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DEVELOPMENT ARTICLE

Investigating the effectiveness of a learning activity supported by a mobile multimedia learning system to enhance autonomous EFL learning in authentic contexts

Rustam Shadiev[1] · Wu-Yuin Hwang[2] · Tzu-Yu Liu[3]

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Abstract A learning activity supported by a mobile multimedia learning system (MMLS) was designed in this study. We aimed to test the effectiveness of the learning activity to enhance autonomous language learning in quasi-experimental Study 1 using a pre-test/posttest design. Two groups participated in the learning activity: the students in a control group (n = 27) completed the activity using traditional approach whereas the students in an experimental group (n = 26) completed the activity using MMLS. The results of Study 1 showed that the experimental students outperformed their counterparts on the post-test ($F = 29.602$, $p < 0.005$, partial eta-squared = 0.372). In a non-experimental Study 2, the experimental students (n = 26) were assigned two learning tasks, the first task was completed individually and the second task in collaboration. We aimed to investigate which learning approach to complete tasks (i.e. individual vs. collaborative) enhances learning performance better by comparing students' scores on two tasks. In addition, we explored students' perceptions towards MMLS. The results of Study 2 showed that the students had better learning performance when they completed tasks in collaboration than individually. The results also showed that the students had high perceptions towards MMLS. Based on our results, we make suggestions and provide directions for future research.

Keywords Autonomy · Language learning · Mobile multimedia learning system · Individual versus collaborative learning · Perceptions · Authentic contexts

✉ Wu-Yuin Hwang
wyhwang@cc.ncu.edu.tw

[1] Nanjing Normal University, No. 122, Ninghai Road, Nanjing 210097, China

[2] National Central University, No. 300, Jhongda Rd., Jhongli 32001, Taiwan

[3] Bei-Zheng Junior High School, No. 14, Ln. 2, Sec. 3, ZhiNan Rd., Taipei 11605, Taiwan

Introduction

English is the most widely used language. So it is critical to be proficient in English in order to sustain competitive edge on an international scale (Guilherme 2007). This is the reason why so many countries emphasize the importance of English as a foreign language (EFL) proficiency and initiate various events to promote EFL learning at different levels (Nunan 2003). For example, the general guidelines of grade 1–9 curriculum for elementary and junior high school education proposed by the Ministry of Education of Taiwan (1998) emphasize cultivation of EFL knowledge and skills from an early age. According to the guidelines, core EFL competences should be developed and one should know how to apply them in daily life (Kelch 2010). The guidelines also point out learner autonomy as a key element of EFL learning. The reason is because a learner takes charge of his/her own learning (Holec 1981), discovers the language, and has very little guidance from the instructor so he/she is able to fully understand the language (Lee and Hannafin 2016; Tilfarlioglu and Ciftci 2011). Therefore, learner autonomy needs to be promoted and its principles incorporated into the learning process (Huang et al. 2017). This is very important goal for any language programs (Chan 2001; Dang 2010; Oxford 1999).

Recent development of information technology has contributed to the emergence of new literacy practices in mobile contexts (Hwang et al. 2016; Shadiev et al. 2017, 2018). These new practices are characterized by learning across multiple contexts, through social and content interactions (Ma 2017). For example, Chai et al. (2016) suggested that mobile technology extends the language learning process beyond the classroom where learners have opportunities to use the target language meaningfully and extensively in their daily life. Learners can actively create their own learning content, share it with the instructor and other students, and receive instant feedback anytime and anywhere using mobile technology (Kondo et al. 2012). Furthermore, the potential of mobile technology for autonomous language learning is recognized by earlier studies (Leis et al. 2015; Ma 2017; Zhang 2016). Scholars claimed that mobile technology is useful to facilitate autonomous language learning (Chai et al. 2016; Kondo et al. 2012; Leis et al. 2015). For example, mobile technology is useful for students not only to practice listening (Agbatogun 2014; Hsu et al. 2013), reading (Lin 2014; Wang and Smith 2013), speaking (Hwang et al. 2014b; Shadiev et al. 2015), and writing (Hwang et al. 2014a; Li and Hegelheimer 2013) skills but also to plan, monitor, and reflect on their own learning (Chai et al. 2016; Leis et al. 2015; Zhang 2016) as well as to receive peer support (Kondo et al. 2012). However, a search of the literature revealed that not many scholars explored the effects of learning activities supported by mobile technology to enhance autonomous language learning in authentic contexts using empirical evidence. Most studies have based their findings on subjective evidence (e.g. questionnaires and interviews data) instead of objective one (e.g. data obtained from an experiment in which mobile autonomous language learning and traditional autonomous language learning were compared). So it is not very clear how mobile technology applications can be beneficial to facilitate language learning and learner autonomy in authentic contexts compared to traditional approach.

A number of studies have explored effects of individual or collaborative learning on learning achievement. According to Retnowati et al. (2017), individual learning occurs when students study individually whereas collaborative learning takes place when students learn in collaboration with others. Watanabe and Swain (2007) argued that collaborative learning approach has an advantage over individual learning because students can share information and learn from each other when they collaborate (Sweller et al. 2011). However, Retnowati et al. (2017) claimed that individual learning approach is more

beneficial for learning when instructional content contains sufficient information, rendering collaboration unnecessary. So there are contradictory arguments favoring one learning approach over the other. Furthermore, previous studies did not give sufficient consideration to autonomy and authenticity of learning process when comparing the difference between individual and collaborative learning supported by mobile technology (Awofeso et al. 2016; Retnowati et al. 2017; Watanabe and Swain 2007). That is, it is still not clear whether learning alone or collaboratively contribute to more efficient autonomous language learning in authentic contexts. Therefore, in this research, we attempted to bridge the gaps which we identified in related literature. To this end, we designed a learning activity in authentic contexts supported by mobile technology to facilitate language learning and autonomy, and we carried out an experiment. First, we investigated the effectiveness of our learning activity supported by MMLS to enhance autonomous language learning by comparing autonomous language learning in a traditional environment with that in a mobile environment. Second, we carried out an exploratory study to research the effectiveness of different learning method (i.e. individual and collaborative) on autonomous language learning by comparing individual and collaborative learning outcomes. Finally, we explored how students accept mobile technology to support their language learning and autonomy in authentic contexts.

