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Students' Reactions to Different Levels of Game Scenarios: A Cognitive Style Approach

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ABSTRACT

Game-based learning comprises of a set of concrete scenarios, which can be presented with various presentation modalities (e.g., text, text with graphic, and context). Such presentation modalities disseminate information in different ways. On the other hand, cognitive styles affect how people process information. Accordingly, the study presented in this paper investigates the influences of cognitive styles on students' performance within different levels of game-based scenarios. More specifically, this study examines how students with different cognitive styles (i.e., Holist/Serialist) react to three presentation modalities (i.e., text, text with graphic, and context) in game-based scenarios. The results of an empirical study with 96 students revealed that all students made improvement, regardless of any presentation modalities. However, Holists significantly performed better than Serialists in the context version. According to the results, further suggestions for system design are discussed.

Keywords

Cognitive styles, Game-based learning, Situated contexts

Introduction

With the advance of multimedia technology, the use of multimedia in education has been regarded as a promising approach to optimizing student learning. Such advocacy is underpinned by the theory of multimedia learning (Mayer, 2002), which involves an assumption of how people learn from words, sounds, and images (Mayer & Moreno, 2003). More specifically, multimedia learning asserts that optimal learning occurs when visual and verbal information is presented together simultaneously. This is due to the fact that students have separate channels to process visual and verbal information. Accordingly, students have more opportunities to receive integrative information when visual and verbal forms are linked together. By doing so, students' comprehension (Rusanganwa, 2013) can be enhanced and information can also be stored in the long-term memory structure (Kulhavy, Stock, & Kealy, 1993).

In spite of such benefits, it is still difficult for students to apply what they have learned to real situations because multimedia learning highlights the integration of multiple representation channels, rather than authentic transferable examples. To facilitate such learning transfer, scenario-based learning (Clarke, & Mayer, 2011; Clark, 2009; Kindley, 2002) is proposed based on the principles of situated learning theory (Lave & Wenger, 1991), which argues that learning should be situated in a specific context, or embedded in a particular social and physical environment (Kindley, 2002). Scenario-based learning makes students immerse in authentic works, and then integrates needed knowledge and skills in the context, instead of abstract or decontextualized knowledge (Clarke, & Mayer, 2011). In other words, scenario-based learning advocates that students should learn in concrete situations and by examples.

In short, scenario-based learning highlights the significance of real situations, which provides three major potential benefits: engaging, meaningful, and transfer learning. Regarding engaging learning, unlike abstract information, information presented in an authentic way can stimulate students to be engaged in the learning process (Herrington, Reeves & Oliver, 2014), where different scaffolding designs can also be applied to enhance their engagement. Regarding meaningful learning, such a scenario could offer students rich information, including objects themselves as well as the relationships among various objects. Such rich information might help students understand how to organize them in an appropriate way so students can undertake meaningful learning. Regarding transfer learning, scenarios could trigger students to propose questions and acquire knowledge with concrete examples. When students learn from a number of different examples, they could synthesize and analyze similarities and differences among such examples. This experience can help them conduct and deduct what they have learned. Thus, they can know better how to apply their knowledge and skills from one scenario to similar scenarios in the future (Cormier & Hagman, 2014; McKeough, Lupart, & Marini, 2013).

Due to such benefits, the scenario has been widely applied in different learning settings, such as game-based learning and technology-enhanced language learning. On the one hand, game-based learning is often represented as a virtual world, which comprises of a set of concrete scenarios, to allow students to explore every place or interact with each other (Chien et al., 2013; Toscano et al., 2015). For instance, Barab and his colleagues (2005) developed a game scenario, which was designed as a virtual island to facilitate students' scientific inquiry. In the virtual island, students were guided by a set of quests to observe, propose and evaluate their hypotheses. Such exploration and interaction in digital games are beneficial to student learning, especially in motivation and learning performance (Kebritchi, Hirumi, & Bai, 2010; Papastergiou, 2009; Tsai, Yu, & Hsiao, 2012; Tüzün et al., 2009). On the other hand, technology-enhanced language learning often involves different scenarios, where technologies are used as tools to engage or enrich students' learning experience. For instance, Di Blas and Paolini (2014) created a 3D multi-user learning environment to promote students' language learning. Students are situated in a scenario, where they can control their avatars to interact with other students or communicate with NPCs (Non-player-characters) to practice their foreign language (Ibáñez et al., 2011).

