Yang, J. C. et al. (Eds.) (2018). Proceedings of the 26th International Conference on Computers in Education. Philippines: Asia-Pacific Society for Computers in Education

Comparing the effect of cognitive style on learners' engagement levels and learning performance by analyzing LMS logs

Liang-Yi LI
Program of Learning Sciences, Institute for Research Excellence in Learning Sciences, National Taiwan Normal University, Taiwan
lihenry12345@ntnu.edu.tw

Abstract: Teachers can publish a variety of multimedia learning materials on learning management system. Students can freely access these materials for their self-regulated learning. Students with different verbalizer-visualizer cognitive style may have different engagement levels in accessing different kinds of online multimedia learning materials, and thus may affect their learning performance. Therefore, this study analyzed the system logs for understanding the effects of verbalizer-visualizer cognitive style on students' engagement levels and learning performance. The results revealed that cognitive style did not affect the engagement level of the students. However, students learning performance was affected by cognitive style. These results were then discussed.

Keywords: Cognitive style, learning analytics, video lecture, engagement

1. Introduction

With the development of internet and the promotion of flipping instruction, more and more teachers have used Learning Management Systems (LMSs) to publish a variety of multimedia learning materials, such as lecture slides and videos, for students to learn after class. Learning on LMSs is a self-regulated learning process, in which students can freely select the learning materials and control their learning path and pace. However, students with different individual characteristics may have different preferences, abilities, and motivations in using these learning materials (de Barba, Kennedy, & Ainley, 2016). These preferences, abilities, and motivations influence their engagement levels and in turn may affect their learning performance (Cheng & Chau, 2016; Graff, 2003).

Thus, there is a need to consider individual differences. Several individual differences have been examined in the past two decades, such as gender (Padilla-Melendez, del Aguila-Obra, & Garrido-Moreno, 2013), prior knowledge (Taub, Azevedo, Bouchet, & Khosravifar, 2014), and learning style (Graf, Liu, & Kinshuk, 2010), and cognitive style (Graff, 2003). Among these individual differences, verbalizer-visualizer cognitive style is the most relevant with multimedia learning (Bos, Groeneveld, van Bruggen, & Brand-Gruwel, 2016; Mendelson & Thorson, 2004) Students with different verbalizer-visualizer cognitive styles should have different preferences in accessing these online multimedia learning materials. Therefore, this study attempts to examine whether verbalizers and visualizers have different engagement levels in accessing different kinds online learning materials (i.e., lecture slides and video lectures), and whether their cognitive style can affect their learning performance.

2. Related works

LMSs can record learners' behaviors of online tool uses and navigational paths into system logs. These logs can be analyzed to understand students' online learning behaviors. Studies have analyzed system logs to examine the effects of individual differences on the online participation behaviors and learning performance (Heffner & Cohen, 2005; Lust, Vandewaetere, Ceulemans, Elen, &

Clarebout, 2011) and have explored the relationships between students' characteristics, online participation behaviors, and learning performance (Chang, Chen, & Wang, 2011; Macfadyen & Dawson, 2010). However, most of the studies focused on the individual differences of gender, age, learning styles (Cheng & Chau, 2016; Huang, Lin, & Huang, 2012), and motivation (de Barba et al., 2016; Giesbers, Rienties, Tempelaar, & Gijselaers, 2013). We found few studies to examine how verbalizer-visualizer cognitive style affect online participation behaviors and performance.

Cognitive style refers to an individual's habitual and preferred way for acquiring, processing, and organizing information (Frias-Martinez, Chen, & Liu, 2008; Lei, Sun, Lin, & Huang, 2015; Mendelson & Thorson, 2004). Several dimensions of cognitive style have been proposed, such as verbalizers/visualizer, field independent/field dependent, and wholistic/analytic (Frias-Martinez et al., 2008; Gulliver & Ghinea, 2010). Among these dimensions, verbalizer-visualizer is the most related to multimedia learning because multimedia involves multiple information representation formats (Bos et al., 2016; Mendelson & Thorson, 2004), which include text, pictures and animations. Such different representation formats may be appreciated by verbalizers and visualizers differently. For example, verbalizers like to learn from reading text, writing text, and listening, while visualizers like to learn from reading text with pictures and viewing animations or videos. This is due to the fact that verbalizers prefer to think and process information by words, while visualizers prefer to think and process information by pictures, charts, and graph (Frias-Martinez et al., 2008; Lei et al., 2015; Mendelson & Thorson, 2004).

