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CONTEXT-AWARE WRITING IN UBIQUITOUS LEARNING ENVIRONMENTS*

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With the popularization of wireless networking and with the progress of mobile computing technology, the efficiency of handheld devices has been improved and more applications are possible. Combining handheld devices and *E*-learning will become an important way of learning in the future. This research uses access to a wireless network, handheld devices, and RFID tags to build a Context-Aware Writing System (*C*-Writing for short) for ubiquitous learning environments. Based on the practical use of *C*-Writing by students in a ubiquitous learning environment, we evaluated the learning results. We used a questionnaire to evaluate the learning situations regarding the users' attitudes, system acceptance, system quality, content quality, and interaction with the environment. The result of the research shows most of the students approve this system's benefit, and he/she is willing to use similar system for learning in the future. Moreover, students are able to efficiently improve their learning performance and students' attention and interest will be attracted to observe different things by using this system.

Keywords: Collaborative learning; context-aware learning; mobile learning; situated learning; ubiquitous learning.

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1. Introduction

In recent years, with advances in information technologies and high-speed networking, *e*-learning has become a new way of learning. This has gone along with a shift of pedagogic paradigms from a teacher-centered and lecture-centered model into a constructivist, interactive and student-centered model. Students are able to browse and download information anytime and anywhere through *e*-learning platforms, however it is not easy to apply *e*-learning in outdoor activities. Many studies of mobile learning (*M*-learning) and ubiquitous learning (*U*-learning) have been conducted in order to improve and extend technology support for learning over the past ten years. Thus, *M*-learning and *U*-learning play an important role in advancing *e*-learning environments. These research projects showed that students accept this learning approach, which provides context awareness, and that it can lead to enhancing learning performance (Moushir, El-Bishouty, Ogata & Yano, 2007; Yatani, Onuma, Sugimoto & Kusunoki, 2004). *M*-learning can provide more learning opportunities for students not limited by time and location. Advancements originating from using this technology include the creation of virtual language learning environments. This has opened a new dimension in real world language learning and cultural experiences (Godwin-Jones, 2004). When students go into and observe an environment, they are capable of writing more vivid essays reflecting their viewpoints and ideas.

In traditional classroom-based learning environments, the teacher-centered style of instruction confines the students' motivation for active learning, which leads to a passive learning attitude of seeing and listening. Writing can help to express personal emotion, e.g. by capturing the surrounding ambience or by recording anecdotes in conversational style. However, writing is unlike conversation in that it cannot easily express one's own mind and feelings through using body language such as voice, facial expression, or limb movements. The writing is a critical element for Chinese language learning, and it requires frequent reading, observation, and practice.

> *Writing is a technologically displaced form of conversation. When we write, having already internalized the "skill and partnership" of conversation.... Writing is at once two steps away from conversation and a return to conversation. We converse; we internalize conversation as thought; and then by writing, we re-immerse conversation in its external, social medium* (Bruffee, 1984) (p. 641).

Cho & Schunn (2007) have proposed the SWoRD (scaffolded writing and rewriting in the discipline) system, which is a web-based mutual peer reviewing system. SWoRD supports a writing practice in which students have to review, back-review, and rewrite following the process of journal publication as an authentic practice model. Through this practice model, students gain content knowledge as well as writing and reviewing skills. For this reason, we think that writing abilities must be accumulated from reading, observing, thinking, and practicing constantly. Students are able to acquire words, idiomatic phrases, and rhetoric by reading without

interruption. This encourages creativity by observing and reflection and enhances writing abilities through practicing at every moment. To make this effective, we have to overcome the limitations of traditional classroom practice in Taiwan and need to provide a well-designed learning environment abundant in learning materials and stimuli for the students.

Situated learning is a general theory of knowledge building that is based on the "community of practice" approach (Lave & Wenger, 1991). Situated learning takes place in the context of activities that include problem or task solving and interaction (e.g. conversation, discussion, and argument) with other people within social experience and culture (Brown, Collins & Duguid, 1989). An environment full of activity, culture, and content has great potential to stimulate students to engage in curricular activities, and to gain more knowledge, skills and, experience as compared to traditional learning in the classroom. Teachers can use vivid examples to explain natural phenomena whereby students obtain the learning content, information, and knowledge from their interaction with the environment in a meaningful context. Context-aware technologies can play an important role for setting up the bridge of conversation between students and their social environment.

In this study, we introduce the design of a context-aware learning system in real world settings, called Context-Aware Writing system (*C*-Writing). *C*-Writing opens new opportunities for students in reading, observation, conversation, and writing by using technologies such as wireless networks, handheld devices, and RFID (Radio Frequency Identification) tags. The purpose of *C*-Writing is to extend the students' learning opportunities and to enhance their abilities to be creative and engage in conversations and critical thinking. This is achieved through using handheld devices to write in different situations, to communicate with other people, and to review their peers' writing products. *C*-Writing helps to broaden the student's perspective in the outdoor environment and overcomes the limitations of learning with books. The rest of this article is organized as follows: Section 2 discusses several fundamental theories related to situated learning, collaborative learning, and context-aware

Table 1. Relationships between elements, reason, and solution for student.