Learner autonomy and language learning

Autonomy was defined as "the ability to take charge of one's own learning" (Holec 1981, p. 3). That is to say, autonomous learners understand the purpose of their learning program, take significant responsibility for their own learning, and have the ability to organize and control themselves (Lee and Hannafin 2016; Little 2007; Oxford 1999; Tilfarlioglu and Ciftci 2011). Following this notion, Dang (2010) suggested that autonomous learners decide what to learn, how and when. According to Oxford (1999), autonomy strongly associates with self-regulation, i.e. the process of planning, guiding, and monitoring one's own learning. Therefore, autonomous learning consists of different self-regulatory steps such as setting learning goals, identifying and developing learning strategies to achieve such goals, developing study plans, reflecting on learning, identifying and selecting relevant resources, and supporting and assessing own learning progress (Chan 2001). Barrett (2007) listed several main characteristic qualities of the autonomous language learner. That is, the autonomous learner is highly motivated, goal-orientated and has an inquisitive mind (e.g. willing to ask questions in class). The autonomous learner is well-organized, hard-working, curious about language, interested and enthusiastic about what is learnt (Cotterall 2000). In addition, the autonomous learner is active, has initiative, make use of every opportunity to improve his/her standard, and flexible. Oxford (1999) claimed that the autonomous learner does not detach him/herself from other people, institutions, or materials. That is, the autonomous learner can learn both independently and in collaboration. Thus, the scale of autonomous learning can range from dependent to independent; the learner functions at any point on this continuum by choosing to receive support from someone or work without any assistance (Chan 2001).

Dafei (2007) suggested that, in order to promote learner autonomy in language courses, responsibility for aspects of the language learning process needs to be transferred from the teacher to the learner. The five principles of the language learning activity design were proposed by Cotterall (2000) which contribute to such transfer. They relate to (1) learner

goals, (2) the language learning process, (3) tasks, (4) learner strategies, and (5) reflection on learning. The first principle states that *the activity should reflect learners' goals in its language, tasks, and strategies*. That is, the activity must set out to achieve the goals which the learners deem important. In addition, learners' awareness of ways of identifying goals, specifying objectives, identifying resources and strategies needed to achieve goals, and measuring progress need to be raised. Furthermore, the learners make decisions about language, tasks, and strategies to focus on during the activity based on the stated goals (Huang et al. 2017). According to the second principle, *activity tasks are explicitly linked to a simplified model of the language learning process.* The learners need to understand the language learning process in order to manage their own learning. That is, their learning will be autonomous if they are aware of a range of learning options, and understand the consequences of choices they make. When the learners have such understanding, they are able to question the role of language input/output and tasks, to try alternative strategies, and to seek feedback on their performance (Hwang et al. 2016). The third principle is that *activity tasks should either replicate real-world communicative tasks or provide rehearsal for such tasks*. The main aim of the language learning activity should be to improve performance of certain L2 tasks in which the learners learn, practice, and receive feedback based on their goals and needs, and the tasks should be those in which the learners will participate in the future (Huang et al. 2016). The fourth principle states that *the activity incorporates discussion and practice with strategies known to facilitate task performance*. Language teachers need to present to and discuss with the learners those learning strategies which are useful for facilitating their performance on tasks. The learners need to have conceptual understanding on various learning strategies and how each strategy may contribute to their learning. In this case, the learners will have a choice and be able to try alternative strategies (Huang et al. 2017). The fifth principle is that *the activity promotes reflection on learning*. According to this principle, the learners should be able to reflect critically on their learning. That is, the learners need to learn to review their past and future learning experiences in order to reflect upon the learning experiences of the past and make plans for future action. Such reflection can be useful to enhance the learners' insight into their learning processes and facilitate language learning (Hwang et al. 2014a).

Researchers argued that fostering learner autonomy is an important goal in language course design because learning autonomy has numerous benefits. Dafei (2007) argued that benefits can be considered in three different aspects, i.e. learning efficiency, learning motivation, and effective language use. For example, the relationship between learner autonomy and English proficiency was investigated in related studies and scholars found that language proficiency was influenced by learner autonomy substantially (Dafei 2007; Kondo et al. 2012; Lee and Hannafin 2016; Tilfarlioglu and Ciftci 2011). According to Little (2007), language learning becomes more efficient and effective because autonomous learners reflectively engage with their learning, are more focused, and consider their learning as personalized. Recent evidence suggests that learner autonomy increases not only learning effectiveness but learning motivation as well (Lee and Hannafin 2016; Tilfarlioglu and Ciftci 2011). Learners who have greater control over the learning content, purpose and process have more intrinsic motivation (Barrett 2007). Little (2007) argued that if autonomous learners are proactively committed to their learning, the problem of motivation can be solved. Autonomous learners have developed the reflective and attitudinal resources to overcome temporary motivational setbacks about some aspects of their learning. According to Lee and Hannafin (2016) and Tilfarlioglu and Ciftci (2011), autonomy enhances students' positive feelings about themselves and their school work and fosters affective benefits, such as engagement, satisfaction, happiness, and wellbeing. In

terms of language use, learners become more communicative than before and take control over their learning when they are autonomous. Autonomous learners prefer a more process-oriented approach to language learning rather than a product-oriented one which leads them to become more successful in their English classes (Tilfarlioglu and Ciftci 2011). Little (2007) claimed that autonomous learners can easier master the full range of discourse roles and develop a complex set of procedural skills through use of language. This in turn may lead to effectiveness of their communication (Little 2002).

