The Effect of Affective Tutoring System in the Teaching of Dengue Fever Epidemic Prevention Curriculum on the Cognitive Loads and Learning Outcomes with Different Levels of Information Literacy

Hao-Chiang Koong Lin, Meng-Chun Tsai, Chia-Hsun Lee

Department of Information and Learning Technology, National University of Tainan, Taiwan
koonglin@gmail.com, cherrybearpipi@gmail.com, cs1326@csps.kh.edu.tw

Abstract

As the traditional teaching method is mainly textbook based and face-to-face oriented, it tends to cause students' negative emotions and learning effectiveness in their learning process even though a commonly fact that emotion is one of the important factors affecting learning. The purpose of this study is to establish an affective tutoring system (ATS) for dengue fever to assist seeded teachers to propagandize dengue fever epidemic prevention. The researchers used the "Questionnaire of Elementary School Students' Information Literacy" and "Questionnaire of Elementary School Students' Cognitive Load Scale" as the tools for the quantitative study of this teaching experiment. The comprehensive evaluation results of this study showed that the affective tutoring system for dengue fever is supported in improving students' learning outcomes; students with different information literacy have significant differences in the interface operation aspect of cognitive load, but not in the overall cognitive load, the content aspect of cognitive load and learning outcomes; the student's information literacy and cognitive loads were correlated with the supports of partial significant negative correlation in the quantitative analysis; while the correlation among the students' information literacy, cognitive loads and learning outcomes is not supported in the quantitative analysis.

Keywords: Affection Tutoring System, Dengue fever, Information literacy, Cognitive load, Big six skills

1 Introduction

With the confirmation of the World Health Organization [1] that the Dengue fever (DF) is a mosquito borne virus infection, called dengue virus (DENV), and the incidence of dengue fever has increased dramatically in the world over recent decades. Now, about half of the world's population is at risk. It is estimated that the number of annually infected persons is 100-400 million. In some Asian and Latin American countries, severe dengue fever is the main cause of serious diseases and deaths. DENV is transmitted by two kinds of vector mosquitoes, i.e. "Aedes aegypti" and "Anopheles albopictus" [2] with different breeding environment respectively. In 2015, a largest dengue outbreak with high morbidity and mortality occurred in Taiwan [3]. DENV replicates within mosquitoes and spreads rapidly from one person to another through female Aedes mosquito bites [4-5]. Realizing that prevention in advance is much easier than remedy afterwards, the Centers for Disease Control of Taiwan has been striving to prevent the spread of dengue fever in the very first time in the hope of cultivating students' correct and effective epidemic prevention consciousness since their childhood. Meanwhile, the traditional teaching method is mainly textbook based and face-to-face oriented, tending to cause students' negative emotions and learning effectiveness in their learning process even though a commonly known fact that emotion is one of the important factors affecting learning. Therefore, an affective tutoring system can be utilized to identify students' current emotional states through the interaction with students, on which to give students feedback and adjust the curriculum pace.

In this study, an affective tutoring system (ATS) is proposed, where the semantic emotion recognition mechanism is adopted to promote user interaction. Incorporating with the "Dengue Fever Epidemic Prevention" course, an ATS system for dengue fever is therefore developed. With the help of this innovative teaching mode, students' participation and learning motivation are improved. The purpose of this study is to explore the interaction between the cognitive load and learning outcomes of students with different information literacy in their learning process It is expected that this study will provide teachers with more diversified epidemic prevention curriculum

*Corresponding Author: Meng-Chun Tsai; E-mail: cherrybearpipi@gmail.com
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models and contribute to Dengue fever epidemic prevention education; consequently, this study explores the following issues:

(1) To explore what the current states of students' information literacy are, and what their self- aware cognitive loads are when using ATS teaching?

(2) To explore whether ATS teaching can improve students' learning outcomes.

(3) To explore whether there are any differences in the cognitive loads of students with different information literacy when using ATS teaching.

(4) To explore whether there are any differences in the learning outcomes among students with different information literacy after using ATS teaching.

(5) To explore whether students' information literacy is correlated with their cognitive loads and learning outcomes respectively.

2 Literature Review

2.1 Research and Application of Emotion Recognition

Researchers can measure human emotions in a scientific way by using multiple emotional medias, and using the methods of psychology and statistics, the original chaotic physiological signals or fragments of sentences can be transformed into a reference for emotion recognition. Wang and Guan [6] used Mahalanobis distance to select the representative feature values of speech and facial features, and set up the feature value's being greater than 50% as a benchmark of emotion recognition. In recent years, researchers have shifted their focus from emotional recognition process to emotional tutoring process [7].

Affective Tutoring System (ATS) originated from the development of Intelligent Tutoring System (ITS), is expected to improve the adaptability of ITS [8-9], thereby helps learners learn in a way that can effectively adjust their emotional states like what a real person does [10-11]; the purpose thereof is to arouse learners' motivation and improve their participation and self-confidence [12-14]. Learners can achieve significant learning outcomes in the aspects of knowledge and learning through ATS [15]; in the process of learning, learners' emotions, such as joy, frustration, surprise, curiosity and doubt, have a strong correlation with and influence on learning experience [15-18]. Picard provided a conceptual module that can affect learners' learning emotions. It can identify learners' emotional states, give timely feedback, and improve learners' learning [19-20].

As a result, we can know that ATS can detect learners' learning states and emotional states, give learners appropriate feedback by identifying their different emotions, and help rectify learners' learning states and emotional states [21-23]. ATS has been applied in general disciplines, technical fields and social behaviors, showing that ATS does have room for further development and research. However, no research related to epidemic prevention propaganda has been found yet in ATS application and research categories, thereby triggered the idea of this study.

2.2 Information Literacy (IL)

Information Literacy (IL) is the basis of lifelong learning and a set of abilities requiring individuals to recognize when information is needed and have the ability to locate, evaluate, and use effectively the needed information [24-27]. It is defined as the ability of individuals to collect, evaluate and use information from large resources [28-29]. It covers all disciplines and learning environments, enabling learners to effectively evaluate and manage information and better control their learning process [30]. It is also an ability to actively construct knowledge rather than passively accept knowledge, and plays a key role in conceptual understanding [31-34]. At present, it is widely used in K-12 information literacy standards internationally.