Element	Reason	*C*-Writing Solution
Creativity	The aim of learning needs to foster creativity rather than memory	Exciting inspiration of writing through providing right content, at the right time in the right way
Conversation	Learning requires social interaction and collaboration	Encouraging discussion for students of similar interest
Critical thinking	Information and knowledge need to be assessed rather than habitual absorbing	Search related information and review other peer's writing for each students
Context-awareness	Most of information, knowledge, or ideal exists in real world	Infrastructure such as wireless network, context-awareness technology, and content

learning. In Section 3, we explain how the learning scenario can be used as a framework for designing new context-aware learning environments. Also, we explain the system architecture to support student's writing. In Section 4, we describe our experience with elementary school children using *C*-Writing collaboratively. In Section 5, we analyze learning attitudes and learning performance of students. Section 6 concludes the paper by discussing the relation between the innovative learning activities (i.e., using the *C*-Writing system) supported by pervasive technologies and traditional teaching, and by explaining the students' attitude toward the *C*-Writing system.

2. Literature Review

2.1. *Situated learning theory*

Learning is an integral part of generative social practice in the lived-in world (Lave & Wenger, 1991). Brown, Collins and Duguid (1989) argued that knowledge is situated. It exists as part of the activity, context, and culture, in which it is developed and used. They note that traditional education too often overlooks the influence of school culture on what is learned in school. Collins (1988) defines situated learning as the notion of learning knowledge and skills in contexts that reflect the ways in which knowledge will be used in real life (p. 2). Billett (1994) noted that the whole nature of the interaction changes and understanding becomes more complex when the learning is without appropriate context and it is only based on description. Thus, situated learning immerses students in an environment that approximates realistic context in which their new ideas and behaviors will be applied and tested.

Further research indicates that students are not able to apply concepts that have been learned in a formal way to real-world situations, because they lack practical experiences (Brown *et al.*, 1989; Lave & Wenger, 1991). However, situated learning puts emphasis on knowledge as a tool that is produced by students when interacting with their environment. Students are able to acquire knowledge, promote reflection, and arouse creativity when immersed in a social and cultural context. Herrington & Oliver (2000) claimed that situated learning environments have some critical characteristics:

(1) Providing *authentic contexts* that reflect the way the knowledge will be used in real life.
(2) Providing *authentic activities*.
(3) Providing access to *expert performances* and the modeling of processes.
(4) Providing *multiple roles* and *perspectives*.
(5) Supporting *collaborative construction of knowledge*.
(6) Promoting *reflection* to enable abstractions to be formed.
(7) Promoting *articulation* to enable tacit knowledge to be made explicit.
(8) Providing *coaching* and *scaffolding* by the teacher at critical times.
(9) Providing for *authentic assessment* of learning within the tasks.

Collins (1988) indicated that the benefits of situated learning include: students learn conditions for applying knowledge; situated learning fosters invention; students see the implications of knowledge; learning in context leads to knowledge structures appropriate for application. Consequently, many researchers believe that knowledge is effectively acquired in real-life environments (authentic context) of social-cognition and culture through problem-solving and social practice (Billett, 1996; Brown *et al.*, 1989; Schell & Black, 1997; Young, 1993).

Based on recent advances in Information and Communication Technologies, many mobile learning systems have been provided by researchers to support situated learning. Kurti, Milrad and Spikol (2007) have designed and supported innovative learning activities based on ubiquitous computing. Here, the main objective is to enrich the curricular content by providing field experiences through using multimedia resources and mobile devices in outdoor settings. Shang, Jong, Lee and Lee (2006) proposed VISOLE (Virtual Interactive Student-Oriented Learning Environment) as a new game-based situated learning paradigm to support web-based teaching and learning, the purpose of which is to assist students studying experiences and social constructions of knowledge from near real-world situations. Hsieh, Chen and Hong (2007) suggest a context-aware ubiquitous English learning system in a campus environment, which can recommend appropriate English course materials based on sensing the student's location. Combining education (including teaching strategy, learning approach, and learning content) with technology (such as wireless networks, multimedia and handheld devices) can create a rich learning environment in which students are able to leave the classroom and get more and more knowledge and experience (Specht, Lorenz & Zimmermann, 2006; Tretiakov & Kinshuk, 2003).

2.2. *Collaborative learning*

The concept of learning as social interaction within communities of practice can be seen as a form of collaborative learning. Several authors (Bruffee, 1984; Chatti, Srirama, Kensche & Cao, 2006; Panitz, 1996) describe collaborative learning scenarios in which student gather in small groups to accomplish a common goal. "Collaborative learning is a situation in which two or more people learn or attempt to learn something together" according to Dillenbourg (1999). As a result, learning is no longer an isolated activity, but it implies mutual trust, shared interests, common goals, commitments, obligations, exchange of services and genuinely proactive, motivated behavior (Allison, Cerri & Gaeta, 2005). This interactive process of collaboration not only emphasizes the element of individual accountability and group interdependence, but also achieves improved learning performance by intercoordination between members.

