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The Effect of Learning Styles and Scaffolding Strategy on Students' Achievement in a VR Learning Environment

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Abstract. It is commonly accepted that non-native speakers immerse themselves in English-speaking countries, currently thought to be the most effective way for second language acquisition. Nevertheless, the majority of elementary school students in China cannot cover the cost of traveling to a country where the citizens generally speak English. Meanwhile, each individual has its own preferred way to acquire knowledge and retain information, which has been considered as a vital factor for personal performance. Thus, in this paper, a virtual reality game based on children's stories for Chinese elementary students to learn English has been built. Moreover, an experiment has been conducted among fourth grade students by situating the experimental group in the virtual reality game under the guidance of specific learning goals, while the control group learned without any guidance using only the virtual reality game only. The experimental results show that: (1) the post-test score for all students was significantly higher than pre-test scores. (2) The post-test score for the experimental group was higher than the control group. (3) Compared with intuitive learners, the sensory learners tend to spend less time to finish the same task.

Key words: Virtual reality (VR), Educational Game, English Learning, Learning Styles, Scaffolding Strategy Elementary Education.

1. INTRODUCTION

English, a universal language, is a vital factor for professional success as it is deemed to be one of the significant capabilities for competition in many countries around the world [1]. It is commonly accepted that non-native speakers immersed in English-speaking countries is effective for second language acquisition [2]. Nevertheless, the students in China lack the environment to learn English through using English in their daily lives. The question arises as how to construct an Interactive Language Learning environment in China for speeding up the formation of students' English skills.

Game-based learning, especially the environment-based learning method, is a rapidly emerging field, with VR technology becoming widely available. Educators already recognize that virtual reality is quite useful for language learning by offering an immersive space [3] Compared with teacher-centered, grammar-driven instruction, simulating a real-world environment for EFL students to communicate with native speakers is much more meaningful [2]. Besides that, the VR game weaves children' stories into its development with the goal of creating a firsthand experience, not only for learning, but also for entertainment.

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Few English-related games with VR technology already exist to target EFL learners. To our knowledge, our virtual reality game with children's stories is the first VR game for EFL students in a wide release specifically geared toward the learners of the English language without the help of a teacher or an English immersive environment.

1.1 Learning English Using Virtual Reality

Many studies indicate that a 3D game is an innovative alternative to traditional language learning for EFL learners, as it is able to build up the motivation and engagement for learners [4]. Yu-Li Chen revealed that a virtual reality environment with immersion positively affected student language cognition [3]. Susan Jang etc. described direct manipulation of the virtual environment as being more useful for learning than passive viewing [5]. In this experiment, interestingly, the learners with different learning styles could communicate with game characters in English very well in the virtual-reality-based, game-like learning environment (VRGLE).

1.2 Children's Stories for EFL Learners

A previous study found that digital storytelling projects could help student understand their curriculum content efficiently[6]. Interactive CD-ROM storybooks enhance the skill of reading comprehension for pupils as well[7]. Furthermore, ESL preschoolers can acquire new vocabulary significantly through reading storybooks [8]. Abu Rashid concluded that Vocabulary-learning with children's native stories is effective for ESL secondary students [9]. Whereas we want is to help students to make out the plot in all English VR environments using familiar children's stories and learn best by doing so.

1.3 Scaffolding Strategy

Scaffolding could guide students and make sure they can be navigated properly. With the support of scaffolding, students are able to achieve higher levels of achievement and study effectively [10].Applying scaffolds to support students' learning could make positive influence as follows: first, with the supportive interventions, students tend to achieve goals that are usually higher than those without scaffolds [11].Besides, an effective scaffold should not restrict the students' learning process but should be able to enhance their performance [12].In this research, the guidance of learning goals helped students focus on the material which is most relevant to the learning objectives by providing them with the learning goals, key points and difficult points before immersing themselves in the VR game.

1.4 Learning Styles

We all have preference for absorbing information, analyzing information and making decisions from different environments. Educators have showed interest towards various learning styles for many years. Honey and Mumford stated that a learning style could be defined as an individual's preferred way of learning [13]. Besides learning styles were considered as an useful educational tool, each individual has different abilities to capture different types of information, for example some students may be good at

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acquiring aural information, while others may learn well with pictures and tables[14]. Therefore, unique learning environments may help students with their studies.