In order to effectively evaluate the problem-solving ability of students, this study adopts the Big Six Skills proposed by Eisenberg and Berkowitz [35], as shown in Figure 1. Yi chin Chou [36] also believed that the information literacy standard of elementary school students, both at home and abroad, is still mainly based on Eisenberg's "Big Six Skills" theory, to cultivate students to find information needs, seek information, analyze and present information, so that students can have the ability to understand and effectively use information technology, and then do self-study and lifelong learning. In this study, the measurement tools based on Big Six Skills theory are used.

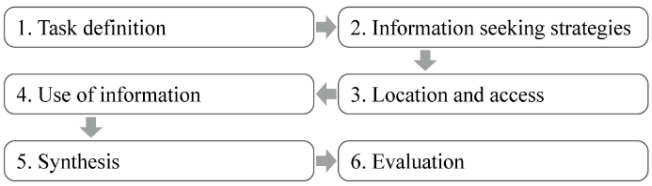

Figure 1. Big six skills

2.3 Cognitive Load

In 1988, Australian scholar Sweller [37] proposed the Cognitive Load Theory, which refers to three types of cognitive load generated in the process of working memory operation, i.e. intrinsic cognitive load, extraneous cognitive load and germane cognitive load. This theory has opened up a new category of cognitive psychology. The teaching principle of this theory is based on the long-term memory and working memory hypothesis of human cognitive framework [38]. Cognitive load theory emphasizes that in the process of learning, all novel information is initially processed by working memory, but working memory has the

limitation of capacity and duration [39-40]. According to Sweller [41], if the teaching design and teaching content exceed the working memory capacity of learners, then learners will generate cognitive loads, which will also damage learners' ability to understand, think and learn, With the aforesaid definition and basic assumptions of cognitive loads, cognitive loads could be further understood.

3 Research Methods

3.1 Participants

In this study, 77 fifth and sixth graders from a public elementary school in Kaohsiung City, Taiwan, were selected for questionnaire, wherein 70 questionnaires were recovered with 4 invalid ones due to incomplete data and answers, which made a total of 66 valid ones (32 female and 34 males; aged between 11 and 12). In order to reduce the influence of external factors on students' overall emotions, the experiment was conducted in the school's computer lab. SPSS software was used to analyze the questionnaire in this study.

3.2 System Development

The ATS for dengue fever is developed based on the teaching content of dengue fever epidemic prevention course produced and distributed by the Taiwan's Environmental Protection Administration, together with the introduction of the related modules mainly based on semantic emotion recognition. The system is divided into two main axes: emotional operation and course teaching.

3.2.1 ATS for Dengue Fever

The threshold of semantic recognition equipment is not high but more universal. Users are allowed to use just the keyboard and mouse to convert their current emotions into text entering the system for analysis. In the ATS for dengue fever, a semantic recognition module is applied to recognize students' sentimental keywords defined in a sentiment lexicon, wherein the SeCeVa (Semantic Clues Emotion Voting Algorithm) proposed by Lin, Hsieh, Loh and Wang in 2012 [42] is adopted as a method of sentiment recognition. Learners can enter their current learning emotions and situations in the system dialog box, and the system can immediately identify learners' emotions and provide appropriate interaction accordingly. The setup method and operation process are as follows: (1) Building keyword dictionary; (2) Processing semantic structure information; (3) Getting emotions, as shown in Figure 2.

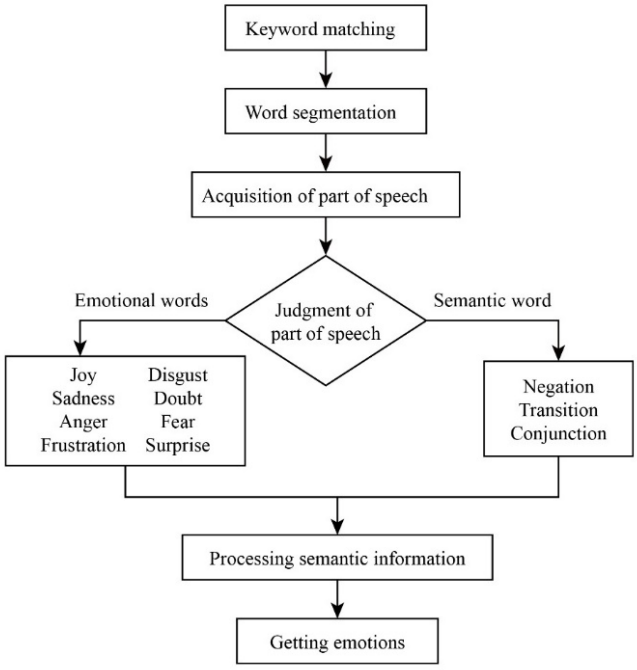

Figure 2. Flow chart of the method of building semantic recognition module and its operation

Sentiment lexicon vocabulary is established by using the vocabulary of students' general sentiment lexicon and referring to the vocabulary of "Academia Sinica Balanced Corpus of Modern Chinese" developed by Academia Sinica to classify relevant emotions and parts of speech. By integrating six emotion classifications provided by Ekman with eight learning states provided by other scholars, the sentiment lexicon vocabulary is further categorized as: Joy, Sadness, Anger, Surprise, Frustration, Doubt, Disgust and Fear, which is shown in Table 1.

Table 1. Sentimental keyword classification table

ON	COE	DCK	NE
1	Joy	kuài lè (happy), hěn bàng (excellent), and so on.	Sadness (Negative emotion)
2	Sadness	shāng xīn (heart-broken), bēi āi (woeful), and so on.	Joy (Positive emotion)
3	Anger	qì fèn (indignant), shēng qì (angry), and so on.	Joy (Positive emotion)
4	Surprise	jīng huáng (trepidation), jīng yà (surprised), and so on.	Non positive and negative emotions
5	Frustration	méi rén yào (unwated), kě xī (pity), and so on.	Joy (Positive emotion)
6	Doubt	kùn huò (perplexed), huái yí (distrust), and so on.	Joy (Positive emotion)
7	Disgust	tǎo yàn (hate), yàn wù (detest), and so on.	Joy (Positive emotion)
8	Tension	jǐn zhāng (nervous), zhāo jí (anxious), and so on.	Joy (Positive emotion)

Note. ON=Ordinal number, COE=Classification of emotion, DCK=Defined Chinese keywords, NE=Negative Emotion.