The aforementioned studies deliver information within scenarios, which could be categorized as three different levels: text, graphic, and context. The three levels of the scenarios vary in how much information conveyed to students and how such information is presented. The text reveals symbolic and abstract information whereas the graphic offers visual and concrete information. The context not only delivers rich information about individual object, but also their detailed relationships among these objects. Accordingly, students have to process various types of information simultaneously in the scenarios (Kalyuga & Plass, 2009). On the other hand, not all of students can effectively cope with such multiple information sources (Ishii & Yamauchi, 1994). Therefore, individual differences should be considered in scenario-based learning.

Among various individual differences, cognitive styles particularly represent consistent individual different preferences of organizing and processing information and experience (Messick, 1976). Cognitive styles refer to the way of how students think, perceive, and remember information, or their preferred approaches to using such information (Riding & Grimley, 1999). For instance, Pask's Holistm and Serialism are one of significant classifications of cognitive styles. More specifically, Holists prefer to process information in a "whole-to-part" sequence whereas Serialists favor a "part-to-whole" processing of information (Jonassen & Grabowski, 2012). Recently, differences between Holists and Serialists are investigated in several studies. Specifically, it has been found that Holists and Serialists had different preferences for their navigational styles (Clewley et al., 2011). The former tended to take a non-linear pattern by "jumping" between different levels of subject contents with hypertext links. Conversely, the latter preferred to follow a linear pattern by having a suggested route or looking at the subject content step-by-step with back/forward buttons. The differences between Holists and Serialists are also found in their reaction to collaborative learning (Chen & Chang, 2016), where there is a need to provide either Holists or Serialists with additional help because heterogeneous groups with both Holists and Serialists can obtain the best learning performance. In addition, to meet the different needs of Holists and Serialists, an adaptive hypermedia learning system was developed to enhance student learning (Mampadi et al., 2011). The result showed that such an adaptive hypermedia learning system had positive effects on students' perceptions and performance.

Although the aforementioned studies demonstrate fruitful results, there is a lack of studies to investigate how Holists and Serialists react to different levels of scenarios in the context of a game-based learning system. This issue is significant because it can provide concrete guidance on how to accommodate the needs of different cognitive style groups. To this end, this study aims to fill this gap. More specifically, the research question of this study is: *How do Holists and Serialists react to different levels of scenarios in game-based learning systems?* To answer the question, an empirical study was conducted. The details are described in the following sections.

Methodology design

Development of a game-based learning system

As mentioned in the earlier section, to facilitate learning transfer, digital games with different scenarios are paid enough attention in the area of learning technologies. Accordingly, we developed a game-based learning system, which taught English vocabularies on the topics of life and leisure, including the scenarios of a living room, bedroom, bathroom and kitchen. The goal of the game is to nurture a cartoon monster to grow up by satisfying all of its needs in life, such as eating, sleeping, and playing. The monster would tell the student objects that are needed so he/she is required to go to a specific scenario (e.g., living room, bedroom, bathroom, or kitchen) to look for such objects. For instance, if the monster is hungry, the student is required to go to the kitchen to cook. Then, the student can learn related foods (e.g., beansprout, carrot, chicken breast) in such a scenario. In other words, a scenario-based learning approach was adopted in this game, where students learn English vocabularies in an authentic scenario and then integrates what they have learnt to satisfy the needs of the monster.

To do comprehensive investigation to answer the research question of this research, the scenario of the game-based learning system was divided into three different levels: text, text with graphic, and a whole context. Thus, three versions were produced to correspond to the aforementioned three levels. More specifically, the three versions have some features in common.

- *Audio elements:* Audio was considered in all of three versions, which can provide the pronunciation of each vocabulary and its Chinese explanation because audio is one of most common elements in multimedia presentations (Clarke & Mayer, 2016) as well as important to vocabulary learning.
- *Non-linear learning:* The game-based learning system presents vocabularies in a non-sequential format. In other words, the learning system does not limit the orders of movements or learning paths, and allows the students to freely choose vocabularies by themselves.

