Cultivation and Assessment of Creativity in the Foreign Language Classroom: Association-based Activities and Biometric Data Analysis

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Doctoral Dissertation

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Abstract

Cultivating students' creativity has become an important part of teaching foreign languages at the university level. This study proposed a creative pedagogy for the foreign language classroom. Activities that involve association and mind mapping in a student-centered mode can encourage students to think creatively. This study implemented association-based activities with mind mapping to encourage students to exercise creative, divergent thinking in their learning process. The setting for the study was a school of Japanese studies at a university in Dalian city in China. At this university, the students generally follow a traditional curriculum, which is unconcerned with improving creativity. The fundamental aim was to explore whether a creative pedagogy could effectively promote creativity development in students' creative thinking skills, language proficiency, and learning motivation. The experimental group received an 8-week intervention that combined the regular curriculum with association-based activities with mind mapping. The control group received the regular curriculum. It assumed that association-based activities with mind mapping positively impact the cultivation of creativity.

At present, few studies have investigated to what extent association-based activities influence foreign language learning among university students in terms of creativity outcomes. To clarify the effect of the association-based activities on creativity, we employed an experimental methodology involving a pre-test/post-test repeated measures design. All students were tested on creativity performance using three assessment instruments, a creative thinking test, a foreign language proficiency test, and a motivation questionnaire: evaluating creative thinking skills through creative thinking test, performance rating by three factors of fluency, flexibility, and originality; assessing Japanese language proficiency through Japanese-language proficiency test, in terms of vocabulary, reading comprehension, and writing; administering a motivation questionnaire, including choice, executive, and increased motivation questionnaire, to assess students' learning motivation.

Besides using traditional tests to measure students' creativity outcomes, an electroencephalography (EEG) investigation was taken for testing students' divergent thinking skills, and an eye tracking analysis was taken for assessing students' Japanese language proficiency, which provided biometric data to further verify the effectiveness

of creative pedagogy. In recent years, with the rise and development of cognitive neuroscience, the research techniques of EEG and brain function imaging have provided powerful research tools for directly observing the activity of the brain when processing complex information, which provides a more direct method for exploring the brain mechanism of creative thinking, especially divergent thinking. In this study, the EEG data of the two groups students were compared and analyzed during the divergent thinking tasks' process. It's expected that the findings will deepen understanding and promote the study of the effectiveness of creative thinking skills. In addition, this study used eye tracking sensors to explore creative pedagogy's effects on reading ability that is considered as the comprehensive reflection of foreign language proficiency. Eye tracking sensors was used to record eye movement indicators in real time, going on to map the eye movement indicators to the reading process that can effectively analyze the reading ability, which provides a quantitative assessment and data evidence of creative pedagogy's effectiveness on students' language proficiency.

In summary, the findings in this study suggest that association-based activities could be taken into consideration when cultivating creativity in foreign language teaching in university. Data and insights culled from the findings in this study establish the knowledge framework of creative foreign language teaching methods and evaluation, which will contribute to the knowledge science to set future directions for the creative pedagogy in the field of foreign language teaching and learning in undergraduate education.

Keywords: creativity; association-based activities; creative thinking skills; foreign language proficiency; learning motivation

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Chapter 1
Introduction

1.1 Research background

1.1.1 The necessity of creativity cultivation in foreign language teaching

At present, we are part of the global society that face many complex and large-scale problems, which need diverse knowledge to deal with. Besides professional knowledge and analytical skills, it is more important to obtain multidisciplinary creativity and practical skills that can solve complex and large-scale social problems (Miyata, Nagai, Yuizono, & Kunifuji, 2017). Promoting creativity has become an important educational objective (Simonton, 2000; Sawyer, 2006; Craft, 2011), and the incorporation of creativity into curriculums has become a popular topic (Amabile, 1983; Shaheen, 2010; Craft, 2011; Cremin, 2015). Recently, creativity education has become the goal of educational reform policy and teaching strategy in Chinese universities. Creativity is the core of language learning and teaching (Jones & Richards, 2016). The goals of foreign language teaching in undergraduate education are practical application and the development of students' personality (Sadykova & Shelestova, 2016), especially creativity. It is an inevitable choice and basic requirement for the reform of foreign language education system, in order to cultivate students' creativity, especially creative thinking skills in the area of university foreign language teaching. Traditional teaching modes and methods are being changed into those that give full play to students' subjectivity, shift from passive learning to active learning, making students more willing to participate in foreign language learning as well as encouraging students' inquiry and thinking skills. This plays an important role in improving the efficiency of foreign language teaching and achieving teaching objectives.

The author is a Japanese language teacher at a Chinese university, and has been engaged in Japanese language teaching for 10 years. The author has always been thinking about the cultivation of students' creativity in Japanese classrooms, and explored what kind of creative teaching methods could be constructed and what approaches should be taken to carry out creativity education. Within the Japanese language classroom, key issues are how to define students' creativity and what kind of creative pedagogy should be adopted. If a type of creative pedagogy is applied for creativity development, it is important to further consider how to evaluate the effects of that kind of creative pedagogy and how to judge whether the creativity of students has improved, etc.

Foreign language learning is inseparable from creative thinking skills. Cultivating students' creative thinking skills in foreign language teaching can help students to better understand, master and use the foreign language. With practical applications and communication activities, students can more easily master foreign language grammar points, memory, practice, and in that process of constantly discovering and using language, they can then improve their self-study abilities and comprehensive language abilities (Shu & Zhuang, 2000). This study puts emphasis on the cultivation of creative thinking skills. The methods of cultivating students' creative thinking skills are added into the teaching process. This study then goes on to explore how to make sure that students master foreign language expertise and skills, at the same time, applying students' learning motivations to the whole teaching process, as well as embody personalized teaching, broaden students' knowledge, and improve their learning abilities and creative thinking abilities. This can then compensate for the disadvantages of traditional teaching methods, such as "emphasizing knowledge, neglecting ability" and "emphasizing teaching but neglecting thinking", so as to promote the development of students' creativity.

1.1.2 The need to apply appropriate creative pedagogy for creativity cultivation

Many studies have concluded that creativity can be cultivated through appropriate teaching methods and enhanced with activities (Esquivel, 1995; Craft, Jeffrey, & Liebling, 2001; Runco, 2004; Eleonora et al., 2014; Liao et al., 2018). Cultivating creativity entails integrating appropriate activities into everyday teaching so that they complement foreign language learning, rather than compete with it (Maybin, 2016), and enhance students' creativity (Maley, 2015). Regular curriculum-infused creative activities, especially those involving student-centered, interactive, and open-based elements that are well-suited to developing students' creativity. A foreign language classroom that offers a playful, student-centered atmosphere can foster creativity (Ghonsooly, 2012). Maley (2015) offers tenets for using creative pedagogy to teach a foreign language, including the random principle (presenting unexpected combinations to encourage students to find connections), the association principle (using students' imagination), and the divergent thinking principle (finding as many solutions as possible). Activities that involve imagination and novel idea generation in a student-centered mode can encourage students to think creatively.

This study presents a creative pedagogy that uses association-based activities with mind mapping for the foreign language classroom. Association-based activities are a learning process to select a knowledge as a starting point for associating related knowledge in the process of drawing a structure diagram, which could help students firmly grasp the knowledge they have learned, and help them to establish connections among knowledge and perform a flexible transfer of the knowledge. As an effective tool of thinking, mind mapping can help students to associate ideas, develop creative thinking skills and potential (Buzan & Buzan, 2010). It can also facilitate creative thinking through invigorating the classroom atmosphere during the learning process.

There are three individual components of creativity, that is creative thinking skills, expertise, and motivation (Amabile, 1996). It is expected that through the creative pedagogy presented in this study, students' creative thinking skills could be well trained and improved. In addition, it would give full play to the students' subjectivity, and mobilize their initiative in learning. Therefore, students' foreign language learning could be changed from passively receiving knowledge to actively exploring knowledge, which could improve students' performances. Moreover, the knowledge structure diagram drawn by the students themselves can show their own thinking process and enjoy the fun of thinking to enhance their enthusiasm and learning motivation.