Autonomous mobile language learning

Much of the current literature on mobile assisted language learning pays particular attention to learner autonomy (Chai et al. 2016; Kondo et al. 2012; Leis et al. 2015; Shadiev et al. 2017b). For example, in the study of Chai et al. (2016) mobile technologies were employed to facilitate self-directed language learning. In the classroom, students read prescribed texts and learned new vocabulary. Outside of school, students used smartphones to participate in learning activities which included selecting unfamiliar vocabulary and checking their meanings, taking pictures and making sentences associated with newly learned vocabulary, posting the artifacts online, and writing comments for their peers' artifacts. Kondo et al. (2012) focused on enhancing student EFL scores. Students used mobile devices to accomplish learning activities in the class, in the campus, or outside the campus. Kondo et al. (2012) designed learning activities based on self-regulation learning principles. Results of their study were positive; with the help of mobile devices, learning performance improved and the technology allowed learners to be more autonomous and to personalize their learning. Leis et al. (2015) introduced mobile technology to students in order to facilitate their EFL learning and autonomy in class. Students participated at three learning activities such as videoing, practicing pronunciation, and testing using mobile technology. In videoing, students practiced newly learned concepts and recorded themselves on video. In practicing pronunciation, students read texts aloud into the microphone and speech-to-text application generated texts on the screen to show exactly which parts of language they were able to pronounce accurately/inaccurately. In testing, tests were administered to students to measure their EFL learning performance. Results demonstrated that students were motivated to learn with mobile technology and showed a tendency towards being autonomous.

Individual and collaborative learning

In recent years, there has been an increasing interest in exploring effects of learning individually versus collaboratively on learning achievement. In Awofeso et al. (2016), students used Q&A discussion forums to improve their learning quality and assessment. The researchers explored student perceptions towards learning in technology-mediated environments. It was found that Q&A discussion forums facilitated individual and collaborative learning and course assessments. Retnowati et al. (2017) explored the difference between learning to solve problems and learning from worked examples in collaborative and individual learning settings. They found that individual learning was superior to collaborative one when using worked examples whereas collaborative learning was more effective compared to individual one when students were solving problems. The reason is

that worked examples provided sufficient learning information (i.e. they contained step-by step explanations) so that collaboration (i.e. discussing worked examples) was unnecessary. In contrast, collaboration was beneficial when solving problem because assigned problems had not detailed information and collaborators had to communicate, share, and obtain necessary information from each other. Watanabe and Swain (2007) investigated the effects of language proficiency differences and patterns of pair interaction on language learning. Students of higher and lower proficiency interacted with each other under different interaction patterns. Results showed that the patterns of pair interaction greatly influenced the post-test performance. That is, collaborative patterns of interaction resulted in achieving higher posttest scores no matter what their partner's proficiency level was.

Research motivation and questions

Our literature review revealed the following gap in the knowledge. Despite the emergence of studies on mobile assisted language learning to facilitate learner autonomy, most of them were descriptive in nature (Chai et al. 2016; Kondo et al. 2012; Leis et al. 2015). That is, there is lack of empirical evidence in the literature regarding the effectiveness of mobile technologies on autonomous language learning. For example, Chai et al. (2016) used a questionnaire to survey student perceptions and so all claims in the study were made based on subjective evidence; such evidence tends to be influenced by systematic error or bias (Aranda et al. 2014). A control group was absent in Kondo et al. (2012), so the effectiveness of the treatment was measured using a non-experimental design. Furthermore, previous studies did not give sufficient consideration to autonomy and authenticity of learning process when comparing the difference between individual vs. collaborative learning (Awofeso et al. 2016; Retnowati et al. 2017; Watanabe and Swain 2007). For example, Watanabe and Swain (2007) focused on collaborative dialogues or written communication in the target language among students. In Retnowati et al. (2017), students learned with worked examples and they also solved problems. Awofeso et al. (2016) explored the benefits of individual and collaborative learning approaches on learning achievement in tandem but not the difference between them. In neither of these studies, students learned autonomously or contexts were authentic.

In our present study, we aimed to bridge the gap in the literature. Related literature informed the design of our research. First, we designed a learning activity supported by a mobile multimedia learning system (MMLS) to facilitate EFL learning and learner autonomy. Our learning activity reflected the core principles of the autonomous language learning activity design (Cotterall 2000) such as students' goals in its language, tasks, and strategies, and the activity was explicitly linked to a simplified model of the language learning process. In addition, our learning activity replicated real-world communicative tasks, and it incorporated discussion and practice with strategies for facilitating task performance. Furthermore, our learning activity promoted reflection on learning. Second, to obtain empirical evidence of the effectiveness of mobile technologies on autonomous language learning, we compared autonomous language learning in a traditional environment with that in a mobile environment. Third, we compared individual and collaborative autonomous language learning in authentic contexts which was not considered in earlier research. Finally, we explored student perceptions towards the technology to support autonomous language learning. The following research questions were addressed:

1. Do autonomous students who participate in an authentic language learning activity supported by MMLS have better learning performance compared to those who participate in the same activity but without MMLS support?
2. Is learning performance of students who participate in an autonomous authentic language learning activity supported by MMLS better when they work on learning tasks individually than when they work on learning tasks in collaboration?
3. What are students' perceptions towards a mobile multimedia learning system to support an autonomous authentic language learning activity?

