Supporting the diversity of the E-learning 2.0 learners: The development of a psychological student model

Asli Adisen
School of Computer Science, University of Hertfordshire
UK
a.adisen@herts.ac.uk

Trevor Barker
School of Computer Science, University of Hertfordshire
UK
t.1.barker@herts.ac.uk

Abstract: This paper describes the development of a psychological student model based on the visual and verbal skills of learners. These skills are important factors of the learners' mental models that are employed when interacting with complex computer applications, such as the ones involved in E-Learning 2.0. In order to develop such a student model, it was important to identify a range of verbal and visual skills that are likely to be required in learning. In a laboratory based study with 50 learners, using software developed for the purpose, learners' performances on those skills were compared against their scores on the Wholist-Analytic (WA) and Verbaliser-Imager (VI) dimensions of Riding's Cognitive Styles Analysis (CSA). Findings of the study indicate that VI dimension of Riding's CSA was not a useful measure of the visual and verbal skills required to interact with complex computer applications. A factor analysis conducted on the data gathered from the visual and verbal skills test was able to identify important components of the necessary skills for inclusion in the student model.

Introduction

With the development of increasingly large and complex computer applications that are used by diverse groups of users, consideration of individual differences has become an important issue in designing usable and useful applications. Increasingly, software system designers are becoming aware of the need to create applications that accommodate the needs of individuals by adapting the system in accordance with their requirements and capabilities. In educational applications, student modelling is a technique that is often employed to this end, helping learners to perform tasks, by taking different interaction approaches with applications, depending on diverse features of their personalities, abilities, preferences, performances or intentions. This approach is placing the control of learning into the hands of learner (Marzano, 1992). This paper reports the development of a student model which is capable of accommodating an individual's mental model (Adisen et al., 2004). Earlier work has shown that a student modeling approach is beneficial to learners using multimedia applications (Barker et al., 2002). We argue that a modelling approach will also be beneficial to learners while interacting with complex learning applications such as those described as web 2.0 or social software. New tools and services are being used increasingly in areas of education, including learning and teaching, scholarly research, academic publishing and libraries. Some examples of these preliminary activities include wikis, such as are used at the University of Arizona's Learning Technologies Centre to build a wiki-based glossary of technical terms they learned while on the course; blogs used by University of Hertfordshire's staff and students to create their own personal pages and folksonomies, used by Southampton University which involved the development of a formal ontology for laboratory work. These services offer an alternative platform for peer editing, supporting the now-traditional elements of computer-mediated writing-asynchrous writing, groupwork for distributed members and so on that informs a way of making, sharing and consuming digital documents in a non-traditional approach (Alexander, 2006).

The significant attributes displayed by new tools and services are that they are about knowledge creation, knowledge management, knowledge sharing and knowledge dissemination (Owen et. al, 2006) which in turn has led learners to develop a range of new skills or manipulate the existing ones in multiple ways. These new skills include the ability to navigate through virtual worlds, to perform complex tasks by locating specific information in a meaningful way that is presented in a variety of formats, such as text, image, animation, audio and video. Often the information contained in such formats is integrated and has to be manipulated and decomposed in order to obtain meaning. According to Alexander (2006), education is more like a conversation and learning content is something you perform some kind of operation on rather than "just reading" it.

The skills required to interact with complex applications are often very different from the traditional working and learning skills that served computer users in the past. It is argued that a new set of visual and verbal skills are important characteristics of a student's natural mental model which is important in organizing processing and communicating information while interacting with computers. According to Schnotz, et al. (2002), texts and graphics are complementary sources of information insofar as they contribute in different facets in the construction of a domain based mental model. For these reasons it was decided to establish a student model that accommodates different levels of visual and verbal abilities.

To this end, it was essential to understand the different visual and verbal skills required to undertake complex tasks on computer applications. Important visual and verbal skills, shown in Tables 1 and 2, were identified based on the understanding of the complexity of modern computer interaction, a review and evaluation of existing tests as well as the information provided in the literature (Hegarty, 1992, Kozhevnikov et al., 2003).

