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Hao-Chiang Koong Lin,
Sheng-Hsiung Su, Yi-Chun Hsieh,
Shang-Chin Tsai
Taiwan

Impacts of Affective Tutoring System on the Academic Achievement of Primary School Students with Different Cognitive Styles – An Example of Marine Education

Abstract

The study is trying to use ATS (Affective Tutoring System) with emotional calculating technology in the activity of the shell education program. The result is used to study the academic achievement of students with different cognitive styles and system usability. There were 61 fifth-grade children from two different classes participating in this experiment. Every child had to do GEFT (Group Figure-Embedded Test) and academic achievement pre-test before they started the ATS. Then students engaged in ATS learning. Academic achievement post-test was done and the System Usability Scale for Learning Questionnaire after they finished the ATS. The experiment yielded the following results: (1) Learning with ATS not only can give learners an excellent feeling of system usability, but also help learners to promote academic achievement more effectively. (2) According to the system usability and academic achievement, the Field-independent learners were acting better than the Field-dependent learners.

Keywords: *academic achievement, Affective Tutoring System, cognitive style*

Introduction

Research Problem

In this study, we hoped to integrate affective computing into the intelligent tutoring system. With regard to recognizing learners' emotions, image processing, affective computing, and semantic computing are used to increase the recognition

rate so as to obtain the correct information of learners' needs. The purposes of our research were as follows: (1) to discuss the system usability felt by users with different cognitive styles; (2) to discuss the academic achievement of users with different cognitive styles.

Research Focus

Affective Tutoring Systems (ATS)

An intelligent tutoring system (ITS) is a system that provides customized instruction or direct feedback to students through computer analyses. It can replicate the action of real-person tutoring, analyze the students' problems and solving strategies. Ammar et al. (2010) combined the affective computing and intelligent tutoring system to detect and judge the facial expressions for affective computing, to strengthen the interaction in teaching and to help learners increase their interest in and assimilation of learning. The ATS detects the learning status and affective status of students, giving timely affective feedback and guiding learning conditions (Mao, & Li, 2010; Lin, Chen, Sun, & Tsai, 2012). With the development of affective computing technologies, computers can already recognize humans' affection and be applied in all kinds of research (Lin, Hsieh, Loh, & Wang, 2012; Lin, Wang, Chao, & Chien, 2012).

Cognitive Styles

Cognitive styles mainly include personal preferences or feelings, behaviors or ways of doing, cognition and comprehension, for individuals to gradually establish personal learning strategies and form individualized learning styles (Lo & Chan, 2012). In a broad sense, cognitive styles represent individuals' preferences in information experience and organization (Lee, Cheng, Rai, & Depickere, 2005; Chen & Macredie 2002).

Cognitive styles of field independent (FI) and field dependent (FD) is the most complete and widely researched and applied theory in the education situations (Lee, Cheng, Rai, & Depickere, 2005; Mampadi, Chen, Ghinea, & Chen, 2011). Therefore, this study adopts "FI/FD" to categorize users' cognitive styles.

Discourse of marine education

The marine education referred to in this study is aimed at primary school students and defined as follows: The basic philosophy of developing marine education is to foster students' concepts and attitudes toward the ocean through education, for them to be willing to get to know and get close to the ocean, care about marine ecology, and think about marine problems and solve them.

Research Methodology

Research background

The ATS in this research allows students to learn by themselves. With virtual tutoring agents, young museum guides are more motivated to be trained. This study experiments on the teaching material design course, combined with ATS, to discuss the academic achievement and motivation among students with different cognitive styles.

Research samples

The experiment subjects of this study are 2 classes of the fifth grade in elementary school. Prior to the experiment, Group Embedded Figures Test was administered to form different groups. Subjects who scored by 0.5 standard deviation higher than the average were categorized into field independent group, totaling 25 people. Subjects who scored by 0.5 standard deviation lower than the average were categorized into FD group, totaling 20 people.

Research process

There were three stages in this study. The first stage was to establish the research frame and develop research tools. The second stage was to enter the research field and conduct shell teaching activities using the ATS, collecting and organizing the responses in the questionnaire and scales. The third stage was to analyze, summarize and conclude experiment data.