Compared to collaborative learning, individual learning is characterized by monotony and isolation (Zhang, Jin & Lin, 2005). Students not only share their information and knowledge, but also enhance creativity and critical thinking by discussion or interaction with members within small groups (Gokhale, 1995). Bruffee

(1984) states:

> "*I think I have been more successful. The reason for that increased success seems to be that I know a little more now than I did in the past about the complex ideas that lie behind collaborative learning*" (p. 636).

Therefore, in a collaborative learning environment, students may disagree with other members when they bring their own unique knowledge and perspectives into a forum in which they can develop their skills of comprehension and knowledge in a team (Chang & Chen, 2007). However, many researches have pointed out that the cognition of each participant remains sub-optimal when a group comprises individual members of much higher competence than the others (Schwartz, 1999). We think that having too many competent members in a small group increases competition and can thus obstruct productive cooperation, because each competent member wants to dominate the work and demonstrate their own superior ability. This question is also relevant in collaborative learning. Beside the low degree of participation, research also shows that most of the discussion threads in CSCL environments are very short (the average size of a thread discussions was only 2.8 notes), containing only a few contributions. Schwartz (1999) suggest that the ability to express agency plays an important part in people's motivation and potential benefit in collaborative learning. This leads to two postulates: First, people need to have the intention to learn while interacting in a collaborative group. Second, people should be motivated to collaborate to the degree they are also able to exert their agency through productive behavior.

The advantages and disadvantages of CSCL have been widely discussed in past research. Nowadays, we should ponder how to take advantage of the advantages of CSCL to improve students' ability to think and to improve the students' degree of participation. Advances in information and communication technology bring new opportunities of communication and conversation for students. Students are able to communicate with their peers rapidly and conveniently at different times and locations. Therefore, collaborative learning can be viewed as a process of community in which students can share their ideals, information, and knowledge and mutually engage in creative work in learning environments supported by internet and ICT (Chang & Chen, 2007). Ubiquitous learning not only provides learning material at the right time and in the right place to students, but also improves the interaction with others such as teachers, peers, or experts. Therefore, introducing collaborative learning into the curriculum can open new perspectives and ideas and can help to cultivate interpersonal and team skills. Nguyen, Guggisberg and Burkhart (2006) proposed a multimedia forum called CoMobile, which allows the students to work collaboratively using heterogeneous devices, at anytime and from anywhere. Yatani *et al.* (2004) presented the Musex system based on an orientation game using mobile devices to support collaborative learning in a museum. This research attempts to build a system that combines context-awareness with collaborative learning, which brings effective learning to students.

2.3. *Context-aware learning*

> Dey and Abowd (1999) state: "*Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves.*"

Context information includes *h* as identity, spatial information, temporal information, environmental information, social situation, nearby resources, availability of resources, physiological measurements, and activity according to Korkea-aho (2000). In other words, context is anything that surrounds people who can listen, see, and contact others to interact. Advancements in information and communication technology, especially context-aware computing, can help to assess and use contextual information (such as location, time, nearby resource and activity), as propagated by the mobile computing paradigm already a decade ago (Brown, Bovey & Chen, 1997; Chen & Kotz, 2000). Using these technologies, users can immerse in realistic ambient environments to acquire more and more experience and application skills and interact with other people.

Knowledge is acquired through interaction between individuals and the environment. In order to foster effective learning, we have to provide students with a learning situation that is similar to the real world and offers authetic learning activities. Chen, Li and Chen (2007) proposed a personalized context-aware ubiquitous English vocabulary learning system that can exploit appropriate context based on the student's location, leisure learning time, and individual abilities to adapt learning contents toward students for promoting the learning interests and performance. Moushir *et al.* (2007) provided a learning system, called PERKAM, which can suggest the best matched educational materials and peer helpers in accordance with the detected objects and the current location utilizing the RFID technology. In addition, PERKAM allows the students to share knowledge, to interact and collaborate, and to exchange individual experiences. Context aware ubiquitous learning defines a new stage of *e*-learning and mobile learning, moving from learning at anytime anywhere to learning at the right time and in the right place with the most appropriate learning resources and peers (Wang, Ci, Zhan & Xu, 2007).

2.4. *Summary*

Learning requires the acquisition and accumulation of application skills, as well as knowledge and experience from the external world consecutively. In addition, learners need to foster their own social skills and thinking abilities rather than learning in a fixed situation just by seeing and listening. In Taiwan, students lack creative abilities, such as conversation and critical thinking because the educational system forces them to concentrate on scores instead of rich activities under the pressure of being admitted in a prestigious institution. In our research, we have built a ubiquitous learning environment for writing, which combines a context-aware writing system with realistic experience to foster students' creativity, conversation and critical thinking skills.

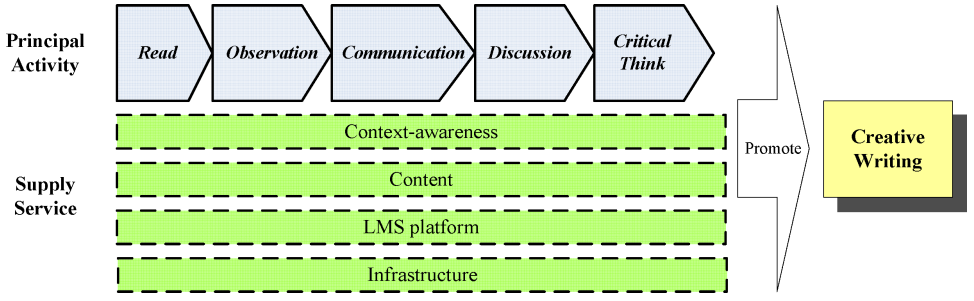

Figure 1. Value chain for creative writing.

