e-Learning Material Presentation and Visualization Types and Schemes

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Abstract: Multimedia and content visualisation provide ability to transform electronic materials into more dynamic format. This can provide positive aspect on learning, but also can overload the limited information processing capacity in human brains. Cognitive load in technology-enhanced learning is closely related to the learning styles of learners. This study examines interactions between learning styles of students and how these are related to student's working memory and cognitive traits. To investigate the learning styles of learners the Felder- Soloman questionnaire was chosen. It allows analyse students' learning styles with respect to the Felder-Silverman learning style model, which is the most appropriate for a web-based learning. Also the interaciton between cognitive traits and learning styles is analysed. The results of this analysis prove the importance of multimodal learning in technology-enhanced learning. Also some relationships between learners with higher working memory capacity and learners with lower working memory capacity were demonstrated. The results will help to improve students' model for better adaptivity of learning materials.

1 INTRODUCTION

The development of information and communication technologies (ICT) has made the emergence of such visual media as interactive simulations, animations, video, and other electronic media more rapid in educational process.

One of the greatest benefits of electronic media is its opportunity of adaption, which provides learners with more flexible usage of learning material. That makes the learning material more appropriate for learners' cognitive style (Chen and Macredie, 2002; Wang et al., 2000). The analysis on the adaptivity of e-learning materials has pointed out the importance of the modelling of learners' cognitive aspects. One of the instructional designer's tasks is to make learning process more effective, involving the use of new media and visualisation techniques. The explanation of the positive effect of visualisation is provided by cognitive load theory (Bannert, 2002) and cognitive theory of multimedia learning which is presented by Mayer (Kalyuga, 2011). These theories show the information processing limitations of our cognitive system in learning.

Traditional learning does not always allow the adoption of different learning styles or the adoption of socio-cultural differences during learning process. It should be taken into account that each learner has different learning characteristics, like motivation, prior knowledge, and learning style, which influence learning process. This is the reason why some learners perceive the subject more easily, but others find the same subject rather difficult. The increase of multimedia usage in teaching has provided a lot of possibilities to adapt it for different learning styles, and also a lot of research has been done to analyse materials' adaptivity on learners' perception. The essential part of adaptivity nowadays is made feasible by adaptive virtual learning environments, which can adapt their content and activities according to student's needs. Therefore the learning systems require implementation of student's model, which would allow system understand students' needs. Basically it is a challenging process, because students do not possess solely one of the styles – each student has his own mix of characteristics. CISCO researchers (Fadel and Lemke, 2008) has shown that multimodal learning is more effective than traditional uni-modal learning, but there is a

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lack of evidence-based research. The research is intuitive and based on educational theories. It shows that the visualisation in learning process has a potential to support learner's needs in learning process, but interactivity and dynamic animations are not always the best aids for learning. This research gives an overview of the relationship between learner's cognitive traits and learning styles thus providing theoretical grounds for instructional designers.

2 BACKGROUND

To provide the context for understanding the differences between several aspects of learner's cognitive traits and learning styles, this paper briefly summarizes the key elements of the research about brain functionality, of how people learn, and the prior research on cognitive abilities of learners and how to support them in a learning process.

2.1 Memory Systems

The research in cognitive science has shown that human brain has three types of memory: sensory memory, working memory, and long-term memory (Fadel and Lemke, 2008; Mayer, 2001). These types of memory can be described as follows:

- Sensory Memory – when human senses allow people receive signals from outside world and experience various situations, it is said to be sensory memory. Involuntary signals from sensory memory are sent to long-term memory as episodic knowledge. It stays in a long-term memory if a learner pays attention to the episodes of sensory memory. In that case these episodes are loaded into working memory. If something goes into a learner's working memory, then learner can work with this information accordingly to the common context;
- Working Memory – this is a main part of a thinking process. Brain functions are dual coded with a buffer for storage of verbal and text elements and also with a buffer for visual and spatial elements. The main limitation in human brains is that those buffers can process approximately four objects of visual information and seven objects of verbal information. Working memory is a place where verbal and visual information work together, without interference;
- Long-term memory – this is a brain function which allows humans store information during lifetime. It acts in parallel with sensory and working memory. There are too types of long-term memory – episodic and semantic. Episodic memory derives directly from a sensory memory and is involuntary. Semantic memory receives information from working memory, and it automatically triggers storage in a long-term memory.