Experiment design

One week prior to the experiment, the students were given embedded figures test and pretest. When the experiment began, the teachers used ATS for teaching and then allowed the experiment subjects to explore and learn. The whole class learned at the same time, and the activities for both classes were the same. Each research subject learned by themselves with the use of a PC with ATS and a web camera installed. After the experiment, the students filled in the system usability scale and questionnaire about academic achievement, and focus group interviews were conducted. Finally, all data were analyzed.

Research tools

In the ATS, course teaching and affective computing are two main schemes, and there are four modules, which are teaching, teaching assistant agents, facial recognition and semantic recognition.

System operation interface

There are five zones, including menu, course presentation zone, facial recognition zone, semantic conversation zone, and teaching assistant feedback zone. The menu includes the written description of the system and parameters for adjusting facial recognition. You can watch courses by clicking the options on the menu. The facial recognition zone starts automatically after the user answers the teaching assistant's first question. In the semantic conversation zone, users can input what they want to say to the teaching assistant. The lowest zone is the teaching assistant's feedback zone. The teaching assistant gives feedback after the data of affection is obtained.

Teaching design

The course content is presented in the format of "electronic books" combined with life experience to introduce how to observe shells, how to collect shells and the relationship between shells and daily human life.

Teaching procedures are divided into three parts for a time period of 65 minutes. (1) In the preparation activity, users input "emotional status" in the semantic conversation box to start the course and facial recognition; (2) In the development activity, learners use ATS to learn by themselves. The system gives appropriate feedback based on facial recognition and the contents in the semantic conversation box. (3) In the general activity, users fill in the questionnaire about academic achievement and system usability scales.

Teaching assistant agent

In this study, a virtual teaching agent is set up in the ATS, serving as the communication channel between the users and system to alleviate the students' learning emotions and to diagnose their learning conditions, giving eight emotional kinds of feedback, including joy, anger, sadness, frustration, surprise, confusion, fear and detestation, to strengthen learning motivation and achievement.

Facial recognition

This study develops the facial recognition module using the open library of EmguCV, with an accuracy rate of 55%, reaching more than a half. The most accurate are joy and surprise, and the secondly most accurate are anger and sadness. The least accurate are detestation and fear. The steps are as follows: (1) Identify the location of the face in the facial recognition zone; (2) Use a classifier to compare emotions; (3) Obtain the emotions.

Semantic recognition

Learners input feelings and conditions of learning in the semantic conversation zone. The system obtains the learners' emotions and proceeds with teaching strategies. The most highly recognized emotions are joy and confusion, and then sadness and surprise. The least recognized are anger and detestation. There are three steps in the recognition method: (1) Establish keyword dictionary; (2) Process information of semantic structures; (3) Obtain emotions.

Research scale and questionnaire

The Group Figure-Embedded Test (GEFT) used for categorization in this study is a speed test, designed for children over 10 years of age and adults. System Usability Scale (SUS) is used to test the users' subjective feelings toward the system. The questionnaire for learning achievement in this study is self-designed, with a pretest questionnaire and a posttest questionnaire. The purpose is to discuss if using ATS has influenced the users' academic achievement, and the content validity is based on expert validity.

Data Analysis

This study uses Triangulation Design to collect quantitative and qualitative data simultaneously, including user observation, questionnaires and interviews, all adopted to explain the research achievement, to increase reliability and validity.

We used SPSS17.0 as the quantitative data analysis tool to analyze the quantitative data. Explained as follows:

Descriptive statistics

Cognitive styles and system usability are presented by averages, standard deviations, skewness and kurtosis in the descriptive statistics for the understanding of the students' performance in this study.

Reliability analysis

Cronbach's α was used to analyze the internal consistency reliability of the research tools, "System Usability Scale" and "Questionnaire for academic achievement," to ensure reliability.

Independent-Samples t Test

Independent-Samples t Test was used to test the variation of academic achievement in the shell course and system usability among the students with different

cognitive styles when using ATS, to find out if the research purposes were reached and research questions solved.

