Determining the User Profile for an Adaptable Training Platform

Mardé Greeff, Quentin Williams, Ronéll Alberts and Harriet Pretorius
CSIR Meraka Institute
P.O. Box 395
Pretoria, 0001
{mgreeff, qwilliams, ralbers, heaston}@csir.co.za

ABSTRACT

Adaptive computer-based training systems aim to enhance the learning experience by personalising the presentation and content delivery according to the preferences of each particular user. The complexity of humans - the many factors influencing learning, from learning styles to physical abilities; and the proliferation of human-computer interface modalities - proves difficult for a system to fully determine when modelling diverse user profiles. Therefore most research has only focussed on the user's learning preferences and training via the "normal" auditory-visual channels. In this paper it is shown how a user model can be determined that includes the learning style, learning preference, abilities and the various available computing modalities. The model further incorporates how each of the elements influence each other. Such a model can be trained and expanded to allow for different training paradigms.

Keywords

User profile, learning style, perceptual learning preference, abilities, training

1. INTRODUCTION

People perceive and process information through different means based on their preferred learning style, learning preferences, literacy level and physical disabilities [13][16]. Human-computer interaction (HCI) systems must therefore take into account this plethora of human factors that influence user interaction, as well as the specific capabilities of the computing system. Cassell [2] shows that an intelligent system has to represent: (1) the input and output modalities of the computing system; (2) the order and medium or modality in which information is presented; (3) the user's profile/characteristics; and (4) how each factor influences the interaction between human and computer. To determine all of these factors and subsequently model them, is a challenging task and most research has opted to determine one aspect while keeping the other factors constant or the same for each user.

In this paper it is shown how to determine a user profile that consists of various individual traits, including a user's learning style, learning preference/cognitive style, literacy level and physical disabilities. Included in the profile is the causal relationship each one of these factors has on the adaptation of the user interaction by modeling the impact on the system input and output modalities. This user profile is then used in a computer based training application to adapt the medium through which interaction takes place; what type of content is best suited for a particular user; and the navigation structure through the content. Adaptation can happen dynamically as the user's preferences or circumstances change ensuring that training is always effective. The application is an adaptive computer based training platform developed for experimental purposes in Adult-based training domains where low-literacy and disabilities are prevalent.

The next section describes the research project and the various individual traits that make up the user profile are presented in Section 3. Section 4 provides an overview on the training material used, while Section 5 highlights the user evaluations conducted, as well as lessons learned.

2. ABTI PROJECT

The Ability Based Technology Interventions (AbTi) project aimed to research how the acquisition of new knowledge and skills could be facilitated and improved through the use of multiple modalities. Based on the results of this research the ultimate project vision is to develop a fully functional ability-based training platform that will

facilitate training, through technology interventions and different modalities, based on the abilities, learning style, preferences and literacy level of a trainee.

This project is particularly relevant to a developing economy (i.e. South Africa) where the transfer of skills and associated training is of critical importance. This is of importance not only to everyday learners that have different learning preferences, but also to the large number of people living with disabilities (physical, visual, intellectual, hearing, etc.) and illiterate people in such economies. For these persons, becoming economically self sustainable is difficult due to the lack of adequate and effective training that matches their unique training needs.

The activities within the AbTi project were based on the action research methodology and included research on how to combine various input and output ICT modalities (as appropriate for a specific ability) with a smart reasoning engine (which facilitates the extraction of the most appropriate configuration and combination of modalities) and an adaptive user interface. Thus, the determination of an appropriate user profile that faciliated effective training was an important part of the AbTi project and is the basis of this paper.

3. TRAINEE PROFILE

The AbTi project aims to enhance the training experience of the trainees by adapting the material according to the trainee profile, determined by the trainee's:

- *Abilities*, e.g. whether the user can see, hear or speak.
- *Perceptual Learning Preference* as defined by the VARK system [8] and represents the medium or modality that is used to present the material, such as images, video, audio and text.
- *Learning Style* as defined by Honey and Mumford and Kolb [11, 12], which influences the order in which the material is presented to the trainee, such as the theory, summary, questions, examples, etc.

Below, each of these elements that determine the trainee profile, is discussed in more detail.

3.1 Abilities

The International Classification of Functioning, Disability and Health (ICF), defined by the World Health Organisation (WHO) [18], has the following classifications: (i) body functions; (ii) body structures; (iii) activities; (iv) participation; and (v) environmental factors. The following body functions from the ICF are relevant to the AbTi project: mental-, sensory-, speech-, neuromusculoskeletal- and movement-related functions; as well as functions of the skin and related structures.

