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Facilitating English-Language Reading Performance by a Digital Reading Annotation System with Self-Regulated Learning Mechanisms

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ABSTRACT

Since English has been an international language, how to enhance English levels of people by useful computer assisted learning forms or tools is a critical issue in non-English speaking countries. Past studies confirmed that reading articles with annotated contents enable knowledge sharing and improve the reading comprehension of learners. However, the self-regulated learning (SRL) ability of individual learners when reading learning materials and contributing annotations becomes a key factor affecting reading performance. Thus, this work proposes a SRL mechanism combined with a digital reading annotation system (DRAS) to enhance Grade 7 students to generate rich and high-quality annotations for promoting English-language reading performance. To evaluate the effectiveness of the proposed system, this work adopts a quasi-experimental design to assess an experimental group and control group learners who respectively use the proposed DRAS with and without the SLR mechanisms when reading English-language texts online. Compared with the control group learners, experimental results demonstrate that the reading comprehension and reading annotation abilities of the experimental group learners were significantly improved. Analytical results also confirm that gender differences in reading comprehension and annotation ability existed when using the proposed DRAS with and without the SRL mechanisms to read English-language texts online. Experimental results also show that significant differences existed in the reading comprehension and annotation abilities of learners with good and poor SRL abilities in the experimental group. Additionally, the reading annotation ability of learners in the experimental group was significantly correlated with reading comprehension.

Keywords

Self-regulated learning, Digital reading, Reading annotation, Second language learning

Introduction

As English is now considered the dominant business language worldwide, how to enhance the English-language reading ability of students is of utmost importance, as good English-language reading ability improves an individual's competitive advantage (Mahapatra et al., 2010; Risko et al., 2011). To enhance English reading performance, students typically use annotation techniques, such as underlining, highlighting, notes, and summarizing, to support their reading in traditional printed books. These annotation techniques are very helpful in understanding and memorizing the reading contents in an article (Hoff, Wehling & Rothkugel, 2009). In recent years, many computer-assisted reading annotation systems have been developed to assist learners in learning by reading digital texts (Belz, 2004; Patrick Rau, Chen & Chin, 2004; Mendenhall & Johnson, 2010; Johnson, Archibald & Tenenbaum, 2010; Wolfe, 2008; Johnson & Nádas, 2009) because using computer monitors and other digital reading devices for reading or browsing texts has gradually become common reading modes. Hence, this work developed a novel web-based digital reading annotation system (DRAS) for individual learners to enhance their reading comprehension of English-language texts. The proposed system designs several annotation functionalities that can support individual or collaborative annotation of digital texts and saves annotations in a log database. To promote reading performance, learners can utilize the Internet anytime and anywhere to share their annotations and interact with others. That is, the proposed web-based digital reading annotation system provides a flexible learning environment that improves reading comprehension and performance of individual learners.

However, when utilizing the proposed DRAS to promote English reading performance, learners must often perform self-directed learning. Therefore, the SRL abilities of individual learners associated with actively learning the reading materials and contributing annotations are main factors that affect learning performance. Many studies have demonstrated that learners who are unable to self-regulate their learning strategies tend to misunderstand complex

topics (Hannafin & Land, 1997; Jacobson & Archodidou, 2000). Thus, this work proposes a SRL mechanism combined with DRAS to enhance English-language reading performance. The research questions of this study include whether the proposed DRAS with SRL mechanisms can promote reading comprehension and annotation abilities of individual learners, whether gender difference and correlation between reading comprehension and reading annotation ability exist, and how different SRL abilities affect reading comprehension and annotation abilities of individual learners.

Literature review

Web-based language learning

In recent years, conventional computer-assisted language learning (CALL) has gradually moved toward web-based language learning (WBLL) because WBLL provides language teachers with network-based teaching environments in which they can assign meaningful tasks and use various materials for language learning (Son, 2008). Particularly, the hypermedia character of the Internet has markedly enhanced the power of CALL by allowing learners to explore and discover their learning processes and offering learners access to online resources (Son, 2008). Additionally, WBLL provides learners with an interface for interaction and gives students and teachers alternative ways to communicate. Khan (1997) indicated that web-based instruction helps learners complete a series of instructional activities, and helps learners increase the number of opportunities for constructing and sharing their knowledge with others. In other words, as current WBLL paradigms offer advantages in promoting language learning effectiveness and teaching, their impacts on language learning should be investigated (Chang, 2005; Chang & Ho, 2009).

