) was developed to qualitatively assess the student population’s profile with respect to four domains: self-assessment of ability; attitude towards computers; previous experience with computers and contact with other related technology. The first seven items with regard to previous computer experience were asked in the context of experience at home, friends’ or relatives’ homes or at school. Demographic details were obtained from the university student database, and not from the questionnaire. These included gender, age, population group, home language and Mathematics and English marks.

The assumption was made that IAL would prepare students sufficiently to complete the computer proficiency questionnaire on computer. The interaction style and navigation was kept consistent with that of the tutorial, making it easier for inexperienced computer users to answer questions. Students had the option of using the keyboard or the mouse to answer questions, and were given practice questions beforehand. Due to the fact that some of the responses in the questionnaire would determine what would be asked next, the questionnaire was made adaptive. For example, if a student responds to a question that he/she has never used a computer before, then subsequent questions regarding computer experience are excluded. This increases the reliability of the data and decreases the number of questions to which users would have to respond.

4.2 Research Methodology

A total number of 827 first year students performed the Interactive Learner tutorial and completed the questionnaire during February 2000. Students were asked to complete the tutorial as fast and as accurately as possible. The maximum time allowed for the tutorial was 25 minutes. Students, who did not finish within the time limit, were automatically logged out from the system. A total number of 111 students did not complete the tutorial within the time limit. These students were identified to be an important group of the sample population, and the total time to complete the tutorial for students in this group was not available. However, all students completed the tutorial up to screen 16. Using the time spent up to screen 16 and the total time spent on the tutorial, a regression formula was obtained and the total time was predicted for the 111 students.

From the group of 827 students, 21 students who had never used a computer before, were randomly selected. (Data regarding their frequency of computer use was obtained from the user profile questionnaire.) The assumption is made that this group’s performance in the tutorial represents the general performance of novice users in the tutorial. This group of students were removed from the sample during subsequent statistical analysis, leaving a sample of 806 students. However, the same method could not be used to obtain performance measures regarding expert users. It was not possible to identify expert users from the sample population, as it was found that students overrate their skills in the questionnaire. In the sample of 111 students who did not finish the tutorial in time, 8 stated that they use computers almost every day, 5 once a week, 12 several times a month, 14 about once a month and 72 had never used a computer. This clearly indicates that some students in this group overrated their frequency of computer usage. Instead of selecting a sample of expert users from the sample student population, 21 staff members and postgraduate students from the Department of Computer
Science and Information Systems completed the Interactive Learner tutorial. The assumption was made that these users and their performance in the tutorial represents expert computer users. Only 21 expert users were able to complete the tutorial, hence the equal sample size of 21 novice users drawn from the sample population.

4.3 Research Results

Correlations between the time spent on instruction, exercise and question screens with the total time were high, with the time spent on question screens having the lowest correlation of \( r = 0.85 \) (\( p<0.01, N=704 \)). Key-type rates had lower correlations with total time, but were still relatively high. It was interesting to learn that the key rate during exercises had a high correlation of \( r = 0.71 \) (\( p<0.01, N=704 \)) with performance on IAL. Correlations regarding mouse usage were surprisingly lower than that of keyboard usage, indicating that the user’s ability to use the keyboard had a greater influence on total time spent on the tutorial. As the time spend on instructional, exercise and question screens, key-type rates, mouse usage (measured in mouse clicks and distance moved) and the number of errors made correlated significantly with the total time, it was decided to use total time as the single variable for an indicator of proficiency.

Two control groups (Novices and Experts) were used to define the performance of novice and expert users on the tutorial. The novice control group (defined as students who have never used a computer before) finished the tutorial in an average of 24.21 minutes (St. Dev. = 9.75). The decision was made to classify users as Novice if their performance in the tutorial exceeded 14.46 minutes (24.21 – 9.75). In a similar fashion, the expert control group finished in an average of 8.84 minutes (St. Dev. = 1.7), resulting in classifying experts as users having a performance of less than 10.54 minutes (8.84 + 1.7).