3. *C*-Writing Learning Environment

3.1. *The design of learning scenario*

"*Technologies are supportive tools that cannot replace instruction and curricula for students*". We consider that the building of new learning environment is not done just for the sake learning technology, but it should be based on an improved underlying learning strategy. The design of *C*-Writing is based on the theories of situated learning and collaborative learning and uses context-aware technology to create and develop an authentic environment for students. In addition, we have designed a sequence of learning scenarios that modify Porter's Value Chain model (Porter, 1985), which is called Value Chain for Creative Writing as shown in Figure 1. We think that creative writing can be compared to creation of products in enterprises; it comprises a succession of value-adding activities. The learning scenario includes two parts, principal activities and supply service. The principal activities request students to immerse and participate in ways of writing, whereas supply service provides learning technologies and learning contents whose major goal is to assist students in writing in a real environment.

In each process of principal activity, students can accumulate practical experience and assimilate specialized knowledge to be later applied in their daily lives. In this research, we provide five kinds of different learning activities for students to foster different abilities, which include reading, observation, communication, discussion, and critical thinking.

(1) Reading is an important prerequisite for writing. Writing is about structuring statements and takes advantage of a large vocabulary. It is essential for developing the writing ability to acquire new terms by reading and reviewing a variety of books or articles. Therefore, students have to develop the habit of reading extracurricular texts and books in their free time.
(2) Observation is an important activity to extend the viewpoints of students, also to improve their writing. The students' ability to to understand or describe the surrounding environment or episodes is constrained by the learning environment of the traditional classroom. In this conservative way, it is difficult

for students to write or describe any experiences in depth. Immersing students in the environment can produce more ideas and impressions by giving them different external stimuli.

(3) Communication is a fundamental means of social interaction between humans. Communication is not only confined to the interaction between people, but includes interaction with things or situations and can be supported by technology. In the process of communication with the environment, students are able to write essays from situational or object-centered viewpoint. Such communication experiences can be internalized and later be utilized for writing in daily life.

(4) Discussion with other peers is a key element to collaborative learning. Students can experience their own blind spots, express their own opinions, try to persuade others, and then produce new ideas or concepts. In addition, the most important thing is that students can study the ability to negotiate in the process of discussion.

(5) Critical thinking plays a significant role in the learning process. It includes a complex combination of skills with rationality, self-awareness, honesty, open-mindedness, and judgment (Kurland, 2000). However, students have difficulties in developing critical thinking in basic education because most teachers or parents only pay attention on the students' obvious achievement. For this reason, fostering critical thinking is an urgent need for students; they should reflect themselves the drawbacks of their own writing and should comment others' writing products through peer reviewing and finally amend the details of their own writing.

3.2. *The system design*

Neale, Carroll and Rosson (2004) provided a model for evaluating activity awareness that focuses on evaluation strategies for remote collaboration involving long-term activities including both synchronous and asynchronous interaction. They appear to consider effective support for "activity awareness" as a core challenge for CSCW systems. They have adopted the term activity from the very broad and multi-layered concept of activity theory and focus on user experience to evaluate the awareness support in CSCW designs. In our evaluation, we also focus on user experience in the environment to assess context-awareness.

This section deals with the design and implementation of the *C*-Writing system. The purpose of this system is to enhance the learning interest and motivation of students for their writing ability. The design and development concept depends on situated learning theory and combines handy characteristic of mobile device with context-aware technology to provide a writing environment for "context interaction" as shown in Figure 2. Situated learning indicates that knowledge is embedded in any activity and environment in our daily life. When learners intend to acquire experience and knowledge, they should immerse themselves in a learning situation

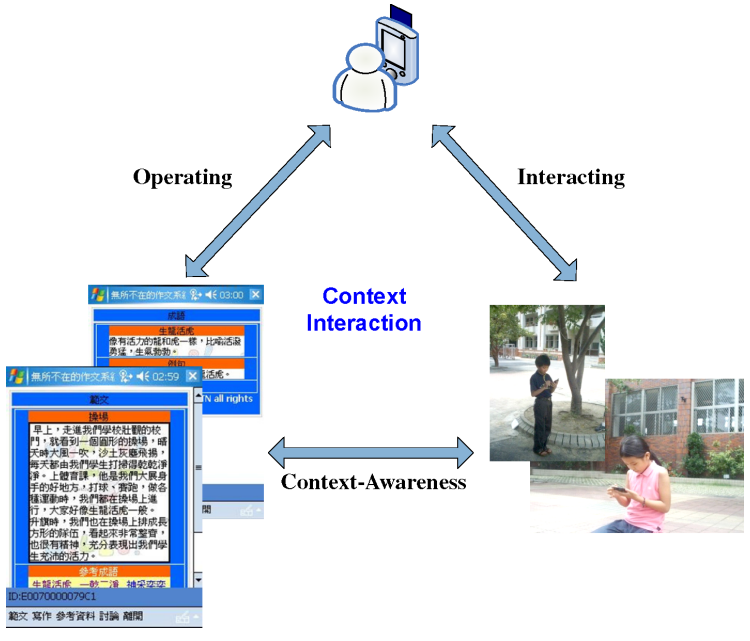

Figure 2. Model for context interaction.

that emphasizes the authentic activities, observation of the situation, demonstration, explanation, etc. Students act individually or in groups to operate this system and to carry out the writing activity in the learning environment. The system facilitates authentic exploration and can actively provide learning content to each student in accordance with their status, location and time. Therefore, in different places, students can receive different contents through this writing environment.