The AbTi team decided to focus on a limited list of abilities, based on the ICF, namely:

1. Seeing - The ability to see;
2. Hearing - The ability to hear sound;
3. Tactile perception - The ability to feel or touch;
4. Gross arm control and movement - The ability to perform controlled gross movement with the arms, e.g. making circular movements with the arms;
5. Fine hand control and movement - The ability to perform controlled fine movement with the hands, e.g. typing with a keyboard or moving the mouse;
6. Speech - The ability to speak.

3.2 Perceptual Learning Preference

The different learning styles as defined in the VARK model [8] are: (i) Visual learners; (ii) Aural learners; (iii) Read/write learners; and (iv) Kinaesthetic learners.

Visual learners learn most effectively through the use of their eyes and memorise facts best when they see the information [15], e.g. when the information is presented through the use of graphics and pictures [1, 6].

The aural learner, also known as the auditory learner [5], likes to read out loud to themselves, is not afraid to speak in class and likes oral reports.

Read/Write learners prefer material and information displayed as words, with the emphasis on text-based input and output that is supported through reading, writing and/or typing [8].

Kinaesthetic learners learn through experience or doing things and prefer to use their sense of touch and movement of the whole body for effective learning [4, 15].

It is important to note that most learners have a combination of these styles with one or two styles more dominant than the others. For the purpose of this project we focussed on the most dominant learning style of the trainee. To optimise the effectiveness of the learning or training effort, the four learning styles of VARK has been mapped to a specific collection of modalities that are used to present the training material. Dunn et al. found that by teaching individuals initially through their most preferred modality and then later through their secondary or tertiary modality, proved to increase the effectiveness of learning [4]. Therefore, understanding the different learning styles and their needs in terms of training, is an important requirement to deduce the most effective modalities in which the training material should be presented for optimum learning.

3.3 Learning Style

The AbTi project used a variation of the learning styles of Kolb [12] that was introduced by Peter Honey and Alan Mumford [10]. The Honey and Mumford model defines the following four learning styles: activist, reflector, theorist and pragmatist. Challenge and immediate experience are preferred by the activists. The reflectors are thoughtful, listen to others before they speak and prefer to first gather data, analyse it, and to delay reaching conclusions. Theorists prefer to think things through in logical steps, putting together disparate facts into coherent theories, and being rationally objective. Pragmatists are practical, like to seek and try out new ideas, enjoy problem-solving, prefer

to make decisions quickly and are bored with long discussions. In order to increase the effectiveness of the training experience, the sequence in which training material is presented to the trainee, should be adjusted according to the trainee's learning style.

4. TRAINING MATERIAL

Most training systems present the material in a specific way to all users and do not adapt the order in which the material is presented to the user. Since each person has a unique way of learning, as well as unique abilities (whether the person can speak, see, hear, feel with his/her hands, and gross- or fine-motor control), the way in which the material is presented should cater for these differences.

4.1 Training Material Units

The training material is divided into the following units or sections:

1. Introduction that provides a step-by-step outline of what will be/have been covered;
2. Theory Presentation that includes definitions, descriptions and the actual theory of the concept;
3. Questions that assess whether the trainee has mastered the material;
4. Examples that provide concrete instantiations of concepts or examples that illustrate how the material is applied;
5. Activities such as case studies, computer simulations or explorative activities that enable the trainee to learn while doing something concrete;
6. Exercises that provide the trainee with the opportunity to practise what s/he has learned;
7. Links to other resources that can provide additional information;
8. Summary that provides an overview of what has been presented.

The abilities of the trainee influences the modalities or media that are used to present the material to the trainee, as well as the method of interaction that the trainee uses to interact with the system. The perceptual learning preference of the trainee determines how the material is presented to him/her, e.g. if the trainee has a visual and audio preference, the material will be presented through images, video and audio. The influence of the perceptual learning preference and learning style of the trainee on the order in which the material is presented, is discussed in the next section.