Having identified potential candidates for the student model, the next key task was to measure these skills in learners and to test the validity of these measures in the context of the intended use for the appropriate domain. It is claimed that Riding's CSA Test is an important test of verbal and visual ability along a Verbaliser-Imager dimension, as well as the cognitive skills of learners along the Wholist-Analytic dimension (Riding 1991a, 1991b). This computer-based test was a good candidate to be included in the student model since it was reported to be simple and easy to administer and an objective measure of an individual's skills along two important dimensions (Riding, 1997). In order to evaluate the potential of Riding's CSA test, empirical laboratory based studies were undertaken to relate Riding's measures along the Verbaliser-Imager (VI) and Wholist-Analytic (WA) dimensions to the new skills identified.

Table 1. Important visual skills required to undertake complex tasks

Remember an image and compare with the one seen earlier
Compare an image with one present on the screen at the same time
Remember details of an image not present
Ask learners whether they adopt a V or I strategy – hypothetical
Measure whether learners adopt a V or I strategy – actual task
Ask learners whether they adopt a W or A strategy - hypothetical and actual
Analyze information contained in a graph or chart
Remember verbal instructions about an image not present and perform task
Remember verbal instructions about an image present and perform task
Remember and estimate the size of an image not present
Rotate and manipulate an image present on the screen
Remember objects in an image not present and compare to other similar images

Table 2. Important verbal skills required to undertake complex tasks

Answer a question related to a passage that is present on the screen
Answer a question related to a passage that is not present on the screen
Answer questions regarding a passage listened to
Complete the sentences with the most appropriate choice given
Find the analogies between words
Find the antonyms of the given words
Find the synonyms of the given words
Answer some questions that requires analytical skills
Remember the words that were presented on the screen
Remember the words that were listened to
Answer some questions regarding verbal instructions

Method

The sample in this study consisted of 50 paid volunteer participants (26 male, 24 female) who were mainly undergraduate and postgraduate students of the University of Hertfordshire. All participants were native English speakers with normal eyesight. Ages ranged from 18 to 54 (mean age=22.16).

Two computer applications intended to measure the skills presented above were developed, the verbal and visual skills tests. These tests required learners to perform tasks similar to those required when using complex computer applications. Performance on the tests was measured and recorded in order to be compared with the performance of participants on Riding's CSA test.

Participants were allocated to take the visual skills test, verbal skills test and Riding's CSA Test in a random order, with a short break in between in order to allow for bias, learning and effects of fatigue.

Results

The scores obtained for Riding's CSA test [Table 3] were mostly similar to reported studies (Riding, 1997). To test the independence of the Riding's WA and VI dimensions, Pearson's PM correlation was performed on the summarized scores. The value of the correlation coefficient (r=-0.063, N=50, p=0.67) in Table 4 supports the assumption of independence between the WA and VI dimensions. Any relationships between then can be ascribed to chance alone.

Table 3. Summary of the results obtained in Riding's CSA Test.

	N	Minimum	Maximum	Mean	Std. Deviation
WA	50	0.73	3.04	1.23	0.45
VI	50	0 .69	1.54	1.07	0.18

Table 4. Pearson's correlation on the summarized scores obtained from CSA test

	WAxVI
Pearson Correlation	0.63
Sig, (2-tailed)	0.66
N	50

Pearson's PM correlation was performed on the data gathered from CSA Test results and Visual Skills Test, Verbal Skills Test results to investigate the significance of any relationships between them. Table 5 shows the relationship between the mean time taken to answer a question in the visual skills test (Mean TIME) and the total score obtained (ACC), with the WA and VI scores obtained in the CSA Test. The results of this analysis show a significant positive correlation between the WA dimension and the total score obtained (ACC) from the visual skills test (correlation is significant at the 0.01 level). This suggests that the Wholists were more likely to give correct responses in visual skills test. No other significant correlations were found. Table 6 shows the relationship between the mean time taken to answer a question in verbal skills test (Mean TIME) and the total score obtained (ACC), with the WA and VI scores obtained in the CSA Test. The results of this analysis showed no significant correlations between any of the variables.