Using the cut-off points defined by the two control groups, 137 users from the sample population were classified as experts and 408 were classified as novices. A group of 261 students had a total time between these two limits and were classified into an intermediate user group. The study performed by Kirsch et. al. [9] revealed that 16% of the sample population (of which the source is largely from Asia and the United States) were classified as having low computer familiarity, 34% as having moderate familiarity and 50% as having high computer familiarity. However, it is interesting to observe that the sample population in this study had a converse classification, having 17% expert users and 50.6% novice users. In both the sample populations, the intermediate groups have approximately the same magnitude of 34% and 32.4% respectively. Figure 3 depicts the distribution of the three different user groups in the sample population. Table 1 shows a summary of the total time spend on the tutorial by the three user groups defined in the study.

![Figure 3: User group distribution.](image)

Four population groups (White, African, Coloured and Indian) were represented in the sample population. White students had the highest percentage of expert users (28.82%), followed by Indians (13.16%), Coloured (10.23%) and African (1.19%) students. African students had the highest percentage of novice users (91.67%), followed by Coloured (67.05%), Indian (42.11%) and White (22.06%) students. The user category distribution for each of the four population groups is depicted in Table 2.

Five language groups (Afrikaans/English, English, Afrikaans, Xhosa and other African languages) were represented in the sample population. Of the five groups, the Afrikaans/English group had the smallest performance mean of 12.53 minutes. English, Afrikaans and Xhosa followed with means of 14.82, 14.96 and 22.38 minutes respectively. Similar results were obtained when the amount of previous computer experience was kept constant. Figure 4 depicts these findings. It can thus be concluded that users’ home language does have an influence on interface performance. Xhosa-speaking students tend to have larger performance times, followed by Afrikaans and English speaking students.
A total of 35.26% of the entire sample population do not have access to computers at home and 44.79% of the population use computers on a daily basis. Grouped by population, 69.42% White students have access to computers at their home on a daily basis, as opposed to 9.92% for African, 32.95% for Coloured and 44.74% for Indian students. On the other end of the spectrum, 11.78% White students, 69.84% African students, 40.91% Coloured students and 39.47% Indian students do not have access to computer at their homes at all. Of the 274 students in the sample population who do not have access to a computer at home, 92 (34%) have access to a friend’s or relative’s computer and 112 (41%), to computers at school.

The age range of the sample population was between 17 and 38 years with the majority of the population between 17 and 22 years. To investigate the effect of age, the sample population was divided into two similar sized age groups. Group A (N = 414) defines students less than 20 years and group B (N = 389) defines students 20 years and older. No significant differences were found between the two age groups when their user category or amount of previous computer experience was kept constant. No differences were expected between these age groups, as the ages of the sample population fell in a narrow range. However, other researchers have found differences between groups with broader age distributions [3, 5].

Table 3 depicts the significance between the gender groups in each of the three user categories defined in the study. For each of the user categories, males completed the tutorial faster than their female counterparts.
Similar results were found when amount of previous computer experience are kept constant. Males outperformed females in all the groups of experience, except in the “Once a month” group. However, the small sample of 51 may be responsible for this exception.

With regard to verbal aptitude (measured as the final English school mark), the correlation with performance on IAL was \( r = -0.43 \) (\( p<0.01, N=697 \)). When the amount of previous computer experience was kept constant, verbal aptitude had higher correlations with groups that use computers less, with the correlations ranging between -0.35 (\( p<0.01, N=116 \)) and -0.38 (\( p<0.01, N=92 \)). For the group of students that uses computers almost every day, verbal aptitude had a lower correlation of \( r = -0.31 \) (\( p<0.01, N=410 \)).

With regards to technical aptitude (as measured by final Mathematical school marks), the correlation with performance was \( r = -0.31 \) (\( p<0.01, N=697 \)) without keeping previous experience constant. When the amount of previous computer experience was kept constant, correlations were only found to be significant for two (“Almost every day” and “Several times a month”) groups.

The six variables related to the use of software were grouped into a single Software Experience variable, with a maximum value of 30 indicating that all the types of software were used on a daily basis. A correlation of \( r = -0.54 \) (\( p<0.01, N=806 \)) was found between the performance on IAL and this variable, indicating that previous software experience increases performance.