Method

Participants

Fifty three junior high school students from two classes participated in this research. Students were non-native English speakers studying English as a foreign language. Students were between thirteen and 14 years old. We assigned students from one class to a control group ($n = 27$) and from the other class to an experimental group ($n = 26$) using convenience sampling (Creswell 2014). Fraenkel et al. (2014) suggested using convenience sampling when it is difficult to use random sampling. The prior knowledge, gender, and age distribution across two groups was equal ($p > 0.05$). Both groups studied the same learning content and participated in the same learning activity. The only difference between two groups was in the learning method; the control students used traditional method whereas the experimental students used mobile multimedia learning system (MMLS) to study learning content and to participate in a learning activity.

Experimental procedure

The experimental procedure is shown in Fig. 1. Consent forms were signed by parents and returned to the teacher in the beginning. The forms informed parents about this present study and gave details about their children's participation. Our research was carried out as two studies; Study 1 was as a quasi-experiment using a pretest/posttest design and Study 2 was an exploratory study. In Study 1, students were assigned into two groups. A pre-test was conducted in the first class for students in both groups. Tablet PCs were distributed among students in the experimental group. The instructor carried out autonomous language learning activity orientation for both groups and taught students in the experimental group how to use Tablet PCs. Experimental students were given 1 week to get acquainted with Tablet PCs and the system. After that, all students attended English class in a conventional classroom. In class, students learned learning content (i.e. new vocabulary and grammar) from their textbooks related to three topics and applied new knowledge to complete textbook exercises and read dialogues. Each class was 1 h long and carried out three times a week. After class, outside of classroom, students worked on an autonomous language learning activity. Lessons were taught and a learning activity was guided in the control and experimental classes by the same instructor. Learning content was also the same for the two groups. However, the control group studied learning content and participated in learning activity using a traditional method whereas the experimental group using MMLS installed on the tablets. At the end of Study 1, we conducted a post-test for students in both groups. After that, Study 2 was carried out. Only students in the experimental group

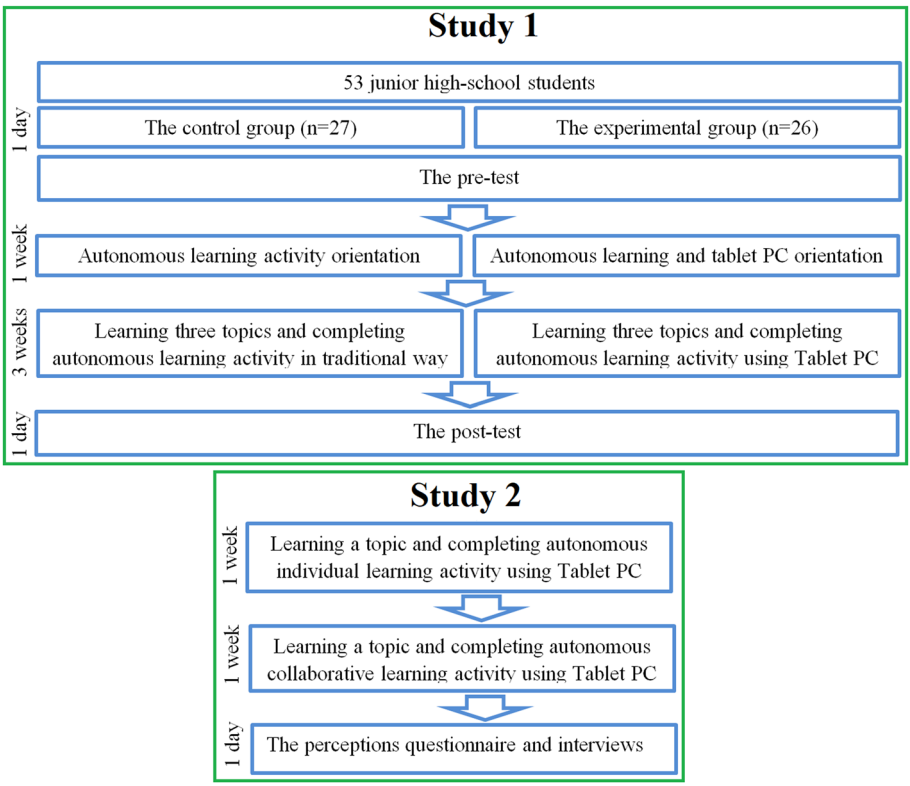

Fig. 1 Experimental procedure

participated in it. They learned two topics and completed two related learning tasks. For the first topic, students completed learning task individually, and for the second topic in collaboration with a partner. Learning performance of students in the experimental group was evaluated after each task. Finally, we carried out a questionnaire survey and interviews with all experimental students in the last class.

Learning activity

In Study 1, students in the control and experimental groups were assigned three learning tasks. In Study 2, students in the experimental group were assigned two learning tasks. The students worked on all tasks individually except the last task which was completed collaboratively. All five tasks (i.e. three in Study 1 and two in Study 2) were related to learning topics from the textbook. In the following, we give two examples to explain the tasks; one example for the individual task and one for the collaborative one.

Individual task For the topic "How can we get to Chih-Kan tower?" in which students learned new vocabulary, prepositions of place and movement, and grammar related to giving directions, they were assigned "Give directions!" task. In this task, students were asked to create their own learning content in authentic contexts outside of school. Students had to explain how to get to a place of his/her choice from the school. Students had to draw a map, take a picture of it, and then write down directions. Students were also asked to take

photos of some special spots, like a coffee shop or a convenience store on the way to their place that can help others to find a destination easily. Then students had to write down directions. Finally, they had to verbalize the directions and audio record them. The idea behind such design was that students learned new concepts from the topic and then applied newly acquired knowledge to solve real life problems which were meaningful to students. So, instead of giving directions of Chih-Kan tower which is located in a different city, they selected places in their local community.