Table 5. Pearson's PM correlation showing the correlation between accuracy of responses, mean time taken to answer a question in the visual skills test and Riding's WA and VI scores

Variable		**Mean TIME**	**ACC**	**WA**	**VI**
Mean TIME	Pearson Correlation	1	-0.48	-0.75	0.36
	Sig. (2-tailed)	.	0.73	0.60	0.80
ACC	Pearson Correlation	-0.48	1	0.37	0.06
	Sig. (2-tailed)	0.73	.	0.008	0.68
	N	50	50	50	50

Table 6. Pearson's PM correlation showing the correlation between accuracy of responses, mean time taken to answer a question in the verbal skills test and Riding's WA and VI scores

Variable		**Mean TIME**	**ACC**	**WA**	**VI**
Mean TIME	Pearson Correlation	1	0.80	0.13	0.11
	Sig. (2-tailed)	.	0.58	0.92	0.42
ACC	Pearson Correlation	0.80	1	0.20	0.12
	Sig. (2-tailed)	0.58	.	0.16	0.41
	N	50	50	50	50

Pearson's correlation was also performed on the variables identified for the visual and verbal skills tests and Riding's WA and VI dimensions. Table 7 presents the correlations found between some of the dependent variables of the Visual Skills Test and Riding's WA and VI dimensions. One-tailed statistics were used, as it was possible in all cases to predict a direction for the relationships found. Most values of the correlation coefficient were small. Only those correlations that were significant at 0.01 and 0.05 levels are given. Table 8 presents the correlations found between some of the dependent variables of the Visual Skills Test and Riding's WA and VI dimensions.

Table 7. Significance of correlations seen between performance of visual skills and Riding's WA and VI cognitive style dimensions

Variable	**WA**		**VI**	
	P	**R**	**p**	**R**
Number of wrong responses	0.01	-0.38		
Ability to remember the features of an image that is not present on the screen and answer some questions about it.	0.05	0.31		
Ability to analyze graphical information	0.05	0.32		
Ability to estimate a size of an image that is not present on screen			0.05	-0.36
Ability to manipulate an image	0.05	0.29	0.05	-0.34
Number of correct responses to questions related to WA	0.05	-0.27		

Table 8**.** Significance of correlations seen between performance of verbal skills and Riding's WA and VI cognitive style dimensions

Variable	**WA**		**VI**	
	P	**R**	**P**	**R**
Time taken to recall the words from a list that has been presented on the screen			0.05	0.31
Ability to recall the words from a list that has been listened			0.05	0.31
Time taken to recall the words from a list that has been listened to			0.01	0.44

It is interesting to note that even significant differences were relatively small, with *r* in the region of 0.3; that the direction of correlations is sometimes difficult to explain and that many of the dependent variables relating to ability had no significant relationships with the WA or VI dimensions. Our interpretation of these findings is given in the discussion section of this paper.

An ANOVA was performed on the visual skills and verbal skills tests variables presented in Tables 1 and 2 to test for the significance of any differences observed for the dependent variables and participants grouped according to their scores along Riding's WA and VI dimensions.

Tables 9 and 10 present the results of ANOVA tests of the significance of any differences between the dependent variables and learners grouped according to their scores on the CSA test for visual and verbal skills respectively. Only one significant difference was found between the performance of Verbalisers and Imagers, or between Wholists and Analytics when they were divided into two groups at the midpoint. To allow for the effect of those classified as Intermediates (Riding, 1991a) the data was divided into three equal groups at appropriate points along each of Riding's WA and VI dimensions and the analysis repeated. Intermediate values were also removed from the data set and the remaining values were subjected to ANOVA to test for the significance of any difference in the means of the remaining extreme WAVI groups for all the dependent variables as before. With the middle values removed, some significant differences in the means were found ($p<0.05$). Significant differences at the 0.1, 0.05 and 0.01 levels are shown in tables 9 and 10 below.

