Effects of Multimodal Learning Analytics with Concept Maps on College Students’ Vocabulary and Reading Performance

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(Submitted December 5, 2016; Revised April 30, 2017; Accepted June 2, 2017)

ABSTRACT
This study integrated the multimodal framework of learning analytics (IMFLA) with the concept mapping (Cmap) approach to improve students’ vocabulary and reading abilities. A total of 70 participants were divided into 2 classes, Class 1 (experimental) and Class 2 (control), for a 1-year period. Vocabulary and reading tests were implemented 3 times. Repeated measures were conducted to test the effect of the program. The results indicated that Time had a significant effect on enhancing both outcome measures (p < .01 for vocabulary; p < .001 for reading). Moreover, significant interaction effects between Time and the program on both vocabulary (p < .05) and reading (p < .001) further suggest that a longer period of time spent on the program would result in a significant effect on both the vocabulary and reading outcome measures. That is, a significant interaction effect occurred between IMFLA and the time factor. Such interaction effects resulted in better vocabulary and reading abilities when students of Class 1 spent more time on the IMFLA procedure. The multimodal and learning analyses of students’ weekly logs confirmed this improvement. We therefore suggest that instructors use digitalized wordlists and Cmaps in language instruction to enhance students’ vocabulary and reading abilities.

Keywords
Multimodal, Learning analytics, Concept map, IMFLA

Introduction
It has long been recognized that vocabulary knowledge is closely related to reading comprehension (Qian, 2002). Vocabulary learning through reading has direct influences on classroom practice (Nation & Webb, 2011). On the one hand, language instructors often use concept mapping (Cmap) in reading activities to enhance reading comprehension (Wang, Huang, & Hwang, 2016). Learning analytical methods are further needed to observe the details of learning processes, students’ language use and learning behavior.

On the other hand, the process of learning to read through digital approaches is rather complicated. Such a process involves three critical components (Park, Zheng, Lawrence, & Warschauer, 2014): word recognition (e.g., reading development and software for word recognition), language comprehension (e.g., multimedia glosses, vocabulary learning, and corpus-based wordlists), and text interpretation (e.g., textual structures, digital reading materials, translation, and interactive feedback). However, few studies have investigated the process of applying Cmap to vocabulary and reading learning by making a book using digital methods. To probe such a complicated process, the current study aimed to explore the effect of integrating multimodal learning analytics (LA) with Cmap on students’ vocabulary and reading abilities.

First, as the popularity of computer technology has brought multimodal approaches into the digitalized epoch, many studies have demonstrated the effectiveness of Cmap in language and content learning (Liu, Chen, & Chang, 2010). The computerized approach has simplified the Cmap learning process, which enables more flexible presentations and interactions with the learning content (Hwang, Wu, & Ke, 2011; Yang, Hwang, Hung, & Tseng, 2013). It is evident that students understand better and remember more while learning from a Cmap than from a textual presentation (Kim & Olaciregui, 2008). In addition, Cmap is considered a technical tool for LA studies; it is used for students to organize and visualize knowledge experience, which can be tracked to support LA studies in ubiquitous environments (Hwang, Hung, Chen, & Liu, 2014).

Second, LA has been developing rapidly in recent years. It uses intelligent data, learner-produced data, and analysis models to discover information along with social connections to predict and advise on learning (Siemens, 2010). Johnson, Adams, and Cummins (2014) defined LA as an educational application of “big data” within online and hybrid environments.
Literature review

Corpus-based wordlists and reading comprehension

A frequency list has long been considered an essential tool of corpus linguistics (Barker, 2010). Frequency, wordlists, and the corpus should be considered in vocabulary teaching (Nation & Webb, 2011). The benefits of using corpora for creating word lists for vocabulary learning are well recognized. There are two main considerations regarding wordlists for L2 learners (Coxhead, 2011). First, frequency plays a significant role in creating wordlists. Second, digitalized or online L2 vocabulary learning is closely related to reading ability (Abraham, 2008; Cobb, 2007). Tribble and Jones (1997) argued that the most effective starting point to appreciate a text is a frequency-based word list. For instance, a substantial frequency list can be compiled and derived from the British National Corpus (BNC), a large corpus of modern English (Burnard, 2007). Additionally, one of the most commonly used wordlists is the Academic Word List (AWL), selected from the Academic Corpus (Coxhead, 2011). However, few studies have explored how a learners' corpus used together with Cmap can be analyzed, or how Cmap can be used in teaching vocabulary to reinforce reading ability.