1.1.3 Biometric data analysis toward creativity assessment

At present, in the foreign language education, few studies have investigated to what extent creative pedagogy influence students' creativity outcomes. Based on the three components model of creativity: creative thinking skills, expertise, and motivation, this study examined the pedagogy's effectiveness on the development of creative thinking skills, foreign language proficiency, and learning motivation, and administered before and after the intervention: a creative thinking test (fluency, flexibility, originality), a foreign language proficiency test (vocabulary, reading, and writing), and a motivation questionnaire (choice, executive, and increased motivation).

The traditional creative thinking test can provide analytical data, but whether the scores of fluency, flexibility, and originality obtained by these tests are related to real life creative problem solving ability has not been fully confirmed (Dietrich & Kanso, 2010). In recent years, with the rise and development of cognitive neuroscience, the research technology of EEG and brain function imaging provides a powerful research means for directly observing the activity of brain when processing complex information, thus providing a more direct method for exploring the mental mechanism of creative thinking (Bowden & Jung-Beeman, 2007; Fink et al.,2007; Luo & Knoblich, 2007; Srinivasan, 2007). Applying EEG acquisition equipment to measure EEG effectively can effectively and intuitively reflect the characteristics of cerebral cortex electrical

signal of divergent thinking, visualize thinking and explain the operation process of divergent thinking. To our knowledge, no study appears to exist that has analyzed EEG correlates of creative pedagogy in the foreign language education. In this study, we measured the students' EEG signals to effectively obtain information from the whole brain, in order to realize more direct empirical research, and lay a solid foundation for verifying the effectiveness of creative pedagogy in the development of creative thinking skills.

In addition, we conducted an eye tracking analysis for assessing students' reading ability, which provide biometric data to further verify the effectiveness of creative pedagogy on foreign language proficiency. Reading ability is significant in foreign language learning (Nuttel, 1982). Linguistic psychology demonstrates that reading refers to the process of extracting information from the word system and then understanding the article through brain coding processing (Peng, 1991). Nerves emanating from the cerebral cortex dominate eye movement, which is dominated by the brain and then reversed back to it. Eye movement is a biological signal, and its exploration may reveal lots of information which enables greater understanding of the biology and mechanisms of the brain (Katarzyna & Pawel, 2019). Thus, eye movement can reflect our minds. Reading is a complex cognitive process; through eye movement analysis, the real-time language understanding cognitive processes are grasped accurately, and the reading process can be researched more in-depth (Just & Carpenter,1980; Zhan, Shen, & Wang, 2014). Eye tracking technology provides more accurate and effective support with high universality in the field of language understanding, which could capture and analyze data of cognitive processing process in reading behavior and conduct comprehensive reading process analysis. It can not only provide real-time and visual measurement for language understanding but also continuously measure and record the entire process of reading comprehension. In this study, the eye tracking research method was used to investigate eye movement characteristics of students in the process of reading. Data and insights culled from the findings were used to provide analysis data further supporting the hypothesis that creative pedagogy presented in this study can improve the foreign language proficiency.

1.2 Research objectives

The overall purpose of this study is to construct a new type of foreign language classroom teaching method to achieve the teaching goal of promoting the development of foreign language learners' creativity, and to investigate what extent the creativity could be cultivated. Through applying association-based activities with mind mapping teaching method design, to explore the feasibility based on the analysis of biometric data valuation, and suggest practical implication for creative pedagogy design in the foreign language classroom.

Based on Amabile's three component of creativity components: creative thinking skills, expertise, and motivation, we pursue specific research objectives as follows.

I. Construction of a creative pedagogy of association-based activities with mind mapping that centered on the development of creativity, including creative thinking skills, foreign language proficiency, and learning motivation.

II. Presenting traditional measurement methods for investigating the association-based activities' feasibility, including creative thinking test, foreign language proficiency test, and learning motivation questionnaire.

III. Applying biometric data analysis of EEG investigation for creative thinking skills, and eye tracking detection for reading ability that can reflect the comprehensive foreign language proficiency to present more accurate numerical results.

This study takes "creativity is the inherent endowment of each student" as it's starting point, and therefore does not regard creativity training as an additional teaching task in the process of foreign language teaching, but rather believes that it can promote learning motivation and improve the positive aspects of foreign language expertise in the daily classroom. It is hoped that the teaching methods and the evaluation pattern that are presented in this study can be extended to other foreign language education fields in colleges and universities and promote the reform of foreign language teaching.

1.3 Research design

This study carried out according to the following research process (Figure 1).

In the preparatory stage, research materials were sorted, and the theoretical analysis and the construction of creative teaching methods were explored.

During the implementation stage, we explored appropriate creative pedagogy in foreign language classrooms We conducted practical lectures using the creative teaching method of association-based activities with mind mapping that focused on cultivating students' creativity, including creative thinking skills, foreign language proficiency and learning motivation.

In the verification stage, we conducted experimental methods, which were done for the investigation of the creative pedagogy's implementation effectiveness. In order to verify the effectiveness of association-based activities, besides traditional measure methods, we applied biometric data analysis, including EEG investigation to evaluate creative thinking skills, and eye tracking detection to measure foreign language proficiency.

Finally, in the summary stage of the study, the models for creativity cultivation and assessment were proposed, and the contribution and future research directions of this study was outlined.

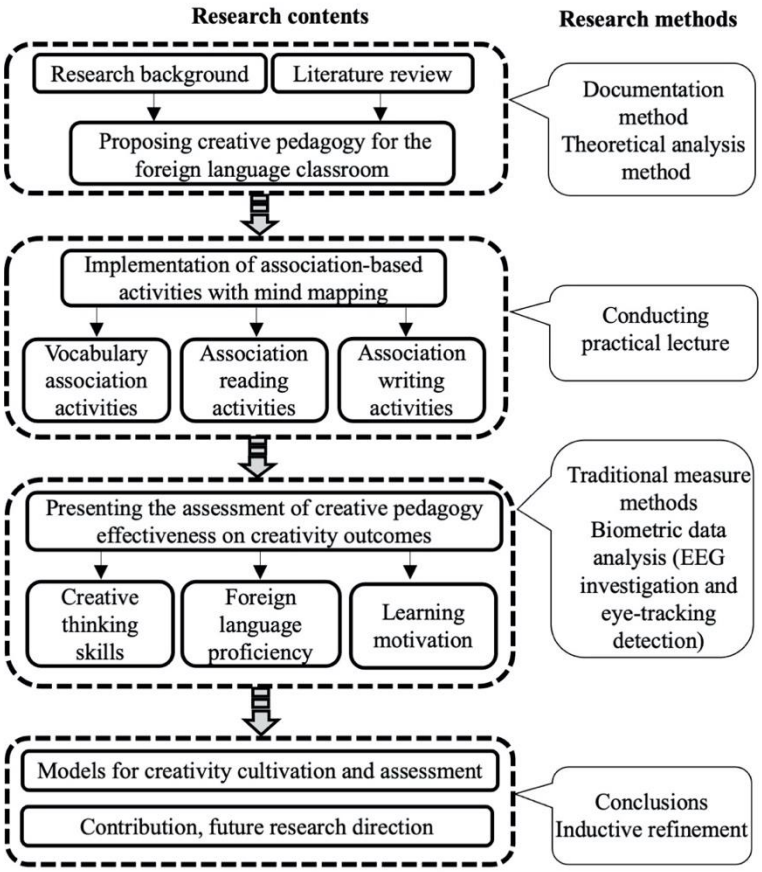


Figure 1. Research contents and methods.

1.4 Research significance

1.4.1 Theoretical significance

The promotion of creativity education and full development of students' creative spirits can be considered a requirement for foreign language teachers in both modern and future society. Classroom activities plays an important role in the development of students' creativity. In this study, creative pedagogy was applied to teaching practice. The main focus is on the development of students' creativity, especially the cultivation of creative thinking skills, rather than the general training and foreign language knowledge teaching. This is conducive to the innovation and reform of foreign language teaching. The creative pedagogy proposed in this study focuses on cultivating students' creative thinking skills, as well as constructing a student-centered learning atmosphere in order to improve students' foreign language ability and interest in

learning. It is hoped that this creative pedagogy can be extended to other foreign language education fields in colleges and universities and promote the reform of foreign language teaching.