Collaborative task For the topic "What's the weather like in Australia?" students were assigned "What's the weather like in your city?" task. From the topic, students learned vocabulary and sentence patterns to describe the weather in Australia. The textbook required students to describe the weather in Australia or in other foreign countries, like Canada and USA; however, we asked students to talk about the weather in their city. Students were asked to create their own learning content by taking photos to show what the weather looked like, and writing and talking about the weather in their city. In addition, students were invited to write and talk about what people in their local community usually do in such weather. Because this task was collaborative, students were asked to review content created by other students, and give comments in writing or verbally using the system.

We ensured that the two tasks were of similar difficulty in the following three ways. First, we asked the students to indicate their perceptions of the tasks difficulty using a five-point Likert scale, anchored by the end-points "very easy" (1) and "very difficult" (5) to answer a question "Is this task difficult?" It turned out that student perceptions of tasks difficulty (Task 1: $M = 2.81$, $SD = 1.41$; Task 2: $M = 2.73$, $SD = 1.18$) were not different, $p > 0.05$. Second, the equal difficulty level was also confirmed by the teacher involved in this research and two other invited instructors. All of them were experienced EFL teachers with more than 10 years of teaching experience. All instructors confirmed that the two tasks were designed based on two different topics from the same textbook and by following the national curriculum. The tasks were focused on basic conversations that occur in daily life and were aimed at teaching the students how to express their own simple opinions and ideas. That is, the tasks were equivalent in terms of vocabulary and grammar but different in terms of the two different themes, for example, giving directions in the first task or describing the weather in the second one. Third, we carried out a statistical analysis. It has been suggested that the comprehension and complexity of learning content can often be determined based on its vocabulary profile, i.e. the complexity of learning content and vocabulary are related (Reynolds 2015). Therefore, following the general recommendations of Nation (2006) and Reynolds (2015), we computed the vocabulary size of the learning content. The results indicated that 93.14% of the words in Topic 1 and 95.1% of the words in Topic 2 appear in the first 2000 words typically learned when studying English, making learning content of the three topics quite comparable. Next, we computed and compared the difficulty level of the tasks. Following the general recommendations of Matlock-Hetzel (1997), we invited another class of junior high school students to complete the three tasks. Matlock-Hetzel (1997) suggested that task difficulty is the percentage of students who complete it correctly. To compute this percentage, we had to divide the number of students completing the task correctly by the total number of students working on the task. According to our results, 73% of students completed Task 1 and 66% completed Task 2. The results of the paired sample t-test showed that no significant differences existed among the computed values of the two tasks ($p > 0.05$).

Language learning process during the learning activity was autonomous. That is, students took over the responsibility for aspects of the language learning process from the

teacher. They planned, guided, and monitored their own learning. In other words, students took charge of every stage of their learning such as setting their learning goals, identifying and developing learning strategies to achieve such goals, developing study plans, reflecting on learning, identifying and selecting relevant resources and support, and assessing one's own progress (Chan 2001).

Mobile multimedia learning system

We developed a mobile multimedia learning system (MMLS) to support autonomous language learning. The system was installed on Tablet PCs, and the students used it to study learning content as well as to participate in the learning activity by creating their own learning content. The system was developed by using Apache, PHP and MYSQL. The client platform ran on Android and a Linux-based open source operating system, and the server platform ran on a Windows® Server 2003. The Tablet PCs were Asus Transformer Pads. A screenshot of the system is shown in Fig. 2. The system featured the following main functions:

- *Annotating* it enabled the students to take photos of objects from authentic contexts and attach them to learning content; in addition, the students were able to add textual annotations to describe objects or explain them.
- *Recording* when the students described objects verbally, this feature allowed them to audio record their own voices.
- *Dictionary* this feature enabled the students to get a list of words in alphabetical order with their meanings and translations, and it helped them translate unfamiliar vocabulary.
- *Sharing* the students were able to share their own annotations and recorded audio files with other students; moreover, sharing enabled the students to review peer annotations and comment on them.
- *Calendar* this feature enabled the students to organize their work on learning tasks to specific date and time.

These functions were useful for autonomous language learning. In terms of autonomy, the students were able to plan, guide, monitor, reflect on learning, identify and select relevant resources and support, and assess one's own progress. For example, the students planned and organized their work using Calendar. They could always refer to the calendar to check what they accomplished and what needs to be done. With regards to language learning, annotating and recording functions enabled the students to capture relevant resources in authentic environments (e.g. take photos of the weather or record audio files with sounds of the rain) and to describe them in written form (i.e. textual annotations) or verbally (i.e. audio annotations). Later, the students were able to return to their annotations and review them to reflect on their learning. Dictionary supported the students to translate unfamiliar vocabulary whereas through sharing, the students were able to review works of others and get inspirational ideas for their own work. Furthermore, with sharing function, the students were able to review others' work and compare with their own work to understand how well their learning progresses are. Using the system, the students could apply newly learned concepts to solve their real life problems in authentic contexts. The functions of the system enabled the students to practice their language skills anytime and anywhere. The traditional method included the use of the printed textbook to study learning material, digital camera to take photos of objects from the real world, notebook, pen, pencil and voice recorder to describe objects in written and verbally, and electronic

Fig. 2 Learning system: (1) an annotation with audio content, (2) an annotation with textual content, and (3) sharing function

dictionary to translate unfamiliar vocabulary. So in this research, we aimed to test whether student learning achievement will be better after learning activity supported by the system compared to that in which the students used traditional approach.

Data collection and analysis

We evaluated students' prior knowledge through a pre-test and learning achievement through a post-test. Test items were created by an experienced junior high school teacher (i.e. with more than 10 years of EFL teaching experience), based on the learning material and activity. Learning performance (i.e. speaking and writing) on the two tasks was measured based on content created by the students; we coded the verbal and written content using a sentence as a coding unit. Students' answers to the tests as well as their tasks content were scored on a 100-point scale. Three raters were involved in the rating process. Notable differences in the assessment were resolved through raters' discussions until a consensus was achieved. Inter-rater reliability of the tests was evaluated by using Cohen's kappa. The result exceeded 0.80 (before the discussion) and 0.90 (after the discussion), indicating high reliability.