Concept map analysis

A Cmap is considered a technical tool for LA studies (Hwang, Hung, Chen, & Liu, 2014). According to Hughes, Maccini, and Gagnon (2003), visual displays can be shown in temporal, sequential, hierarchical, semantic, and cyclical patterns. Each pattern has its particular function and purpose to arrange the information explicitly. For example, graphic organizers are based on the way they arrange information, typically including four general types: hierarchical, conceptual, sequential, and cyclical patterns (Novak & Cañas, 2007).

Concept maps are also used in facilitating cooperative learning (Novak, 1991). Especially, many studies have shown the effectiveness of Cmap for engaging students in meaningful learning. For example, Hwang, Hung, Chen, and Liu (2014) reported that Cmap is an assessment tool for helping instructors evaluate students’ cognitive levels and knowledge structures. In their “Mindtool- Assisted In-field Learning” project, Cmap was employed in context-aware ubiquitous learning activities, and the authors claimed that the students’ learning achievements and attitudes were significantly improved.

Cmap can also improve students’ literal and inferential comprehension ability. Dias (2010) suggests that the application of the Cmap strategy may enhance L2 learners’ reading comprehension. However, the online learning processes of Cmap should be observed, and the learners’ behavior and language use should be noticed and analyzed through learning analytics to improve students’ vocabulary and reading proficiency.

Learning analytics

Learning analytics (LA) is the use of data produced by the learner, and analysis models to discover information and social connections in order to offer advice for learning (Siemens, 2010). More recently, the 2016 Horizon Report (p. 38) highlighted LA as “an educational application of web analytics aimed at learner profiling, a process of gathering and analyzing details of individual student interactions in online learning activities.”

The data analysis of LA has developed rapidly and requires both quantitative and qualitative analyses to improve the student learning experience. LA plays an important role in learning processes through online learning logs, insights, and information for instructors and learners (Hwang, Hung, Chen, & Liu, 2014). In other words, LA includes the following features (Johnson, Adams, & Cummins, 2014):

- Using “big data” and adaptive learning data,
• Using learner-produced data to discover information,
• Individualizing personal learning experience,
• Providing online-interactive feedback,
• Transforming education “from a standard one-size-fits-all delivery system” into a flexible framework to meet students’ needs and interests.

The multimodal approach

Multimodal methods deal with communicative language in different modes and other devices. Herring (2015) proposed a framework of multimodal computer-mediated communication (CMC), including (1) interactive multimodal platforms— used to support a union of modes such as text, audio, video, and graphics for user-to-user communication; and (2) robot-mediated communication – human-human communication through “voice, video, and motion” in physical space via a remotely controlled robot.

In other words, language is not the only approach and source for conveying meaning and informing one’s social identities (Cameron & Panovic, 2014). Language must cooperate with other communication modes, which refers to other non-verbal signals, such as facial expressions, gazes, gestures, and the like, to achieve the characteristics of language through which people can express the meaning of their utterances and identities. Sindoni (2014) claimed that there are three ways in which we gain information from non-verbal resources and language cues: (1) the speaker’s facial expression, (2) kinetic action, and (3) proxemics, which can be used to analyze the classroom discourse. “Kinetic action” is related to body movement such as head-nodding and hand-waving, while “proxemics” refers to the distance between speakers.

One specific approach to delving into how language is integrated with other communication modes is multimodal discourse analysis. Such analysis intends to investigate how other tools and other multiple modes (e.g., gaze, gesture, and proxemics) are combined together with discourse (Jones, 2012). One key principle of multimodal analysis is that the aim is not to understand how those outside factors exploit their power in language, but rather, to explore how language “works together” with other multiple communication modes.