3.3. *System architecture and system interface on PDA*

In this learning environment, students cannot only obtain related information in different places, but can also observe and perceive the surrounding environment as well as communicate with other people. This kind of learning platform suit students to stimulate the inspiration for writing, to encourage ideas and creativity, and to enhance writing by reading, observing, communicating, discussing and critical thinking.

The design and implementation of the *C*-Writing system allows students to write, read, observe, and discuss conveniently and efficiently. The system is based on a three-tier architecture consisting of client sites, an application server, and a database system as shown in Figure 3. On the client side, the system permits the students to assess the learning contents from anywhere at any time via handheld devices, like PDA (Personal Digital Assistant), smart phone, or laptop computer. It can transmit appropriate content to the learner according to his/her position

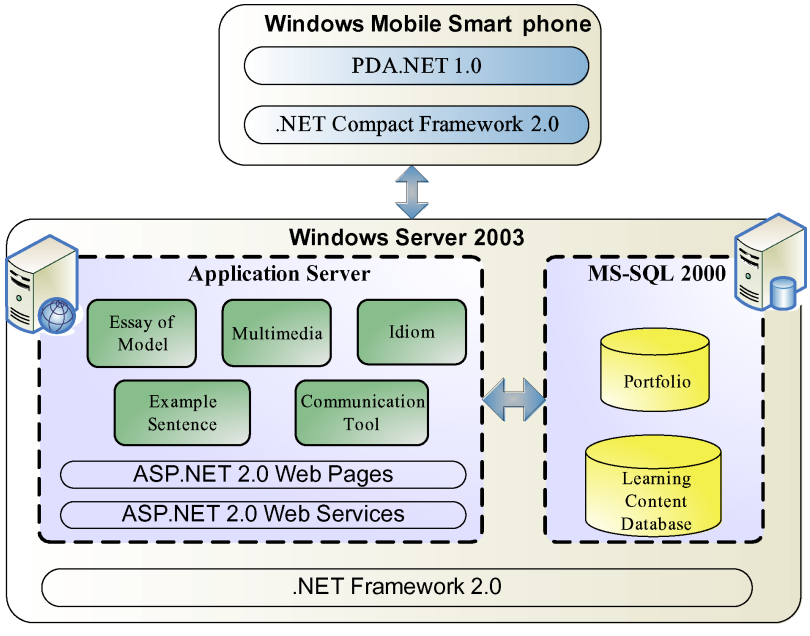

Figure 3. System architecture.

through utilizing RFID technology. On the application server side, a context-aware writing platform is built to provide appropriate learning contents automatically in accordance with each student's needs. This includes the functions of essay model, multimedia, idioms, example sentences, and the use of a communication tool. The application server connects the client side with the central database. On the database system side, the LCD (Learning Content Database) sub-system and a Portfolio sub-system are implemented to store the data in a SQL 2000 database server. The data in the LCD sub-system include the essay model, multimedia, idioms, and sample sentences. Different templates have been designed for all these objects to support easy use and access. The portfolio sub-system stores the learning portfolios and writing products of students, which can be used to analyze or assess the writings, observations, discussions and thinking processes of students. There are three components in the design of the *C*-Writing, which will be described in the following.

The component of context-aware devices: In the learning environment, we install RFID tags in several different locations related to writing themes, respectively. The experimental device for end users (i.e. students) is the ***PDA*** with an attached RFID reader as shown in Figure 4(a). In our system, students are able to use a PDA with an RFID reader to trigger RFID tags. By this kind of assistance and support, students can observe their surroundings and receive the learning contents, which are provided by system to provide a skeleton and describe the content in an essay. The system serves as a *means of observation and communication.*

(a) context-aware device

(b) writing interface

(c) essay model

(d) idiom

(e) sample sentence

(f) multimedia data interface

(g) other related resources

(h) online discussion

Figure 4. The implemented learning system.

Furthermore, the students can be stimulated and trained while writing their essays and communicating with others as shown in Figure 4(b).

The component of learning contents: The mobile device (PDA) will be connected to the context-aware writing server through Wireless LAN. The student can take a PDA to a location related to a writing theme. Then, the student has to trigger an RFID tag to download the corresponding learning contents. The learning contents are classified into essay model, idiom, sample sentence, and multimedia. The essay models have been guided by relevant books of composition (such as prototype composition for primary schools, book of pupils' composition, etc) by experts and teachers as shown in Figure 4(c). In the part of the idiom, we look for idioms relevant to the essay model established by Ministry of Education in Taiwan as shown in Figure 4(d). Afterwards, the idiom is explained by experts and teachers, and the corresponding sample sentences are shown in Figure 4(e). Student can easily understand the meaning of the idioms and use them. In the part of multimedia, we prepare multimedia for each situation and stored these in the system in order to let learners obtain diverse information relevant to the students' current location as shown in Figure 4(f). Finally, if the learning content does not satisfy the students' requirements, they can consult learning websites to search for different information and contents via the wireless network as displayed in Figure 4(g). These system functions have been built in accordance with the *elements of reading and critical thinking*.