Table 9. Significance of differences in visual skills for learners grouped according to their scores on the WA and VI dimensions

Variable	**WA**			**VI**		
	2 groups	**3 Groups**	**Int. rem**	**2 Groups**	**3 Groups**	**Int. Rem**
Number of correct responses	0.05	0.1	0.05			
Number of wrong responses	0.05	0.1	0.05			
Ability to remember the features of an image that is not present on the screen and answer some questions about it.	0.01		0.05			
Time taken to remember the features of an image that is not present on the screen and answer some questions about it.	0.05	0.05	0.05			
Ability to estimate a size of an image that is not present on screen					0.05	0.05
Ability to analyze graphical information	0.05	0.05	0.05			
Ability to deal with verbal instructions about an image present	0.05*		0.1			
Ability to manipulate an image	0.01	0.05	0.05	0.1	0.05	0.01
Score of self reported WA questions	0.05					
Time taken to answer questions related to WA dimension	0.1	0.05*	0.05			
Number of items recalled from the photo					0.05 *	0.05*

* = one-tailed

Table 10. Significance of differences in verbal skills for learners grouped according to their scores on the WA and VI dimensions

Variable	**WA**			**VI**		
	2 groups	**3 groups**	**Int. rem**	**2 Groups**	**3 groups**	**Int. Rem**
Number of correct responses	0.1					
Mean time taken for correct responses			0.1			
Number of wrong responses	0.1	0.1				
Ability to read a passage and answer some questions about it when the passage is not present on the screen.	0.05					
Time taken to read a passage and answer some questions about it when the passage is not present on the screen.	0.05	0.05*	0.05			
Ability to complete sentences			0.1			
Ability to find the synonyms of the given words	0.1	0.1	0.1			
Time taken to find the synonyms of the given words	0.1		0.1			
Time taken to remember verbal instructions that have been listened to	0.05	0.1	0.05			
Ability to recall the words from a list that has been read	0.05		0.05	0.05*	0.1	0.1
Time taken to recall the words from a list that has been read				0.05*	0.05	0.05
Ability to recall the words from a list that has been listened to				0.05*	0.01	0.01
Tine taken to recall the words from a list that has been listened to					0.05	0.05
Analytical score		0.05				

* = one-tailed

A factor analysis was performed on the results obtained from the study reported above in order to identify the most important factors required to undertake visual and verbal tasks in complex computer applications. The results of this analysis are shown in Tables 11 and 12 for visual and verbal respectively. These tables present the factors with Eigen values greater than 1.0 for the skills identified. For each of the factors the more important skills (component >0.5) are reported. The validity of the factors identified for visual skills is 65% and for verbal skills 64%.

Table 11. Component Matrix relating to visual skills

Variable	**Component**					
	1	**2**	**3**	**4**	**5**	**6**
Remember an image and compare with the one seen earlier	.546					
Compare an image with one present on the screen at the same time	.608					
Remember the features of an image that is not present on the screen and answer some questions about it.						
Analyze the information presented with a graphical format	.721					
Ability to estimate a size of an image that is not present on screen		.659				
Ability to manipulate an image		.661				
Self reporting on VI approach					-.727	
Strategy used for VI questions						.563
Self reporting on WA			.809			
Number of items recalled in a photograph	.664					
Number of removed items recalled in a photograph	.546					
Noticing the items removed from a photograph				.590		

There were six important factors identified for the visual skills profile which are as follows:

- Factor 1: Analyzing the information given in image or graph format
- Factor 2: Predicting information based on an existing image
- Factor 3: Self reporting on WA dimension
- Factor 4: Recalling information about information seen earlier
- Factor 5: Self reporting VI preference
- Factor 6: Verbal-Imager strategy used

Table 12. Component Matrix relating to verbal skills

Variable	**Component**			
	1	**2**	**3**	**4**
Answering questions about a passage read	.667		.818	
Answering questions about a passage listened to				.760
Completing sentences			.690	
Finding the synonym of a given word	.805			
Finding the antonym of a given word	.877			
Answering analytical skill questions		.637		
Recalling the words read		.706		
Recalling the words listened to		.742		

Four important factors were identified for the verbal skills profile:

- Factor 1: Finding the synonyms and antonyms of the given word
- Factor 2: Analytical skills required to recall information
- Factor 3: Completing sentences

- Factor 4: Ability to recall the information heard

More work will take place in future on the application of these verbal and visual skills factors, as these are likely to be important components of the psychological student model.