Research questions

The current study integrated a multimodal framework of learning analytics (IMFLA). We investigated its effect on all the participants’ vocabulary and reading abilities during a period of two academic semesters. Accordingly, the following research questions were proposed to guide the current study:
RQ 1: Is Time effective in terms of improving students’ (1a) vocabulary and (1b) reading test performance?
RQ 2: Is IMFLA effective in terms of improving the students’ (2a) vocabulary and (2b) reading test performance?
RQ 3: Is there any interaction effect between Time and IMFLA on the students’ (3a) vocabulary and (3b) reading test performance?
RQ 4: How did the learning analytics support the log analysis, concept mapping and multimodal approaches?

Method

Participants

A total of 70 students from a public university in Taiwan in two intact classes: Class 1 (experimental group; n = 35) and Class 2 (control group; n = 35) participated in this study. They were students enrolled in a Vocabulary and Reading course. The students’ English vocabulary and reading abilities were evaluated three times, first at the beginning of the course, second time at the end of the first semester, and finally at the end of the second semester.

Materials, treatment, and course design

The vocabulary teaching material, a textbook entitled Most Essential Prefixes and Word Roots (Hsu, 2006), was adopted to improve the students’ advanced academic vocabulary. Students were provided with a list of the first 900 words extracted from this textbook based on their frequency ranking in the BNC. Besides the extracted wordlist, the online Cmap was also used for vocabulary teaching.
We tried to use concept maps to examine students’ word power and engaged them in the collaborative construction of Cmaps. *Inspiration 9* was used to draw Cmaps. Only students of Class 1 were encouraged to use any Cmap tools to draw Cmaps. For example, Figure 1 demonstrates examples of two types of Cmap. Based on two domains (*prefix* and *root*) and propositions (= linking lines with linking words), a prefix “ad-” (“to”) linking with a root “-orn” (“to deck”) becomes “adorn” (“to decorate”). Likewise, the prefix “contra-” (“against”) linking with a root “-dict” (“to say”) becomes “contradict” (“to oppose”).

<table>
<thead>
<tr>
<th>Cmap for teaching prefix ad- (Web-like pattern)</th>
<th>Cmap for teaching prefix contra- (Sequential pattern)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prefix: ad-</td>
<td>Prefix: contra-</td>
</tr>
<tr>
<td>toward, to</td>
<td>contra</td>
</tr>
<tr>
<td>decorate</td>
<td>admit</td>
</tr>
<tr>
<td>damage</td>
<td>deny</td>
</tr>
<tr>
<td>synonym</td>
<td>antonym</td>
</tr>
<tr>
<td>Part of speech</td>
<td>Cmap analysis with exercises</td>
</tr>
<tr>
<td>V.</td>
<td>Multimodal analysis (with LA to analyze weekly logs)</td>
</tr>
<tr>
<td>adjoin</td>
<td>Vocabulary and reading exams</td>
</tr>
<tr>
<td>adjacent</td>
<td>Vocabulary and reading exams</td>
</tr>
<tr>
<td>synonym</td>
<td>Cmap analysis without exercises</td>
</tr>
<tr>
<td>antonym</td>
<td>No IMFLA (no electronic, interactive, or online logs/activities)</td>
</tr>
<tr>
<td>admit</td>
<td>A book (one year project)</td>
</tr>
<tr>
<td>deny</td>
<td>A book (one year project)</td>
</tr>
</tbody>
</table>

*Figure 1. Cmaps of vocabulary teaching and learning*

As for the reading materials, both classes were required to read English news articles and short essays. They watched the movies *Pride and Prejudice* and *Dead Poets Society*, read the novels on which the movies were based, and then translated one of them into Chinese as their final project, i.e., their own translated book. There were six small teams (5-6 students per team) in each class; but, the teaching methods were different. In Class 1, the multimodal method was made available to the students with the Cmap practices and the electronic, interactive, or online materials to explain the plot, characters, facial expression, body language, and gestures of the characters in the novel. In Class 2, the traditional grammar-translation approach was mainly used without interactive Cmap exercises or the electronic online materials.