We developed a questionnaire survey based on Technology Acceptance Model (Davis 1989) to measure students' perceptions towards MMLS. The survey included three dimensions: (1) Perceived ease of MMLS use (six items) - the degree to which a student believes that using MMLS would be free of physical and mental effort; (2) Perceived usefulness of MMLS during autonomous language learning (six items)—the degree to which a student believes that using MMLS would enhance his or her learning performance; and (3) Behavioral intention to use MMLS (three items) - a major determinant of whether a student would feel like using MMLS again or not. TAM has been successfully employed in a wide array of educational research areas (Hwang et al. 2014a, 2016). The researchers demonstrated that TAM-based questionnaire reliably measures learners' perceptions towards the technology (Davis 1989). Twenty six valid answer sheets were obtained out of 26 students. The students responded to the questionnaire items using a five-point Likert scale, anchored by the end-points "strongly disagree" (1) and "strongly agree" (5). The internal consistency of the survey was tested by employing Cronbach's α. The obtained value ($\alpha > 0.90$) demonstrated the high reliability of the questionnaire.

We conducted one-on-one semi-structured interviews with the students to explore their experiences of using MMLS and to obtain insights into their perceptions towards MMLS. Each interview lasted for 20 min, in which interviewees were asked the following open-ended questions: (1) Please describe your learning experience with MMLS during the learning activity; (2) was MMLS useful for learning? If yes, please explain why. All interviews were audio-recorded with the students' permission and were then fully transcribed for analysis. The text segments that met the criteria to provide the best research information were highlighted and coded. The codes were then sorted into categories; codes with similar meanings were aggregated together. Established categories formed a framework to report findings pertinent to the research questions. The inter-rater reliability of the interview data was also evaluated by using Cohen's kappa and the result exceeded 0.90.

To test the effectiveness of learning activity supported by MMLS on learning performance we employed analysis of covariance (ANCOVA). This analysis allowed us to compare the differences in the post-test scores between the control and experimental group while controlling for the pre-test scores (Creswell 2014). To measure the difference in learning performance between Task 1 (i.e. individual) and Task 2 (i.e. collaborative) we employed paired sample t-test. This test is usually used to compare the values of means

from two related samples (Creswell 2014). A priori alpha-level was set at 0.05 because an alpha level of less than 0.05 is acceptable in most educational research as statistically significant.

Results and discussion

First, we explored whether the students who used MMLS have better learning achievement compared to the students who used traditional approach. Results of the analysis of covariance are reported in Table 1 and they showed that a significance difference exists in the post-test scores of the control and experimental groups after controlling for their prior knowledge, $F = 29.602$, $p < 0.005$, partial eta-squared $= 0.372$. That is, the experimental students outperformed the control students. This finding suggests that our learning system was beneficial for students' EFL learning as to enhance their learning achievement. Specifically, the functions of MMLS facilitated language learning and learner autonomy. We interviewed the experimental students to find out how the system was beneficial. In the interviews, the students mentioned that when they worked on the tasks, e.g. to describe the weather in their city, they took several photos outside of school using tablets and attached them to the learning content. After that students created textual or audio annotations to describe the weather in their photos in writing and verbally, and then they attached these annotations to the learning content anchoring to photos. In the interviews (please see Table 2), students mentioned that annotation function enabled them to practice their writing skills whereas recording function enabled them to practice their speaking skills. With annotating and recording functions, the students were able to write and talk about the weather in their city and record their written and verbal output. So students created rich content (i.e. including photos, texts, and audio files) using multimedia tools and it made their learning process more fun (i.e. amusing and enjoyable) and motivating. On the contrary, the control students used the traditional way to accomplish tasks and their created content wasn't rich and learning process wasn't as fun and motivating as that of their counterparts. With the dictionary of the system, the experimental students learned new vocabulary which they could use to complete the tasks. The dictionary helped the students find out translation of unfamiliar vocabulary, find out its meaning, and how to use it in different contexts. Sharing function of MMLS helped the experimental students share their textual annotations and recorded audio files with other students. Then students were able to review/listen to content shared by other students. Reviewing others' work enabled the students to learn from it; for example, how other students accomplished the tasks. In this way, they could get inspirational ideas to complete their own tasks or locate mistakes in their own work and then improve it. The students' learning behavior to use annotating, recording, dictionary, and sharing functions led to frequent language practice as well as to

Table 1 ANCOVA results

	The control group		The experimental group		*F*	Sig. 2-tailed	Partial eta squared
	M	SD	M	SD			
Pretest	50.04	21.15	43.96	21.38			
Posttest	59.22	20.92	70.15	16.58	29.602	0.000	0.372

Table 2 Interviews data related to affordances of mobile technology

Category	Sub-category	Description	Type of work on the task
Learning	Vocabulary learning	Students translated unfamiliar vocabulary using Dictionary	Individual/collaborative
	Language output	Students took photos of objects in authentic contexts to describe them	Individual/collaborative
		Students described objects from authentic contexts in writing and verbally in their textual and audio annotations	Individual/collaborative
	Language practice	Students frequently practiced writing and speaking skills thorough language output	Individual/collaborative
	Learn from others	Students reviewed content created by other students to get inspirational ideas for their own work or find mistakes in their own work	Individual/collaborative
	Improving their work	Students improved their own work based on shared work of others	Individual/collaborative
		Students improved their work based on other students' comments	Collaborative
Affective state	Less anxiety	Students experienced less anxiety during language output using the system	Individual/collaborative
	Fun	Students felt that it was amusing and enjoyable to learn using the system	Individual/collaborative
Learner autonomy	Organizing work	Students organized their work on learning tasks to specific date and time using Calendar	Individual/collaborative
	Monitoring learning progress	Students referred to their calendars to check their learning progress	Individual/collaborative
		Students reviewed others' work to compare with their own work in order to understand how well their learning is	
		Students monitored their own learning progress better because if some parts of the task were incomplete, other students would comment	Collaborative
	Reflecting on learning	Students reviewed their annotations to reflect on their learning	Individual/collaborative
	General	Better planning, monitoring and reflection on learning compared to traditional approach	Individual

make the quality of language output better. Furthermore, the students felt less anxious to produce language output using MMLS. On the other hand, the control students had no such benefits, so this is the reason their performance was significantly lower compared to that of their counterparts.