Based on the Chinese grammatical framework, the short sentences entered by the learners for semantic analysis and recognition should be processed against three semantic structures: semantic negation, semantic transition and semantic conjunction, wherein semantic negation and semantic transition are the very important basis on which the judgment of semantic emotion is affected; taking the Chinese sentence, "wǒ bù gāo xìng (I am not happy) "as an example, if we only see the emotional word "gāo xìng (happy)" in the literal sense of the word without recognizing the semantic negation of the word "bù (not)," we would misunderstand learner's original intention. In this study, we refer to Lin et al. (2012) to sort out the available vocabulary for the semantic framework and expand the sentiment lexicon.

"Ambiguity" is a special feature in the process of Chinese word segmentation, which might cause different word segmentation results. For example, when "tài kōng rén (astronaut)" appears in the sentence, different segmentation results such as "tài kōng rén (astronaut)" or "tài kōng (outer space) rén (person)" will be produced due to semantic ambiguity. This system adopts the rule of "long word priority" to avoid this problem.

After the learners input the sentences into the system, the system would first match the keywords of the sentences. System uses the word segmentation method to divide a sentence into several word strings. Following that, the system judge the emotions and semantics according to the content of the word strings, and determines the final emotions according to the semantic structure to achieve the accuracy of judgment. As semantic negation, transition and conjunction will affect and change the result of emotions expressed in the sentence, in this study the system would perform a logical analysis of semantic emotions to find out whether the semantic words in the sentence change the dimension of emotion. Figure 3 show the screenshots of system display.

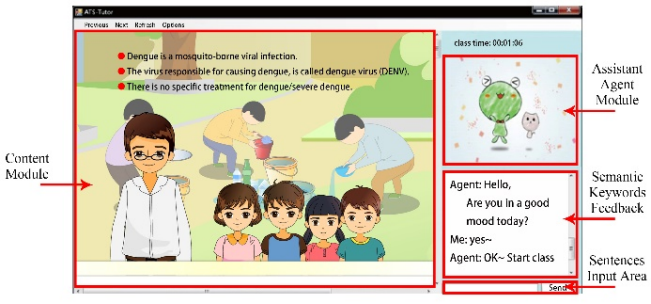

Figure 3. Screenshot of the analysis system

Therefore, the system tests and trains related sentences iteratively to define the related logic rules, wherein it is found that more than two kinds of emotions are bridged by semantic transition and semantic conjunction so that the emotional semantic collocation analysis is carried out, as shown in Table 2.

Table 2. Table of structure of emotional dimension

ON	SED	DEJ
1	Positive + Transition + Negative	Judge the emotion undergone semantic transition as the actual emotion
2	Negative + Transition + Positive	
3	Positive + Conjunction + Positive	Positive emotion
4	Positive + Conjunction + Negative	Do not deal with compound emotions.
5	Negative + Conjunction + Positive	
6	Negative + Conjunction + Negative	Negative emotion

Note. ON=Ordinal number, SED=Structure of emotional dimension, DEJ=Definition of emotional judgment.

Having undergone the above processing procedures, users' emotions are obtained through their sentences input at the time, and feedback is given, and the appropriate teaching strategies are then selected.

3.2.2 Curriculum Teaching

The curriculum teaching is divided into three modules: Assistant agent module, Dengue fever epidemic prevention teaching material module, and Teaching strategy module. In the assistant agent module, the assistant agent can give learners appropriate feedback in time through the assistant agent as a medium of information exchange between learners and the system, and by the informing learners of the current actions of the system or understanding learners' needs, which is a two-way interactive process, having the emotional feedback (such as happiness, sadness and doubt). Therefore, the assistant agent can help learners to enhance their learning motivation, and give guidance related to the system or the course at the end of each learning stage or the whole course. The Dengue fever epidemic prevention teaching material module includes the dengue epidemic prevention courses, which are presented with different manners according to the difficulty of course content. There are three units in total; there will be a unit test at the end of each unit; if students fail in the unit test, the assistant agent will immediately give them encouragement and feedback and start the review mechanism, or the assistant agent will immediately give the ones who pass in the unit test positive feedback and start the next unit. In the teaching strategy module, the strategy of rectifying users' negative emotions in learning is adopted during the recognition of their emotions according to the sentences they input. When the system detects that the learners' active and/or passive emotions are negative and reach the preset threshold value, the system will temporarily suspend the course, and switch to the joke website, and resume the original course again 2 minutes later, whereby the learning outcomes can be improved, as shown in Figure 4 and

Figure 5. The system has a prevention mechanism, which would immediately enter a unit test in case the number of times that students temporarily stop the course at the ATS exceeds a default threshold. If the student cannot pass the unit test, the system would return to the unit course and pause the emotion detection.