The component of writing and discussion platform: Students can write essays using the writing function. The system provides a communication tool for students, which allows them to communicate with others to discuss and share their ideas and impressions as shown in Figure 4(h). This system function is based on the *elements of communication and discussion*.

4. Research Method

We have conducted an empirical study focused on the influence of the context-aware writing system in elementary education. The participants of this experiment were 53 students (an experimental group with 25 students and a control group with 28 students), all 3rd grade students from two classes of Dong-Guang Elementary School, Tainan City, Taiwan. The students in these two groups do not have significance difference ($F_{1,51} = 2.726$, $P > 0.05$) on Chinese ability. Data was collected by a survey questionnaire and a test to assess the subjects' attitude toward the *C*-Writing system. The experimental procedure comprised three steps:

(1) First step: Teacher teaches students how to write a good essay (for both the experimental group and the control group) using the traditional approach (instruction and seminar in classroom) in the writing course. This teaching activity spanned over eight weeks (two hours of every week). In the first two weeks, the teacher teaches students how to set up the skeleton of the essay which include the four steps in the composition of an essay. In the second two

weeks, teacher instructs students how to employ the corresponding words and phrases in the essay. And then, after two weeks, the teacher teaches students how to embellish sentences and paragraphs. It takes two weeks on the whole. In the final stage, teacher instructs students how to integrate the paragraph to form a full essay, which let essay become more clear and coherent. Afterward, students to write an essay in the classroom using *paper and pen*; the writing topic is "My Campus". This essay is used in this study as "pre-examination achievement".

(2) Second step: First of all, in order to ensure that students are able to write their essays using the *C*-Writing system, two weeks are dedicated to teaching students (experimental group) on how to use the *C-Writing system* and to guide students in its practical handling. After that, some devices of the context-aware writing system such as RFID tags and wireless networks have been set up on the campus. This environment allows students to engage in free-floating writing activities on campus as shown in Figure 5. For the other group, the teacher points out the shortcomings of the students' last article (control group). Furthermore, students are asked to improve on these shortcomings in order to reinforce their writing ability. Afterward, students (control group) write another essay using

(a) (b) (c) (d)

Figure 5. Students in real operating circumstance.

Table 2. The items in assessment scale.

A1	The content of essay is coherent.
A2	The handwriting is neat and correct.
A3	The viewpoint of the essay is clearly represented.
A4	The punctuation and format of the article are correct.
A5	The idiom and sample sentences are used flexibly and correctly.
A6	The style is relaxed and lively, and sentences are fluent.
A7	The rhetorical skill is good.
A8	The paragraphs are clearly demarcated, and have substantial content.
A9	The materials are original and show the author's own intention.
A10	Describe content in a deep way.

again *paper and pen.* The topic of writing is "My Campus" for the two groups. Similarly, this essay is used in this study as post-examination achievement.

(3) Third step: All participants (experiment group) are asked to answer the questionnaire after using the *C*-Writing system. Excluding the unreturned and incomplete questionnaires, the valid sample is 30. The questionnaire has 18 items, all with a 5-point Likert scale (from "1"/"strongly disagree" to "5"/"strongly agree"). After that, descriptive statistics were used to analyze and explain the students' attitudes toward the *C*-Writing system.

4.1. *Assessment of student's writing*

This research employs an assessment scale that is designed by the teachers of the Dong-Guang elementary school to confirm whether the student's writing ability has significantly advanced through using the context-aware system. The assessment scale includes ten assessment items as shown in Table 2. The full mark of each item is 10 points; therefore, the total achievement of the assessment scale is 100 marks. The pre-test and post-test achievements that include experimental group and control group are graded by two writing experts. Afterwards, we compared the achievements of the experimental group and the control group using an ANOVA in order to understand which of writing approaches led to better results.

5. Results

Most students of the experimental group have experience (at home, school or library) of computer use (100%, 25/25) and Internet (84%, 21/25). There are computers in their homes (100%, 25/25), but only a few students have used PDA (28%, 7/25) and there are some PDA in their homes (32%, 8/25). This result revealed that most of students have basic computer operation ability and experience, but ability and experience of operation of PDA are insufficient.

5.1. *Student's attitudes toward the C-Writing system*

The descriptive statistics (means M and standard deviations SD) of student attitudes (experiment group) toward the *C*-Writing system are shown in Table 3. The

Table 3. Descriptive statistics of student's attitudes toward the *C*-Writing system.