However, the three versions differ in representational levels (i.e., text, text with graphic, and context). The first version (the text version) presented vocabularies in the form of text only. This version offered a basic setting when compared with the other two versions. The second version (text with graphic version) offered students additional explanations in the form of both text and graphic. The third version (context version) presented comprehensive information, including text and graphic explanations of the vocabulary as well as the surrounding objects to form as a meaningful learning environment. In addition, the text version and the text with graphic version presented vocabularies in an alphabetical order, whereas the context version presented vocabularies based on the arrangement of objects displayed in a scenario. Table 1 summarizes the common and different features among the three versions.

Table 1. Common and different features among the three learning systems

Text version	Text with graphic version	Context version
		
Common features: • To show vocabularies with pronunciation • To present the Chinese explanations of vocabularies • To display vocabularies in a non-linear format		
Different features: • To show vocabularies in the format of text only (one channel) • To list vocabularies in an alphabetical order	Different features: • To show vocabulary in the formats of text and graphic (two channels) • To list vocabularies in an alphabetical order	Different features: • To show vocabulary in the formats of text, graphic and context (multiple channels) • To list vocabularies based on the arrangement of a scenario

Instruments

- *Study preferences questionnaire:* Among various instruments, the Study Preferences Questionnaire (SPQ) can do a quick and easy measure of Holists and Serialist biases. Additionally, the SPQ had been used in several studies (e.g., Clewley, Chen, & Liu, 2011) and showed adequate reliability (α = 0.67) in past research (Mampadi, Chen, Ghinea, & Chen, 2011). Consequently, this study adopted the Chinese version of the SPQ to identify Holists and Serialists and followed the criteria suggested by the original producer (Ford, 1985) to identify Holists and Serialists. More specifically, the participants were provided with two sets of 17 statements and they were requested to choose the statements they agreed or to indicate no preferences. Based on their choices, if they agree with over half of the statements related to Holists, they are identified as Holists. Conversely, they are considered as Serialists.

- *Achievement test:* The pre-test and post-test were employed to evaluate the participants' levels of knowledge of the subject domain (i.e., English vocabulary). Each test consisted of 20 items, which asked the participants to fill out appropriate vocabularies according to the given sentences and such vocabularies were introduced in the system presented in the section of "development of a game-based learning system". To enhance the reliability, same vocabularies were applied in both of the tests but sentences that presented the vocabularies in the pre-test were rephrased in the post-test. More specifically, the test item used in the pre-test, e.g., "*An _____ is a round vegetable with many white layers on its inside which have a strong, sharp smell and taste*" was initially developed by a college teacher and then the other college teacher rephrased this sentence as "*An _____ is a round vegetable with many white layers on its inside which have a strong, sharp smell and taste*" in the post-test. By doing so, the test items used in these two tests were compatible in order that the reliability of the results could be enhanced. Regardless of the pre-test or post-test, each test item had 5 point, and the total scores of a test ranged from 0 to 100.

Participants and procedure

To answer the aforementioned research question, a between-subjects quasi-experimental design was conducted. In total, three classes participated in the experiment and they were randomly assigned to the three groups, each of which used one of three levels of game scenarios. Regardless of any groups, all participants (N = 96) were second-year students in a University in Taiwan and they had basic computing skills and Internet experience. More specifically, the first group is control group one (CG1), where 37 participants used the text version; the second group is control group two (CG2), where 27 participants used the text with graphic version; the third group is the experimental group (EG), where 32 participants used the context version. During the experiment, each group needed to follow the procedures below:

- Identification of cognitive styles: All participants of the three groups were requested to fill out the SPQ. According to the results of the SPQ, the participants were furthermore classified into Holists and Serialists. The details are illustrated in Table 2.
- Conduction of the pre-test: The participants were asked to take the pre-test to identify their prior knowledge.
- Brief introduction: Before using the game-based learning systems, the participants were given a 10-minute introduction to the functionality of the game-based learning system assigned to this group.
- Interaction with the game-based learning system: To make students pay attention to the features of subject domain in the game-based learning system, they were asked to do the task sheet. More specifically, the participants were required to learn English vocabularies and then to complete sentences by filling out appropriate vocabularies in the task sheet, which included 20 fill-in-the-blank questions. By doing so, the participants needed to put effort to find those answers from the game-based learning system. In addition, to avoid the topic bias, the questions were designed to cover various topics, including accommodation, food and clothing. Regardless of the system versions, 40 minutes were allocated for each participant to complete the tasks.
- Conduction of the post-test: The participants were further requested to take the post-test to identify their learning performance.