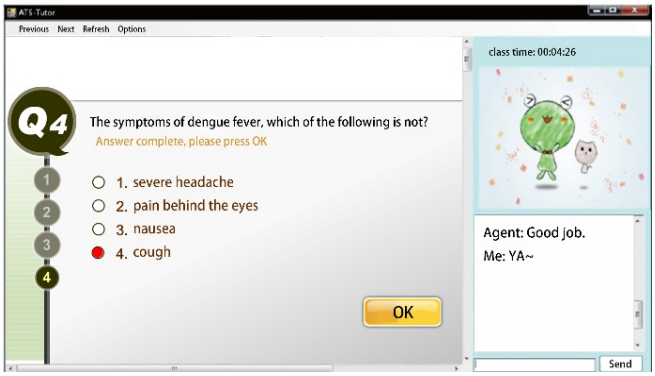

Figure 4. Screenshot of the interaction between assistant agent and learners

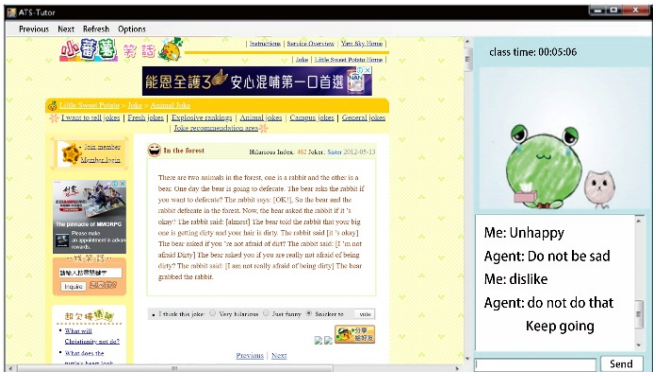

Figure 5. Web page screenshot of the strategy of rectifying learning emotion

3.3 Study Tools

3.3.1 Questionnaire of Elementary School Students' Information Literacy

In this study, Chou's [35] questionnaire was used to measure students' information literacy. It was divided into six dimensions with 30 questions in total: The ability to retrieve information, the ability to identify problems, the ability to seek information, the ability to use information, the ability to synthesize information, and the ability to evaluate and share information. In the questionnaire, the 4-point Likert Scale was used (1: Strongly Disagree, 4: Strongly Agree). Through factor analysis, 30 questions of the questionnaire were categorized into six factors, and the six factors of the questionnaire can explain 52.653% of the total variance, which shows that the questionnaire has good construction validity. The reliability of the questionnaire was further tested by Cronbach α coefficient, and the internal consistency α value is .917, which shows that the questionnaire has stable reliability.

3.3.2 Questionnaire of Elementary School Students' Cognitive Load Scale

In this study, the "Questionnaire of Elementary School Students' Cognitive Load Scale" compiled by Wei [43] was used to measure the cognitive loads of elementary school students when using ATS teaching, wherein the content framework is divided into two dimensions of "Cognitive load of content" and "Cognitive load of interface operation" after referring to relevant literature and theories, with 12 questions in total. The questionnaire was compiled according to the 6-point Likert Scale, where the score was calculated from "totally disagree" 1 to "totally agree" 6, wherein the higher the score is, the higher the cognitive load is; and conversely the lower the score is, the lower the cognitive load is. Through factor analysis, 12 questions of the questionnaire were categorized into two factors, and the two factors of the questionnaire can explain 54.076% of the total variance, which shows that the questionnaire has good construction validity. The questionnaire also tested the reliability of the questionnaire with Cronbach α coefficient, and the internal consistency α value is .651, which shows that the questionnaire has a stable reliability.

3.3.3 Test on the Knowledge of Dengue Fever Epidemic Prevention

The results of the dengue epidemic prevention knowledge test are the basis of learning effectiveness analysis. Since the purpose of this study is to explore the differences in students' learning outcomes after using ATS teaching, the test questions were taken from the test questions attached to the EPA's teaching materials, with only change in their numbering, so as to facilitate the analysis and comparison of learning outcomes. Regarding the test content architecture, the test content consists of three parts: the part about the characteristics and habits of dengue vector mosquitoes, the part about the characteristics of dengue fever and the part about the concept of dengue epidemic prevention, with 12 questions in total. The full score is 100, so the mean score of each question is 8.33.

3.4 Procedure

ATS Teaching and Questionnaire Implementation

The teaching experiment adopted the one-group pre- and post-test design. After obtaining the authorization of the questionnaires of Chou [36] and Wei [43], the researcher first gave the information literacy questionnaires and then the dengue epidemic prevention tests in the school before the ATS teaching started so as to obtain the students' pre-test results, while the same process was repeated four times according to the class order. After ATS teaching was

given, the cognitive load questionnaire and dengue epidemic prevention test were carried out immediately to obtain the students' post-test results, while the same process was repeated four times according to the class order. The entire teaching experiment lasted for two weeks. In this study, students were grouped according to their scores of information literacy, where the students with scores of top 27% were grouped as the high score group, the students with scores of bottom 27% the low score group [44]. The process of teaching, questionnaire and test implementations is shown in Figure 6, while the test implementation is shown in Figure 7.

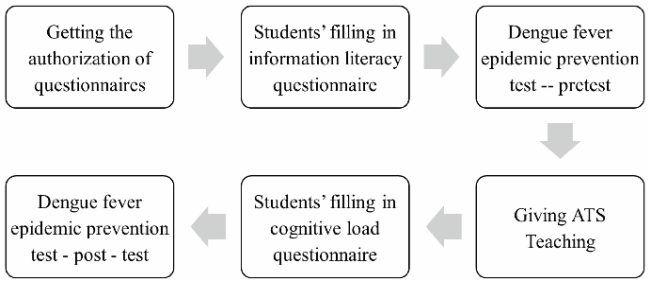

Figure 6. Flow chart of teaching, questionnaire and test implementations

Figure 7. ATS teaching formally given to the fifth graders and sixth graders

4 Data Analysis

4.1 Analysis of Current Situation of Students' Information Literacy and Cognitive Loads

According to Table 3, for the overall information literacy, the mean score of each question was 3.34, which showed that the information literacy of the elementary school students was still good. The score of each factor was greater than the mean score of 2.5, and the mean score of single question was between 2.87 and 3.58, which indicated that the experience extent of elementary school students in various factors of information literacy was between "partially disagree" and "partially agree". In addition, among the mean scores of single factor, the highest was at the factor of information retrieval (M = 3.58), followed by the factor of seeking information (M = 3.42), the factor of problem identification (M = 3.24), the factor of information synthesis (M = 3.10), and the factor of information usage (M = 3.07), and the lowest was the factor of information evaluation and sharing (M = 2.87).

Table 3. Summary table of current situation analysis of students' "information literacy questionnaire" (N = 66)

Scale item	MS	SD	NQ	MSQ	SDQ
Information retrieval	21.45	2.66	6	3.58	.44
Problem identification	19.44	3.61	6	3.24	.60
Seeking information	13.70	2.11	4	3.42	.53
Information usage	21.48	3.25	7	3.07	.54
Information synthesis	18.61	4.11	5	3.10	.69
Information evaluation and sharing	5.74	1.92	2	2.87	.96
Overall information literacy	100.45	14.31	30	3.34	.48

Note. MS=Mean score, SD=Standard deviation, NQ= Number of questions, MSQ=Mean score of single question, SDQ=Standard deviation of single question.