Felder and Soloman have divided students' learning styles into four dimensions: active style – reflective style, sensing style – intuitive style, visual style – verbal style, and sequential style – global style [15].Gary Cheng indicate that active learner mostly valued the ease of use and usefulness of VR game, and verbal students were mostly satisfied with the communication and identity features in VR game [16]. Additionally, the visual-auditory-kinesthetic model focuses on students' strengths in absorbing information as well [17]. VAK learning style concludes three sensory modes of learning: Visual, Auditory and Kinesthetic. Visual learners learn best by seeing. Auditory learners learn best by hearing, and kinesthetic leaners learn best by doing. Based on research done on what extent virtual reality environments affect the process of exercising spatial abilities for different modal and personality type learning styles, Hauptman and Cohen assumed that the achievement of the visual students were greater, but not significantly [14].

Philip suggested that educational research and resources should be directed toward those educational interventions which demonstrate improvement of student learning. However, there is a lack of evidence to support the efficacy of the Learning Styles hypothesis[18]. Practical classroom implication educators should find a cross-over point where both visual learner and auditory learner can learn best [19]. It is difficult to meet all students' preference in a classroom. And the efforts to study learning style in a classroom are less meaningful. With the advent of technology, educators can put their efforts of learning style onto the individual level. For example, Gwo-Jen Hwang et al. developed two versions of the computer games (a global and a sequential version) to meet the individual's learning style based on the cognitive features of the global and sequential learning styles. And they found that the personalized educational computer game not only promotes learning motivation, but also improves the learning achievements of the students[20].

In this study, the sensing style and intuitive style dimension of Felder-Silverman learning style has been adopted to measure each individual's performance based on an English immersive environment, as it matched with our experiment. And the students' preference can be minimized to an individual level through adaptive technology in the English VR environments rather than measuring the whole group of students' preferences in a classroom. Students with the sensing style are more likely to learn something which is relative to the real circumstance, while students with the intuitive style prefer to have abstract conception.

1.5 The Aim

This experimental study aims to demonstrate that game-based language education with VR technology can help primary grade students with different learning styles learn English. Moreover, the aim of the study is also to find out if the game applied with a scaffolding strategy can develop the skill of English usage.

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2. METHOD

2.1 The Setting and Developed VR Educational Game

In order to explore the achievements and efficiency of students' English learning in a VR environment, we constructed this game-based VR educational game and chose the contents from an English textbook for fourth grade students in China. The game engine was controlled by the HTC Vive Tracker enabling high levels of presence. Figure 1 shows a model of the VR English educational system based on children' stories, which contain a virtual reality environment, a learning materials database, and students' action database. This system was built based on task-oriented learning model, so students were not free to choose where they should begin with. They would follow the task sequence which we arranged and study all the content step by step. If they did not finish a task, they could not go on to the next one. For the learning of English as second language students, the most difficult part is the pronunciation. Therefore, this game demands students to try again if the pronunciation is not correct through speech recognition. However, we offer students hints to help them when they feel it is difficult to pronounce the sentences or finish certain tasks, which can ensure that all the students finish the tasks although with different speeds. Actually, there is no need to provide tasks rigidly, and we prefer to offer hints for learners by cloud computing, as too much anxiety can lead to learners' negative behaviors [21].

One of the important features of this VR game is formative assessment, including immediate feedback and minimized interaction for learners. Besides that, students in this VR game play a role along with completing the tasks, which brings entertainment. In addition, the task for a theme was designed with certain parts, including learning part, practice part and applying parts.