Chang and Ho (2009) indicated that WBLL provides more opportunities for individualized instruction with feedback than conventional classroom instruction. Son (2007) explored learner experiences in WBLL activities for English as a second language (ESL) learning. Analytical results confirmed that the Internet is a useful tool and supplementary resource for ESL learning. Moreover, participants who use Internet for ESL learning had positive attitudes toward WBLL, and indicated that they would like additional activities that could be completed in and outside class time (Son, 2008). Furthermore, some studies have demonstrated that WBLL can increase learner motivation and engage learners in culturally authentic and highly interactive language experiences (Chun & Plass, 2000; Mosquera, 2001). In short, compared with conventional CALL, WBLL provides learners with new and alternative ways of learning a language. Thus, this work designed a DRAS with SRL mechanisms for ESL learning and investigated its potential in promoting English-language e-reading performance.

Digital reading annotation system

Annotation can be used to summarize important ideas in an article and is an explicit expression of knowledge in the form of comments. Annotation also reveals the conceptual meanings of thoughts of annotators (Yang et al., 2011). People frequently have differing opinions about the same text; therefore, comments from different annotators may differ. Generally, a college freshman may be helped markedly by reading annotations from such experienced users as experts or senior students. Therefore, preserving and sharing comments is a key function of any effective annotation system. Frumkin (2005) indicated that if users can leave comments or annotations, this practice would open the door for sharing research experiences, facilitate collaborative research, and make it easy for future researchers to find materials they need in a particular collection.

Marshall (1997) argued that book annotations are useful to subsequent readers. Traditionally, annotating printed books by pencil or pen is the most common method of recording book-related knowledge, but has disadvantages when compared with knowledge storage in computers, knowledge dissemination, and knowledge sharing via the Internet. That is, using a digital annotation tool to annotate digital documents can overcome these shortcomings. Driss, Rachida and Amine (2006) designed a collaborative web annotation tool called SMARTNotes, which allows learners to conduct collaborative annotation for a digital reading article. Maristella and Nicola (2007) indicated that annotations can explain and enrich a resource with personal observations, and can be used to share ideas, thereby improving collaborative work practices. Yi et al. (2010) demonstrated that annotations are an effective means of interaction between students and teachers. Yang et al. (2007) developed a personalized annotation management system (PAMS) and evaluated how the PAMS can enhance knowledge sharing in online group reading activities.

They demonstrated that PAMS-enabled knowledge sharing improves the reading comprehension of students. Additionally, Mendenhall and Johnson (2011) applied an online annotation system to foster the development of critical thinking skills and reading comprehension of university undergraduates. To enhance the reading comprehension of ESL learners, this work develops a DRAS with SRL mechanisms that can facilitate individual learners to generate rich and high-quality annotations, thus helping them to improve the English-language reading comprehension via sharing their reading annotations.

Web-based self-regulated learning system

Self-regulated learning (SRL) was defined by Zimmerman as the degree to which learners are metacognitively, motivationally, and behaviorally active participants in their learning processes (Zimmerman, 1986a, 1986b). That is, SRL refers to a learning scenario in which learners set their own learning goals and plans, and then regulate and evaluate their own learning process (Narciss, Proske & Koerndle, 2007). Zimmerman, Bonner, and Kovach (1996) referred to various aspects of SRL in different studies when developing their SRL model, which contains the following four interrelated learning processes: self-evaluation and monitoring; goal setting and strategic planning; strategy implementation and monitoring; and, strategy outcome monitoring (Zimmerman, Bonner & Kovach, 1996). Notably, SRL helps learners self-examine and self-evaluate their learning performance by monitoring the learning goals they set during learning processes. Once learners set goals, they must be able to revise their learning strategies to achieve these goals.

Many recent studies have focused on the development of web-based learning systems with SRL mechanisms to promote web-based learning performance (Chen, 2009; Chang, 2005; Shih et al., 2010). Lee, Shen and Tsai (2008) experimentally determined whether web-based problem-based learning and SRL, or their combination, assist low-achieving students improve their computer skills in deploying application software. They demonstrated that the effects of SRL in promoting the computer skills of students were mostly positive and encouraging. Wang (2011) proposed a multiple-choice web-based assessment system, the Peer-Driven Assessment Module of the Web-based Assessment and Test Analysis (PDA-WATA) system, to help learners conduct SRL and to improve e-learning effectiveness. They demonstrated that the PDA-WATA system facilitates use of SRL behaviors and improved e-learning effectiveness. Shih et al. (2010) developed an SRL system with learning scaffolding supporting the independent learning skills of students. They indicated that SRL skills of students within a group with poor SRL abilities were significantly improved. Chang (2005) used a one-semester web-based course incorporating SRL strategies to help students improve their learning motivation. Analytical results demonstrated that a web-based environment with SRL strategies was helpful in keeping learning motivation so that students became increasingly confident in their understanding of course material and class performance. Our previous study (Chen, 2009) proposed a personalized e-learning system with SRL assistive mechanisms based on the SRL model proposed by Zimmerman, Bonner and Kovach (1996) to help learners enhance their SRL abilities for mathematical learning. Experimental results confirmed that the proposed SRL-assisted mechanisms helped learners accelerate their acquisition of SRL abilities in a personalized e-learning system, and promoted student learning performance. This work modifies the previous SRL assistive mechanisms (Chen, 2009) and embeds them into the proposed DRAS to help learners improve their reading comprehension and annotation abilities.