4.2 Training Material Order

The order of these elements are determined by the trainee's learning style and perceptual learning preference. It is important to have all the training material units available to all users, but the order through which the material is navigated or presented does influence the learning experience [17]. According to research conducted on the VARK learning preference model [6, 7] visual users process information best when they can envision a topic and thus starting with a summary of the content will suit them. Similarly aural users will benefit if you begin new material with a brief explanation of what is coming (an introduction), and conclude with a summary of what has been covered. Read/Write learners learn more effectively when there is enough opportunity to read and re-read the information presented, while kinaesthetic learners want to experience the content. Literature in the domain of learning styles was further used to determine how best to order content based on a user profile. Papanikolaou et al. [14] showed that for reflectors who are example-orientated these types of material must be presented first to optimise the training strategy. Activists who are activity-orientated must be presented with material through which they can experience the content and learn in thus manner. Theorist prefer to obtain a lot of information about the subject first, before doing anything active, while Pragmatist are keen on understanding the techniques associated with the training material. Given these preference and learning styles, the material units was ordered as shown in Table 1.

4.3 Modelling the User Profile

The link between a user's profile (i.e. characteristics and preferences) and the format of information is a vital element in providing the most effective means of communicating and gaining knowledge. The user's profile consists of his/her abilities, learning styles, learning preferences and literacy level. On the other hand, information can be stored in various data formats (e.g. text, images, audio, etc.), while the input and presentation of information can happen through a range of computing modalities (e.g. screen, audio, braille, etc.). This situation presents a host of dimensions, variables, features and parameters with differing levels of influence on each other. In this space, the decision must be made as to the optimal input modality, output modality and processing of information (e.g. adjusting for navigation through material) for a specific user in any given circumstance.

In order to model the user profile all the variables that forms part of the profile (refer to Section 3) were extracted and represented (both in a mathematical mapping model and visual manner) using a Bayesian network. Bayesian networks [9] are machine learning models that can take the user profile as an input and infer, as output, the most suitable computing modalities (ex. voice, images, text, etc.) and navigation order (e.g. summary - examples - exercises, etc.) to use. At the same time, as more data is added to the model, it can learn and adjust the output to suit the current circumstances of the user. The Bayesian network was initiated using the mappings between specific user profiles and the required interaction modalities known from literature, as well as utilising cost-based experiments [3] conducted during this project.

5. USER TESTING

User testing was conducted to test whether the way in which the presentation of the material, and the order in which the material is presented, provide a more efficient way of presenting training material to a trainee. This

Table 1: Order of Training Material Units

Profile	Material Order
Visual Activitst	Summary - Activities - Examples - Theory - Exercises - Questions - Links - Introduction
Visual Reflector	Summary - Examples - Theory - Exercises - Links - Activities - Questions - Introduction
Visual Pragmatist	Summary - Exercises - Examples - Theory - Activities - Questions - Links - Introduction
Visual Theorist	Summary - Theory - Links - Examples - Questions - Exercises - Activities - Introduction
Aural Activist	Introduction - Activities - Examples - Theory - Exercises - Questions - Links - Summary
Aural Reflector	Introduction - Examples - Theory - Exercises - Links - Activities - Questions - Summary
Aural Pragmatist	Introduction - Exercises - Examples - Theory - Activities - Questions - Links - Summary
Aural Theorist	Introduction - Theory - Links - Examples - Questions - Exercises - Activities - Summary

section presents the process that has been followed, as well as lessons learned from the user testing.

5.1 User Testing Process

A request for volunteers was sent out to Meraka staff to complete questionnaires to determine their abilities, perceptual learning preference and learning style. From the volunteers, those with a visual perceptual learning preference were selected to participate in the user testing. The profiles of the participants are presented in Table 2. In Table 2, V refers to a Visual, A to an Aural, R to a Read/Write and K to a Kinaesthetic perceptual learning preference.

The selected participants were invited to participate in the user testing. The facilitator provided background information about the AbTi project and explained what was contained in the consent form. The participant then had the opportunity to read through the consent form and to ask any questions or raise any issues that s/he was unclear about. If the participant agreed, s/he signed the consent form and the user testing process began.

The training application was set up according to the trainee profile that was determined for the specific parti- cipant through questionnaires. The participant then navi- gated through the training material that was adapted according to the trainee profile of the participant. After working through the training material, the participant was asked to fill out a questionnaire that asked questions to determine the ease of use of the system, as well as a questionnaire that asked questions to determine the effectiveness of the training system.

5.2 Lesssons Learned

Determining a trainee's profile through questionnaires provides a good starting point. However, to truely adapt the material to the trainee's profile, some continuous learning as the trainee is using the system, is still required. For example, a read/write trainee may get tired of reading text and prefers to graphically view or listen to content for a short while. One way of ensuring that the system continously learns and provides a better fit for specific profiles, is through the use of a Bayesian network as discussed in Section 4.3.