Table 2. Settings of the three groups

	Text version (CG1)	Text with graphic version (CG2)	Context version (EG)
Basic computing skill	From average to excellent	From average to excellent	From average to excellent
Internet experience	From average to excellent	From average to excellent	From average to excellent
Holists/Serialists	27/10	15/12	17/15

Data analysis

The independent variables of the experiment were the game-based learning systems (with three levels of game scenarios) and cognitive styles (with two different styles) whereas the dependent variable was score obtained from the pre-/post-tests. Since the independent variables involves two factors (i.e., game scenarios and cognitive styles), a two-way ANOVA was conducted to examine whether interactions occur between these two factors. Then, the analysis of scores was further carried out from two aspects: within-group and all-groups.

- *Within-group aspect:* Paired-samples t-test for each group was conducted to examine the difference between the pre-test and post-test on each cognitive style group. In addition, one-way analysis of covariance (ANCOVA) for each group was further carried out to examine the difference between Holists and Serialists, with cognitive styles as a between-subject variable and pre-test scores as a covariate.

- *All-groups aspect:* One-way analysis of variances (ANOVA) for each cognitive style was conducted to examine the difference among the three groups, using groups as a between-subject variable. All these analyses were conducted with a Statistical Package for the Social Science (SPSS v20).

Results and discussion

To examine whether interactions occur between these two factors (i.e., game scenarios and cognitive styles), a two-way ANOVA was first conducted. The result showed that no interactions exist ($F_{(1,2)} = 2.315$, $p > .05$) between the two factors. It implies that the two factors only had simple main effects on the students' achievement test. Consequently, the analysis of scores was further carried out from two aspects, i.e., within-group and all-groups.

Holists and Serialists within each group

Table 3 displays the means and *SD*s for the pre-/post-test of each group. The results from the paired-sample *t*-tests indicated that the scores of the post-tests in all groups were all significantly higher than the pre-test scores in these groups, regardless of Holists or Serialists. It implied that students with all of the versions could make significant improvement. This might be because all of the three versions had text and audio, which presented visual and verbal information together simultaneously. As suggested by the dual-coding theory, visual and verbal cues are processed differently to create separate representations (Paivio, 1971). Information coded by the two channels can increase the retrieval efficiency when compared with the information coded in a single channel. In other words, combining two channels, i.e., visual channel and verbal channel, could work better than using one channel only (Clarke & Mayer, 2016).

Table 3. Pre-/post-tests of Holists and Serialists within each group

		Pre-test		Post-test		*t*-test
		Mean	*SD*	Mean	*SD*	
Text version	Holists	29.81	18.42	49.26	14.25	7.934^{**}
	Serialists	28.50	15.10	47.50	12.96	7.125^{**}
Text with graphic version	Holists	28.67	18.94	47.33	19.98	4.920^{**}
	Serialists	29.58	11.17	49.16	12.93	8.093^{**}
Context version	Holists	22.64	12.38	43.23	15.80	8.504^{**}
	Serialists	34.00	20.19	43.33	17.49	4.525^{**}

Note. $^{**}p < .01$.

Furthermore, the one-way ANCOVA was applied to examine whether a significant difference existed between Holists and Serialists within each group, in terms of their improved scores (Table 4). The results indicated that there was a significant difference ($F_{(1)} = 8.181$, $p < .01$) within the context version but such a significant difference was not found within the other two versions. After examining the means difference between Holists and Serialists within the context version (20.59 and 9.33), we found that Holists gained two times scores more than Serialists. In other words, Holists could get more benefits from the context version than Serialists.