Research methodology

The proposed digital reading annotation system

Figure 1 shows the user interface of the proposed DRAS system providing several useful annotation functionalities that can annotate digital texts in the HTML format. These annotation functionalities include below

1. *Selection of annotation type:* When learners mark up a selected text, a popup menu with five options—word meaning, antonym, grammar, phrase and related links—appears to assist individual learners in annotating a digital text.
2. Underlining: This function can be used to identify and emphasize important points in a text.
3. Browsing: This function helps learners browse all annotations in an article.
4. Voting: Via this function, learners vote on the usefulness of annotations.
5. Highlighting: This function marks texts with annotations in *bright yellow*. When the mouse cursor is dragged

over highlighted text, the best annotations, which are identified based on voting, are shown in a popup window. When learners click on highlighted text, all annotations associated with the highlighted texts are displayed.

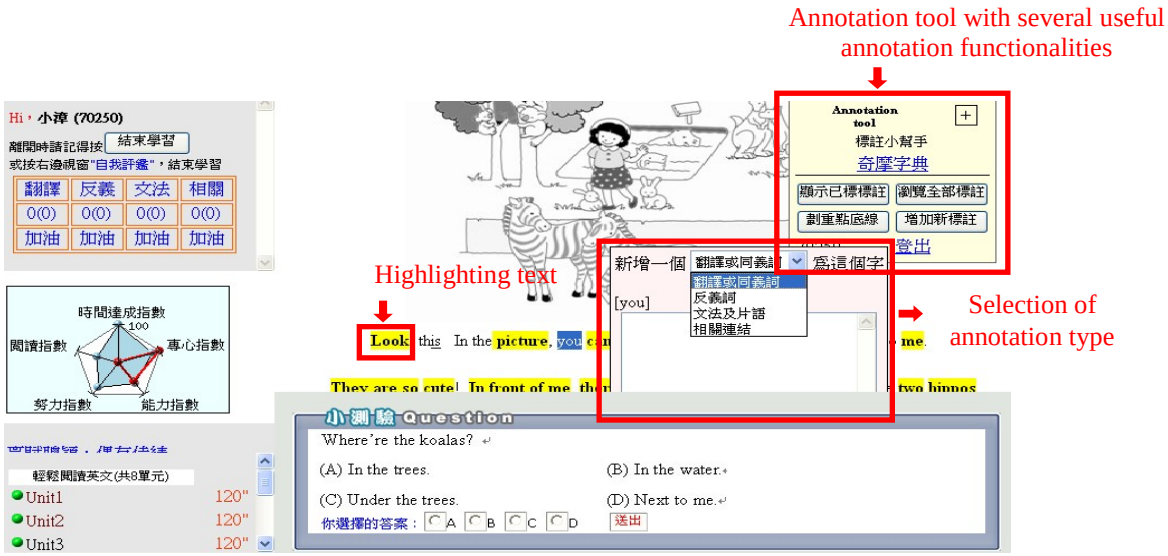

Figure 1. The user interface of the proposed DRAS system

The SRL assistive mechanism in the proposed DRAS

Although the proposed DRAS provides useful functionalities to help learners generate reading annotations, how to excite learners to contribute rich and high-quality reading annotations is obviously an essential issue. Consequently, functionalities of the DRAS are extended to include the SRL-assistive mechanisms that help learners self-observe and self-evaluate their learning processes, thus promoting learners' spontaneous and autonomous abilities to increase the amount of reading annotations for enhancing ESL learning. This section describes the system components of the SRL mechanism embedded in the proposed DRAS as follows.