All of the students took three reading and vocabulary tests, but only Class 1 maintained online weekly logs used as a corpus for further learning analysis. Logs for 36 weeks were collected, 18 for each semester. To observe the learning behavior, each student’s weekly log was analyzed, including three sections for the analysis of word frequency, wordlist, and concordances: (1) What I have learned today, (2) How I helped my classmates, (3) Suggestions for the instructor, who could then reply to the student’s feedback or give online comments immediately. Based on these criteria, the logs entered by the students in Class 1 were accessible to the in-group participants and the teacher. Table 1 summarizes the course design, including the vocabulary and reading materials.

<table>
<thead>
<tr>
<th>Table 1. Course design</th>
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<tbody>
<tr>
<td>Item</td>
</tr>
<tr>
<td>I. Vocabulary</td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td>II. Reading</td>
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<td></td>
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<tr>
<td></td>
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<tr>
<td></td>
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<tr>
<td></td>
</tr>
<tr>
<td>III. Outcome</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
Measurement

Quantitatively, the students’ performance was measured via the vocabulary and reading tests. The vocabulary tests (Wang, 2006) were designed based on a modified academic wordlist with example sentences from the BNC (see the sample test in Table 2).

A pilot test (using test-retest) was administered (n = 345; average= 65; higher group = 84, lower group = 44) for the reliability coefficient \((t/stest-retest coefficient = .74, p < .01; \text{Cronbach’s alpha} = .97)\) and the Predictive criterion-related validity was evaluated using the vocabulary test and Joint College Entrance Exam (the predictive validity coefficient = .76, \(p < .01\)). The reading test was based on the TOEFL reading test (three short essays with 10 multiple choice questions). Since each dependent measure was implemented three times, test-retest reliabilities were calculated. The results indicated that the reading and vocabulary tests reached acceptable reliability, 0.73 and 0.77, respectively.

Qualitatively, students of Class 1 maintained weekly online logs collected as a corpus (included in IMFLA), which is the difference between these two groups. A summary of the material used for testing and outcome measures was the wordlist, modified AWL for testing only, the TOEFL Reading test, the Project (a book), and the Weekly logs (Online interactive for Class 1).

Table 2. Item analysis for example questions (50 questions)

<table>
<thead>
<tr>
<th>Vocabulary questions with example sentences</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ( ) Search facilities as well as browse facilities are available now.</td>
<td>.000***</td>
</tr>
<tr>
<td>a. useful b. reliable c. obtainable d. valuable</td>
<td></td>
</tr>
<tr>
<td>2. ( ) This formula, very common in law examinations, means “Can B sue A successfully?”</td>
<td>.005**</td>
</tr>
<tr>
<td>a. form b. rule c. movement d. fortunate</td>
<td></td>
</tr>
<tr>
<td>3. ( ) As we have seen they may involve other types of expert as well.</td>
<td>.010*</td>
</tr>
<tr>
<td>a. include b. invent c. resolve d. solve</td>
<td></td>
</tr>
<tr>
<td>4. ( ) It was this principle that seemed now to be inadequate.</td>
<td>.016*</td>
</tr>
<tr>
<td>a. principal b. prime c. answer d. law</td>
<td></td>
</tr>
<tr>
<td>5. ( ) I am sure that our readers have their pens ready to respond.</td>
<td>.003**</td>
</tr>
<tr>
<td>a. respect b. resign c. resolve d. reply</td>
<td></td>
</tr>
</tbody>
</table>

Note. *\(p < .05\); **\(p < .01\); ***\(p < .001\).

Analysis

Figure 2 is the proposed model (i.e., IMFLA) involving four equally important modes (adapted from Herring, 2015): The stakeholders (instructor-learners), data (weekly logs \(\rightarrow\) corpus), audio-video (clips), and instruments (Cmap, WordSmith Tools, etc.) in addition to an interactive multimodal platform based on the online Blackboard to maintain the consistency of the different modes.