According to Table 4, for the overall cognitive load, the mean score of each question was 2.44, which showed that the cognitive loads of the elementary school students given ATS teaching was to a medium low degree. Among the mean scores of single question in each aspect, the aspect of content scored higher (M = 3.76), which showed that the elementary school students' cognitive loads in content aspect was between "slightly disagree" and "slightly agree," while the aspect of interface operation scored lower (M = 2.00), which indicated that the elementary school students' cognitive loads in interface operation aspect were roughly "mostly disagree"

Table 4. Summary table of situation analysis of students' "cognitive load questionnaire" (N = 66)

Scale item	M	SD	NQ	MSQ	SDQ
Content	11.29	4.24	3	3.76	1.41
Interface operation	18.00	7.66	9	2.00	.85
Overall cognitive load	29.29	9.08	12	2.44	.76

Note. M=Mean, SD=Standard deviation, NQ=Number of questions, MSQ=Mean score of single question, SDQ= Standard deviation of single question.

4.2 Learning Outcomes of ATS Teaching

To explore the learning outcomes of the students using ATS teaching, a t-test was applied to understand the difference of students' learning outcomes before and after giving ATS teaching. The mean, standard deviation and t-test results of students' learning outcomes after ATS teaching are shown in Table 5. The t-test results showed the students' learning outcomes in the post-test were better than those in the pre-test, and the students unanimously expressed their high affirmation for the predicted learning outcomes of using ATS teaching.

Table 5. Summary table of students' differences in learning outcomes (N = 66)

	T	NS	MS	SD	T value	DO
Learning outcomes	Pre-test	66	76.73	14.50	-4.357***	Post-test > Pre-test
	Post-test	66	84.73	11.38		

***p<.001

Note. T=Test, NS=Number of students, MS=Mean score, SD=Standard deviation, DO=Difference outcomes.

4.3 Analysis of the Difference Between Cognitive Loads and Learning Outcomes of Information Literacy

Independent sample t-test was applied to analyze the difference between students' cognitive loads and learning outcomes of information literacy. Table 6 shows the results of the mean, standard deviation and t-test of the two aspects of cognitive load and the overall cognitive load of the elementary school students with different information literacy. In the interface operation aspect of cognitive load, there was a significant difference between the students with high score and low score in information literacy, with the p value being less than .05 and the t-value being - 2.20, which indicated that the cognitive loads of the students with high scores in information literacy was significantly lower than that of the students with low scores in information literacy. However, in the content aspect of cognitive load and the overall cognitive load, neither reached a significant level which indicated that there was no significant difference in the overall cognitive load and the content aspect of cognitive load among the elementary school students with different information literacy. Table 7 shows the mean, standard deviation and t-test results of the learning outcomes of the elementary school students with different information literacy. The results showed that there was no significant difference in learning outcomes between the students with high and low scores in information literacy.

Table 6. Summary table of the analysis of the cognitive load differences between the groups of students with different information literacy

DCL	ILG	NS	MS	SD	T value
Content	H	18	12.94	3.50	1.42
	L	19	11.11	4.29	
Interface operation	H	18	15.06	6.88	* (H < L)
	L	19	20.16	7.21	
Overall cognitive load	H	18	28.00	8.04	-1.25
	L	19	31.26	7.91	

Note. DCL=Dimension of cognitive load, ILG=Information literacy grouping, NS=Number of students, MS=Mean score, SD=Standard deviation, H: High-score group, L: Low-score group.

*p < .05.

Table 7. Summary table of analysis of learning outcomes difference between the groups of students with different information literacy (N = 66)

	ILG	NS	MS	SD	T value
Learning outcomes	H	18	90.22	9.33	1.78
	L	19	82.74	15.38	

Note. ILG=Information literacy grouping, NS=Number of students, MS=Mean score, SD=Standard deviation, H: High-score group, L: Low-score group.

4.4 Correlation Analysis of Information Literacy, Cognitive Loads and Learning Outcomes

The Pearson product-moment correlation was used to explore the correlation between students' information literacy and cognitive loads, where the relevant analysis results are shown in Table 8. There were significant negative correlations with the p values less than 0.05 between the "interface operation" factor of cognitive load and the "problem identification," "seeking information," and "overall information literacy" factors of information literacy (r = -.27, -.29, -.30) respectively. The "interface operation" factor of cognitive load had significant negative correlations with the "information retrieval" and "information synthesis" factors of information literacy (r = -.42 and -.33) respectively, with the p values less than 0.01; with the correlation coefficients' being between -.27 and -.42, the correlations were regarded as lowly correlated. While the overall cognitive load was negatively correlated with the "information retrieval" and "information synthesis" factors of information literacy (r = -.32, -.27) respectively, with the p values less than 0.05, they were also regarded as lowly correlated. On the whole, the correlation coefficient between information literacy and cognitive load was -.18, which was not significant. According to the survey on the current situation of students' information literacy, it was found that the overall information literacy of students at this stage was to a medium high degree.

Table 8. Summary table of the correlation between information literacy and cognitive loads of the elementary school students (N = 66)

	C	IO	OCL
Information retrieval	.08	-.42**	-.32*
Problem identification	.20	-.27*	-.13
Seeking information	.09	-.29*	-.20
Information usage	.16	-.04	.040
Information synthesis	.03	-.33**	-.27*
Information evaluation and sharing	.11	-.03	.02
Overall information literacy	.14	-.30*	-.18

Note. C=Content, IO=Interface operation, OCL=Overall cognitive load.

*p < .05. **p < .01.

The correlations of all factors of students' information literacy with their learning outcomes were shown respectively in Table 9. None of the correlation coefficients of all factors of students' information literacy and the overall information literacy with their learning outcomes reached significant level.

Table 9. Summary table of the correlations of the students' information literacy with their learning outcomes (N = 66)

	IR	PI	SI	IU	IS	IES	OIL
Learning outcomes	.13	.07	.19	-.04	.16	.00	.11

Note. IR=Information retrieval, PI=Problem identification, SI=Seeking information, IU=Information usage, IS= Information synthesis, IES=Information evaluation and sharing, OIL=Overall information literacy.

The correlations of all factors of students' cognitive loads with their learning outcomes were shown respectively in Table 10. None of the correlation coefficients of all factors of students' cognitive loads with the overall cognitive load and their learning outcomes reached significant level.