Setting the self-monitor table

While a learner uses the SRL mechanism for first time, the self-monitor table menu is displayed (Fig. 2). In total, nine SRL indexes must be set in the self-monitor table for SRL. These SRL indexes include scheduled learning time (5–45 minutes), scheduled learning units (1–8 units), class ranking of the number of translation-type annotations, class ranking of antonym-type annotations, class ranking of phrase- and grammar-type annotations, class ranking of related link-type annotations (1–4), degree of effort (1–10), degree of concentration (1–10), and expected learning abilities (-3–3). After the self-monitor table is filled out, the proposed DRAS will guide learners entering the user interface for learning English-language texts based on contributing annotations and reading existed annotations. Moreover, when a learner logs into the system a second time, the system will show a record table of previous SRL outcomes as a reference.

Self-regulated radar plot

The radar plot of SRL has five SRL indicators, including four SRL competence indexes, and one learning performance index (Fig. 3). The four SRL competence indexes are the learning time index, effort for learning courseware index, reading rate index, concentrated learning index, and understanding index for learned courseware (Chen, 2009). In the self-regulated radar plot, blue points indicate a learner's set values in the self-monitor table after the learner logs in the system. Conversely, red points represent a learner's SRL status. The SRL radar plot can remind and motivate learners to achieve their learning goals.

Annotation ranking table

When a learner logs into the proposed DRAS, the upper left frame of the proposed system will show the annotation ranking table (Fig. 3), which aims to display the number of the four types of annotations including translation, antonym, grammar, and related link contributed by each learner and the ranking statues of the four types of annotations. A high level ranking status indicates good overall annotation performance. Based on the ranking level of the annotation type, the proposed system will show the corresponding encouraging words for learners for promoting them to contribute much more high-quality annotations.

Figure 2. The self-monitor table of the designed SRL mechanism

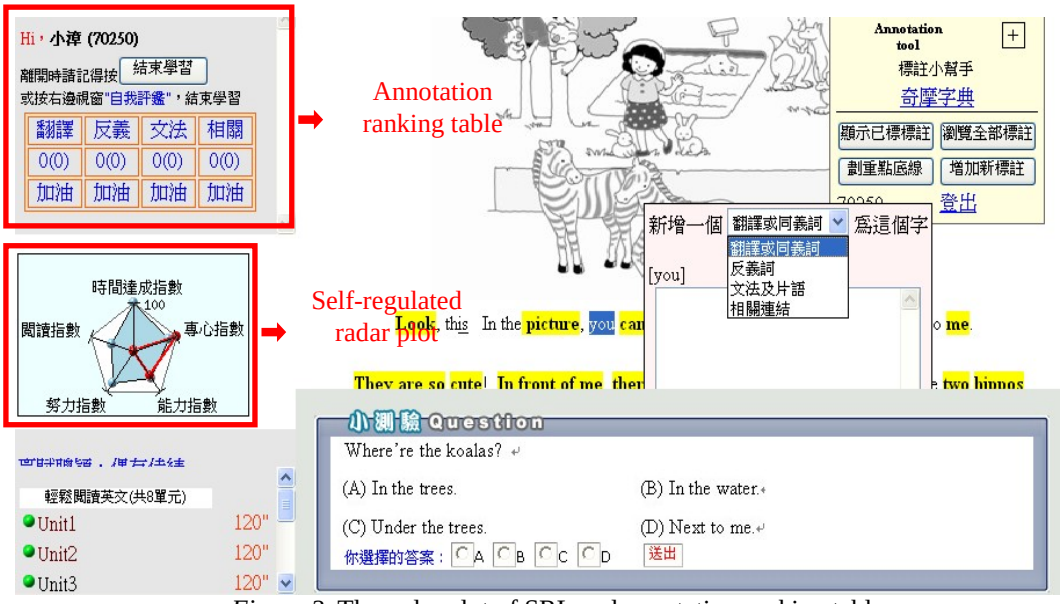

Figure 3. The radar plot of SRL and annotation ranking table

Assessment scheme for reading annotation ability

Annotation types

According to differences in cognitive levels of annotation types, the proposed DRAS assigns different reward points to annotators who contribute different levels of annotations. Based on content analysis (Stemler, 2001), this work

divided annotations into two annotation levels—"basic annotation" and "advanced annotation." To assess learner's annotation ability, this work gave one reward point for "basic annotation" including word meaning and related links and two reward points for "advanced annotation" including antonym and grammar or phrase. Additionally, the validity of all annotations annotated by individual learners is confirmed by several senior English-language teachers. Invalid reading annotations do not receive reward points.