The main problem in Instructional Design is that working memory has limited capacity, which can cause cognitive overload. The Felder -Silverman model describes student's characteristics in four dimensions, pointing out that not always students act as expected, even if they have strong preferences to one of the styles. However, taking into account the learning styles in virtual learning environments could help to adapt students learning styles and reduce their cognitive memory system load.

2.2 Cognitive Load Theory and Instructional Design

Cognitive load theory (CLT) assumes, that the amount of working memory is limited, but at the same time it is related with a long-term memory, which is unlimited. According to CLT the knowledge in long-term memory is stored in mental schemas. Learning is possible due to the construction of schemata. Schema can be treated as a single element in working memory and functions to overcome working memory limitations (Hollender et al., 2010).

There are different types of cognitive load which can affect learning performance (Sweller et al., 1998).

The main load which can arise from instructional design is extraneous cognitive load. It is directly connected with instructional designer impact on study process, and the main target is to reduce extraneous cognitive load in instructional materials. It is caused by an unnecessary increase in the number of elements that must be processed simultaneously in working memory (Wong et al., 2012).

Intrinsic cognitive load (ICL) refers to the learning and its level of difficulty. ICL mostly depends on the interactivity of elements. High ICL occurs when interactivity of the material is high. For example, if the interactivity of a learning definition is low, but some grammar analysis must be learned, then the interactivity should be made much higher.

The last type of cognitive load is a germane cognitive load which results from active schema construction process and therefore is beneficial for learning. Germane cognitive load refers to working memory resources required to deal with ICL in learning, as well as working memory resources which are required to deal with extraneous resources. If extraneous cognitive load is reduced, then germane cognitive load can be increased.

The research process in CLT area has resulted in a range of instructional design guidelines and factors that impact student's cognitive load. Firstly, there should be as low pressure on extraneous cognitive load as possible. Secondly, it should optimize the level of germane cognitive load. This is the portion of load that directly contributes to the learning process. Furthermore, an efficient training is characterized by favourable effort-performance ratio. This is a relatively low mental effort that results in relatively high performance (Gerven et al., 2002).

It is also proven that multimodal learning in which information is presented in multiple modes such as visual and auditory, is more effective for electronic environments, and it can provide several benefits, including:

- promoting learning by providing an external representations of information;
- deeper processing of information;
- holding learners attention by making the information more attractive and motivating, hence making complex information easier to comprehend (Sankey et al., 2010).

Implementation of students characteristics and students' model in Cognitive Trait Model (Lin, 2007) include cognitive traits such as working memory capacity, inductive reasoning ability and information processing speed. It would help automate instructional design process and improve learning environment adaptivity. Cognitive Trait Model is a domain independent, so it can be used in different learning environments. As the working memory has been already evaluated, it needs to provide the description about reasoning ability, associative learning and information processing speed.

2.3 Reasoning Ability and Information Processing Speed

There are different methods of reasoning which are mainly distinguished among inductive, deductive and adductive reasoning. During this research the main focus is on inductive and deductive reasoning since they are more related with learning abilities.

Inductive reasoning is one of the most important abilities in learning process by means of which it is possible to construct concepts from examples. During problem analysis, learners look for known examples to construct internal hypothesis. As a result cognitive load is reduced and learning process becomes more efficient. It means that higher inductive reasoning ability allows build up mental models of the information learned, which leads to better learning results.

Deductive reasoning is a process during which logical consequences are drawn from premises; it is basically naturalistic decision making process what people do in real-world situations. Learners with greater experience can recognize appropriate actions to take in various situations that might arise, but learners with less experience almost always perform random search of alternatives. The problem becomes more noticeable during complex problem analysis, where learners often fail to find appropriate solution. But if a necessary amount of skills is acquired and learned then it becomes more effective.

Reasoning ability is closely connected with information processing speed, which determines how quickly learners can acquire information correctly. Instructional designers should take this aspect into account, because learners with low information processing speed should be presented with only the important points of material and also a number of ways should be decreased. In contrast, for learners with high information processing speed, the information space can be enlarged by providing greater amount of information (Lin, 2003).

2.4 Associative Learning

The associative learning is ability to link acquired knowledge to existing knowledge. It is a mechanism where behaviours are influenced by experiences. For instructional designers it means that material for learning support must assist to the recollection of learned information, as well as it should clearly show the relationships of concepts, where the new knowledge is connected to the existing one. That means that it is useful to provide some additional information and links for learners with low associative learning skills – it would help to associate one concept with another.