1.4.2 Application significance

Foreign language education in Chinese universities basically adopts a teacher-centered traditional teaching method (Ying, 2007). There are very few courses that adopt creative pedagogy to cultivate students' creativity. In the process of traditional foreign language teaching, there is little emphasis on students' foreign language learning concepts and strategies (Van Lier, 1996; Lantolf, 2006). Teachers pay less attention to the individual language knowledge and learning interest of students. The teaching process is mechanical, with more teachers' monologues, less students' practice, which is not easy to arouse students' interest in learning, and students are in a passive learning state (Zhang, 2005; Su & Zhuang, 2008). As a result, the accuracy of pronunciation, vocabulary, and grammar is too pursued, and students' language creation ability is ignored, and the subjective initiative of foreign language learners cannot be fully utilized. This study innovated the traditional foreign language teaching concepts and advocate student-centered creative teaching concepts in foreign language classrooms. In foreign language teaching, the learning process is not a process of knowledge transfer from teachers to students, but a process of knowledge construction in which students' new and old knowledge and experience interact in a specific learning environment (Cazden, 2001; Jordan, 2004). Foreign language learning is not the passive acceptance of the knowledge granted by the teacher, but the active construction based on students existing knowledge and experience (Van Lier, 1996; Lightbown, 2000; Lantolf, 2006). The creative pedagogy presented in this study applies daily association-based activities with mind mapping that emphasizes the cultivation of students' creative thinking skill and the improvement of language proficiency and learning motivation, which made up for the lack of curriculum-level development of creativity in foreign language education in universities.

1.4.3 Knowledge science significance

This study constructed a creative pedagogy and evaluation criterion for creativity in the foreign language classroom, and technological equipment were used to investigate the effects of the creative pedagogy, which innovate teaching evaluation methods in the field of foreign language education. The assessment methods combine science and technology with teaching, establish the knowledge framework of creative foreign language teaching methods and evaluation, provide the basis for the evaluation of the effects of foreign language creativity teaching and aim to promote the development of foreign language creativity education. In addition, from the perspective of knowledge creation, the creative pedagogy could establish basic creativity-based activities for contributing to the foundation of motivator of creativity based on the experimental science.

1.5 Structure of the dissertation

In chapter 1, the research background is described from the issues of creativity cultivation in the foreign language education. In addition, the research aims, design, methods, significance and the structure will be summarized.

In chapter 2, focusing on literature review of creativity, research theories will be organized. The definition of creativity, influence components of creativity, cultivation and assessment of creativity for the foreign language classroom will be summarized.

In chapter 3, based on the research theories in literature review, this chapter describes the issues of creativity cultivation and evaluation in foreign language education. Integrating the creative pedagogy into foreign language classrooms, implementing association-based activities with mind mapping for cultivating creativity.

In chapter 4, providing biometric data analysis on association-based activities by EEG investigation, which is considered to further verify the effectiveness of creative pedagogy on creative thinking skills.

In chapter 5, providing biometric data analysis on association-based activities by eye tracking detection, which can investigate the creative pedagogy's effect on reading ability that is significant for language performance.

In chapter 6, in summarizing this research, proposing creativity cultivation and assessment models, and discussing the contribution and future research direction.

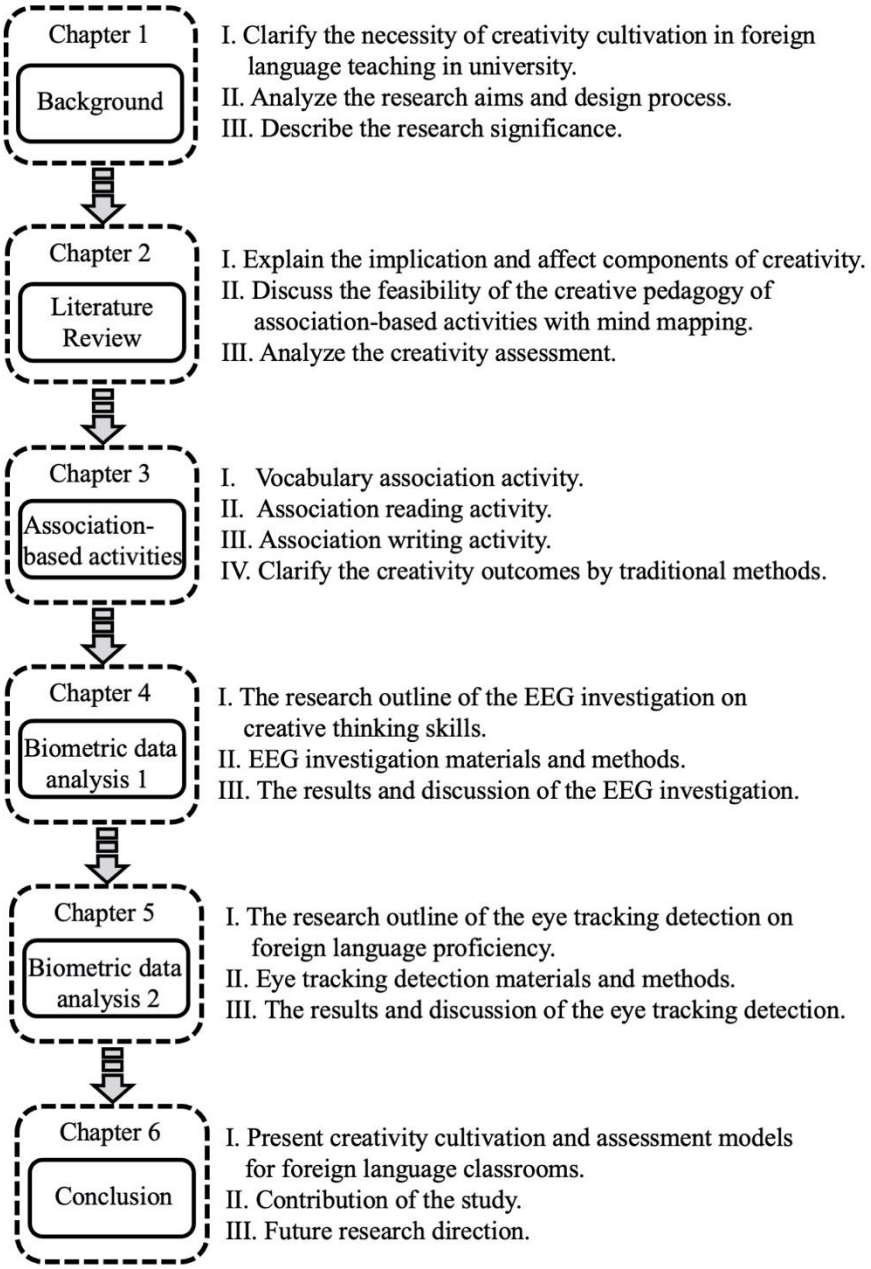


Figure 2. Structure of the dissertation.

Chapter 2 Literature review

Content

- **Definition of creativity**
- **Individual components of creativity**
- **Creativity cultivation, association-based activities**
- **Summary**

Chapter 2
Literature review

This chapter first explains creativity from the perspectives of psychological, linguistic and educational, and discusses the relationship between foreign language learning and creativity. And then this chapter analyzes the factors that affect creativity from intrinsic influence components, and presents creative pedagogy of association-based activities with mind mapping and discusses its feasibility.