Voting for high-quality annotations

As is known, exploring high-quality annotations based on the collective intelligence of learner voting is helpful in recommending useful reading annotations to individual learners. High-quality reading annotations promote the reading comprehension of learners who read English-language texts online. To encourage learners to identify high-quality annotations, the proposed DRAS has a voting reward mechanism. In addition to encouraging learners to identify high-quality annotations, the reward mechanism also enhances the achievements of annotators, thereby encouraging learners to contribute high-quality annotations. Because each vote has the same value, 1 reward point is given for all annotation types.

Evaluating the annotation ability of individual learners

To investigate the relationship between annotation behaviors and reading comprehension, this work first calculates the total reward points based on the sum of the reward points of different levels of annotations and annotation voting, and then normalizes the total reward points based on the maximum total reward points to serve this value as the annotation abilities of individual learners. In other words, in addition to considering the frequency of annotations, the study also simultaneously considers annotation levels and whether annotations are valid to evaluate the annotation ability of individual learners.

Reading materials, participants, and experimental procedures

To provide articles for collaborative reading annotation, three reading units—each unit is composed of eight topics—were selected from the *English reading* textbook for Grade 7 students. All topics and posttest questions for assessing reading comprehension were designed by several senior English teachers at a junior high school in Taiwan. Additionally, this work applies the quasi-experiment nonequivalent control group design, as randomly selecting examinees as a research target is a difficult task in actual teaching scenarios. Experimental participants were randomly recruited from Grade 7 students in two classes at a junior high school in Taoyuan County, Taiwan. Each class has 32 students, 17 males and 15 females. The experimental group was randomly assigned from one of the two classes. The other class was assigned to the control group. The experimental group and control group used the proposed DRAS with and without the SRL mechanism for reading English-language texts, respectively. The learners of both the groups learnt the same English articles and performed self-directed learning without English teacher instruction during learning processes. The experimental procedures comprised an assessment of prior English proficiencies of both groups, performing cooperative reading annotations for the assigned English articles, learning the English articles with annotations, and an evaluation of reading comprehension and annotation abilities of both learner groups. The learning activities based on learning the English articles with annotations lasted 3 weeks. The annotated contents help readers obtain a deeper and broader understanding than when reading the English articles without annotations. Furthermore, compared to the learners of the control group, the learners of the experimental group will be immediately alerted by the SRL mechanisms during learning processes while their predetermined goals for SRL have not been achieved, thus cultivating their spontaneous and autonomous learning abilities as well as promoting their willingness to contribute annotations for cooperative ESL learning.

Experimental results

Analysis of reading comprehension of both learner groups

Before performing the reading annotation activity, three times English scores of school midterm exams are used to

confirm that both groups have the same English-language proficiencies based on the independent sample *t*-test. Next, this study determines whether reading comprehension of both groups differ significantly when using the DRAS with and without the SRL mechanism to support English-language texts reading. Table 1 shows analytical results, demonstrating that reading comprehension of both groups for the three reading units differed significantly (t = -2.584, p = .012 < .05; t = -2.473, p = .016 < .05; t = -2.702, p = .009 < .05). The experimental group had better reading comprehension than the control group, confirming that the reading comprehension of learners was significantly improved by the proposed DRAS with the SRL mechanism support.

Table 1. Statistical analysis of the reading comprehension performance of both groups

Reading unit	Group	Number of learners	Mean	Standard deviation	t	Sig.
Unit 1	CG	32	45.31	22.47	-2.584	.012*
	EG	32	60.63	24.88		
Unit 2	CG	32	45.00	18.18	-2.473	.016*
	EG	32	56.72	19.70		
Unit 3	CG	32	47.34	21.48	-2.702	.009*
	EG	32	62.19	22.47		

* indicates p < .05

Next, the effect of gender on reading comprehension between both groups is assessed. Tables 2 and 3 show analytical results based on the independent sample *t*-test. The results show that reading comprehension of males in both groups did not differ significantly (t = -1.188, p = .243 > .05; t = -1.823, p = .078 > .05; t = -1.286, p = .208 > .05). For the female learners, except for reading comprehension for the second reading unit, reading comprehension for the first and third units differed significantly (t = -2.708, p = .011 < .05; t = -1.648, p = .111 > .05; t = -2.636, p = .014 < .05). This indicates that the females in the experimental group using the proposed DRAS with the SRL mechanism had better reading comprehension than the females in the control group. That is, a gender difference in reading comprehension existed when using the DRAS with and without the SRL mechanism support. Obviously, the proposed DRAS with the SRL mechanism support promotes reading comprehension of female learners more than that of male learners.