Table 10. Summary table of the correlations of the students' cognitive loads with their learning outcomes (N = 66)

	Content	Interface operation	Overall cognitive load
Learning outcomes	-.00	-.13	-.11

5 Conclusion

In this section, research questions that were proposed in this study were answered and the conclusions are as follows:

In terms of overall information literacy, students' experience in information literacy scale was above middle value in this 4-point scale. Thus, the current situation of students' information literacy was regarded as good enough, which was to a medium or above degree. In addition, in terms of six dimensions of information literacy, students scored the highest in the dimension of "information retrieval," and the lowest in "information evaluation and sharing," which shows that students had better ability in information search, but weaker in information evaluation and sharing. Students given the ATS teaching, the average score of each question was 2.44. It can be shown that the cognitive loads experienced by the elementary school students, given ATS teaching by their teachers, were comparatively lower, with the average number lower than the middle value. In addition, in terms of two dimensions of cognitive load, in ATS teaching, students' experience in cognitive load was higher in the dimension of "content" than "interface operation," which shows that the cognitive load brought by the content was slightly higher than that brought by the interface operation. Regarding students' cognitive loads being lower in the "interface operation" of the system, the researcher also obtained further support after analyzing and comparing the interview data of the respondents. The respondents all gave good feedback on the interface presented in the system during the process of operating the system practically.

As the teaching experiment adopted the one-group pre- and post-test design, before carrying out ATS teaching, the students were tested for dengue fever epidemic prevention knowledge, whereby their pre-test results were obtained. Afterward, after given ATS teaching, the students were post-tested to obtain their post-test results. After obtaining the pre- and post-test results, the scores of students in the pre- and post-test of ATS teaching are statistically analyzed in the way of t-test to understand the differences of students' learning results before and after ATS teaching. The results show that the differences between the average numbers of pre- and post-test were significant, indicating that ATS teaching can effectively improve students' learning outcomes.

The cognitive loads of the high and low score groups generated in ATS teaching and then compared to see whether there were any differences. The results showed that the cognitive loads of the students with high information literacy were significantly lower than those of the students with low information literacy, but among the elementary school students with different information literacy, there were no significant differences in the aspects of overall cognitive load and content.

The learning outcomes of the high score group and low score group generated in ATS teaching and then compared to see whether there were any differences. The results showed that the difference in learning outcomes of the students with high and low information literacy did not reach a significant level, indicating that there was no significant difference in learning outcomes among the students with different information literacy.

Although there was no significant correlation between the overall information literacy and the overall cognitive load, the "interface operation" factor of cognitive load was significantly negatively correlated with "overall information literacy," as well as the "problem identification," "seeking information," "information retrieval" and " information synthesis" in the dimension of information literacy respectively. The correlations thereof were categorized as lowly correlated. In addition, the "overall cognitive load" was significantly negatively correlated with the "information retrieval" and "information synthesis" in the dimension of information literacy respectively. The correlations thereof were also categorized as lowly correlated. The

results showed that neither any factor of information literacy nor overall information literacy was significantly correlated with learning outcomes. The results showed that neither factor of cognitive load nor overall cognitive load was significantly correlated with learning outcomes.

From the perspective of skills, information literacy is a set of skills, abilities or behaviors that an individual demonstrates when seeking information in a digital environment [45-46]. In the cognitive theory of learning and guidance, cognitive load has been emphasized as an important factor of successful and efficient learning [47-48]. The emotion dictionary keyword matching is the most commonly used method [49]. Araque et al. also used emotional dictionaries and semantic models to calculate the semantic similarity between input words and dictionary words to obtain the features in the text [50]. This study obtained the results consistent with those of other scholars in the facts that the emotional dialog of encouraging phrases used by the assistant agents has a positive impact on the learning motivation of students facing learning difficulties [51], and the emotional teaching system is good for students with learning difficulties [52-53]. This is because students facing learning difficulties need more motivation to achieve their goals, and need guidance and support in their learning process.

6 Final Remarks and Future Work

Overall, our work shows that ATS teaching hold the potential to capture learning experience intuitively and in an almost real-time manner, can detect learners' learning states and emotional states, give learners appropriate feedback by identifying their different emotions, and help rectify learners' learning states and emotional states [21-22]. The main reason why the text input method was used as the way through which students communicate with their assistant agents is subject to the constraint of course giving style; if students use voice input, it may be a very noisy during the course. The possible limitation of this study may lie in that the recruited subjects are 11- to 12-year-old students in Taiwan, and the field of application is limited to the dengue fever epidemic prevention course, whose survey uses semantic recognition module to carry out emotion recognition and analysis; the system may not be able to obtain effective results about the real emotional states of the learners, while in the process of text input, negative emotions of the students under test might be aroused. Concerning future prospects, it is expected that the semantic recognition module can be added with students' popular words and voice input, and be incorporated with wearable devices or the face recognition capability to increase the reliability of emotion recognition. The 2 minutes break system setting is determined after discussion with the domain experts, In future work, we will test different settings to determine the best time of break. As for the verification part, such conditions as learning achievement and learning motivation are also expected to be added further.

Some additional measurement items may be used to collect students' views on the ATS teaching, it is expected that the students can be further analyzed according to their different characteristics or groups. Moreover, the sample size is supposed to be increased to enhance the effectiveness of future research results.

References

[1] World Health Organization, *Global Strategy for Dengue Prevention and Control 2012-2020*, WHO/HTM/NTD/VEM/ 2012.5, August, 2012.

[2] M. A. M. Behnam, C. Nitsche, V. Boldescu, C. D. Klein, The Medicinal Chemistry of Dengue Virus, *Journal of medicinal chemistry*, Vol. 59, No. 12, pp. 5622-5649, June, 2016.

[3] W. H. Wang, C. Y. Lin, K. Chang, A. N. Urbina, W. Assavalapsakul, A. Thitithanyanont, P. L. Lu, Y. H. Chen, S. F. Wang, A Clinical and Epidemiological Survey of the Largest Dengue Outbreak in Southern Taiwan in 2015, *International Journal of Infectious Diseases*, Vol. 88, pp. 88-99, November, 2019.

[4] World Health Organization, *Global Tuberculosis Control: Epidemiology, Strategy, Financing: WHO Report 2009*, WHO/ HTM/TB/2009.411, March, 2009.

[5] W. J. Chen, Dengue Outbreaks and the Geographic Distribution of Dengue Vectors in Taiwan: A 20-year Epidemiological Analysis, *Biomedical Journal*, Vol. 41, No. 5, pp. 283-289, October, 2018.