Multimodal Framework for Learning Analytics

Stakeholders \(\rightarrow\) Data (corpus) \(\rightarrow\) Audio-Video \(\rightarrow\) Instruments

Instructor learners \(\rightarrow\) wordlists weekly logs movies clips Cmaps Others

Electronic Blackboard as the interactive platform

Figure 2. Integrated multimodal framework for learning analytics (IMFLA)

In this study we adopted repeated measures to answer research questions 1-3, using SPSS 22 statistical software. The current design measured the effect of IMFLA over three points of time, treating reading and vocabulary abilities as dependent measures, while IMFLA was a major factor. There are two reasons for the choice of repeated measure: (1) to enhance the power to detect effects, and (2) to detect interaction effect.

According to Seltman (2018) and Loerts (2008), when the same variable is measured more than once for each subject, the use of repeated measure reduces unsystematic variability in the design, resulting in greater power to
detect effects. Furthermore, Seltman (2018) suggested that the primary purpose of repeated measure is to detect an interaction effect. If the interaction is significant, then both factors, the IMFLA and time, affect the outcome. To answer research question 4, WordSmith Tools was used to analyze the online weekly logs in terms of word frequency (%), wordlist, clusters, and concordance.

Procedure

All participants took reading and vocabulary tests before the launch of the course. An online Blackboard was used as a platform for IMFLA. The procedure is summarized in Figure 3.

![Figure 3. The IMFLA procedure](image)

After the first test, the Class 1 students learned English vocabulary using the corpus-based wordlist with Cmap-interactive word parts and reading, and then wrote their online logs (36 weeks). They also translated the novel and submitted it as a book (learner-produced data). Additionally, their online weekly logs were collected and downloaded as an electronic corpus for learning analysis to discover information, to predict and advise on learning in order to improve their learning. They took the second set of tests at the end of the first semester and the final set of tests at the end of the second semester.

However, students of Class 2 used a relatively more traditional approach. They memorized English vocabulary focusing on word parts (i.e., prefixes, roots, and suffixes), wrote assignments, and submitted hardcopies of their assignments. Both classes finished translating a movie novel and submitted it as a book by the end of the second semester. They also took the second tests and the final tests.

Results

Descriptive statistics

Table 3 shows the results of the descriptive statistics. The students’ vocabulary scores increased from 83.89 to 86.74 and further to 88.23 for Class 1, while they increased from 88.69 to 89.20 but then decreased slightly from V2 to V3 (89.20 to 89.14) for Class 2. As for the students’ reading scores, they increased from 57.43 to 74.29 and further to 79.71 for Class 1, while they increased from 80 to 90 but then decreased to 85.43 for Class 2.
Results of within-subject and between-subject effects for vocabulary ability (RQ1a-3a)

To investigate the differences in the vocabulary scores in repeated measure, Mauchly’s W was first implemented for the Sphericity test. The result (p = .411 > .05) indicated that the variances in the differences between all possible pairs of levels of vocabulary tests were equal; that is, there was no violation of repeated measure assumption; therefore, Sphericity could be assumed. As a result, a test of within-subject effect (repeated measure) was considered. To answer RQ1a, Repeated measure for within subject effect on vocabulary scores indicates that Time was significant in enhancing the learners’ vocabulary ability (F = 5.460, p < .01, partial \( \eta^2 = .074 \)), as shown in Table 4.

<table>
<thead>
<tr>
<th>Source</th>
<th>Type III SS</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
<th>Partial eta squared</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tests of Within-Subject Effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time</td>
<td>212.610</td>
<td>2</td>
<td>106.305</td>
<td>5.460</td>
<td>.005</td>
<td>.074</td>
</tr>
<tr>
<td>Time * Class</td>
<td>133.981</td>
<td>2</td>
<td>66.990</td>
<td>3.440</td>
<td>.035</td>
<td>.048</td>
</tr>
<tr>
<td><strong>Tests of between-Subjects Effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class</td>
<td>389.505</td>
<td>1</td>
<td>389.505</td>
<td>1.926</td>
<td>.170</td>
<td>.028</td>
</tr>
</tbody>
</table>