The four items in each of the two sections assessing ability and attitude have been grouped together forming two variables, (Sum of) Ability and (Sum of) Attitude. The correlation between these two variables was found to be high, with \( r = 0.72 \) (\( p<0.01, N=806 \)). Students’ attitude towards computers and self-assessment of ability correlates both \( r = 0.48 \) (\( p<0.01, N=806 \)) with software experience. This indicates that more frequent use of software promotes positive attitudes towards computers and self perceived abilities.

Seven items assessed contact with related and other technology. These variables have been grouped into one (Sum of) Technology variable. A correlation of \( r = -0.35 \) (\( p<0.01, N=806 \)) was found between this variable and the performance on IAL. When the amount of previous computer experience was kept constant, correlations between technology and performance were found to be higher for groups with lower levels of previous computer experience than for groups with higher levels of previous computer experience.

5. User classification model

The previous section shows that IAL can be used successfully to quantitatively classify users in three groups. However, quantitative classification is not always viable, as users need to perform actual computer tasks for the categorisation. It was found that various demographic details and factors in the user profile questionnaire are significant indicators of performance for computer-based tasks, at least for the tasks performed in IAL. The possibility of using the user profile questionnaire as a classification methodology was investigated. The goal was to develop a qualitative model for user classification, using factors which are easily available and obtainable from users.

Using demographic details and information gathered in the user profile questionnaire, a stepwise regression analysis was performed to predict user performance in IAL. Variables found significant and selected for the analysis were frequency of computer use, self-perceived ability, attitude towards computers, contact with technology, software experience, gender, Mathematics and English marks, and home language. For the representation of culture in the model, it was decided to only include the user’s home language and not the population group. The variables mentioned above accounted for 58% of the variance in performance times (\( R^2 = 0.58, p<0.0000, N=693 \)).

However, three of the variables were identified to place limitations on the model. The Mathematics and English school marks limited the model to users with school marks available. The third variable, namely self-perceived ability as obtained in the questionnaire, relates to IAL specifically. After these variables were removed, the factors remaining in the model were frequency of computer use, attitude towards computers, contact with technology, software experience, gender, and home language. These variables accounted for 54% of the variance in the performance time (\( R^2 = 0.54, p<0.0000, N=806 \)).
Using results from the step-wise regression analysis, the formula in Figure 5 was derived to predict user proficiency. A description of each of these variables is presented in Table 4.

**Formula for predicting user proficiency:****

\[
\text{Proficiency} = 33.325 +
(\text{Computer Usage Frequency}) \times -0.29 +
(\text{Is Xhosa}) \times 0.052 +
(\text{Software experience}) \times -0.149 +
(\text{Is English}) \times -0.329 +
(\text{Is Afrikaans}) \times -0.185 +
(\text{Technology}) \times -0.102 +
(\text{Is Male}) \times -0.083 +
(\text{Attitude}) \times -0.09
\]

**Table 4: Description of the variables used in the user proficiency formula.**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Usage Frequency</td>
<td>As indicated in item 3.1 of the questionnaire</td>
</tr>
<tr>
<td>Is Xhosa</td>
<td>1 if home language is Xhosa, otherwise 0</td>
</tr>
<tr>
<td>Software experience</td>
<td>Sum of items 3.2 to 3.7 in the questionnaire</td>
</tr>
<tr>
<td>Is English</td>
<td>1 if home language is English, otherwise 0</td>
</tr>
<tr>
<td>Is Afrikaans</td>
<td>1 if home language is Afrikaans, otherwise 0</td>
</tr>
<tr>
<td>Technology</td>
<td>Sum of items 4.1 to 4.7 in the questionnaire</td>
</tr>
<tr>
<td>Is Male</td>
<td>1 if Male, otherwise 0</td>
</tr>
<tr>
<td>Attitude</td>
<td>Sum of items 2.1 to 2.4 in the questionnaire</td>
</tr>
</tbody>
</table>

Using the same cut-points that were used for IAL, users with a proficiency less than 10.54 are classified as experts, between 10.54 and 14.46 as intermediate, and higher than 14.46 as novice users.