[6] Y. Wang, L. Guan, Recognizing Human Emotion from Audiovisual Information, *IEEE International Conference on Acoustics, Speech, and Signal Processing*, Philadelphia, PA, USA, 2005, pp. II-1125-II-1128.

[7] S. Petrovica, Tutoring Process in Emotionally Intelligent Tutoring Systems, *International Journal of Technology and Educational Marketing (IJTEM)*, Vol. 4, No. 1, pp. 72-85, January-March 2014.

[8] A. Landowska, Affect-awareness Framework for Intelligent Tutoring Systems, *6th International Conference on Human System Interactions (HSI)*, Sopot, Poland, 2013, pp. 540-547.

[9] S. Petrovica, A. Anohina-Naumeca, H. K. Ekenel, Emotion Recognition in Affective Tutoring Systems: Collection of Ground-truth Data, *Procedia Computer Science*, Vol. 104, pp. 437-444, February, 2017.

[10] M. Ochs, C. Frasson, Optimal Emotional Conditions for Learning with an Intelligent Tutoring System, *International Conference on Intelligent Tutoring Systems*, Maceio, Alagoas, Brazil, 2004, pp. 845-847.

[11] T. J. Hickey, W. T. Tarimo, The Affective Tutor, *Journal of Computing Sciences in Colleges*, Vol. 29, No. 6, pp. 50-56, June, 2014.

[12] S. L. Spaulding, *Developing Affect-aware Robot Tutors*, Ph.D. Thesis, Massachusetts Institute of Technology, Cambridge,

Massachusetts, 2015.

[13] A. Kaklauskas, A. Kuzminske, E. K. Zavadskas, A. Daniunas, G. Kaklauskas, M. Seniut, J. Raistenskis, A. Safonov, R. Kliukas, A. Juozapaitis, A. Radzeviciene, R. Cerkauskiene, Affective Tutoring System for Built Environment Management, *Computers & Education*, Vol. 82, pp. 202-216, March, 2015.

[14] C. H. Wang, H. C. K. Lin, Emotional Design Tutoring System Based on Multimodal Affective Computing Techniques, *International Journal of Distance Education Technologies (IJDET)*, Vol. 16, No. 1, pp. 103-117, January-March, 2018.

[15] S. Craig, A. Graesser, J. Sullins, B. Gholson, Affect and Learning: An Exploratory Look into the Role of Affect in Learning with AutoTutor, *Journal of Educational Media*, Vol. 29, No. 3, pp. 241-250, October, 2004.

[16] W. Burleson, R. W. Picard, Affective Agents: Sustaining Motivation to Learn through Failure and a State of Stuck, *7th Conference on Intelligent Tutoring Systems: Workshop on Social and Emotional Intelligence in Learning Environments*, Maceio, Brazil, 2004, pp. 1-8.

[17] S. K. D'mello, S. D. Craig, A. Witherspoon, B. Mcdaniel, A. Graesser, Automatic Detection of Learner's Affect from Conversational Cues, *User Modeling and User-adapted Interaction*, Vol. 18, No. 1-2, pp. 45-80, February, 2008.

[18] A. Graesser, A. Witherspoon, B. McDaniel, S. D'Mello, P. Chipman, B. Gholson, Detection of Emotions during Learning with AutoTutor, *28th Annual Meetings of the Cognitive Science Society*, Vancouver, British Columbia, Canada, 2006, pp. 285-290.

[19] B. Kort, R. Reilly, R. W. Picard, An Affective Model of Interplay between Emotions and Learning: Reengineering Educational Pedagogy-building a Learning Companion, *IEEE International Conference on Advanced Learning Technologies*, Madison, WI, USA, 2001, pp. 43-46.

[20] H. C. K. Lin, W. C. Hsu, T. H. Wang, Y. C. Ma, M. C. Tsai, Development and Research of an Affective Learning System Combined with Motion-Sensing Interaction, Augmented Reality, and Mid-Air Projection, *Journal of Internet Technology*, Vol. 19, No. 6, pp. 1951-1960, November, 2018.

[21] X. Mao, Z. Li, Agent Based Affective Tutoring Systems: A Pilot Study, *Computers & Education*, Vol. 55, No. 1, pp. 202-208, August, 2010.

[22] M. Abu Ghali, A. Abu Ayyad, S. S. Abu-Naser, M. Abu Laban, An Intelligent Tutoring System for Teaching English Grammar, *International Journal of Academic Engineering Research (IJAER)*, Vol. 2, No. 2, pp. 1-6, February, 2018.

[23] D. Mastorodimos, S. A. Chatzichristofis, Studying Affective Tutoring Systems for Mathematical Concepts, *Journal of Educational Technology Systems*, Vol. 48, No. 1, pp. 14-50, September, 2019.

[24] Association of College, Research Libraries, & American Library Association, *Information Literacy Competency Standards for Higher Education*, ACRL, January, 2000.

[25] S. Andretta, *Information Literacy: A Practitioner's Guide*, Elsevier, 2005.

[26] American Association of School Librarians, & Association for Educational Communications, *Information Power: Building Partnerships for Learning*, American Library Association, 1998.

[27] L. C. Chen, T. W. Huang, Y. H. Chen, The Effects of Inquiry-based Information Literacy Instruction on Memory and Comprehension: A Longitudinal Study, *Library & Information Science Research*, Vol. 39, No. 4, pp. 256-266, October, 2017.

[28] Y. L. Lai, An Exploration of the School Library Media Program: The Designing Curriculum Based on Information Literacy Education, *Journal of National Taichung Teachers College*, 2000, Vol. 14, pp. 293-320, June, 2000.

[29] C. S. Doyle, *Information Literacy in an Information Society: A Concept for the Information Age*, Diane Publishing, 1994.

[30] T. Rosman, A. K. Mayer, G. Krampen, A Longitudinal Study on Information-seeking Knowledge in Psychology Undergraduates: Exploring the Role of Information Literacy Instruction and Working Memory Capacity, *Computers & Education*, Vol. 96, pp. 94-108, May, 2016.