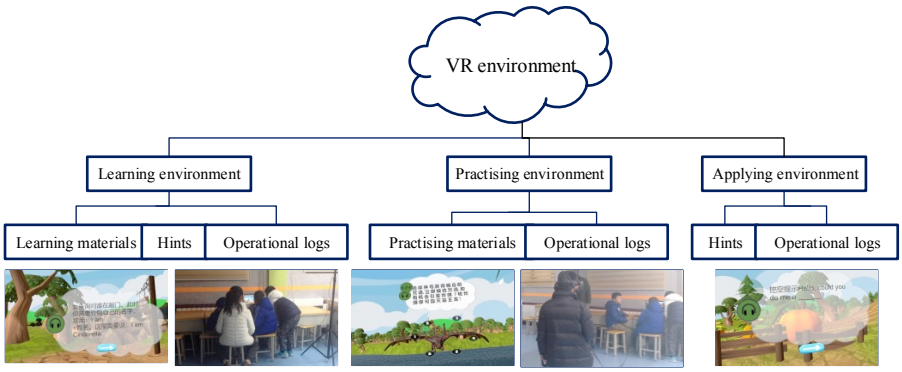

Fig.1 The model of VR English educational system based on children' stories

The game's background story was presented after the students logged into the virtual reality game. The storyline is based on a well-known fairy tale named Cinderella. In this story, Cinderella wants to go to the Prince's ball, but she has no carriage. Cinderella finds a witch who tells her about a magic pumpkin which can be turned into a carriage. The pumpkin can be found at a farm across a bridge. After receiving help from a farmer, Cinderella finds the magic pumpkin.

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The students play the role of Cinderella who requests help from the witch. While speaking to the witch, the students can learn a few sentences, such as, “Could you do me a favor?”, “I want to go to the prince's party, but I have no carriage.”, “It is very kind of you.” and so on. At this point, the system gives the students a study card for each sentence needed to speak to the witch. There is also an opportunity to receive feedback and to allow the students to retry, re-listen and skip each sentence. Students could hear the sentence being read out by clicking the button on both the study card and feedback card. After the students finish this stage, the system would give feedback for the whole conversation in the witch’s house. This feedback card displayed their ranks of achievements and frequency of practice. Before the students cross the bridge, they were asked to defeat the Tyrannosaurus by imitating some English mantras triggering a cannonball. This stage is for practicing the sentences which they have received the lower scores in witch’s house.

When the students arrive at the farm and ask for the farmer’s help, they are provided the opportunity to use the sentences which they have learned in the witch’s house, with the help of hint cards and feedback cards. When they finished the conversation, the system gives them additional feedback. When they find the magic pumpkin, they need to talk to the magic pumpkin as well. This conversation and functions are like those on the farm. After they finish all the tasks, the system provides feedback based on their scores, ranks and coins representing the frequency of practice, their weakness and the top 5 ranks in their class. The framework of the system is shown in Figure 2.

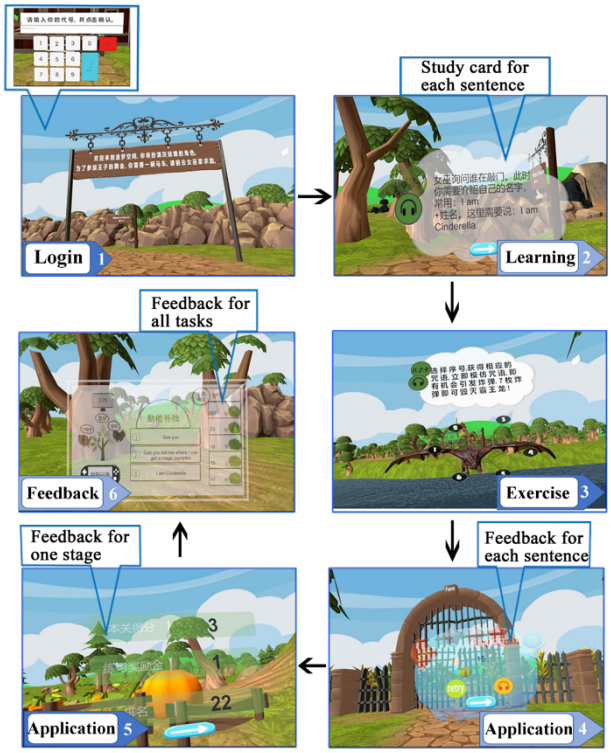

Fig.2 Six screenshots illustrating the VR English educational game

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2.2 Participants

There were 38 fourth grade students who took part in this experiment. All of them were 9 to 10 years old and were studying in the same class at an elementary school in Xi'an, China. 20 students, 13 boys and 7 girls, were in the experimental group while 18 students, 11 boys and 7 girls, were in the control group. All students had at least 3 years of experience of learning English. Most of them learned English using digital game on computers, iPads or mobile phones every week. However, only two of them had previous experience of playing virtual reality game. Usually there are 30 individuals selected in each group. However, a small sample size of 10 to 20 is tightly controlled [1]. A small sample size could help with the individual level. In this study, a sample size of 38 was selected.