Table 4. Improved scores of Holists and Serialists within each group

	Holists		Serialists		*F*
	Mean	*SD*	Mean	*SD*	
Text version	19.44	12.73	19.00	8.43	0.08
Text with graphic version	18.67	14.69	19.58	8.38	0.057
Context version	20.59	9.98	9.33	7.98	8.181^{**}

Note. $^{**}p < .01$.

In short, the results seemed to imply that all of the three versions could foster both Holists and Serialists to improve their learning performance and that the context version was more beneficial to Holists than Serialists. A possible explanation was that Holists preferred to process information in a "whole-to-part" sequence (Jonassen

& Grabowski, 2012). The context version not only provided text and graphic explanations of the vocabulary, but also displayed the surrounding situation, which offered Holists a global picture to guide their vocabulary learning. Thus, the context version matched with Holists' preferences so that they could make great improvement.

On the other hand, the context version might not match with the preferences of Serialists, who preferred to follow a "part-to-whole" sequence. More specifically, the context version provided multiple vocabularies in a situation so that Serialists might feel distracted. In other words, the context version might make Serialists have difficulties in identifying each individual vocabulary. This might be due to the fact that they tended to use a predominantly local learning approach, concentrating on one thing at a time (Ford, 1995). Because of such a local learning approach, they did not leap great improvement in the context version.

Holists and Serialists for all groups

Table 5 displays the means and *SD*s of the improved scores of Holists and Serialists for all groups. To examine how Holists react to the three versions, an ANOVA was further conducted. The results showed that no significance existed among the three groups ($F_{(2)} = 0.096$, $p > .05$). It implied that Holists showed similar improved scores in the three versions. A possible reason was that all of the three versions displayed information in a non-sequential format so Holists were allowed to use a non-linear approach to restructure information. Such an approach matched with internally directed characteristics that Holists possess (Mampadi, Chen, Ghinea, & Chen, 2011). More specifically, Holists are good at re-organizing information to adjust themselves to suit to existing environments (Clewley, Chen, & Liu, 2011), regardless of the text version, text with graphic version or context version. This may be the reason why Holists performed similarly in these three versions.

Table 5. Improved scores of Holists and Serialists for all group

	Text version		Text with graphic version		Context version		*F*
	Mean	*SD*	Mean	*SD*	Mean	*SD*	
Holists	19.44	12.73	18.67	14.69	20.59	9.98	0.096
Serialists	19.00	8.43	19.58	8.38	9.33	7.98	6.568^{**}

Note. $^{**}p < .01$.

Unlike Holists, the results from an ANOVA demonstrated that Serialists showed significantly different reactions to the three versions ($F_{(2)} = 6.568$, $p < .01$), and a further Tukey HSD post-hoc test revealed that Serialists with the text version and the text with graphic version significantly obtained higher improved scores than those with the context version. It seemed to imply that the text version and the text with graphic version, instead of the context version, were useful for Serialists to improve their learning performance. In other words, the context version seemed to be inappropriate to Serialists.

A possible explanation is that the context version offered massive information in the same situation at a time. Such rich information was not appreciated by Serialists, who preferred to concentrate on one thing at a time (Ford, 1995). In short, the context version did not match with their preferences of "part-to-whole" sequence that Serialists possessed. Inversely, the text version, and the text with graphic version offered a predominantly local learning sequence—one vocabulary at a time, which supported the needs of Serialists. Therefore, Serialists could gain great improvement in the text version and the text with graphic version, rather than the context version.