6. Conclusions and further research

The purpose of this study was to develop a user classification model for first year students at the University of Port Elizabeth with respect to proficiency with interfaces. Several population groups were found to have limited access to computers and experience with software. Performance differences of up to 10:1 were found in a tutorial (IAL) teaching students basic keyboard and mouse skills. A number of factors were found to be the cause of these performance differences. These included the amount of previous experience with computers and software, gender, self-perceived ability to work with computers, attitude towards computers, contact with related technology and home language. The most significant of these was the amount of previous computer experience.

IAL was used in a quantitative approach to classify users. Two control groups were used to define cut-off points for expert and novice performance on the tutorial. Using these cut-off points, it was possible to classify students into three categories, namely novice, intermediate and expert. Seventeen percent of the population was classified as experts, 32.4% as intermediate users and 50.6% as novices. As it is not always possible for users to perform a task on computer in order to be categorised, a user profile questionnaire was constructed in a qualitative approach to user classification.

This study clearly indicates that various characteristics are responsible for performance differences in HCI. Using these characteristics, it is possible to classify users into different groups, each group having a different level of ability to work with computer interfaces. However, further research is required to match user categories with different interface metaphors and interaction styles for computerised testing systems. Providing students with appropriate testing system interfaces which match their skills and abilities, may minimise (if not eliminate) the introduction of construct-irrelevant variance in test scores.

References


Appendix A - User Profile Questionnaire

1. Self-assessment of ability

<table>
<thead>
<tr>
<th></th>
<th>Poor</th>
<th>Not so Good</th>
<th>Reasonable</th>
<th>Good</th>
<th>Excellent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>The Interactive Learner has taught you some basic skills on how to use the KEYBOARD. How would you rate your ability to use the typing and cursor sections of the keyboard?</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>1.2</td>
<td>The Interactive Learner has taught you some basic skills on how to use the MOUSE. How would you rate your ability to use the mouse (for example, moving the mouse cursor on the screen and clicking on objects on the screen)?</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>1.3</td>
<td>The Interactive Learner has taught how to use buttons, checkboxes and radio buttons. How would you rate your ability to use these objects?</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>1.4</td>
<td>How would you rate your ability to use a computer in general?</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>
2. Attitude towards computers

<table>
<thead>
<tr>
<th>Almost every day</th>
<th>Once a week</th>
<th>Several times a month</th>
<th>Once a month</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>TV (Digital Satellite)</td>
<td>How often do you select programs on Digital Satellite? (4.7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How often do you use a cell phone? (4.6)</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>How often do you use a TV game? (This question does not refer to computer games) (4.5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How often do you use a CD player? (4.4)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>How often do you use a tape recorder? (4.3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATM (4.2)</td>
<td>How often do you use an Automatic Teller Machine?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How often do you use a Video Cassette Recorder (VCR) (4.1)</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

3. Previous experience with computers

<table>
<thead>
<tr>
<th>Almost every day</th>
<th>Once a week</th>
<th>Several times a month</th>
<th>Once a month</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did you take Computer Science as an additional subject at school? (3.1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did your school offer Computer Science as an additional subject? (3.2)</td>
<td></td>
<td></td>
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<tr>
<td>How often do you use email facilities? (3.6)</td>
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</table>

4. Contact with technology

<table>
<thead>
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5. Access to computers at school

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2. Attitude towards computers

<table>
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<tr>
<th>Very Easy</th>
<th>Easy</th>
<th>Fairly Easy</th>
<th>Not too difficult</th>
<th>Difficult</th>
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<tbody>
<tr>
<td>How do you find working on a computer in general? (2.1)</td>
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<tr>
<td>How do you find it working with a keyboard? (2.2)</td>
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<td></td>
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<tr>
<td>How do you find it working with the mouse? (2.3)</td>
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<tr>
<td>How do you find reading and understanding information on the computer screen? (2.4)</td>
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