2.1 Definition of creativity

2.1.1 Psychological definition of creativity

Creativity is a complex psychological phenomenon. The concept of creativity, which has received much scholarly attention, is generally described as the ability to generate original, imaginative, and unique ideas (Guilford,1967; Torrance, 1988; Ruscio et al., 1998; Jones & Richards, 2016). Creativity includes elements such as originality, novelty, value (Nęcka, 2001; Runco & Jaeger, 2012), which is the ability to come up with original, novel and valuable ideas (Boden, 2004). According to Csikszentmihalyi (1996), creativity is an ideological behavior that can change an existing field or transform an existing field into a new field. Simonton and Damian (2013) believed that only the novel, unique, adaptable and effective idea can be called creative idea. Kaufman and Sternberg (2015) summarized the characteristics of creative idea, that is, representing novel or innovative things, and completing the task which is about to be completed with high quality. To sum up, creativity is the ability to produce creative ideas, which need to be novelty (uniqueness, surprising) and functionality (appropriateness, effectiveness, value).

Creativity is a universal human characteristic, and all people have varying degrees of creativity (Rogers, 1959; Rogers, 1961). According to Gardner (1999), creative people mainly have three features. First, they are very smart and have unusual ideas; Second, they often experience a certain field in novel and unique ways; Third, they usually discover new problems with free spirit. This classification also reflects the impact of creativity on people's creative ideas. Everyone has the potential of creativity, and some creativity is hidden without a chance to be released, which requires proper excavation. If there are proper conditions, creativity will be released and manifested (Rogers, 1961). Creativity is related to factors such as emotion, motivation, environment, knowledge, and learning styles (Sternberg & Lubart, 1995).

De Dreu, Baas and Nijstad (2008) believe that a higher level of creativity is related to active emotions. When emotions are positive, it implies an environment that supports cognitive flexibility and can also stimulate the motivation, because emotion and motivation are related. Motivation also affects creativity. The type of motivation is divided into intrinsic and extrinsic. When people have intrinsic motivators, in order to find fun in the process of performing tasks, they will be more focused and engaged in work or study than people who have external rewards, and therefore more creative (Amabile, 1996; Csikszentmihalyi, 1978; Nęcka, 2001). The release of creativity potential mainly depends on people's autonomous creative consciousness and creative motivation (Rogers, 1959). At the same time, knowledge and practical exercises are necessary for earn recognition, and they are related to creative attainment (Kaufmann & Sternberg, 2015). The environment is also connected with creativity through emotion and motivation (Simonton & Damian, 2013).

In summary, from a psychological point of view, creativity is an ability characterized by novelty and functionality. It is associated with a series of individual characteristics and environmental factors. A full understanding of the psychological definition of creativity is very important for the implementation of creativity education. When carrying out creativity education in foreign language teaching in universities, it

is necessary to tap the creativity potential of students, develop their creativity awareness, and stimulate creativity motivation. It can improve the creative ideas of students in the process of foreign language learning from two aspects of personality cultivation and learning environment, which can not only increase learning interest, but also promote the accumulation of foreign language knowledge, and at the same time enhance creativity.

2.1.2 Linguistic creativity

Language acquisition is not the result of mechanical imitation of language, but the result of the brain's internalization of external language information. This process is a kind of "creation" (Ellis, 1994). The so-called "creation" is a product of thinking. Language acquisition is the process by which the brain processes, absorbs, processes, and reproduces external language information through thinking. This theory of thought has been recognized by most scholars (Krashen, 1981; Dwight & Donald, 1981; Schmidt & Frota, 1986; Swain, 1995; Swain, 2013). Krashen (1985) proposed language input hypothesis. There is a stage of language intake between language input and language acquisition. Not all language input can promote the occurrence of language acquisition. Only when language knowledge is digested and absorbed by learners, can it enter the brain's long-term memory and play a role in catalyzing language acquisition (Krashen, 1982; Van Patten, 1996; Skehan, 1998). The process of language acquisition is the product of thinking, and a creativity process that transforms through the internal functions of the brain (Schmidt, 1990). Therefore, the process of language acquisition is also the creative thinking process of the brain, and the cultivation of language creativity is a key point to foreign language learning.

Foreign language learning in the traditional way is always carried out in a planned and step-by-step classroom. The lack of a vivid language environment makes the consciousness of language creation in the brain restricted. Therefore, in foreign language teaching, creative pedagogy should be developed that can stimulate students'

consciousness of language creation in the brain, cultivate students' language creativity, promote students' knowledge of foreign languages, and improve their creative thinking. Everyday creativity is a universal feature of language and a key component of interpersonal communication (Carter, 2004; Maybin, 2016). The function of imagination plays an important role in communication (Jakobson, 1960; Halliday, 1975). Through association, the development of language can be promoted, for example, telling jokes, making up stories, word pun games, etc. (Halliday, 1975). The first function of language may be to create the world of association, whether it is fantasy, game, or storytelling (Cook, 2000). This indicates that language is naturally creative and is used daily in creative ways. In the process of foreign language learning, boring and tedious exercises such as memorizing words, grammatical rules, sentence patterns, and sentence structure can be avoided. It should adopt a creative pedagogy focusing on the development and cultivation of brain thinking in language learning, which can promote the flexible use of foreign languages for information exchange and cooperation, and improve the effect of foreign language learning. Just like the association activities mentioned above, it is an effective way to learn foreign languages flexibly and enhance students' creativity.

2.1.3 Creativity education

Creativity has been seen as a much needed human capacity for living in a rapidly changing, globalized, and competitive society (Simonton, 2000; Shaheen, 2010; Runco, 2004). There is an obvious relationship between creativity and education. The cultivation of creativity should be one of the most important goals of education (Karnes et al., 1961; McCabe, 1991). However, the traditional education system often attaches importance to academic skills and test scores, not the cultivation of creative students with new ideas and abilities (Robinson, 2011). The university education system must not only develop students' academic skills, but also cultivate their creativity (Friedman, 2009).

Traditional foreign language classrooms lack a playful atmosphere that supports creativity cultivation, which makes it difficult for students to generate creative ideas because they lack intrinsic motivation (Dörnyei, 2005; Albert, 2006). In foreign language classrooms, traditional teaching ideas and concepts should be changed, and measures should be actively taken to enhance students' creativity. Andrew (1998) believed that, in foreign language learning, we should not ignore the joy of learning in order to achieve the purpose of learning, that is, we should allow students to learn foreign languages in a relaxed and pleasant atmosphere, so that students can fully perceive and understand foreign languages, and cultivate their creative thinking skills.

Students are more creative in dealing with issues that are instructive and meaningful to them (Beghetto & Kaufman, 2014). Classroom activities can help students understand and master a foreign language more readily, and they can help students learn to use a foreign language for communication creatively (Krashen, 1982). Creative tasks and activities supportive of creative teaching can be designed in order to foster creativity, which should have interesting content with novelty, fantasy, and certain challenges. In addition, it should also encourage risk-taking and creative thinking, so that students can enjoy the process of participation in problem-solving, and can learn corresponding knowledge and stimulate their intrinsic motivation while also improve their professional skills. Moreover, the use of technology (e.g., mind mapping) and group cooperative learning methods also support creativity, which can also be actively applied to foreign language classrooms.

When people are interested in an activity, they tend to be proactive in completing the activity, which can encourage them to participate in the learning process more actively and perform better (Cremin et al., 2006; Cheung 2018). Teachers can make students focus more on the learning process, thus promoting their learning attainment (Maghsoudi & Haririan, 2013), and improve creative thinking skill. Thus, this study presents a creative pedagogy of association-based activities with mind mapping in a foreign language classroom. It's expected that this pedagogy is an innovative reform of

traditional foreign language education, which allows students to learn in a playful learning atmosphere, improve their creativity, and at the same time enhance their foreign language proficiency and learning motivation.

2.2 Individual components of creativity

As was mentioned in Chapter 1, the influences on creativity include three within-individual components: creative thinking skills, expertise, and motivation (Amabile 1996; Amabile 1999). This chapter elaborates these three within-individual components respectively.