Table 2. Statistical analysis of reading comprehension performance of the male learners of both groups

Reading unit	Group	Number of males	Mean	Standard deviation	t	Sig.
Unit 1	CG	17	43.53	22.55	-1.188	.243
	EG	17	53.82	27.70		
Unit 2	CG	17	42.35	15.72	-1.823	.078
	EG	17	54.41	22.28		
Unit 3	CG	17	48.82	21.62	-1.286	.208
	EG	17	59.12	24.95		

Table 3. Statistical analysis of reading comprehension for the female learners of both groups

Reading unit	Group	Number of females	Mean	Standard deviation	t	Sig.
Unit 1	CG	15	65.800	24.16	-2.708	.011*
	EG	15	75.507	16.84		
Unit 2	CG	15	47.33	22.98	-1.648	.111
	EG	15	68.33	19.33		
Unit 3	CG	15	48.00	20.77	-2.636	.014*
	EG	15	59.33	16.68		

* indicates p < .05

Analysis of reading annotation abilities of both learner groups

This section assesses whether annotation abilities of both groups differ significantly when using the DRAS with and without the SRL mechanism to support English-language texts reading. Table 4 shows analytical results, demonstrating that the reading annotation ability of both learner groups differed significantly for all reading units (t = -4.402, p = .000 < .05; t = -3.038, p = .004 < .05; t = -2.640, p = .010 < .05), and the annotation ability of the experimental group was superior to that of the control group. That is, the reading annotation ability of experimental group learners was significantly enhanced when using the DRAS with the SRL mechanism support.

Moreover, the effects of the gender difference in reading annotation ability between the control group and experimental group are also assessed. Tables 5 and 6 show independent sample t-test results for males and females in both groups, respectively. The results show that the reading annotation ability of male learners in both groups for the three units differed significantly (t = -3.737, p = .001 < .05; t = -3.009, p = .007 < .05; t = -3.170, p = .003 < .05), and male learners in the experimental group was superior to that of male learners in the control group. Conversely, the reading annotation ability of female learners of the experimental group for the first unit was significantly different from that of female learners of the control group (t = -2.425, p = .022 < .05), and that of experimental group was superior to that of the control group. However, the reading annotation ability of female learners in the second and third units did not differ significantly (t = -1.027, p = .313 > .05; t = -.397, p = .694 > .05). Therefore, a gender difference in reading annotation ability existed when using the proposed DRAS with and without the SRL mechanism. Obviously, the proposed DRAS with the SRL mechanism was more helpful in promoting the reading annotation ability of male learners than those of female learners.

Table 4. Statistical analysis of the reading annotation abilities of both groups

Reading unit	Group	Number of learners	Mean	Standard deviation	t	Sig.
Unit 1	CG	32	14.34	13.25	-4.402	.000***
	EG	32	34.53	22.31		
Unit 2	CG	32	14.16	11.15	-3.038	.004**
	EG	32	27.28	21.75		
Unit 3	CG	32	16.41	12.30	-2.640	.010*
	EG	32	27.94	21.43		

* indicates p < .05; ** indicates p < .01; *** indicates p < .001

Table 5. Statistical analysis of the reading annotation abilities of the male learners of both groups

Reading unit	Group	Number of males	Mean	Standard deviation	t	Sig.
Unit 1	CG	17	14.76	13.76	-3.737	.001**
	EG	17	38.76	22.62		
Unit 2	CG	17	12.82	10.58	-3.009	.007**
	EG	17	33.35	26.06		
Unit 3	CG	17	13.12	8.59	-3.170	.003**
	EG	17	32.76	24.07		

** indicates p < .01

Table 6. Statistical analysis of the reading annotation abilities of the female learners of both groups

Reading unit	Group	Number of females	Mean	Standard deviation	t	Sig.
Unit 1	CG	15	13.87	13.11	-2.425	.022*
	EG	15	29.73	21.69		
Unit 2	CG	15	15.67	11.94	-1.027	.313
	EG	15	20.40	13.27		

Unit 3	CG	15	20.13	14.93	-.397	.694
	EG	15	22.47	17.16		

* indicates $p < .05$

Analysis of the difference in reading comprehension and reading annotation ability of the experimental group learners with different SRL abilities

To assess how different SRL abilities affect reading comprehension and annotation ability in the experimental group, the SRL indexes, including the achievement index of learning time, achievement index of effort level in learning courseware, achievement index of reading rate, achievement index of concentrated learning, and degree of understanding of learned courseware proposed in our previous work (Chen, 2009), are used to categorize learners in the experimental group into a good or poor SRL group. Table 7 shows comparison results based on the independent sample *t*-test. Analytical results show that the reading comprehension of the good *SRL* group and poor SRL group differed significantly ($t = 6.267$, $p = .000 < .05$; $t = 6.517$, $p = .000 < .05$; $t = 5.695$, $p = .000 < .05$; $t = 7.163$, $p = .000 < .05$) for the three units, and the good SRL group was superior to that of the poor *SRL* group.