Analysis of covariance (ANCOVA)

One-Way Analysis of Covariance for Independent Samples was applied to see if there were still variations in the averages of different groups after explanations of the covariates were excluded.

Data analysis of interviews

This study conducted focus group interviews after the experiment ended. The interviews were transcribed for data analysis. Data was entered by open coding in the grounded theory, to supplement the inadequacy of the questionnaire survey. In the course of coding, the interview contents and users' interests in using the system and system usability were related, and thus those were used for axial coding. The axial coding for system usability was coded as "C1;" interface design "C2;" users' intention "C3."

Research Results

Analysis of research subjects' current conditions

Statistics analysis of cognitive styles

The cognitive styles defined in this study are the FI style and FD style proposed by Witkin et al. (1977). Table 1 shows the distribution of the research subjects' cognitive styles.

Table 1. Distribution of subjects with different cognitive styles.

Class	Field independent	Field dependent	In--between	No. of people	Average	Standard deviation	M+1/2D	M-1/2D
5–2	11	11	9	31	11.3115	4.4742	13.5486	9.0744
5–3	14	9	7	30				
Total	25	20	16	61				

Statistics analysis of the research subjects' pretest

In this study, a self-designed questionnaire for academic achievement was used as the pretest questionnaire. The obtained data was analyzed using independent-

samples t-test, to examine whether there were significant differences in the entry ability between the FI style and the FD style. Table 2 shows that it did not reach the significant level (p >.05), meaning the entry abilities of the two groups were similar.

Table 2. Independent-samples t-test of the research subjects' pretest

	Cognitive style	Number	Mean	SD	t test	
					t	Significance
Pretest for academic achievement questionnaire	Field independent	25	7.20	2.291	1.644	.107
	Field dependent	20	6.10	2.150		

Analysis of system usability

The Cronbach α of the system usability scale used in this study is 0.735, indicating that this scale is highly stable and has internal consistency, and thus it has good reliability.

System usability scale-descriptive statistics results

The statistics of each item was obtained, with more than 80% of the people believing they learned to use this system very quickly and easily, indicating that this system is easy to learn.

Comparison of system usability between two groups

To further analyze the usability differences between the two groups, independent-sample test was done for the FI style and FD style. The results are shown in Table 3. The average value (M=67.8) of the FI group is higher than that of the FD group (M=61.5), p = 0.034 (<.05), meaning that there are only slight difference in the system usability between the FI group and the FD group, both accepting this system. It means that the FI group has higher satisfaction in usability.

Table 3. Analysis of results of the independent samples

	Group	Numbers	Mean	SD	Standard error	Significance
System usability	Field independent group	25	67.8	8.789	1.758	.0034*
	Field dependent group	20	61.5	10.079	2.254	
	All	45	65	9.8	1.461	

Note: * means p < 0.05 **means p<0.01 ***means p<0.00

Verification of academic achievement

Cronbach's α obtained in this questionnaire about academic achievement is 0.71, meaning that the scale has very good reliability.

The academic achievement of ATS

Table 4 shows the academic achievement improved by the teaching method of ATS: p=0.000 (p < 0.001) is significant, with effect size d=0.77, between 0.5 and 0.8, belonging to middle-to-high significance.

Table 4. General academic achievement influenced by ATS

Total scores	Number	Mean	SD	t value	Significance (p)	Effect size (d)
Pretest	45	6.71	2.273	-4.604	.000***	0.77
ATS-posttest	45	8.84	3.169			

Note: *means p<0.05 ** means p<0.01 *** means p<0.00

Observing the performance of each group, as shown in Table 5, the average (M=9.88) of the posttest score for the FI group is higher than the pretest average (M=7.20) by 2.68, with a significance of p=0.000 (p<0.01), effect size d=1.07(d>0.8), which shows dramatic significance. The ATS has dramatic and positive significant improvement in the academic achievement of the FI group.