All participants preferred to have many modalities available. However, presenting text, images and video on one screen, at the same time, causes confusion. Therefore, a better solution will be to display the information in the modality that is most important for the trainee's profile and then to have additional links to provide more information through other modalities. In this way the trainee can activate the additional information at his/her own time.

6. CONCLUSION

This paper described a method to determine a trainee profile, taking into account abilities, learning style and perceptual learning preference. This profile was used to determine the order and the way in which the training material was presented to the trainee. User testing showed that as humans are dynamic creatures, it is important for such a system to be able to adapt on the fly to changing circumstances. One cannot just rely on static profiles determined via questionnaires done at the beginning of the training process.

7. ACKNOWLEDGMENTS

The authors would like to thank the whole AbTi team, as well as the staff of the Meraka Institute that were willing to complete the questionnaires and to participate in the user testing.

8. REFERENCES

[1] Learning resource center of polk county inc. Last accessed on: 30 May 2010. Available online at: http://www.lrcpolk.com/.

[2] J. Cassell. Embodied conversational agents representation and intelligence in user interfaces. *AI Magazine*, 22(4):67–84, 2001.

[3] L. Coetzee, I. Viviers, and E. Barnard. Model based estimation for multi-modal user interface component selection. In F. Nicholls, editor, *Proceedings of the Twentieth Annual Symposium of the Pattern Recognition Association of South Africa (PRASA2009)*, 2009.

[4] R. Dunn, J. S. Beaudry, and A. Klavas. Survey of research and learning styles. *Educational leadership*, 46(6):50–58, 1989.

[5] R. M. Felder and L. K. Silverman. Learning and teaching styles in engineering education. *Engineering Education*, 78(7):674–681, 1988.

[6] G. Fleming. Learning styles: Know and use your personal learning style. About.com Guide. Last accessed on: 30 May 2010. Available online at: http://homeworktips.about.com/od/homeworkhelp/a/learningstyle.htm.

[7] N. D. Fleming. I'm different not dumb. modes of presentation (vark) in the tertiary classroom. In *Research*

Table 2: Profiles of Participants

Profile	**Participant A**	**Participant B**	**Participant C**	**Participant D**	**Participant E**	**Participant F**
Learning Style	Reflector	Reflector	Reflector	Pragmatist	Pragmatist/ Theorist	Reflector
Perceptual Learning Preference	VARK	VARK	VR	VARK	VARK	V

and Development in Higher Education, Proceedings of the 1995 Annual Conference of the Higher Education and Research Development Society of Australasia (HERDSA), 1995.

[8] N. D. Fleming and C. Mills. Vark a guide to learning styles, 2001. Last accessed on: 30 May 2010. Available online at: http://www.vark-learn.com/english/index.asp.

[9] Z. Ghahramani and M. Beal. Propagation algorithms for variational bayesian learning. In *Proc Neural Information Processing systems*, pages 507–513, 2000.

[10] P. Honey and A. Mumford. *The manual of learning styles*. Peter Honey, 1986.

[11] P. Honey and A. Mumford. *The Manual of Learning Styles*. Maidenhead, 3rd edition, 1992.

[12] D. Kolb. *Experiential Learning: Experience as the source of learning and development*. Prentice-Hall, Eaglewood Cliffs, N.J., 1984.

[13] T. Mroczek, J. Grzymala-Busse, and Z. Hippe. *Rough sets and current trends in Computing*, chapter Rules from belief networks: a rough set approach, pages 483–487. Springer-Verlag, Berlin/Heidelberg, 2004.

[14] K. A. Papanikolaou, M. Grigoriadou, H. Kornilakis, and G. D. magoulas. Personalizing the interaction in a web-based educational hypermedia system: the case of inspire. *User Modeling and User-Adapted Interaction*, 13(3):213–267, August 2004.

[15] ReadingMaster. Learning styles. Last accessed on: 30 May 2010. Available online at: http://www.readingmaster.com/WebPages/Learning_Styles.htm.

[16] S. Vosniadou. Towards a revised cognitive psychology for new advances in learning and instruction. *Learning and Instruction*, 6(2):95–109, 1996.

[17] E. Wenger. *AI and Tutoring Systems. Computational and Cognitive Approaches to the Communication Knowledge.* M. Kaufmann Publishers, California, 1987.

[18] WHO. International classification of functioning, disability, and health. Last accessed on: 30 May 2010. Available online at: http://www.who.int/classifications/icf/en/.