Table 7. Comparison of the reading comprehension performances of the experimental group learners with different SRL abilities

Reading unit	Group	Number of learners	Mean	Standard deviation	t	Sig.
Unit 1	Good SRL	16	79.06	17.48	6.267	.000***
	Poor SRL	16	42.19	15.81		
Unit 2	Good SRL	16	71.56	14.69	6.517	.000***
	Poor SRL	16	41.88	10.78		
Unit 3	Good SRL	16	78.13	14.93	5.695	.000***
	Poor SRL	16	46.25	16.68		
Average of three units	Good SRL	16	76.24	13.98	7.163	.000***
	Poor SRL	16	43.44	11.83		

*** indicates $p < .001$

Additionally, how different SRL abilities affect the reading annotation ability of learners in the experimental group is also investigated. Table 8 shows analytical results, indicating that the reading annotation ability of experimental group learners for the first and second units did not differ significantly ($t = 1.392$, $p = .174 > .05$; $t = 1.699$, $p = .104 > .05$); however, the reading annotation ability of experimental group learners in the third unit and means of the three units differed significantly ($t = 2.391$, $p = .023 < .05$; $t = 2.083$, $p = .046 < .05$). These comparison results partially demonstrate that reading annotation ability of the good SRL group was superior to that of poor SRL group.

Table 8. Comparison of the reading annotation abilities of the experimental group learners with different SRL abilities

Reading unit	Group	Number of learners	Mean	Standard deviation	t	Sig.
Unit 1	Good SRL	16	39.94	22.27	1.392	.174
	Poor SRL	16	29.13	21.68		
Unit 2	Good SRL	16	33.63	27.15	1.699	.104
	Poor SRL	16	20.94	12.45		
Unit 3	Good SRL	16	36.38	25.00	2.391	.023*
	Poor SRL	16	19.50	13.12		
Average of three units	Good SRL	16	36.65	22.45	2.083	.046*
	Poor SRL	16	23.19	12.80		

* indicates $p < .05$

Correlation analysis between reading comprehension and reading annotation ability in both learner groups

Pearson correlation analysis is applied to assess the strength of correlations between reading comprehension and reading annotation ability for both groups. The correlation coefficient between reading comprehension and reading annotation ability for the experimental group learners was .235 (p = .021 < .05). However, the correlation between reading comprehension and reading annotation ability in the control group was not statistically significant. Obviously, using the DRAS with the SRL mechanism to support reading English-language texts online is the key factor that builds the correlation between the reading comprehension and reading annotation abilities of the experimental group learners although the correlation coefficient is only weakly positive.

Discussion

First of all, this work confirmed the proposed DRAS with the SRL mechanism efficiently promoted reading comprehension of learners who set learning goals and self-monitored their progress for reading English-language texts online. Many studies have indicated that SRL strategies can help learners improve their learning performance (Boekaerts, 1997; Pintrich, 2000; Zimmerman & Schunk 2001; Chang, 2005; Chen, 2009; Shih et al., 2010; Cheng, 2011). Particularly, Cheng (2011) argued that the SRL abilities of students, including learning motivation, goal setting, action control, and learning strategies, have significant effects on learning performance. Moreover, Lei et al. (2001) indicated that setting learning goals can help students understand learning tasks during SRL processes. Study results of this work are consistent those obtained by the above studies. Additionally, experimental results show that the proposed DRAS with the SRL mechanism efficiently enhanced the reading annotation ability of learners by setting reading annotation goals and displaying the rank of reading annotations. Observations indicate that learners frequently cared about the rank of their annotations via the annotation reward mechanism. Therefore, most learners were encouraged to annotate articles, such that high-quality annotations were generated, thereby promoting the reading comprehension of other learners. This work also found that most learners had a positive attitude toward this collaborative learning behavior. This analytical result is similar to that obtained by the study by Chen and Chang (2012), which explored social ranking of individual learners in a cooperative problem-based learning (PBL) environment that can encourage learners to interact actively with learning peers.