Discussion

As learners take greater responsibility for their own learning, they require an increasingly complex range of skills in order to absorb information quickly from text, image, audio and video from multiple sources, often simultaneously. In this research the performances of learners on a set of important visual and verbal skills were related to a generally accepted measure of cognitive style, the CSA test. Cognitive and Learning styles are used extensively in education today to measure the abilities and preferences of learners. Based on such measures, the mode of presentation of information, the teaching style of academics and learning nature of environments are attended to. We have shown in this research that the complex skills required for learning with computers are not related to simple tests of cognitive style, such as Riding's CSA test. It is claimed that those learners classified as Verbalisers according to the CSA test find "speech and text easier than diagrams" and "learn best from verbal presentations". Imagers "learn best from visual displays" and "find pictures easier than words" (Riding, 1998). Although Riding's summary of the relationship between visual and verbal skills and CSA test scores is necessarily a generalization, the results suggest that it is at the very least an over-simplification and is not supported by the results of our study. We were able to provide evidence that Riding's WA dimension was related to the performance of verbal and visual skills. It was surprising however, that many skills that were expected to be performed better by a specific group (such as visual skills by imagers and verbal skills by verbalisers) were not found in this study. Indeed very few relationships were found between skill level and scores along the VI dimension. For this reason it is concluded that the VI dimension is not a useful or valid measure of the ability of learners in complex domains.

The failure of this study to support Riding's ideas is due to an important factor which the CSA test fails to address, that of context. Increasingly with web 2.0, personalized learning is becoming social learning and is being re-defined regularly by learners as new tools and new ideas arise. Barker and Barker (2002) discuss the need to include context in understanding what is meant by reliability and validity when assessing the results of learner evaluations undertaken with computer software. As a result of this study, it is argued that Riding's VI dimension may indeed be valid in simple cases, but when tasks get difficult and complex and have real contexts, it is not possible to relate real-word tasks to a single cognitive style dimension alone. There is also ample evidence in the literature for the interaction of the WA and VI dimensions in real-world tasks (Kozhevnikov et al., 2003, Peterson et al, 2003a). The WA and VI dimensions have consistently been shown to be independent in the CSA test, and in this study. Learning however is framed in an individual context that includes the application of a range of skills simultaneously. In real life tasks, the interpretation of information in various formats (such as pictorial and textual) is a multi-dimensional problem, involving analysis and manipulation of wholes and parts of images and situations that relate to them. Learning tasks involving analysis of information have become increasingly complex and will likely increase in their complexity.

The visual and verbal skills profiles described in this study are based on the skills identified from the literature and are measured directly in the verbal and visual skills tests we developed. The factor analysis reported in the results section was able to identifying important components that we suggest will be useful in a psychological student model suitable for complex learning tasks. Six visual factors and four verbal factors were identified that might be included in the model. Based on the earlier work (Barker et al., 2002) language skills are also likely to be useful in the model and can be measured by locating the general level of a learner's language, based on the type of words used and their basic grammar (Barker et al., 1999). The research reported here also identified Riding's WA dimension as a likely inclusion in this student model. Indeed it was found to be a more useful measure than the VI dimension for inclusion in the model. The student model reported in this study therefore consists of the 6 visual and 4 verbal factors identified a measure of basic language ability and Riding's WA dimension.

We are currently engaged in implementing our student model in a computer information system requiring the application of a large number of verbal and visual skills in order to locate, organize and report on information held in a range of formats and modalities on computer E-Learning systems. We will investigate efficient ways of obtaining values for the components of our student model and also how we might configure the presentation of information and the help provided to learners based on the settings of their individual student models. In the next stage of this research we will move from measuring verbal and visual skills as our independent variable to measuring learning. We will then relate this to our student model. This is a difficult and exciting challenge.

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