2.3 Measuring Tools

The instruments used in this study were the pre-test, the post-test and the questionnaires of learning style for discovering their preferred ways of information acquisition. All the questions in the pre-test were the same as the post-test, and they were used at the beginning and end of the experiment respectively to measure their English performance. Two English teachers in their school have checked and agreed upon all the questions as well.

Students' learning style can be broken into Visual, Auditory and Kinesthetic (V-A-K). Some people possess a preferred or dominant one mode, while some like two modes, and it is also possible that some have three modes. They were classified into the uni-modal(V,A,K), bi-modal(VA,VK,AK) and tri-modal(VAK)[22].The following is the internet link for the VAK questionnaire: http://www.staffs.ac.uk/sgc1/faculty/personal-skills.

For better understanding of the students' learning preferences, we also classified students' personality type by using the Felder–Silverman model, which has four dimensions, including active/ reflective, sensing/ intuitive, visual/ verbal and sequential/global. In this study, the sensing/ intuitive dimension of Felder-Silverman learning style was adopted to figure out how long does each student with certain learning preference finish the same task. And this is the link of the questionnaire: https://www.webtools.ncsu.edu/learningstyles/.

2.4 Data Analysis

In this study, two independent variables of different learning styles were collected, including the VAK learning style and the Felder-Silverman learning style, while the dependent variables were the result of the post-test and the time taken for finishing the task in the VR environment. And all the data was analyzed with IBM SPSS Statistics. Once the data was collected, the method of "one-way ANOVA" was adopted to compare the achievement and efficiency between the two groups and the different learning styles.

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3. EXPERIMENTAL RESULTS

For exploring that the VR English environment is valid, we first collected students' results for the pre-test, and one-way analysis of covariance (ANCOVA) was applied to evaluate students' performances between the experimental group and control group. The assumption of homogeneity of regression was reviewed and no violation was found ($F=1.14$, $P>0.05$). Therefore, the assumption stands and the students' prior knowledge were equal across groups. Figure 3 shows the design of the experiment.

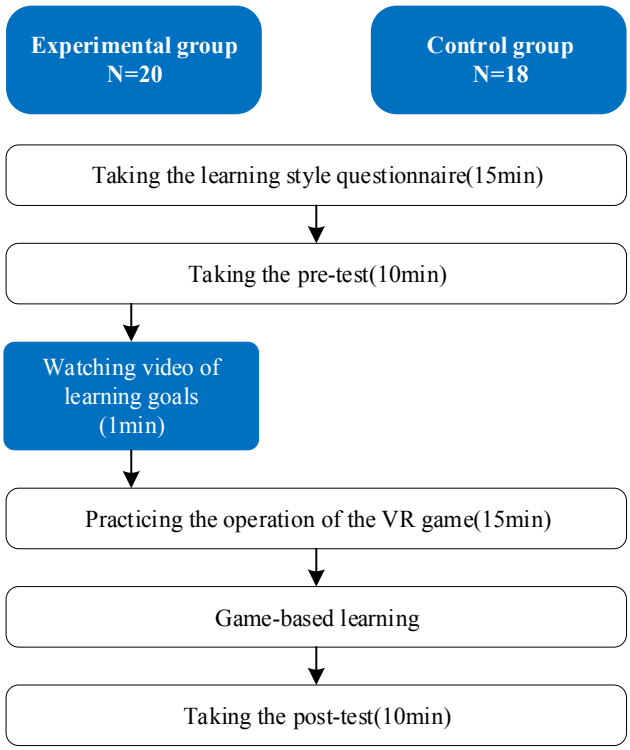

Fig. 3 Diagram of the experiment design

3.1 Analysis Achievement between Two Groups

For better understanding of whether the VR game with children's stories could promote students' achievement of higher levels, two paired-samples T tests were performed, and a significant difference was found for achievement between pre-test and post-test in both experimental group ($t=-5.88$, $P=0.000<0.001$) and control group ($t=-2.61$, $P=0.018<0.05$). The means and standard deviations between two groups were shown in Table1, and there was significant difference between pre-test and post-test scores. That implies the students benefited from the VR English game.

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Table 1. Grade of groups: means and standard deviations

	Pre-test		Post-test	
	M	SD	M	SD
Experimental group	63.60	18.30	77.40	16.28
Control group	56.67	21.70	66.00	15.54

Scaffolding Strategy, telling students the learning goals, can help students to understand the task better and improve their ability. Specifically, it can help them to finish the task by themselves. To better understand whether the Scaffolding Strategy could promote students to perform better, in this study, a one-way ANCOVA was used on the post-test between the two groups. The result is presented in Table 2, showing that students in the experimental group achieved significantly higher than that in the control group ($F=4.85$, $P=0.034<0.05$). This means that students given clear goals performed better in the VR game.