Moreover, gender differences in education have been recognized as an important research focus for a long time (Lee, 2002; Yukselturk & Bulut, 2009). Several previous studies claimed that male and female learners use SRL strategies during their learning processes differently (Lee, 2002; Wolters & Pintrich, 1998; Zimermann & Martinez-Pons, 1990). Zimermann and Martinez-Pons (1990) determined that girls tend to employ self-monitoring, goal setting, planning, and structuring of their study environment more often than boys. Wolters and Pintrich (1998) confirmed that gender differences in motivational and cognitive strategies existed during SRL. Lee (2002) also indicated that gender differences in motivational and behavioral learning strategy components are evident in cyber-learning contexts. Analytical results obtained by this work also confirmed that gender differences in reading comprehension and reading annotation ability existed when using the DRAS with and without the SRL mechanism for supporting English-language texts reading. The proposed DRAS with the SRL mechanism was more helpful in promoting the reading comprehension of female learners than that of male learners; however, the proposed DRAS with the SRL mechanism was more helpful in promoting reading annotation abilities of male learners than that of female learners. In addition to that gender difference may affect SRL performance, there are the other factors outside the research scope of the study to affect SRL performance. Pintrich, Roeser and De Groot's study (1994) confirmed that motivational beliefs (self-efficacy, intrinsic value, test anxiety) was positively related to higher levels of SRL. Moreover, Schapiro and Livingstone's study (2000) suggested that the natural dynamic component, reflecting qualities such as curiosity, enthusiasm, willingness to take risks, and persistence, actually underlies and drives the strategic behavior of SRL.

Moreover, experimental results show that significant differences existed in reading comprehension and reading annotation abilities of learners with good and poor SRL abilities in the experimental group. Reading comprehension and reading annotation abilities of experimental group learners with good *SRL* ability were higher than those of learners with poor *SRL* ability. Young (1996), who examined the effect of SRL strategies on learning performance in learner-controlled and program-controlled computer-based instruction (CBI), found that performance differences between learners with good SRL strategies and those with poor SRL strategies were greatest under learner control. This work found that the reading annotation ability of learners in the experimental group was positively correlated

with reading comprehension; however, no such correlation existed in the control group. These analytical results also prove that the proposed DRAS with the SRL mechanism encouraged learners to contribute high-quality annotations, thereby enhancing the reading comprehension of other learners. Furthermore, the SRL abilities of learners in the experimental group were positively correlated with their reading comprehension, indicating that reading comprehension of learners in the experimental group can be evaluated according to their SRL indexes assessed by the proposed system.

Finally, although the proposed DRAS with SRL mechanism provides benefits on ESL learning, some limitations of this study merit further consideration. First, the SRL indexes which include the scheduled learning time, degree of effort, and degree of concentration are evaluated in accordance with valid learning time identified by detecting the operations mouse and keyboard actions during a specific amount of time. This leads to that the valid learning time is not completely accurate. Second, although the proposed DRAS with SRL mechanism support positively affects learners to contribute rich reading annotations, the quality of learner generated annotations cannot be guaranteed. This may affect learner's reading performance.

Conclusions and future works

This study investigates the effects of the proposed DRAS with the SRL mechanism, which was applied to support online English-language texts reading, on reading comprehension performance and reading annotation ability for Grade 7 students at a junior high school in Taiwan. Based on statistical analyses, several major findings are summarized as follows. First, compared with control group learners, the reading comprehension and reading annotation ability of experimental group learners who used the proposed DRAS with the SRL mechanism for English-language reading improved significantly. Moreover, gender differences in reading comprehension and reading annotation ability existed when using the proposed DRAS with and without the SRL mechanism for English-language reading. The proposed DRAS with the SRL mechanism promoted the reading comprehension of female learners more than that of male learners; however, the proposed DRAS increased the reading annotation ability more for male learners than for female learners. Additionally, reading comprehension and reading annotation abilities of experimental group learners with high SRL ability were all higher than those of learners with poor *SRL* ability. Further, the relationship between reading comprehension and reading annotation ability of experimental group learners was weakly *positive, and* no statistically significant correlation existed in the control group.

Finally, several suggestions for future works are addressed based on experimental results and participant responses. First, to determine SRL indexes accurately, the proposed DRAS can consider assessing valid learning time based on learning attention potentially identified by the brainwave system (Haapalainen, Kim, Forlizzi, & Dey, 2010). Second, to guarantee the quality of learner contributed annotations, developing an intelligent mechanism which can automatically filter out poor-quality annotations based on collective intelligence or data mining should be considered.

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