2.2.1 Creative thinking skills

(1) Characteristics

Creative thinking is the concrete expression of individual creativity and refer to the ability to create new associations from existing ideas and rearrange and link pre-existing ideas (Amabile, 1996). It is the imaginative control (combining experience and knowledge) of a goal, and is a kind of wisdom thinking, which refers to the ability to solve problems (Guilford, 1967). Creative thinking is a way of looking at problems or situations from a fresh perspective. According to Guilford and Hoepfener (1971), there are six features related to creative thinking, that is, sensitivity, fluency, flexibility, originality, elaboration and redefinition. Sensitivity is the ability to accept new things and discover new problems; fluency is the ability to generate a large number of ideas; flexibility is related to the ability to create different types of ideas and to perceive an idea from different angles; originality refers to the ability to generate unique ideas that others cannot think out; elaboration reflects the ability to expand ideas or create complex plans by embellishing details; and redefinition is the ability to find multiple ways to use specific things. Creative thinking which involves sensitivity to problems, fluency of production, flexibility of creative mind, ability to generate novel ideas,

synthesizing and analyzing ability, reorganization of the conceptual structure (Guilford, 1950), might be a factor affecting foreign language learning.

(2) Mechanism

Wallas (1926) proposed four stages of creative thinking, that is preparation, incubation, illumination and verification.

I. Preparation

This is a thinking process, and the stimulus of the situation induces various associations. It's the stage of collecting and selecting information, and finding out the clues to solve the meaningful and valuable problems.

II. Incubation

If the problems cannot be solved immediately, it will enter the incubation stage. During this period, problems are no longer deliberately solved, but unconscious brain activity continues, that is, the brain's underlying consciousness is still unconsciously screening and reorganizing the collected information.

III. Illumination

This stage is also known as the epiphany period or inspiration period, which refers to the stage when suddenly realize how to solve the problem.

IV. Verification

This is the final stage of problem solving. The solution proposed in the previous stage will be further specified, applied and tested.

(3) Divergent thinking

Divergent thinking is the foundational component of creative thinking skill, which is widely considered crucial to the cultivation of creativity (Guilford, 1986; Russ, 2003). It is the process of generating multiple related ideas for a given topic or problem solution, which helps people formulate a wide range of ideas toward solving problems.

Divergent thinking refers to thinking in different directions, reorganizing the information and the information in memory system, so as to produce a large number of unique new ideas (Guilford, 1967; Guilford, 1986). Among the six features related to creative thinking, fluency, flexibility, and originality are the central factors of divergent thinking (Guilford, 1986; Kim, 2006). It overcomes the defects of one-way thinking in conventional thinking and is a kind of thinking form that does not follow rules, seeks variation, and explores answers from various aspects, which is the foundation and important part of creative thinking.

Most university-level foreign language curriculums and pedagogies continue to focus on academic activities (Dörnyei, 2005; Albert, 2006). In turn, many foreign language learning university students still lack the creative thinking needed for their specialty. In foreign language education, instructors should find new ways to teach students so that they learn to apply the target foreign language freely and move away from rote memorization (Andrew, 1998; Mayer, 2002; Maghsoudi & Haririan, 2013), and improve creative thinking during the foreign language learning process. This study presents creative pedagogy focusing on enhancing students' creative thinking skills, especially divergent thinking skills.

2.2.2 Expertise

Domain expertise is crucial for creative attainment (Kaufmann & Sternberg, 2015). According to Ottó (1998), there are statistically significant correlations between creativity and foreign language proficiency. In his research, creativity was measured by a creativity test including association task, Alternative uses (AU) task, common problems task, consequences task and categories task. Foreign language proficiency was assessed by end-of-term grades. Creativity was analyzed based on four factors, that is associational fluency, ideational fluency, originality, sensitivity to problems. The results indicate that the four factors are all related to foreign language learning achievement, and students who score higher on creativity are more successful in learning foreign languages. Ghonsooly (2012) found the relations between foreign

language learning and divergent thinking skills (the ability to provide various reactions to a stimulus). Divergent thinking skills are positively correlated with foreign language learning. Ghonsooly's research results show that students with higher foreign language proficiency significantly perform better than those of low-level proficiency on the divergent thinking skills assessment, such as fluency, flexibility and originality. Therefore, it will be very effective to explore creative pedagogy to promote creativity while improving foreign language proficiency.

2.2.3 Motivation

People rarely do truly creative work unless they enjoy it (Amabile 1996; Amabile 1999). Motivation refers that the students' learning purpose is directed to the learning activity itself, which can make students emotionally satisfied, thereby generating a sense of success. It provides a natural force that promotes learning and development, which can stimulate behavior without external rewards and pressure. Motivation plays a vital role in reflecting whether an individual have creativity in the field he is engaged in. Bruner (1978) emphasized that motivation is the driving force for learning, and it has a great role in promoting human creativity. High-level motivation is an significant feature of outstanding creative talents. According to Amabile (1988) and Amabile (1995), motivation principle is the social psychology foundation of creativity. People are more creative when they are motivated by the satisfaction and challenge of work or learning, rather than external pressure. If the individual has a high motivation, he will actively propose tasks and search for the current situation and the individual's existing knowledge and experience to generate various possible responses. Even if interfered by external stimuli (such as competition, evaluation, etc.), they will maintain an open mind, can keenly perceive the more hidden major clues related to problem-solving in the stimulus, dare to take risks, be challenging, and have novel, unique and smooth thinking, so as to solve problems creatively.

Gardner (1979) proposed that foreign language teaching should not only stay within the scope of curriculum, but should pay more attention to cultivating students'

learning enthusiasm and motivation, and believes that motivation mainly includes three elements: 1). Integrativeness, including integrative orientation and interest in foreign language; 2). Attitudes toward the learning situation, including evaluation of the teacher and the course; 3). Motivational intensity, which refers to the desire to learn foreign language and the attitudes toward learning foreign language. Clement (1980) and Clement et al. (1994) founded that there is also linguistic self-confidence that can enhance students' motivation. This study will propose the creative pedagogy that takes the improvement of student motivation as an important factor in developing student creativity. Teachers can take appropriate activities to create a fun and supportive atmosphere in the classroom in order to make foreign language learning exciting and enjoyable, which create a basic motivational learning environment that can strengthen students' favorable foreign language values and attitudes and improve their confidence and satisfaction toward the foreign language learning (Figure 3).

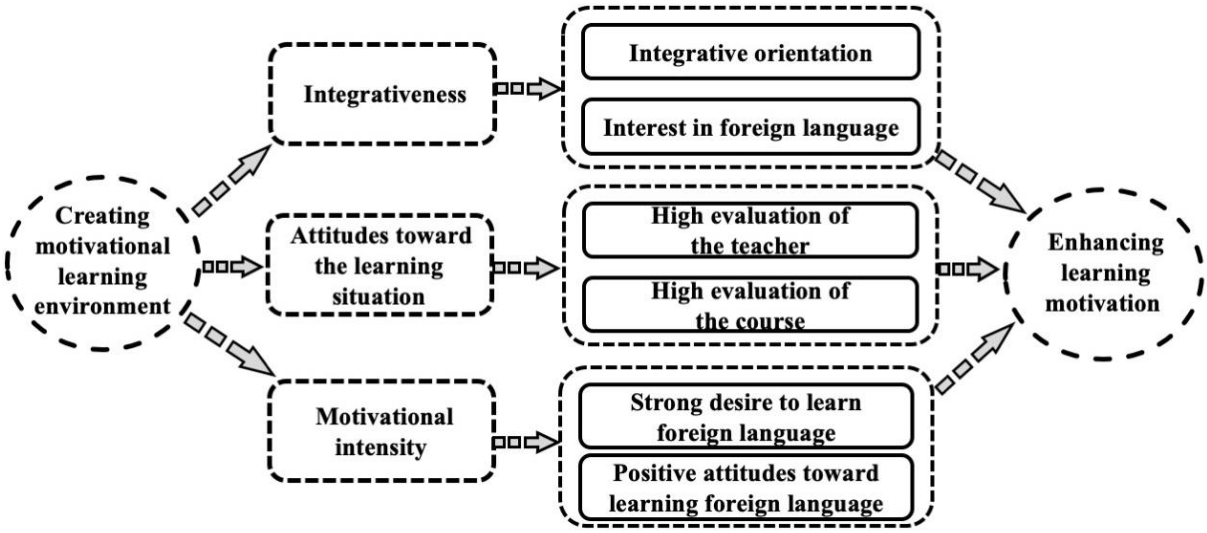


Figure 3. Creative pedagogy guidance of enhancing learning motivation.