Table 2. The one-way ANCOVA result of the English learning achievement of the two group

	N	Mean	SD	Adjusted Mean	F	η 2
Experimental group	20	77.40	16.28	3.64	4.85	0.119
Control group	18	66.00	15.54	3.66		

*p <.05.

The time that students spent to finish the same task in a VR environment between the two groups was also analyzed. The time taken by the students in the experimental group (Mean=21.69, SD=3.80) was about the same as that in the control group (Mean=23.24, SD=5.20).

3.2 Analysis of Learning Efficiency among Their Learning Styles

Currently, lots of educators pay much attention to student's learning style in a Virtual reality environment, and they agree that students learning style plays an important role in their studies in the VREs. Therefore, in this research the students' learning efficiency was investigated according to their learning style. A total of 38 students took part in the experiment. However, due to a technical glitch, one students' time record went missing. The students were divided into two groups: some students preferred sensing (17 individuals) and students preferred intuition (20 individuals), according to the Felder–Silverman model. To further verify the efficiency between students preferring sending and the students preferring intuition, the one-way ANCOVA was conducted. The results are displayed in Table 3, and there is a significant difference in the test between the two groups ($F=4.55$, $P=0.04<0.05$), implying that compared with the students who preferred sensing, the students who preferred intuition spent more time to finish the same task. So students who preferred sensing learn faster than those who preferred intuition in the VR learning environment.

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Table 3. The one-way ANCOVA result of time spent by students to finish the task in VR game

	N	Mean	SD	Adjusted Mean	F	η 2
Sensory learners	17	21.18	3.54	0.86	4.55	0.115
Intuitive learners	20	24.10	4.61	1.03		

*p <.05.

We also investigated the efficiency of 37 students, including 12 students with uni-modal (V, A, K), 12 students with bi-modal (VA, VK, AK) and 13 students with tri-modal (VAK), by using the VAK questionnaire. All the students have been asked to finish same task in the VR environment. The results revealed that there is no significant difference between the three groups (F=0.46, P>0.05). As for performance, there is no significant difference among different learning styles. In other words, learning English in VR games is beneficial to serial learning styles students.

4 DISCUSSION AND CONCLUSIONS

Previous studies have confirmed that a VR environment could improve student's motivation and enhance their problem-solving ability[23]. And proper Scaffolding Strategies would help with students' achievement and efficiency. Therefore, in this study, a game based virtual reality game was constructed and 38 students were asked to finish the same task in the virtual reality game. In addition, students finished the learning style questionnaire before involving themselves in the VR game.

With the result of the pre-test and post-test, it was concluded that all students would benefit by learning English in a game-based VR environment. Meanwhile the students under the guidance of learning goal had higher performance than those without instructions. While the instruction of learning goal did not maximize students' effectiveness, this may be restricted by the small sample size.

Furthermore, as for the sensory-intuitive domain, the VR game offered a tangible representation of abstract concepts. For example, students can experience the stories and talk in the VR environment, which can help student achieve better understanding towards the abstract conceptions[14]. In this study, students who preferred Sensing were able to finish the task faster than those who preferred intuition, while both groups tend to achieve the same level. That is to say, students with particular learning preference tend to have higher learning efficiency, and for some students they may study more slowly, but they would still achieve the same level. As students with a sensing preference can work more effectively under actual learning circumstances, it is reasonable that they can finish the task faster in the VR environment.

On the other hand, according to the results, it took the same time to finish the task among the students with uni-modal, bi-modal and tri-modal. There is no significant difference of achievement among the three groups as well. That is to say, the students with uni-modal (V, A, K), bi-modal (VA, VK, AK) and tri-modal (VAK) performed similar in the VR English game. This result is reasonable, as previous studies have mentioned that the feature of virtual reality environments are as follows: highly immersive, interactive, visually oriented, highly sensory, and colorful [24, 25, 14].