As for the answer to RQ2a (vocabulary), the between-subject analysis (see Selman, 2014) indicated that IMFLA’s effect on the learners’ vocabulary ability was insignificant (F = 1.926, p = .170 > .05), with only 2.8% of the variance in vocabulary ability accounted for by IMFLA. The analysis also confirmed a significant interaction effect between Time and Class on vocabulary ability (F = 3.44, p < .05, partial \( \eta^2 = .048 \)), and thus answered RQ3a (vocabulary). The two figures of partial \( \eta^2 \) (effect size) suggest that 7.4% of the variance in vocabulary scores was explained by the Time factor, while 4.8% of the variance in reading scores was explained by the interaction between Time and the treatment.

Results of within-subject and between-subject effects for reading ability (RQ1b-3b)

Mauchly’s W was conducted to test for Sphericity. Table 5 showed that the variances in the differences between all possible pairs of levels of reading tests were equal (p = .093 > .05). With no violation of the repeated measure assumption, Sphericity could be assumed. As a result, a test of within-subject effect (repeated measure) was considered.

To answer RQ1b (reading), repeated measure shows that Time was significant in enhancing the learners’ reading proficiency (F = 28.157, p < .001, partial \( \eta^2 = .293 \)). Again, to test whether IMFLA affected the learner’s reading ability in two groups (RQ2b), a between-subject test was implemented. Results indicated that the effect of IMFLA was significant (F = 23.924, p < .001, partial \( \eta^2 = .260 \)). The effect size, partial eta squared of .260 indicates that 26% of the variance of reading proficiency can be accounted for by IMFLA.
The analysis also confirmed that there was a significant interaction effect between Time and Class on reading ability \( (F = 8.148, p < .001, \eta^2 = .107) \), as a positive answer to RQ3b (reading). In other words, with both significant effects, the two figures of partial \( \eta^2 \), indicating effect size, suggest that 29.3% of the variance in the reading scores was accounted for by the Time factor and that 10.7% was accounted for by the interaction between Time and the treatment.

**Vocabulary (V) and Reading (R) tests at three points in time**

Visual presentation of the interaction effect is illustrated in Figure 4 where Class 1 kept improving their reading ability even after the experiment at the end of the second semester, while Class 2 improved through whatever approach but showed no further improvement after one more semester.

![Figure 4. Vocabulary (V) and Reading (R) tests at three points in time](image)

This was also true for the smaller effect size of IMFLA on vocabulary \( (\eta^2 = .074) \) as the result of the ceiling effect connected to the relatively high beginning level of the vocabulary tests. Additionally, our pilot study indicates that the average score of the higher group is 84, and Class 1 continued increasing their scores (83.89 \( \rightarrow \) 88.23) significantly, which “broke the bottleneck of the ceiling effect.” That is, the IMFLA helped students keep improving their vocabulary and reading abilities through the interaction effect.

**Learning analytics results**

**Statistical results and textual analysis for weekly logs**

To answer RQ4, the following statistical results and textual analysis are presented in detail. Weekly logs were constructed as a learners’ corpus (=172,607 running words) and downloaded from the online interactive Blackboard. For example, Figure 5 shows that the top four words (i.e., feedback, reflection, suggestion, and comment) are related to students’ learning experience. The “concept map” (frequency = 216) refers to what (contents), how, and how often (behavior) students learned and used it in vocabulary and reading. Both involve the Cmap in the students’ logs with relevant lexical items (e.g., words, vocabularies, and vocabulary).