Students with different verbalizer-visualizer have different preferences in access information. These preferences may influence their learning behaviors. Studies have examined how cognitive style affect learning behaviors (Liu, Kinshuk, Lin, & Wang, 2012; Massa & Mayer, 2006). However, most of the previous studies were conducted in a controlled setting , involved in a shorter time (e.g., one hour), and focused on the search and navigational activities (Frias-Martinez et al., 2008; Graff, 2003; Kinley & Tjondronegoro, 2010) and multimedia learning (Leutner & Plass, 1998; Massa & Mayer, 2006). Fewer studies have examined behaviors in the field, involved a longer time (e.g., one semester), and focused on accessing LMS learning materials. To address this issue, we analyzed a one-semester logs of a LMS, where the course teacher regularly published lecture slides and videos and students learned from these published learning materials after class. By doing so, we can compare the engagement levels and learning performance of learners with different cognitive styles.

3. Method

3.1 Participants

Fifty-six third-year undergraduate students participated in this study. Their major was computer science and they enrolled a course, named as mobile phone programming. In addition to lecture in the classroom, the course teacher published video lectures, lecture slides, and programming homework assignments on the 21CS learning management system (http://www.21cs.tw)/. The students could use the system to learn from the published slides, videos, and shared submissions, to submit their assignments, and interact in a discussion forum.

3.2 Instruments

The students' cognitive styles were measured by Style of Processing (SOP) scale developed by Childers et al.(1985), because it is easy-to-use in field settings and has revealed satisfactory reliability and validity(Sadler-Smith, 2011). The SOP scale has two subscales (i.e. the verbal and visual subscales), consists of 22-item, and uses four-point Likert scale. The total score is 88. High scores indicate a preference for processing visual information; low scores indicate a preference for processing verbal information. Reliability of each subscale is .73 for verbalizers, and .74 for visualizers. Global reliability of the SOP scale is .82. Overall, the reliability of the SOP scale is acceptable. The participants with the SOP scores that are higher and lower than the mean SOP score are identified as visualizers and verbalizers, respectively.

The learning performance of the students was evaluated by a final exam. There were 32 true/false (each correct answer is 0.25 point), 2 single selections (each correct answer is 1 point), 10 open-ended (each correct answer is 1 point) questions in the paper-based test. The total score of the paper-based test is 20. It primarily evaluated students' cognitive levels of remembering and understanding, for example, the syntax of opening a local file and the procedure of setting the permission.

3.3 Procedure

The course lasted for 18 weeks. For each week, the teacher taught the slide content and used a screen capture software to record what he taught in the classroom. Each lecture slide was published before one week of the slide content taught; each video lecture was published immediately after the teacher recorded in the classroom. There were 17 slides published and 56 video lectures published.

The students' cognitive style was measured at the 13th week. Their learning performance was evaluated at the 18th week by the final exam. The time for the exam was continued for one hour.

4. Results and Discussions

4.1 Time spent for accessing the learning materials

Verbalizers prefer to learn from text information and visualizers prefer to learn from visual information. Lecture slides that combine text with pictures and video lectures that combine voice with dynamic images are visual information, visualizers should spend more time on viewing them than verbalizers. In order to understand whether students preferred to use the learning materials that match with their cognitive styles, we compared the time that they spent in viewing lecture slides and time spent in viewing video lectures between verbalizers and visualizers. Two Mann–Whitney tests were conducted. The results did not show any statistical significant differences between verbalizers and visualizers, in terms of the time spent for viewing any learning material. Therefore, these results represent that the behavior that students demonstrated did not reflect their cognitive styles.