People can evaluate their motivation by measuring whether they choose to carry out or persist in an activity on their own, or by evaluating their interest or favorite in an activity. This measure can be called “intrinsic interest evaluation” (Nicholls, 1984). Questionnaire is an effective way to evaluate the relatively stable individual differences of students’ motivation in academic achievement activities (Harter, 1978). This study will mainly adopt the motivation questionnaire method to investigate students’ learning motivation.

2.3 Creativity cultivation, association-based activities

In this study, the creative pedagogy of association-based activities consists of vocabulary, reading, and writing activities designed to let students engage in a playful, student-centered learning process. It seeks to promote their creativity by activating their creative thinking skills, language proficiency, and learning motivation. This chapter will analyze association characteristics, method, the effect on creativity, and discuss association-based activities with mind mapping.

2.3.1 Association definition

Association refers to the thinking process from a certain thing or phenomenon to other related ones. Association is generally divided into four types, that is similar association, close association, contrastive association, and causal association. Similar association refers to thinking of things or phenomena that are similar to the given topic, and then generating new ideas; close association is to perform association based on the closeness in space or time, and then produce a new way of thinking； contrastive association refers to the association of things or phenomenon with opposite properties or characteristics; causal association refers to the association of things or phenomenon that are logically causal (Wang, 2016). In the foreign language learning process, these associations can be used comprehensively for associative learning.

There are two categories of association: short-distance association and long-distance association. Short-distance association can help the retrieval of memory, and

long-distance association is related to creative thinking (Mednick, 1962). Mednick (1962) founded that, the less likely it is to associate one concept to another, the farther the distance between the two is. Highly creative people often associate things or phenomenon in a unique way, they can easily produce more long-distance associations, and their "association level" is very wide, which also means that They are not inclined to choose association words that are "typically high-expectation related to stimulus words". Instead, they tend to choose association words with low expectations. This also echoes with creative thinking's typical features of flexibility and originality.

In the foreign language teaching process, we can cultivate students' long-distance association ability through word association, reading association, composition association activities, and improve students' creativity.

2.3.2 Association method

There are mainly three association methods. First is free association. It is a way of thinking about a certain theme that lets one idea come after another without a predetermined structure (Takahashi, 2002). Second is rational association. This associative approach requires making full use of logic and rules around a core theme, choosing relevant keywords reasonably, focusing on hierarchy and affiliation, and reflecting on the nature, regularity, and overall picture of the words accurately (Budd, 2004). This method can help students memorize and understand the content and think carefully about problems. Third is compulsory association. Compulsory association is the ability to correlate unrelated questions, problems, and ideas. It is often performed along with free and rational association to arrive at unexpected combinations and extend students' ability to associate (Dyer, Gregorsen, & Christensen, 2011). In this study, vocabulary association activity is implemented by free association; association reading activity is implemented by rational association; and association writing activity is implemented by compulsory association.

2.3.3 Association's effect on creativity

There is a close relationship between association and creativity. Cultivating associative thinking is of great help to improve creativity. The ability to connect seemingly unrelated things or phenomena together is considered as the key point for the creative thinking process (O'Malley & Chamot, 1990). The essence of creative thinking is the process of establishing a connection between two seemingly unrelated things or phenomena. In other words, the "ordinary" sporadic ideas are combined to form the "non-trivial" ideas. This new "combination" of ideas is the manifestation of creative thinking. According to O'Malley and Chamot (1990), association refers to a learning strategy that connects new and old knowledge to improve the understanding and memory of learned materials. Association plays an important role in the "combination" of new ideas and things. The association of ideas forms the basis of creative thinking.

Activities that require students to generate association ideas based on a topic or participate in tasks can promote creative minds (Paivio & Desrochers, 1980; Sadoski, 2006). In the teaching process, taking a certain knowledge point as the center, guiding students to link related knowledge, which is conducive to broaden students' horizons, stimulate students' divergent thinking, and cultivate students' creativity. This study adopts association-based activities to facilitate creative learning that can play an important role in promoting creative thinking by breaking a singular mindset and revealing multiple angles, aspects, and levels. In addition, association plays an important role in promoting memory, imagination, and thinking skills (Paivio, 2014; Porter, 2016). Students can learn the simplest language elements to express themselves more clearly and better remember language points (Coleman & Klapper, 2005). The association process builds on imagination, thinking, and logical analysis (O'Malley & Chamot, 1990), which can challenge and keep students interested. It's expected to enhance students' domain foreign language proficiency and learning motivation.

2.3.4 Association-based activities with mind mapping

Creativity is closely related to divergent thinking, that is, if an individual can associate lots of different things from one topic, he may show a high-level creativity (O'Malley & Chamot, 1990). Integrating mind mapping into foreign language teaching is an effective way to cultivate students' divergent thinking and association abilities. Assisted by lines, symbols, text, colors, and graphics elements, a mind map is an effective tool of thinking that can show students' thinking process and result in an intuitive and visual way that offer a view of the "forest" as well as the "trees", which can help them visualize information and develop their thoughts (Hyerle, 1996). A mind map can enhance creative thinking because of its unique radial structure that is good for producing long-distance association and stimulating divergent thinking. Mind mapping can help students to associate ideas, develop creative thinking skills, and reach their potential. This association tool uses images to increase the probability of creative ideas (Buzan & Buzan, 2010). A mind map is a diagram that represents relationships among words, ideas, and other items connected to and arranged around a central concept (Wycoff, 1991). It also develops the ability to memorize, learn, and think creatively (Budd, 2004; San, 2013). This exteriorization of divergent thinking can represent the natural functioning of the brain and help students to explore the possibilities of a given subject and free their imagination.

Creative thinking is a process of comprehensively using multiple thinking, and divergent thinking triggered by association is an important way to cultivate creative thinking. Mind mapping can exercise students' mind in the application process, which helps students to improve thinking ability of students' mind as well as enhancing their learning efficiency (Farrand, 2002). In this study, mind mapping was used as a tool with association-based activities to stimulate students' associations and develop their divergent thinking. Participating association-based activities with mind mapping can invigorate the classroom atmosphere through the learning process of encouraging students to think creatively. It can stimulate students' divergent thinking, help students

break the mindset, establish new connections between different things or phenomenon, and discover new ways to solve problems, thereby improving their creative thinking and thus creativity.

2.4 Summary

Based on the above literature review analysis, this study proposed the creative pedology in foreign language education. Cultivating students' creativity has become an important part of teaching foreign languages at the university level. This study reformed the traditional foreign language classroom model and applied association-based activities with mind mapping to enhance students' creativity. In addition, we examined the effectiveness of the creative pedagogy in terms of three dimensions: creative thinking skills, foreign language proficiency, and learning motivation. This study focuses on the following research questions. In the foreign language classroom at the university level, (1) Can a creative pedagogy effectively improve creative thinking skills? (2) Does a creative pedagogy affect students' foreign language proficiency? (3) Does a creative pedagogy enhance students' enthusiasm and learning motivation? Besides traditional methods, we examined the creativity outcomes by biometric data analysis. There is little research on the effect of creativity cultivation in foreign language education by biometric data analysis. This study added EEG investigation and eye tracking detection. It's expected that the creative pedagogy will play an important role of enhancing students' creativity.

Chapter 3 Association-based activities in the foreign language classroom

Content

- **Research outline**
- **Experimental methods**
- **Results and discussion**
- **Summary**

Chapter 3
Association-based activities in the foreign language classroom

This study presented a creative pedagogy that used association-based activities with mind mapping for the foreign language classroom. As shown in Figure 4, this creative pedagogy consists of vocabulary, reading, and writing activities. It seeks to promote their creativity by activating their creative thinking skills, language proficiency, and learning motivation.