Our findings regarding usefulness of the system for language learning are in line with those obtained in other related studies. For example, multimedia tools were useful for practicing different language skills (Agbatogun 2014; Hsu et al. 2013; Hwang et al. 2014b; Li and Hegelheimer 2013; Lin 2014; Shadiev et al. 2015; Wang and Smith 2013), dictionary enabled translation of new vocabulary and provided related example sentences (Chen and Li 2010; Hsu et al. 2013; Huang et al. 2016; Lin and Yu 2016), and the students learned from others through sharing function (Huang et al. 2017; Hwang et al. 2016;

Shadiev et al. 2017a, b; Shadiev et al. 2018). However, not all above-mentioned studies considered mobile autonomous language learning in authentic contexts. And those studied which focused on mobile autonomous language learning in authentic contexts did not explore the effects of the intervention on autonomous authentic language learning using empirical evidence; most of them were descriptive in nature and used subjective evidence such as questionnaires and interviews data (Chai et al. 2016; Kondo et al. 2012; Leis et al. 2015).

There were also several benefits of MMLS to support learner autonomy during language learning. The experimental students mentioned (please refer to Table 2) that with MMLS they were able to better plan, monitor and reflect on their learning compared to the traditional approach. Calendar helped experimental students plan their learning process, check what they already accomplished, and what needed to be done. The control students could use calendar as well but on their mobile phones and, due to school policy, all mobile phones were taken from students during school hours. Another advantage of using the system over the traditional approach was that the experimental students created content on tablets and thus, they were able to return to it for reviewing and reflecting on their learning; however, the control students created content in their workbooks and couldn't access it after workbooks were handed to the teacher. Furthermore, the students could create content (i.e. annotations) in the same interface of MMLS as their learning material, they just attached their created annotations to related parts of learning material. This approach allowed building a connection between the learning content and the annotation content. It gave students a clear picture of the whole learning scenario with an appropriate explanation of it so that they could easily monitor their learning progress. The control students were not able to do so using traditional approach. Furthermore, due to the sharing function, the experimental students were able to review others' work and to compare it with their own work to understand how well their learning progresses are. In contrast, the control students were not able to do so.

Cotterall (2000) proposed the five principles of the language learning activity design. They relate to learner goals, the language learning process, tasks, learner strategies, and reflection on learning (Huang et al. 2016, 2017; Hwang et al. 2014a, 2016). Our results showed that learning activity supported by the system promoted these principles. Our results are in line with those obtained in other related studies. Other scholars also found that mobile technology was useful to facilitate autonomous language learning; for example, to plan, monitor, and reflect on their own learning (Chai et al. 2016; Leis et al. 2015; Zhang 2016) as well as to receive peer support (Kondo et al. 2012).

Second, we explored which approach (i.e. individual or collaborative) to work on the tasks using MMLS was more beneficial to autonomous language learning. Table 3 presents the results of paired sample t-test. The results showed that there was a significant difference in the scores on the task completed individually ($M = 66.92$, $SD = 15.69$) and collaboratively ($M = 71.92$, $SD = 13.86$), $t = -3.348$, $p = 0.003$, $d = 0.635$. That is, the scores on the task completed individually were significantly lower compared to those on the collaborative task. This result suggests that working on the task collaboratively

Table 3 Paired t-test results

Task 1		Task 2		*T*	Sig. 2-tailed	*D*
M	SD	M	SD			
66.92	15.69	71.92	13.86	− 3.348	0.003	0.635

using MMLS was much beneficial for learning. The students said (please see Table 2) that, during collaborative work on the learning task, commenting on others work was very useful for their language learning and monitoring their learning progress. The students reviewed shared annotations and commented on them using MMLS. In their comments, the students mentioned about mistakes other students made and gave suggestions on how to address these mistakes. The students mentioned in the interviews that such comments helped those students who made mistakes improve their work. They revised their work by re-taking photos, editing textual annotations, or re-recording audio files. In terms of learning autonomy, the students mentioned that they could return to their annotations, review them along with comments left by other students, and reflect on their own learning. The students said that they received comments not only related to the quality of their created content but also on some incomplete parts of the tasks (e.g. in describing the weather, a student missed to explain what people usually do in such weather). On the contrary, the students who worked on the task individually could not get such feedback, especially when they experienced some learning difficulties. The interview results show that collaboration with other students was beneficial for learning and therefore, we may conclude that this was the reason why students' scores on the collaborative task were significantly higher compared to those on the individual task.

Related studies suggested that individual (Retnowati et al. 2017) and collaborative (Watanabe and Swain 2007) learning approaches can foster learning. Retnowati et al. (2017) argued that when the students need to solve a problem and they are provided with a step-by-step solution to this problem, individual learning approach is more beneficial compared to collaborative one. In contrast, Watanabe and Swain (2007) and Sweller et al. (2011) argued that, in solving problems, collaborative learning approach have an advantage over individual learning because the students can share information and learn from each other when they collaborate. In this study, collaborative learning approach was more effective to facilitate language learning compared to individual one because of authentic contexts where the students learned the language and their EFL level. The students were provided with guidelines on how to complete learning activity and the teacher was also ready to help them when necessary; however, guidelines were general to be applied to every authentic context selected by the students and the teacher wasn't always available to provide assistance to the students outside of school. In addition, as the students were from junior high school, not everyone's EFL level was high enough to solve real-life problems in the real world without any assistance.