![Figure 5. Top four words related to learning experience](image)

Figure 6 highlights the concordance of “concept map” (frequency = 216; dispersion value = 0.63, displaying how “concept map” is evenly distributed in the text/corpus), revealing the students’ learning behavior or learning contents. The frequently used 3-word clusters such as “the concept map” (freq. = 86), “a concept map” (43), and “draw a concept” (freq. = 21) demonstrate how and how often students used this Cmap skill in their learning. It seems that they appreciated the Cmap method to learn both reading and vocabulary, which was supported by their feedback. The weekly log information could help the instructor adjust the teaching tempo, encourage students, or solve individual learning problems immediately.
Table 6 indicates how an individual learner (student-1) interacted with the instructor (stakeholders), and how she benefited from the Cmap method in terms of her vocabulary and reading learning with her teammates. She expressed how she enjoyed using Cmap for learning vocabulary and reading through online interactions: for example, “The concept map will really be useful,” “It is a good tool to help me learn,” and “helping us understand the idea of concept map.” Finally, the instructor answered her and adjusted the teaching pace or content to meet the learner’s needs. Student-2 also expressed that she used Cmap to improve her vocabulary and reading ability. It was predictable that the students enjoyed the Cmap methods, and performed better later on. Table 7 indicates how a student drew a concept map based on her personal learning experience. It also shows her learning behavior and her interaction with the instructor.
Table 6. Student’s learning log and comments on Cmap

■Student-1:

1. Working on her Cmap log
2. The instructor reading her online log

(1) What I have learned today
I experienced the importance of teamwork again. We got two handouts of vocabularies, which should be scheduled and finished by ourselves. We should work with our team members. We had a discussion about how to finish those vocabularies in the class. Also, I learned some general ideas of concept map. It has four types of diagram which can help us understand the system or relationships among ideas. I think concept map will really be useful in our daily lives.

(2) How I helped my classmates
2.1 You told us the application of concept map. It is a good tool to help me learn.
2.2 We had a quiz. I tried my best to understand the organization of the article. After the quiz, you gave us two vocabulary handouts. Our group shared ideas of how to schedule our time on studying these vocabularies. I thought that we all had a good time in these two classes.
2.3 We shared our ideas of study plan with each other. We found a way to share the work of finding the meaning of vocabularies. Then, we had a small activity of which purposes were helping us understand the idea of concept map. We shared our thought of which word we should put in the blank.

(3) Suggestions for the instructor
I got some information from the class. You let us know the website BNC. You told us the four types of concept map. You told us that we should memorize vocabularies by synonyms or English sentences. I hoped you to share us more and I expected what you would share with us next class.

■Instructor: Thank you for your comments. I am glad you like concept mapping method. Yes. I will share more about the concept map.

■Student-2: We will use concept map to improve our vocabulary and reading ability…

Table 7. Weekly log example about Cmap

(1) What I have learned today
You guided us to find out the topic sentence step by step. You taught us to observe those words with repetition and cohesion so that we could find out their relation more easily. I really love this skill...
Furthermore, you asked us to use concept map. After drawing out a concept map, I could understand their relationship mentioned in the article. I learned the importance of the concept map again!

Statistics, multimodal analysis and the products
Figure 7 displays the multimodal and multimedia terms with their frequencies (e.g., movie, movies, videos, film; movie titles such as DPS and P&P). These words were frequently used in the weekly logs. It seemed that watching the movie was popular among students.

As shown in Table 8, it became easier to understand the plot with the help of the Cmap method through the learning analytics. Table 8 indicates that the students enjoyed the novels. For example, Cindy considered Cmap as useful for organizing ideas, while Shanna “was fascinated by the plot” with the help of Cmap. Kathy was also drawn to the synopsis. Likewise, Hanna looked forward to watching the remaining portion of the movie.
Frequently used multimedia terms

Variations for DPS & P&P

*Figure 7. Multimedia-related terms used in the weekly logs*

*Figure 8. A clip of DPS using multimodal analysis*

The commonly used aspects for multimodal methods (Sindoni, 2014) include “gesture/facial expression,” “kinetic action” (body language), and “proxemics” (distance). Figure 8 presents the analysis and learning behaviors of our students, demonstrating how a student (Todd) played a shy boy in terms of these stages: (I)
Facial expression, (II) Kinetic action, and (III) Proxemics. With the help of video clips, students understood better the text of the novel through these three stages and analyses.

Finally, Figure 9 indicates that the students worked in groups to make their own books (products) – a translation of the novel. The topic, contents, and supplementary materials of a translation novel were added and modified to some extent according to the course design. We used learner-producing data to discover new information and adjust our teaching contents.