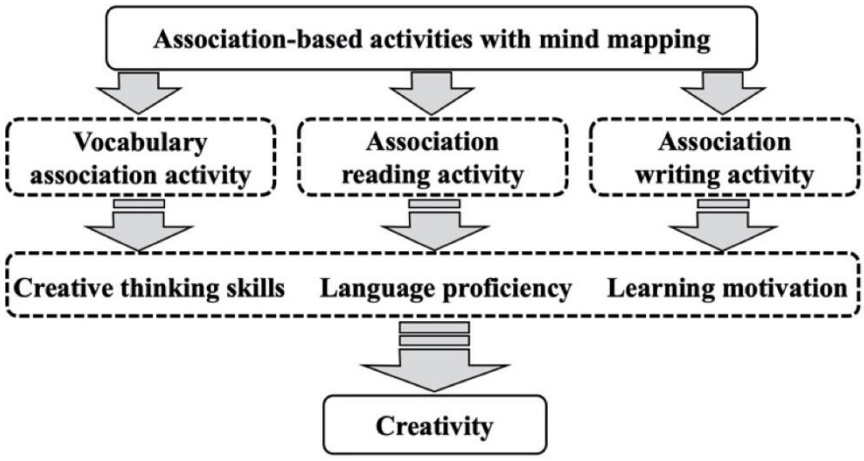


Figure 4. Creative pedagogy.

Table 1 shows the practical lectures for the two groups. The participants consisted of 227 second-year students in a school of Japanese studies at a university in Dalian city in China. The experimental group (115 students, 34% male) and the control group (112 students, 33% male) shared a similar Japanese language level. Both groups received an 8-week practical lecture from their current Japanese teachers and used the same teaching materials. They took a total of 24 Japanese classes, which met for 90

minutes three times a week. Both groups sequentially learned vocabulary, reading, and writing. The materials were selected from the university's existing texts. The experimental group engaged in association-based activities. The control group received the regular curriculum, which ensured that the class was teacher-centered and that the students learned in the traditional way of following a certain sequence. To clarify the effect of the association-based activities on creativity, we employed an experimental methodology involving a pre-test/post-test repeated measures design. All students were tested on creativity performance using three assessment instruments: creative thinking test, foreign language proficiency test, and motivation questionnaire.

Table 1. Practical lectures for the two groups.

Theme	**Experimental Group**	**Control Group**	**Remarks**
Participants	115 students 34% male	112 students 33% male	Second-year students who shared a similar Japanese language level
Conductive teachers	Current Japanese teachers	Current Japanese teachers	Each group was taught by 3 teachers.
Pre-test (Before practical lecture)	(1) Creative thinking test 1 (2) Foreign language proficiency test 1 (3) Motivation questionnaire 1		Scored by experienced Japanese teachers and advanced psychology experts.
Practical lectures (8 weeks)	Engaged in association-based activities	Traditional teaching with regular curriculum	A total of 24 Japanese classes, which met for 90 minutes three times a week.
Post-test (After practical lecture)	(1) Creative thinking test 2 (2) Foreign language proficiency test 2 (3) Motivation questionnaire 2		Scored by experienced Japanese teachers and advanced psychology experts.

3.1 Research outline

3.1.1 Vocabulary association activity

Vocabulary is a basic element of foreign language learning. How to enable students to learn words and phrases more effectively is an important part for foreign language teaching. Students can develop associations and connect a series of words that have a certain connection. In this way, the words learned are not isolated, but are vocabulary groups with certain internal connection, which play an important role in the construction of students' word system memory. It is more effective through meaningful memory than purely memorizing vocabulary (Rumelhart & Ortony, 2012). Vocabularies are organic parts of the language framework, and they have close relationship. However, the traditional "duck-stuffing" type of teaching often requires students to master the vocabularies through rote memorization, which separates their interrelationships and unknowingly increases the burden on students' learning.

Using the teaching method of vocabulary association activity with mind mapping in the classroom can memorize multiple different words in the divergent thinking process, reducing the burden of students' learning and increasing their interest in learning. At the same time, it can cultivate students to develop good divergent thinking habits and improve their comprehensive application ability. As far as the fragmented nature of language teaching is concerned, the use of mind mapping to systematically classify fragmented languages and vocabularies can help improve students' language proficiency. Mind mapping follows the divergent thinking on framework and diverging representation of words and expressions and peripheral topic vocabularies related to the central word. This central point-centered memory method can be reconstructed, reclassified and recreated the knowledge in the learners' mind, so that the new knowledge is integrated with the old knowledge, so as to achieve the purpose of improving learning efficiency.

In this study, we apply vocabulary association activity with mind mapping. It was implemented with free association, which is a way of thinking about a certain theme

that lets one idea come after another without a predetermined structure. Freely associating can help to stimulate divergent thinking and spark students' interest. The students were presented with a worksheet with a word in the center of the page and asked to add related words, phrases, or sentences around the central word. Then, they classified and grouped the words as a group. They formed an inclusive language database on their own so that they could remember all the words according to their mind maps. An example of a vocabulary mind map is shown in Figure 5. Starting from the central word displayed on the worksheet of the vocabulary association activity, students write the words that they think out immediately around the central word within the given time limit. For example, it supposes that the word "fish" is presented. Speaking of fish, some people associate with the sea, others associate with sushi, others with fishing, and so on. Students who associate with the sea may continue to associate with swimming and seagull, for example.

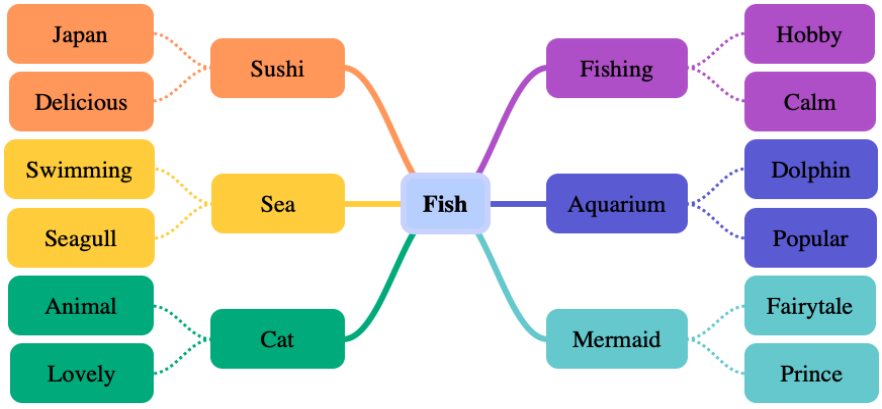


Figure 5. Vocabulary association activity with mind mapping.

3.1.2 Association reading activity

Among the five skills of foreign language listening, speaking, reading, writing and translation, reading is the performance of comprehensive ability. Long and tedious foreign language reading materials are not easy to stimulate students' motivation and association. Mind maps use visual graphics to present the main clues of the reading materials. Students can give full play to their association when making mind mapping,

which can stimulate their reading motivation. In addition, most students tend to focus on comprehension of long sentences when reading articles, and neglect to grasp and memorize key words, which causes them to be unable to understand the reading material clearly. The mind map can highlight the main content of the article through keywords, various colors and hierarchical structure, to make the structure of the article more clearly, and to remove redundant information, so that students can better understand the reading material. Moreover, mind maps use graphics to present knowledge, which are highly visual that can make the reading material easier to understand and memorize longer. Mind mapping is known as an effective learning strategy to promote recall and obtain information from text (Farrand, 2002). According to the characteristics of the reading material, students can exert their divergent thinking to use various forms, colors, images, etc. to draw personal style mind maps, analyze and think about problems from multiple angles.