3 METHODOLOGY

To investigate the learning styles of learners the research was performed with 150 students participating. Students where mixed from different faculties and courses, mostly from bachelor level. To investigate students' learning styles Felder and Soloman questionnaire (Felder and Soloman, 1997) was chosen. It is 44 question form for identifying the learning styles according to Felder-Silverman learning style model (Felder and Silverman, 1998). There are more learning style models in this research area, like Kolb's learning style model (Kolb, 1984) and Honey and Mumford's learning style model (Honey and Mumford, 1982), but Felder-Silverman learning style model is one of the most appropriate for web-based learning. It was confirmed during the comparison of learning style models with respect to web-based learning systems (Kuljis and Liu, 2005).

The chosen questionnaire which is called Index of Learning Styles (ILS), with 44 questions is divided into 4 dimensions, which are expressed by values between +11 and -11 per dimension, with steps +/-2, assuming that each learner has personal preferences for each dimension. Each dimension is assigned to 11 questions of questionnaire. Table 1 shows all dimensions of this questionnaire. Each question is answered either with a value +1 (answer a) or -1 (answer b). Answer a corresponds to the active, sensing, visual or sequential preference of dimensions, answer b corresponds reflective, intuitive, verbal, or global preference of dimensions.

Table 1: Learning style dimensions according to Felder-Silverman model.

Learning Style dimensions	Description
Active – Reflective	Active learners like to try the learned concepts and are tended to work in groups, but reflective learners like to work alone.
Sensing – Intuitive	Sensing learners prefer concrete definitions and practical facts. Intuitive learners are more tended on abstract concepts and theories.
Visual – Verbal	Visual learners are tended on pictures, diagrams and flow charts, bet verbal learners are tended on written and spoken explanations.
Sequential – Global	Sequential learners like processes where the linear link can be clearly distinguished with small steps, but global learner likes holistic thinking and large leaps.

During the research the balanced value is calculated – it shows values in dimension from +3 to -3 from the survey. This result is due to the factor that a lot of learners did not show a strong preference for one of the dimensions.

Another part of the research was to empirically study students' learning behaviour and derive the required information from their behaviour. This study was based on the Cognitive Trait Model (Lin, 2007) to profile learners according to their cognitive traits. The Cognitive Trait Model's (CTM) four cognitive traits – working memory capacity, inductive reasoning ability, processing speed and associative learning skills – are addressed in CTM. Various patterns or manifests of traits are defined for each cognitive trait, as well as the identification of cognitive traits is based on the behaviour of learners within the system or learning process.

4 FINDINGS AND DISCUSSIONS

Firstly, the overall distribution of learners in each dimension was analysed.

Table 2: Learning dimensions between students.

Active	Balanced	Reflective
28%	58%	14%
Sensing	Balanced	Intuitive
34%	49%	17%
Visual	Balanced	Verbal
68%	26%	6%
Sequential	Balanced	Global
18%	65%	17%

The analysis shows that for the learners with active learning style the ability to practically try learned concepts has more impact on memorising and obtaining knowledge than for the reflective learners, but reflective learners have more relevance to social behaviour. These learners are more tended to inductive reasoning and low associative ability, which shows the importance of giving them the opportunity to work individually. These dimensions can be related also with field-dependant and field-independent learners (Witkin et al., 1997). These dimensions are grouped in low working memory and high working memory, which allow making relations to active and reflective learners' working memory capacity.

It was discovered that sensing and intuitive dimensions also have some relationships with field-independent and field-dependent learners. According to Chen, S.Y. et al (Chen 2002) field-dependent learners prefer concrete materials and small learning steps; they could get very good results in cooperation with sensing learners, but they would be less successful in cooperation with intuitive learners, who prefer abstract materials.

The research's results also show that students with low working memory capacity are more tended to visual learning style, but this doesn't mean that learners with visual learning style have low working memory capacity. It could be explained by dual coding theory of multimedia learning.

The sensing learning style requires concrete and specified learning materials. The sensing learners are more careful and attentive during a learning process, but intuitive learners are more tended to abstract materials and they have tendency of not being patient and careful.

The results of sequential/global dimension shows that sequential learners are tended to understand the concepts by building them from smaller parts to the whole solution. We also noticed rather close relation between sensing/intuitive and sequential/global learning dimensions. These dimensions correlated with each other.

5 CONCLUSIONS

This paper analyses the learners' cognitive traits and learning styles. Felder-Silverman learning style model and cognitive trait model was used for the research analysis.