![Figure 9. Six example books as the product](image)

(a) Translation of Dead Poets Society  
(b) Translation of Pride and Prejudice

**Discussion and conclusions**

In summary, both repeated measure analyses (for reading and vocabulary) indicated the significant interaction effect of IMFLA and time, suggesting that both IMFLA and time affected students’ reading and vocabulary abilities as suggested by Seltman (2018). Further analysis of the between-subject effect illustrating IMFLA has significantly affected learners’ reading ability. The effect size shows that 26% of the variance of reading ability is explained by IMFLA while only 2.8% of the vocabulary ability is accounted for by IMFLA due to a near ceiling effect.

On the one hand, students who scored near the ceiling on the pre-test had a relatively small opportunity for improvement in their scores on their post-test. Our vocabulary pilot test indicated that the average of the higher group was 84. In fact, the current study indicates that Class 1 kept improving its vocabulary ability (83.9 ➔ 88.3). The repeated measure results demonstrated that IMFLA was effective in terms of enhancing students’ word power and reading ability. A significant interaction effect was also found between IMFLA and the time factor. This effect resulted in better vocabulary and reading comprehension when the students spent longer on the IMFLA procedure.

On the other hand, learning analytics and log analysis further confirmed that the reinforced application of multimodal approaches is an effective procedure for enhancing students’ vocabulary ability and reading proficiency. The results of the analyses are briefly summarized below:

- The weekly log in the online Blackboard as the platform is a proper channel and environment for language teachers and learners (stakeholders).
- The instructor could answer the individual questions, adjust the course contents, and reshuffle the schedule immediately according to the online weekly logs.
- The quantitative and qualitative results in the logs indicated learning behaviors such as what (contents), how (learning behaviors), how often (frequency) students used or learned specific words and how they created their own Cmaps to learn or to draw the plot of an essay or a novel.
- Students’ learning behaviors were recorded through the online weekly log of the electronic platform, which helped the instructor revise his/her teaching contents.

This study has confirmed the advantage of IMFLA in the process of vocabulary and reading learning. First, we rejuvenated the textbook by using the frequency-based wordlist for the Class 1 students, and used Cmap as a tool to teach word parts. Second, the IMFLA approach was integrated into the instruction to enhance students’ reading comprehension. The weekly log analysis indicated that Class 1 appreciated the Cmap method for vocabulary and reading learning. It was found that the grammar-translation approach (Class 2) did not help the students to a significant extent, but the digitalized design (IMFLA) helped learners significantly increase their vocabulary and reading scores (Class 1).
Overall, the IMFLA demonstrated a significant effect on students’ vocabulary and reading abilities over time. Therefore, this study contributes to highlighting the importance of using Cmaps and frequency-based wordlists to teach word parts. Another contribution is that it demonstrates how the multimodal and Cmap approaches can be integrated to enhance students’ reading. Finally, the texts of weekly logs as a corpus were analyzed to support the findings of our experimental study.

Although the current study showed that IMFLA can be beneficial to students’ vocabulary and reading abilities over time, training is required before teachers and students can make good use of the multimodal approach. Another limitation of the current study lies in the intact grouping of classes which is inherent in most educational settings. To counter this limitation, we used the repeated measure approach since there were measures at three points in time. However, to highlight the effect of the treatment, it would have been better to conduct the experiment for a longer period of time, with measures at more than three points in time.

Our proposed framework has the potential to become a widely-used learning model, and future studies should continue to investigate:

- how multimodal and learning analytic methods are integrated into IMFLA to apply the Cmap method, observe language learning behaviors, and give any feedback to improve teaching and learning quality.
- how video or novels based on movies are incorporated into IMFLA to assist students’ vocabulary and reading learning.

Finally, the development of effective multimodal vocabulary learning and digitalized reading tasks are also needed to improve pedagogical instruction.

Acknowledgements

This project was partially supported by the Ministry of Science and Technology, Taiwan, ROC (MOST: 104-2410-H-011-022-MY2).

References