No.	Items	*M*	*SD*
Users' attitudes		3.91	
1.	Use PDA in outdoor learning is easy.	4.16	0.80
2.	I have confidence in using the system for writing the better essay.	3.80	0.87
3.	I have confidence in using the system for ability to improve writing.	3.80	1.32
4.	I have confidence in using the system for enhance the interest of writing.	3.84	1.18
5.	I like use the system to writing.	3.96	1.02
System acceptance		4.25	
6.	I hold the positive view on similar system.	4.27	0.91
7.	I intend to use the system as a writing tool in the future.	4.36	0.86
8.	I intend to use similar system as a learning tool to learn other course.	4.12	1.01
System quality		3.35	
9.	The function of system is enough.	3.52	1.12
10.	The system is very steady.	3.12	1.30
11.	The on-line quality of system is good.	3.40	1.32
Content quality		3.68	
12.	The content in the system is abundant.	3.60	1.19
13.	The content in the system is clear and easy ready.	3.84	1.07
14.	The content in the system is moderate.	3.60	1.23
Interaction with environment		4.15	
15.	I am willing to discuss with other people (such peer or teacher) while writing.	4.36	1.04
16.	I am able to observe the surrounding environment while writing.	4.20	1.00
17.	I can combine the true environment to carry on the writing.	3.96	1.02
18.	I can be easy describe each impression of location through using PDA.	4.08	0.86

alpha reliability of student's attitudes toward the *C*-Writing system show a high degree of acceptance ($a = 0.89$). Students show a positive opinion in user attitudes. Students consent that using PDA in outdoor learning is easy ($M = 4.16, SD = 0.80$), and like they use of this system for writing ($M = 3.96, SD = 1.02$). In the part of system acceptance, students show a very high for degree of system acceptance ($M = 4.25$) and hope to use a similar system in the future ($M = 4.36, SD = 0.86$). Students' perception regarding the system quality ($M = 3.35$) and the content quality ($M = 3.68$) is ordinary. Students consent that interaction with the environment is effective while writing ($M = 4.15$), and they are willing to discuss with other people ($M = 4.36, SD = 1.04$). Students can observe the surrounding environment ($M = 4.20, SD = 1.00$) and integrate observations with their writing ($M = 3.96, SD = 1.02$). Also, they are able to easily to describe each impression of location using the PDA ($M = 4.08, SD = 0.86$).

5.2. *Assessment of student's writing*

For students of experimental group ($N = 25$), various independent variables (10 assessment items) were assessed to compare student achievements between pre-test and post-test. Table 4 presents the results of ANOVA. The means of "the

Table 4. ANOVA result for assessment of student's writing ($N = 25$).

Variables	Experiment Group				
	M		*SD*		*F* Value
	Pre-test	Post-test	Pre-test	Post-test	
The content of essay is coherent.	7.56	8.56	1.16	1.04	10.23***
The handwriting is neat and correct.	8.08	8.76	1.15	0.78	5.98*
The viewpoint of the essay is clearly represented.	7.60	8.48	1.26	1.09	7.01*
The punctuation and format of the article are correct.	7.84	8.44	1.14	1.16	3.40
The idiom and sample sentences are used flexibly and correctly.	7.80	8.76	1.27	1.16	7.84**
The style is relaxed and lively, and sentences are fluent.	7.76	8.40	1.06	1.04	5.78*
The rhetorical skill is good.	7.48	8.40	1.12	1.15	8.16**
The paragraphs are clearly demarcated, and have substantial content.	7.60	8.64	0.91	1.22	11.64***
The materials are original and show the author's own intention.	7.76	8.80	1.05	1.04	12.34***
Describe content in a deep way.	7.84	8.88	0.94	0.88	16.22***
Total score	77.28	86.24	9.19	9.40	11.60***

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

content of essay is coherent" ($F = 10.23$, $\rho < 0.001$), "The handwriting is neat and correct" ($F = 5.98$, $\rho < 0.05$), "the viewpoint of the essay is clearly represented" ($F = 7.01$, $\rho < 0.05$), "the idioms and sample sentences are used flexibly and correctly" ($F = 7.84$, $\rho < 0.01$), "the style is relaxed and lively, and the sentences are fluent" ($F = 5.78$, $\rho < 0.05$), "the rhetoric skill is good" ($F = 8.16$, $\rho < 0.01$), "the paragraphs are clearly demarcated, and the content is substantial" ($F = 11.64$, $\rho < 0.01$), "The materials are original and show the author's own intention" ($F = 12.34$, $\rho < 0.001$), "describe content in a deep way" ($F = 16.22$, $\rho < 0.001$), and "total score" ($F = 11.60$, $\rho < 0.001$) for the post-test were higher than those of the pre-test. ANOVA results show that this difference is significant. This result shows that the *C*-Writing system can assist students in improving the writing ability and learning performance.

5.3. *Comparison of learning performance among different learning model*

In this selection, we want to understand whether or not there is a difference between learning methods in terms of writing achievements after removing the influence of intelligence. This research employs an ANCOVA to analyze the relation between students' "pre-examination achievement", "post-examination achievement" and "learning model (used/not used *C*-Writing system)". There is an interaction of minor degree between pre-examination achievement and the learning model

Table 5. ANCOVA result for assessment of post-examination achievement.