Third, we investigated the students' perceptions towards MMLS. According to our results in Table 4, the students' perceptions regarding ease of MMLS use, usefulness of MMLS for language learning, and behavioral intention to use MMLS in the future for language learning were high. Students scored the item "Learning to operate MMLS is easy for me" as the highest ($M = 4.36$, $SD = 0.78$) and "I intend to continue using MMLS in future" as the lowest ($M = 3.79$, $SD = 0.63$).

Related studies suggested that the acceptance of technology should be evaluated on a pedagogical basis to interpret its usage (Hwang et al. 2014a, 2016). Davis (1989) suggested that technology acceptance can be measured through perceived ease of use, perceived usefulness and behavioral intention dimensions. Our results suggest that the students accepted MMLS for autonomous language learning in terms of its ease of use and usefulness as well as their behavioral intentions. That is, they perceived that MMLS was easy to use and useful for learning. In addition, most students intended using MMLS in the future for language learning. The interviews with the students supported this finding.

Table 4 Questionnaire results

#	Items	Mean	SD
1	Learning to operate MMLS is easy for me	4.36	0.78
2	I find it easy to get MMLS to do what I want it to do	4.29	0.76
3	Interacting with MMLS does not require a lot of my mental effort	4.18	0.98
4	My interaction with MMLS is clear and understandable	4.25	0.80
5	It is easy for me to become skillful at using MMLS	4.25	0.84
6	Overall, I found MMLS is easy to use	4.14	0.80
7	Using MMLS improves the quality of my autonomous language learning	3.89	0.69
8	Using MMLS helps me to accomplish autonomous language learning tasks more quickly	4.00	0.82
9	Using MMLS increases my productivity	3.86	0.80
10	Using MMLS enhances my effectiveness on the autonomous language learning	3.86	0.76
11	Using MMLS improves my autonomous language learning performance	3.93	0.81
12	Overall, I found using MMLS is useful in my autonomous language learning	3.93	0.86
13	I intend to continue using MMLS in future	3.79	0.63
14	I plan to use MMLS often	3.82	0.61
15	I will strongly recommend others to use MMLS	3.82	0.61

Conclusion

We have three main findings in this research. First, the students who used MMLS outperformed those who used traditional method on the post-test. MMLS was useful for the students to practice language more, to learn from other students, and to better plan, monitor, and reflect on their learning. Second, the students had better performance when they collaborated with other students compared to situations when they learned individually. During collaborative work, the students received comments from other students which helped them improve quality of their work as well as better reflect on and monitor their learning progress. Third, the experimental students accepted MMLS and had high perceptions towards it.

We make two suggestions for teaching and research community in the field. First, we suggest designing autonomous language learning activity supported by MMLS. Under such activity supported by the technology, the students can learn new concepts and apply newly learned knowledge in authentic environments by creating their own learning content. The students can find interesting objects in the real world and describe them in written and verbally as photos, textual, and audio annotations using the system. In addition, annotations can be shared with others so that the students can learn from each other. In this way, student autonomy (e.g. to plan, monitor, and reflect on learning) and language learning (e.g. language practice) will be facilitated. Second, the instructors need to make sure that the students, when they learn in authentic contexts and solve real-life problems, do it not only individually but also in collaboration with others. Collaborative work will be useful, especially for junior high school students whose EFL level is not high enough, in authentic contexts for which guidelines are not applicable and where the teacher's assistance is not

available. This approach will help the students facilitate their language learning and autonomy more efficiently.

In this research, we make the following contributions to the field. First, we reviewed related studies and discussed the gap in the literature. We addressed this gap by designing the learning activity supported by MMLS to facilitate language learning and student autonomy, and we carried out the experiment. First, in our experiment, we investigated the effectiveness of the learning activity supported by MMLS to enhance autonomous language learning by comparing autonomous language learning in traditional vs. mobile language learning environments. Second, we researched the effectiveness of learning approach to facilitate autonomous language learning by comparing individual vs. collaborative autonomous language learning. Third, we explored how the students accept our system. Fourth, some suggestions for educators and researchers were provided based on our results. Findings and suggestions of this present research can be useful to those who design related autonomous language learning activities in authentic contexts supported by the technology.

Three limitations need to be acknowledged and addressed in the future. The first one relates to the small sample size and the second one concerns short term exposure to autonomous language learning activity supported by MMLS. As a result, these issues may limit generalization of our findings to the wider population. The third limitation is that we did not estimate the time spent in the autonomous learning activity by two groups. That is, if the experimental students spent more time on the tasks then it becomes difficult to distinguish whether our results attribute to the time spent or the treatment. These limitations need to be considered and addressed in future studies. We will also explore how other advanced intelligent technologies may support the learning activity and enhance autonomous EFL learning. For example, applications of wearable devices (i.e. clothing and accessories incorporating computing systems) for language learning were overlooked. Optical head-mounted displays, smart watches, and smart bracelets are some examples of wearable devices which provide various educational affordances (Bower and Sturman 2015; Sawaya 2015). Applications of these advanced technologies to support language learning is very promising research direction for future studies.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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Rustam Shadiev is a professor at the School of Education Science, Nanjing Normal University, China. His research interests include online learning and its technology, educational applications of multimedia technology, and computer supported EFL/ESL learning.

Wu-Yuin Hwang is a distinguished professor at the Graduate Institute of Network Learning Technology, National Central University, Taiwan. His research interests include computer assisted language learning, HCI and knowledge construction.

Miss Tzu-Yu Liu is a teacher at Bei-Zheng Junior High School, Taiwan. Her research interests include computer assisted language learning and e-Learning.