Table 5. Academic achievement of the FI group after affective tutoring

Scores of field independent group	Number	Mean	SD	T value	Significance (p)	Effect size (d)
Pretest	25	7.20	2.291	-4.411	.000***	1.07
ATS-posttest	25	9.88	2.713			

Note: *means p<0.05 ** means p<0.01 *** means p<0.001

The FD group's scores are shown in Table 6. The average score (M=7.55) of their posttest is higher than their pretest average by 1.45, with a significance of p=0.000(p<0.01), effect size d=0.52 (between 0.5~0.8), indicating that the ATS has middle-to-high significant improvement in the academic achievement of the FD group.

Table 6. Academic achievement of the FD group after affective tutoring

Scores of field dependent roup	Number	Mean	SD	T value	Signifi-cance (p)	Effect size (d)
Pretest	20	6.10	2.150	-2.067	.000***	0.52
ATS-posttest	20	7.55	3.284			

Note: * means p<0.05 **means p<0.01 ***means p<0.001

The comparison analysis of the two groups' academic achievement

The academic achievements of the course range studied are analyzed through the score difference of the two groups, as shown in Table 7. The FI group shows a higher progressed score (M=2.68), with significant difference (p=0.000, <0.01), indicating that the students with the FI style show a significant positive effect after using the ATS. Observing the effect size, although the FD group shows improvement, it is lower than that of the FI group. As a whole, the two groups of students show a significant positive effect (d=0.77) on learning through the ATS.

Table 7. Comparison of academic achievement between two groups of students

Group	Number	Improved score mean	SD	ES(d)	Signifi-cance
All	45	2.13	3.109	0.77	0.000***
Field independent	25	2.68	3.038	1.07	
Field dependent	20	1.45	3.137	0.52	

Note: *means p<0.05 **means p<0.01 ***means p<0.001

Discussion

The researcher conducted the experiment and participant observation. The results show that the students showed enthusiasm different from normal school days when the course was taught through this system, especially about the semantic emotion recognition, where they kept inputting conversation to test the agent's response to. In facial detection, perhaps because the experiment environment was an open space, they did not show animated expressions. It is apparent that the design of interactive agent affects learners' interests in using it. In addition, it

was found that when the students had this course they all showed attentive facial expressions. They had discussion and mutual help more frequently than usual. Improvement of the students' learning interests and attitudes is evident. The course was presented with both pictures and texts, which increases the students' interests in learning (Infante, et al., 2009).

The two groups of students show significant differences in academic achievement before and after the experiment. This system not only helps with continuous learning, but also results in good academic achievement.

The subjects of the FI style show better academic achievement than the subjects of FD style. Within the course range studied, the results of qualitative and quantitative analyses both show that the ATS is of great benefits to the learners. For the learners of the FI style the influence is greater. It is inferred that the course used in this study is a subject in natural science, and this corresponds to the characteristics of the learners of the FI style preferring natural science and mathematics. Also, the ATS is individualized and adaptive learning, which meets the feature of "independent self-learning" of students with the FI style.

Conclusions

Analysis reveals that all the subjects show a good system usability experience towards the ATS. Within the course range studied, the subjects of the FI style had a higher satisfaction with system usability than the subjects of the FD style, but the difference was not dramatic. This shows that the ATS is a learning system that provides a good system usability experience. The student subjects built a good relationship with the tutoring agents, and talked about the course fervently with their classmates. For students who are shy or have low learning efficiency, this system is a teaching model that improves learning efficiency and helps improve the interpersonal skills effectively. This shows that the ATS can improve the students' learning attitudes.

Our research provides a new direction for integrating information technology into instruction to increase teaching interaction. After interviewing, it was found that the students showed a strong interest in the course presented as "digital books." If teaching courses are presented in digital books for students to learn by themselves, it will be another innovation for integrating information technology into instruction (Frias-Martinez, Chen, & Liu, 2009; Samah, Yahaya, & Ali, 2011; Mohd, Shahbodin, & Hanapi, 2013). The ATS is a one-on-one system. Students use their study halls time freely according to their own progress. The students in our

research praised this learning method and had no difficulty interacting with the agents, to improve their academic achievement and learning interests effectively (Tamim, et al., 2011).

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