Table 1

Time length of viewing the learning materials

	Verbalizer		Visualizer		*p*
	Mean	SD	Mean	SD	
Time spent of viewing lecture slides	29696.39	25239.13	27086.89	15465.51	0.909
Time spent of viewing video lectures	13977.29	16993.96	10353.46	8287.99	0.793

4.2 Learning performance between Verbalizers and Visualizers

Because the learning materials published in this system were visual information (i.e. lecture slides and video lectures), visualizers should learn better on the system than verbalizers did. Therefore, visualizers should have better learning performance than verbalizers. In order to prove this assumption, we compared the final exam scores of verbalizers and visualizers. A Mann–Whitney test was conducted. The results showed that cognitive styles had a marginally significant effect on the final exam score ($U=506.00$, $z=1.869$, $p=0.040$). More specifically visualizers (mean = 10.33) gained higher scores in the final exam than the verbalizers (mean =9.45).

Why visualizer have better learning performance than verbalizers in the final exam. There may be a reason to explain this result. Visualizers may more easily remember and understand visual information than verbalizers (Childers et al., 1985; Darley, 1999; Marks, 1973), so the students with visualizer style have better final exam scores when learning from the learning materials. Please leave one blank Normal (11 point) line before every table caption or figure. Similarly, please leave one blank Normal (11 point) line after every table or figure caption.

5. Concluding Remarks

This study conducted a one-semester instructional experiment, where the course teacher regularly published lecture slides and videos on a LMS; and students learned from these published learning materials after class. In the end of the experimental instruction, the LMS logs were analyzed for comparing the engagement levels and learning performance of learners with different cognitive styles. The results revealed several interesting findings. Firstly, the behavior that students demonstrated did not reflect their cognitive styles. Secondly, the learning performance that students demonstrated did reflect their cognitive styles.

Acknowledgements

This work was supported by the Ministry of Science and Technology of Taiwan under contract numbers MOST106-2511-S-003-063-MY2 and the “Institute for Research Excellence in Learning Sciences” of National Taiwan Normal University (NTNU) from The Featured Areas Research Center Program within the framework of the Higher Education Sprout Project by the Ministry of Education (MOE) in Taiwan.

References

Bos, N., Groeneveld, C., van Bruggen, J., & Brand-Gruwel, S. (2016). The use of recorded lectures in education and the impact on lecture attendance and exam performance. *British Journal of Educational Technology, 47*(5), 906-917. doi:10.1111/bjet.12300

Chang, C. K., Chen, G. D., & Wang, C. Y. (2011). Statistical model for predicting roles and effects in learning community. *Behaviour & Information Technology, 30*(1), 101-111. doi:10.1080/0144929x.2010.516017

Cheng, G., & Chau, J. (2016). Exploring the relationships between learning styles, online participation, learning achievement and course satisfaction: An empirical study of a blended learning course. *British Journal of Educational Technology, 47*(2), 257-278. doi:10.1111/bjet.12243.

Childers, T. L., Houston, M. J., & Heckler, S. E. (1985). Measurement of individual differences in visual versus verbal information processing. *Journal of Consumer Research, 12*(2), 125-134.

Darley, W. K. (1999). The moderating influence of style of information processing on media perceptions and information exposure. *Journal of Marketing Communications, 5*(4), 181-194.

de Barba, P. G., Kennedy, G. E., & Ainley, M. D. (2016). The role of students' motivation and participation in predicting performance in a MOOC. *Journal of Computer Assisted Learning, 32*(3), 218-231. doi:10.1111/jcal.12130.

Frias-Martinez, E., Chen, S. Y., & Liu, X. (2008). Investigation of behavior and perception of digital library users: A cognitive style perspective. *International Journal of Information Management, 28*(5), 355-365.

Giesbers, B., Rienties, B., Tempelaar, D., & Gijselaers, W. (2013). Investigating the relations between motivation, tool use, participation, and performance in an e-learning course using web-videoconferencing. *Computers in Human Behavior, 29*(1), 285-292. doi:10.1016/j.chb.2012.09.005.