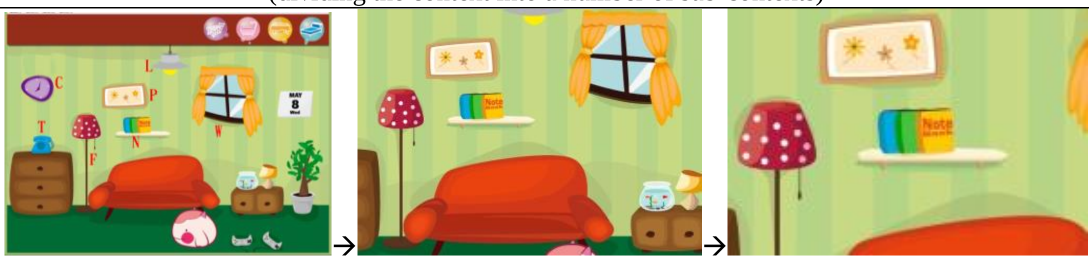
Implication for system design

According to the aforementioned results, three implications for system design could be discussed here. The first implication is about why CG1 (i.e., text version) and CG2 (i.e., text with graphic version) can accommodate the preferences of Holists and Serialists. In CG1 and CG2, all of vocabularies are presented so that Holists can obtain a global picture of the subject content. Consequently, such a way matches with the preferences of Holists so their scores can be significantly improved. Additionally, all of vocabularies presented in CG1 and CG2 are shown in an alphabetical order, which supports Serialists' sequential approaches. In addition to showing these vocabularies (i.e., imagery channel), their pronunciation (i.e., verbal channel) are also offered. According to the dual-coding theory (Clark & Paivio, 1991), their achievements can be significantly improved. This might be the reason why both of CG1 and CG2 can accommodate the preferences of Holists and Serialists.

The second implication is about why the EG (i.e., context version) cannot accommodate the preferences of Serialists. In essence, the vocabularies are presented in a relative complex way in the EG, including the information about vocabularies, the context information and relationships in the scenario, such as their locations, sizes, and colors. Thus, such complex and detailed information does not match with the preferences of Serialists, who tended to take a sequential or part-to-whole learning approach, resulting in some negative influences, such as cognitive overloading or the hesitation for the learning sequence. This reason might explain why the EG cannot support the preferences of Serialists.

Following the second one, the third implication is concerned with how the context version can be adapted to accommodate the preferences of Serialists. Due to the fact that Serialists follow a sequential or part-to-whole approach, the game-based learning environment should include some mechanisms that could guide them step by step. By doing so, they would not be put in a chaotic environment without any guidance. Accordingly, three mechanisms are proposed: index, structure, and story (Table 6). Regarding the index mechanism, students were offered a specific learning path via numbers or letters. For instance, using an alphabetical way to present information can offer students a linear sequential path. Regarding the structure mechanism, the context can be divided into a number of sub-contexts, and then can be presented to students one-by-one. For example, the living room can be divided into three sub-contexts of sofa, television, and bookcase. By doing so, Serialists would not receive a huge number of information at the same time. Regarding the story mechanism, specific objects can be highlighted by the camera movements and can be zoomed in/out. In other words, the story mechanism can use sequencing shoots, which can offer a clear learning path in a context.

Table 6. Three mechanisms suggested for Serialists

Index	 (using an alphabetical way to present information)
Structure	 (dividing the context into a number of sub-contexts)
Story	 (presenting information by the camera movements)

Conclusions

Regarding the research question (i.e., *How do Holists and Serialists react to different levels of scenarios in game-based learning systems?*), the findings of this study revealed that (1) the learning performance of both Holists and Serialists was improved in the three different levels of game scenarios (2) Holists significantly made more improvement than Serialists in the context version of game scenario. It implied that the context version were appropriate to Holists for learning vocabularies whereas the context version were unsuitable to Serialists.

The contribution of this study includes two aspects: theory and application. In terms of the theory, this study deepens the understanding of the importance of cognitive styles in the development of game-based learning. The findings of this study indicated that cognitive style is a key factor that influences student learning in different levels of scenarios. Such findings can not only be used to improve the design of game-based learning systems in the future, but also are able to apply to develop scenario-based learning environments for various subject domains, e.g., language learning (Lin & Lan, 2015), science education (Chiang et al., 2014) and medical education (Pesare et al., 2016). In terms of the application, this study proposes three mechanisms, i.e., index, structure, and story, to support the needs of Serialists. Accordingly, designers can develop a personalized context for game-based learning systems with these three mechanisms. More specifically, we can incorporate the outcome of the SPQ into the development of personalized context, where these three mechanisms will be employed to provide additional support for Serialists.

However, this study has some limitations that should be further investigated in the future. First, this study was a pilot study with short-term treatment duration. However, there is also a need to examine long-term effects in the future. The other limitation is that the sample size of this work is relatively small. Thus, further investigation with large sample size is required. By doing so, we can develop a robust framework for the development of scenario-based learning based on the results of such future works and those of the study presented in this paper.

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