Considering the relationship between cognitive traits and learning styles it is possible to obtain additional information about a learner, which could improve the overall students' mode. The research shows that students with active, sensing visual and global learning style have lower memory than reflective, intuitive and sequential. This could help to support learner's cognitive load with appropriate instructional design automation and integration in learning systems.

Within the research the use of electronic learning materials at high schools was analysed, and it was concluded that most of the materials do not meet the necessary requirements for supporting students' cognitive traits and learning styles.

Learning styles can improve identification of cognitive traits; if the learning style is already detected then it will improve indication of cognitive traits. But at the same time cognitive traits can also help to identify learning styles. Such interaction can better show students working characteristics and provide the analyses of not only learning styles but also the cognitive traits of students. This analysis can lead to more accurate representation of materials which will give ability to provide learning without cognitive overload. Such analysis can improve pedagogical models to provide more adaptive learning, with better effect.

The further work is necessary on the statistical analyses of survey results which could allow analyse the correlation between different learning dimensions. It would also be useful to make more explicit analyses on students' behaviour and to find the ability to detect automatically the learning style from the student's behaviour in learning system. Definitely more research on learning styles and cognitive traits should be made, to provide more adaptive electronic learning materials.

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REFERENCES

Bannert, M., 2002. Managing cognitive load — recent trends in cognitive load theory. Learn. Instr. 12, 139–146.

Chen, S.Y., Macredie, R.D., 2002. Cognitive styles and hypermedia navigation: Development of a learning model. J. Am. Soc. Inf. Sci. Technol. 53, 3–15.

Fadel, C., Lemke, C., 2008. Multimodal Learning Through Media : What the Research Says. Cisco Syst. 1–24.

Felder, R.M., Silverman, L.K., 1998. LEARNING AND TEACHING STYLES. Engr. Educ. 78, 674–681.

Felder, R.M., Soloman, B.A., 1997. Index of Learning Styles questionaire [WWW Document]. URL http:// www.engr.ncsu.edu/learningstyles/ (accessed 9.20.13).

Gerven, P.W.M. Van, Paas, F.G.W.C., Merrie, J.J.G. Van, 2002. Cognitive load theory and aging : effects of worked examples on training efficiency. Learn. Instr. 12, 87–105.

Hollender, N., Hofmann, C., Deneke, M., Schmitz, B., 2010. Integrating cognitive load theory and concepts of human–computer interaction. Comput. Human Behav. 26, 1278–1288.

Honey, P., Mumford, A., 1982. The Manual of Learning Styles. P. Honey & L. Mumford.

Kalyuga, S., 2011. Effects of information transiency in multimedia learning. Procedia - Soc. Behav. Sci. 30, 307–311.

Kolb, D.., 1984. Experiential learning : experience as the source of learning and development. Engelwood Cliffs, NJ: Prentice Hall.

Kuljis, J., Liu, F., 2005. A Comparison of Learning Style Theories on the Suitability for elearning. Web

Technol. Appl. Serv. 191–197.
Lin, T.-Y., 2003. User exploration based adaption in adaptive learning systems. Int.J.Inform.Syst.Educ. 1, 22–31.
Lin, T.-Y., 2007. Cognitive Trait Model for Adaptive Learning Environments. Massey University, New Zeland.
Mayer, R.E., 2001. Multimedia learning. UK: Cambridge University Press, Cambridge.
Sankey, M., Birch, D., Gardiner, M., 2010. Engaging students through multimodal learning environments : The journey continues. PCurriculum, Technol. Transform. an Unkn. Futur. Proc. ascilite Sydney 2010 852–863.
Sweller, J., Merrienboer, J.J.G. Van, Paas, F.G.W.C., 1998. Cognitive Architecture and Instructional Design. Educ. Psyhology 10, 251–296.
Wang, P., Hawk, W.B., Tenopir, C., 2000. Users' interaction with World Wide Web resources: an exploratory study using a holistic approach. Inf. Process. Manag. 36, 229–251.
Witkin, H. A., Moore, C. A., Goodenough, D. R., Cox, P. W., 1997. Field dependent and field independent cognetive style and their deucaiton implications. Rev. Educ. Res. 47, 1–64.
Wong, A., Leahy, W., Marcus, N., Sweller, J., 2012. Cognitive load theory , the transient information effect and e-learning. Learn. Instr. 22, 449–457.