Graf, S., Liu, T. C., & Kinshuk. (2010). Analysis of learners' navigational behaviour and their learning styles in an online course. *Journal of Computer Assisted Learning, 26*(2), 116-131. doi:10.1111/j.1365-2729.2009.00336.x.

Graff, M. (2003). Learning from web-based instructional systems and cognitive style. *British Journal of Educational Technology, 34*(4), 407-418.

Gulliver, S. R., & Ghinea, G. (2010). Cognitive style and personality: impact on multimedia perception. *Online Information Review, 34*(1), 39-58. doi:10.1108/14684521011024119.

Heffner, M., & Cohen, S. H. (2005). Evaluating student use of web-based course material. *Journal of Instructional Psychology*, *32*(1), 74-82.

Huang, E. Y., Lin, S. W., & Huang, T. K. (2012). What type of learning style leads to online participation in the mixed-mode e-learning environment? A study of software usage instruction. *Computers & Education, 58*(1), 338-349. doi:10.1016/j.compedu.2011.08.003

Kinley, K., & Tjondronegoro, D. W. (2010). *The impact of users' cognitive style on their navigational behaviors in web searching.* Paper presented at the Proceedings of 15th Australasian Document Computing Symposium (ADCS).

Lei, P. L., Sun, C. T., Lin, S. S. J., & Huang, T. K. (2015). Effect of metacognitive strategies and verbal-imagery cognitive style on biology-based video search and learning performance. *Computers & Education, 87*, 326-339. doi:10.1016/j.compedu.2015.07.004

Leutner, D., & Plass, J. L. (1998). Measuring learning styles with questionnaires versus direct observation of preferential choice behavior in authentic learning situations: The visualizer/verbalizer behavior observation scale (VV-BOS). *Computers in Human Behavior, 14*(4), 543-557. doi:10.1016/s0747-5632(98)00023-5

Liu, T. C., Kinshuk, Lin, Y. C., & Wang, S. C. (2012). Can verbalisers learn as well as visualisers in simulation-based CAL with predominantly visual representations? Preliminary evidence from a pilot study. *British Journal of Educational Technology, 43*(6), 965-980. doi:10.1111/j.1467-8535.2011.01262.x

Lust, G., Vandewaetere, M., Ceulemans, E., Elen, J., & Clarebout, G. (2011). Tool-use in a blended undergraduate course: In Search of user profiles. *Computers & Education, 57*(3), 2135-2144.

Macfadyen, L. P., & Dawson, S. (2010). Mining LMS data to develop an "early warning system" for educators: A proof of concept. *Computers & Education, 54*(2), 588-599. doi:10.1016/j.compedu.2009.09.008

Marks, D. F. (1973). Visual imagery differences in the recall of pictures. *British journal of Psychology, 64*(1), 17-24.

Massa, L. J., & Mayer, R. E. (2006). Testing the ATI hypothesis: Should multimedia instruction accommodate verbalizer-visualizer cognitive style? *Learning and Individual Differences, 16*(4), 321-335. doi:10.1016/j.lindif.2006.10.001

Mendelson, A. L., & Thorson, E. (2004). How verbalizers and visualizers process the newspaper environment. *Journal of Communication, 54*(3), 474-491. doi:10.1093/joc/54.3.474

Padilla-Melendez, A., del Aguila-Obra, A. R., & Garrido-Moreno, A. (2013). Perceived playfulness, gender differences and technology acceptance model in a blended learning scenario. *Computers & Education, 63*, 306-317. doi:10.1016/j.compedu.2012.12.014

Sadler-Smith, E. (2011). The intuitive style: Relationships with local/global and verbal/visual styles, gender, and superstitious reasoning. *Learning and Individual Differences, 21*(3), 263-270. doi:10.1016/j.lindif.2010.11.013

Taub, M., Azevedo, R., Bouchet, F., & Khosravifar, B. (2014). Can the use of cognitive and metacognitive self-regulated learning strategies be predicted by learners' levels of prior knowledge in hypermedia-learning environments? *Computers in Human Behavior, 39*, 356-367. doi:10.1016/j.chb.2014.07.018