[31] Y. J. Joo, M. Bong, H. J. Choi, Self-efficacy for Self-regulated Learning, Academic Self-efficacy, and Internet Self-efficacy in Web-based Instruction, *Educational Technology Research and Development*, Vol. 48, No. 2, pp. 5-17, June, 2000.

[32] B. Johnston, S. Webber, Information Literacy in Higher Education: A Review and Case Study, *Studies in Higher Education*, Vol. 28, No. 3, pp. 335-352, August, 2003.

[33] S. Brand-Gruwel, I. Wopereis, Y. Vermetten, Information Problem Solving by Experts and Novices: Analysis of a Complex Cognitive Skill, *Computers in Human Behavior*, Vol. 21, No. 3, pp. 487-508, May, 2005.

[34] M. J. Tsai, C. Y. Hsu, C. C. Tsai, Investigation of High School Students' Online Science Information Searching Performance: The Role of Implicit and Explicit Strategies, *Journal of Science Education and Technology*, Vol. 21, No. 2, pp. 246-254, April, 2012.

[35] M. B. Eisenberg, R. E. Berkowitz, *Information Problem Solving: The Big Six Skills Approach to Library & Information Skills Instruction*, Ablex Publishing Corporation, 1990.

[36] Y. C. Chou, *A Study on the Information Literacy of Elementary School Students - An Example in Paikong of Yunlin County*, Master's Thesis, Department of Information Management Nanhua University, 2004.

[37] J. Sweller, Cognitive Load during Problem Solving: Effects on Learning, *Cognitive Science*, Vol. 12, No. 2, pp. 257-285, April-June, 1988.

[38] F. Paas, J. Sweller, Implications of Cognitive Load Theory for Multimedia Learning, in: R. E. Mayer (Ed.), *The Cambridge Handbook of Multimedia Learning*, Cambridge University Press, 2014, pp. 27-42.

[39] Ø. Anmarkrud, A. Andresen, I. Bråten, Cognitive Load and Working Memory in Multimedia Learning: Conceptual and Measurement Issues, *Educational Psychologist*, Vol. 54, No. 2, pp. 61-83, February, 2019.

[40] J. Sweller, J. J. G. van Merriënboer, F. Paas, Cognitive Architecture and Instructional Design: 20 Years Later,

Educational Psychology Review, Vol. 31, No. 2, pp. 261-292, June, 2019.

[41] J. Sweller, I Cognitive Processes and Instructional Procedures, *Australian Journal of Education*, Vol. 34, No. 2, pp. 125-130, August, 1990.

[42] H. C. K. Lin, M. C. Hsieh, L. C. Loh, C. H. Wang, An Emotion Recognition Mechanism Based on the Combination of Mutual Information and Semantic Clues, *Journal of Ambient Intelligence and Humanized Computing*, Vol. 3, No. 1, pp. 19-29, March, 2012.

[43] W. J. Wei, *The Cognitive Load of Elementary School's Student in the Web-Based Environment-Science Text as an Example*, Master's Thesis, Department of Science Education, National Taipei University of Education, 2007.

[44] T. L. Kelley, The Selection of Upper and Lower Groups for the Validation of Test Items, *Journal of Educational Psychology*, Vol. 30, No. 1, pp. 17-24, 1939.

[45] A. Korbach, R. Brünken, B. Park, Measurement of Cognitive Load in Multimedia Learning: A Comparison of Different Objective Measures, *Instructional Science*, Vol. 45, No. 4, pp. 515-536, August, 2017.

[46] D. Mutlu-Bayraktar, V. Cosgun, T. Altan, Cognitive load in Multimedia Learning Environments: A Systematic Review, *Computers & Education*, Vol. 141, Article 103618, November, 2019.

[47] C. Addison, E. Meyers, Perspectives on Information Literacy: A Framework for Conceptual Understanding, *Information Research: An International Electronic Journal*, Vol. 18, No. 3, pp. 1-14, September, 2013.

[48] A. Sample, Historical Development of Definitions of Information Literacy: A Literature Review of Selected Resources, *The Journal of Academic Librarianship*, Vol. 46, No. 2, Article 102116, March, 2020.

[49] E. Cambria, B. Schuller, Y. Xia, C. Havasi, New Avenues in Opinion Mining and Sentiment Analysis, *IEEE Intelligent Systems*, Vol. 28, No. 2, pp. 15-21, March/April, 2013.

[50] O. Araque, G. Zhu, C. A. Iglesias, A Semantic Similarity-based Perspective of Affect Lexicons for Sentiment Analysis, *Knowledge-Based Systems*, Vol. 165, pp. 346-359, February, 2019.

[51] S. Jiménez, R. Juárez-Ramírez, V. H. Castillo, A. Ramírez-Noriega, Integrating Affective Learning into Intelligent Tutoring Systems, *Universal Access in the Information Society*, Vol. 17, No. 4, pp. 679-692, November, 2018.

[52] M. L. Barrón-Estrada, R. Zatarain-Cabada, R. Zatarain-Cabada, A. B. Estrada, Design and Implementation of an Affective ITS, *Research in Computing Science*, Vol. 56, pp. 61-68, 2012.

[53] C. R. Wolfe, C. L. Widmer, V. F. Reyna, X. Hu, E. M. Cedillos, C. R. Fisher, P. G. Brust-Renck, T. C. Williams, I. D. Vannucchi, A. M. Weil, The Development and Analysis of Tutorial Dialogues in AutoTutor Lite, *Behavior Research Methods*, Vol. 45, No. 3, pp. 623-636, September, 2013.

Biographies

Hao-Chiang Koong Lin works as the Chair & Professor of the Department of Information and Learning Technology, National University of Tainan. He received his Ph.D. degree in Computer Science from National Tsing-Hua University, 1997. He has published more than 380 internationally refereed research papers focused on affective computing, learning and education technology, digital arts, interaction design and artificial intelligence.

Meng-Chun Tsai is currently a Ph.D. candidate of the Department of Information and Learning Technology in National University of Tainan in Taiwan, and also a Lecturer of the Department of Visual Communication Design in international Vocational Training Center. Her research focuses on Augmented Reality, Information and Digital learning.

Chia-Hsun Lee works as the engaged in elementary education for many years, and has served as a teacher and tutor, a teacher and health team leader, and a teacher and academic director during the period, and loves to bring new technology to the education scene, helping students to learn happily, effectively.