It should be noticeable however that this study has some limitations. The sample size was relatively small in this study, and the numbers of boys are more than girls, so we

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did not compare the performance between genders. Besides, for most of the participants in this research it was their first time to learn English through a VR game, which could help the VR game to draw their attention easily. So this might help them perform better. We should also notice that no teacher was involved in this research, however teachers play important roles in education. In the future, it would be worthwhile to explore how teachers can use these VR materials to properly help students learn better.

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References

1. Cavus N, Ibrahim D (2017) Learning English using children's stories in mobile devices. British Journal of Educational Technology 48:625-641
2. Chen JC (2016) The crossroads of English language learners, task-based instruction, and 3D multi-user virtual learning in Second Life. Computers & Education 102:152-171
3. Chen Y-L (2016) The Effects of Virtual Reality Learning Environment on Student Cognitive and Linguistic Development. The Asia-Pacific Education Researcher 25:637-646
4. Ak O, Kutlu B (2017) Comparing 2D and 3D game‐based learning environments in terms of learning gains and student perceptions. British Journal of Educational Technology 48:129-144
5. Jang S, Vitale JM, Jyung RW et al. (2017) Direct manipulation is better than passive viewing for learning anatomy in a three-dimensional virtual reality environment. Computers & Education 106:150-165
6. Sadik A (2008) Digital storytelling: A meaningful technology-integrated approach for engaged student learning. Educational technology research and development 56:487-506
7. Doty DE, Popplewell SR, Byers GO (2001) Interactive CD-ROM storybooks and young readers' reading comprehension. Journal of Research on Computing in Education 33:374-384
8. Collins MF (2005) ESL preschoolers' English vocabulary acquisition from storybook reading. Reading Research Quarterly 40:406-408
9. Abrashid R (2012) Vocabulary learning among less proficient young adults using children's Stories. Mextesol Journal 35:15-28
10. Lee C-N (2006) Scaffolding strategies for young learners' EFL/ESL proficiency: focused on task-based activities. Studies in English Language & Literature 32:185-206
11. Schaffer HR (1996) Joint involvement episodes as context for development. An introduction to Vygotsky:251-280

DOI: https://doi.org/10.3217/978-3-85125-609-3-34

12. Behrend DA, Rosengren KS, Perlmutter M (1992) The relation between private speech and parental interactive style. Private speech: From social interaction to self-regulation :85-100
13. Honey P, Mumford A (1992) The manual of learning styles.
14. Hauptman H, Cohen A (2011) The synergetic effect of learning styles on the interaction between virtual environments and the enhancement of spatial thinking. Computers & Education 57:2106-2117
15. Felder RM, Soloman BA (2000) Learning styles and strategies. At URL: http://www. engr. ncsu. edu/learningstyles/ilsweb. html
16. Cheng G (2014) Exploring students' learning styles in relation to their acceptance and attitudes towards using Second Life in education: A case study in Hong Kong. Computers & Education 70:105-115
17. Fleming ND, Mills C (1992) Not Another Inventory, Rather a Catalyst for Reflection. To Improve the Academy:137-149
18. Newton, P. M. (2015) The learning styles myth is thriving in higher education. Front. Psychol. 6:1908. doi:10.3389/fpsyg.2015.01908
19. Willingham, D. T., Hughes, E. M., & Dobolyi, D. G. (2015) The scientific status of learning styles theories. Teaching of Psychology, 42(3), 266-271
20. Hwang, G.-J., Sung, H.-Y., Hung, C.-M., Huang, I., & Tsai, C.-C. (2012) Development of a personalized educational computer game based on students' learning styles. Educational Technology Research and Development, 60(4) :623-638
21. Hwang G-J, Hsu T-C, Lai C-L et al. (2017) Interaction of problem-based gaming and learning anxiety in language students' English listening performance and progressive behavioral patterns. Computers & Education 106:26-42
22. Shenoy N, Shenoy A (2013) The perceptual preferences in learning among dental students in clinical subjects. Journal of clinical and diagnostic research: JCDR 7(8):1683-1685
23. Huang HM, Rauch U, Liaw SS (2010) Investigating learners' attitudes toward virtual reality learning environments: Based on a constructivist approach. Computers & Education 55:1171-1182
24. Bell JT, Fogler HS (1998) Virtual reality in chemical engineering education. In: Proceedings of the 1995 Illinois/Indiana ASEE Sectional Conference :16-18
25. Hale KS, Stanney KM (2014) Handbook of Virtual Environments: Design, Implementation, and Applications. CRC Press, Inc.