Source	DF	Type III Sum of Squares	Mean Square	F Value	Sig.
Corrected Model	2	1606.46	803.23	28.82	0.000
Intercept	1	333.63	333.63	11.97	0.001
Pre-examination achievement	1	1255.78	1255.78	45.06	0.000
Learning model	1	123.86	123.86	4.45	0.040
Error	50	1393.46	27.87		
Total	53	422457.00			
Corrected Total	52	2999.93			

R Square = 0.536 (Adjusted R Square = 0.517)

Table 6. Post hoc analysis for learning model.

Learning Model		Mean Difference (I–J)	Std. Error	Sig.
Used C-Writing System (I)	Unused C-Writing System (J)			
91.21	86.96	4.255	2.019	0.040
Method of Post Hoc analysis: Bonferroni				

($F_{1,50} = 1.571$, $\rho = 0.216$), which is shown by the line of regression overlapping between "pre-examination achievement" and "learning model". Since the homogeneity requirement is still met we could carry on with the ANCOVA analysis. The Table 5 depicts the results of the ANCOVA for post-examination achievement. Based on the premise that the pre-examination achievement is the covariate, the learning model has significance for the post-examination achievement ($F_{1,50} = 4.45, \rho < 0.05$). This result shows that using the C-Writing system leads to differences in writing achievement, after getting rid of the influence of intelligence. The post hoc analysis for the learning model showed (see in the Table 6) that achievement when using the C-Writing system ($M = 91.21$) is higher than the achievement with traditional teaching ($M = 86.96$).

6. Discussion

Regarding the experience of using computer, handheld devices, and Internet, students in elementary schools have basic computer abilities and skills. From Table 2 we see that students are willing to use our system for essay writing. It is essential for users to have adequate basic experiences in computer use. The students believe that using computers and Internet can have a positive influence on their job performance (Liaw, 2007). Therefore, the students have highly positive attitudes toward the C-Writing system (the means is equal to 3.91), provided they have sufficient equipment. In addition, they do not exclude to learn other curricular subjects through similar learning systems even though only few students have used PDA (the means of system acceptance is equal to 4.25). This result infers that nowadays

students are attracted by new information technology no matter whether they have used these devices or not; they are able to adapt and use it rapidly and effectively.

The students are not satisfied with the system quality (the means is equal to 3.35). Especially, the rating for stability is lowest (means is equal to 3.12). This result shows that students are not prepared to use the PDA via wireless networking because the time of training is very short and most of students have not used PDA before. The training time for basic PDA operation was limited so that students did not have enough time to become familiar with the system and functions of the PDA and especially with handwriting input. Therefore, schools and the government will have to improve students' basic skills for operating mobile devices. In addition, the stability of the wireless network is not sufficient because it cannot re-connect automatically when a student has moved from one location (e.g. garden) to another one (e.g. amusement park). This implies that students have to figure out how to connect to the network again. Besides that, the function of PDA is restricted as compared to personal computers (PC). This has a negative effect on the facilitation of cognitive processes. On the other hand, the students are also not satisfied with content quality (the means is equal to 3.68), because the screen size for PDA to display contents is insufficient as compared to the PC. Therefore, our future research must modify the content in order to better adapt to the PDA.

Nowadays, computers are more a communication tool than just a data processing tool (Liaw, Chen & Huang, 2008). From Table 2 we see that students are willing to discuss with others (such as peers or teachers) while writing (the means is equal to 4.36). Student likes to share their viewpoints or ideas through communication and discussion when they find out novel things in their learning process. Collaborative partnerships between academia and practice can help to bridge the gap in terms of supporting opportunities to share perceptions, creating an environment for shared knowledge and social opportunities, enabling a better preparation of potential future staff (Souers, Kauffman, McManus & Parker, 2007).

Students' writing in various fields is improved through using the *C*-Writing system, except for the ability in "A4: the punctuation and format of the article are correct". We found significant differences as to those four items ($\rho < 0.001$): (a) The content of essay is coherent; (b) The paragraphs are clearly demarcated, and have substantial content; (c) The materials are original and show the author's own intention; (d) Describe content in a deep way. As described above, learners are able to improve their writing skills when they are offered relevant additional information (such as the essay model, sample sentences, the idioms, or they can use Google) according to the learner's demand. In addition, learners can stimulate more ideas out and create better results. Results for "The idiom and sample sentences are used flexibly and correctly" ($\rho < 0.01$) show that the learners are able to effective apply idioms and sample sentences in their own writing. This result showed that the learners can promote their own ability of critical thinking.

On the other hand, the students using the *C*-Writing system show significant advancements compared with traditional teaching. This result shows that providing

learning material, combining diverse situations and facilitating communication with peers is useful and appropriate for the learners. They can reflect the context of writing, their inspiration is stimulated, and they write more vividly. Therefore, an advanced learning environment designed to be operated easily will be implemented and provided to students in the future.

7. Conclusion

The purpose of education is to help students apply and implement knowledge to solve problems faced in a real life. This study applied the capabilities of wireless networking, RFID, and portable devices to create a writing environment for students. Students have been able to contact and observe real situations to acquire more information, knowledge, or ideas. The results of our research showed that most of the students approved this system's benefits and are willing to use similar systems in the future. Students can improve their learning performance and attract the attention of other students through this system efficiently.

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