In this study, we used rational association to implement the association reading activity with mind mapping. Rational association requires making full use of logic and rules around a core theme, choosing relevant keywords reasonably, focusing on hierarchy and affiliation, and reflecting on the nature, regularity, and overall picture of the words accurately. This method can help students memorize and understand the content and think carefully about problems. It applies mind mapping to help students visualize their thinking processes and stimulate their interest in reading. First, we asked the students to skim and find the answers to two questions and add them to the first-level trunk of the mind map. The questions were: What is the main idea of this passage? How many parts can it be divided into, and what is the general idea of each part? Next, students were asked to scan and find the keywords and key sentences of each paragraph of the article and add them to the existing mind map. Then, the students were asked to freely associate and add more detailed information to the mind map within the given time limits. For example, they could draw good words and sentences from each paragraph, especially the necessary connectives and transition words, which strengthen students' vocabulary and sentence input. Figure 6 is a mind map sample. Mind mapping

will help students to open up their reading ideas from different perspectives, establish a knowledge structure, and stimulate their divergent thinking in reading.

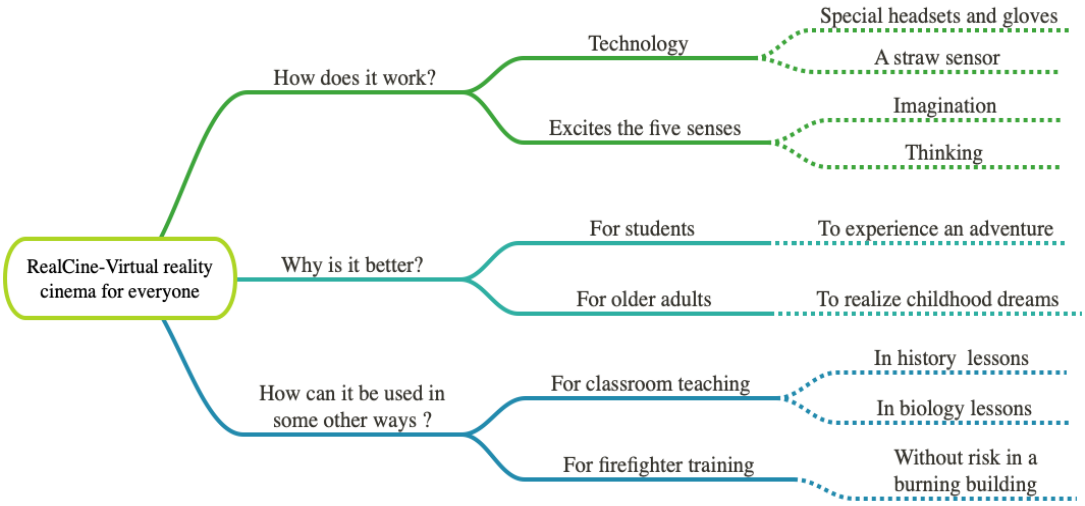


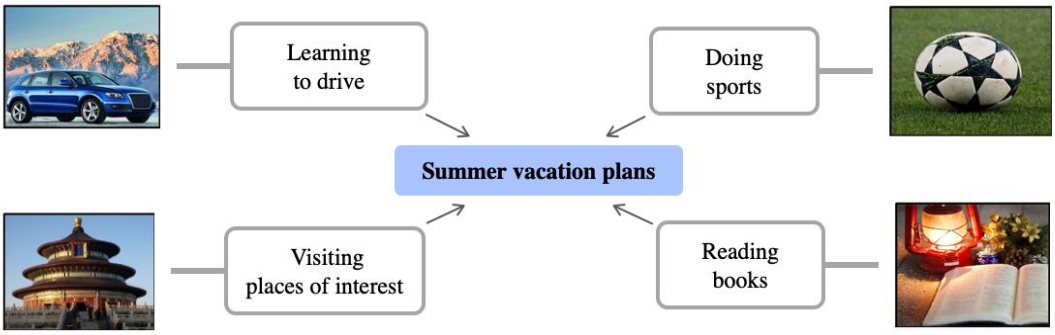
Figure 6. Association reading activity with mind mapping.

3.1.3 Association writing activity

Foreign language writing requires language accuracy, standardization and effective transmission of information. It also requires logical organization of paragraphs to make the content of the article clear. Conception is an important step in writing. Making full use of association and divergent thinking can enrich the content of essays and improve the quality of writing. Mind mapping can effectively help the students diverge their thinking, improve their writing enthusiasm and skills, and make the content richer and the structure more clearly and reasonable. The process of mind mapping to conceive writing is actually a thinking mode that records the thoughts generated in the brain around a center in a networked pattern. Especially when free writing, according to their existing knowledge, students show their ideas and some new creative content focusing on the writing theme in the form of a mind map, and finally edit and adjust, outline the structure and main content of the article.

In this study, we implemented the association writing activity with mind mapping. We used compulsory association, which involves correlating unrelated questions,

problems, and ideas. It is often performed along with free and rational association to arrive at unexpected combinations and extend students' ability to associate. This activity aims to encourage the students to write a creative foreign language essay by combining the compulsory association and free writing. In this activity, the teacher distributed some pictures, which appeared to be unrelated at first glance. The students were asked to write the keywords of each picture and find connections to arrive at a writing topic. Then, the students drew mind maps on the writing topic, summarized the contents, and wrote an essay within the given time limits. The mind map shown in Figure 7 shows an example of the association writing activity. First, the students associate relevant keywords related to each picture: learning to drive, doing sports, visiting places of interests, reading books. Then they connect these keywords to a common topic: summer vacation plans. The students take "summer vacation plans" as the writing topic, engage in divergent thinking by drawing a simple mind map, and form a clear writing framework.



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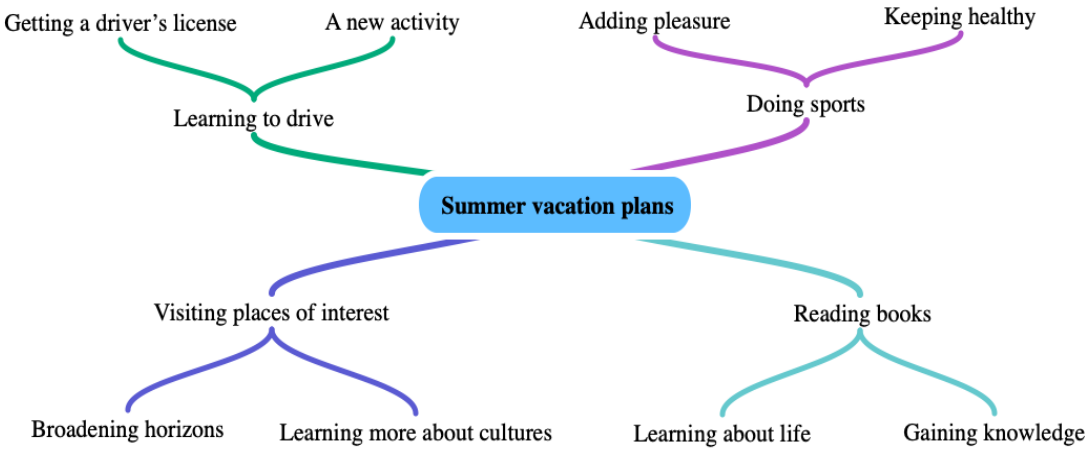

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Figure 7. Association writing activity with mind mapping.
(a) Connecting keywords to a topic; (b) Drawing a mind map.

3.2 Experimental methods

3.2.1 Vocabulary association activity

In the daily vocabulary association activities, students are asked to make thematic associations around certain central word or topic. Students start from a certain word to think about different related words, phrases, or sentences, and draw mind maps within a given time limit of 5 minutes. After having finished their own mind maps, students

were required to change and discuss their ideas according to their different mind maps. Figure 8 is the mind maps drawn by different students when learning the word “frustration”. Mind maps can be used to review and consolidate various words, some of which are the common ones for students, and more are the new vocabularies through knowledge sharing. Different mind maps drawn by students can show their different divergent thinking patterns in dealing with the same vocabulary. Teachers can understand students’ thinking ability and knowledge level. Students can also learn different knowledge provided by each other. Therefore, in the daily vocabulary association activities with mind mapping, students find related words, phrases or expressions through associations, which not only consolidate the ones they have learned before, but also activate students’ divergent thinking to learn and master new vocabularies more comprehensively, meanwhile, get clear and deep memory.

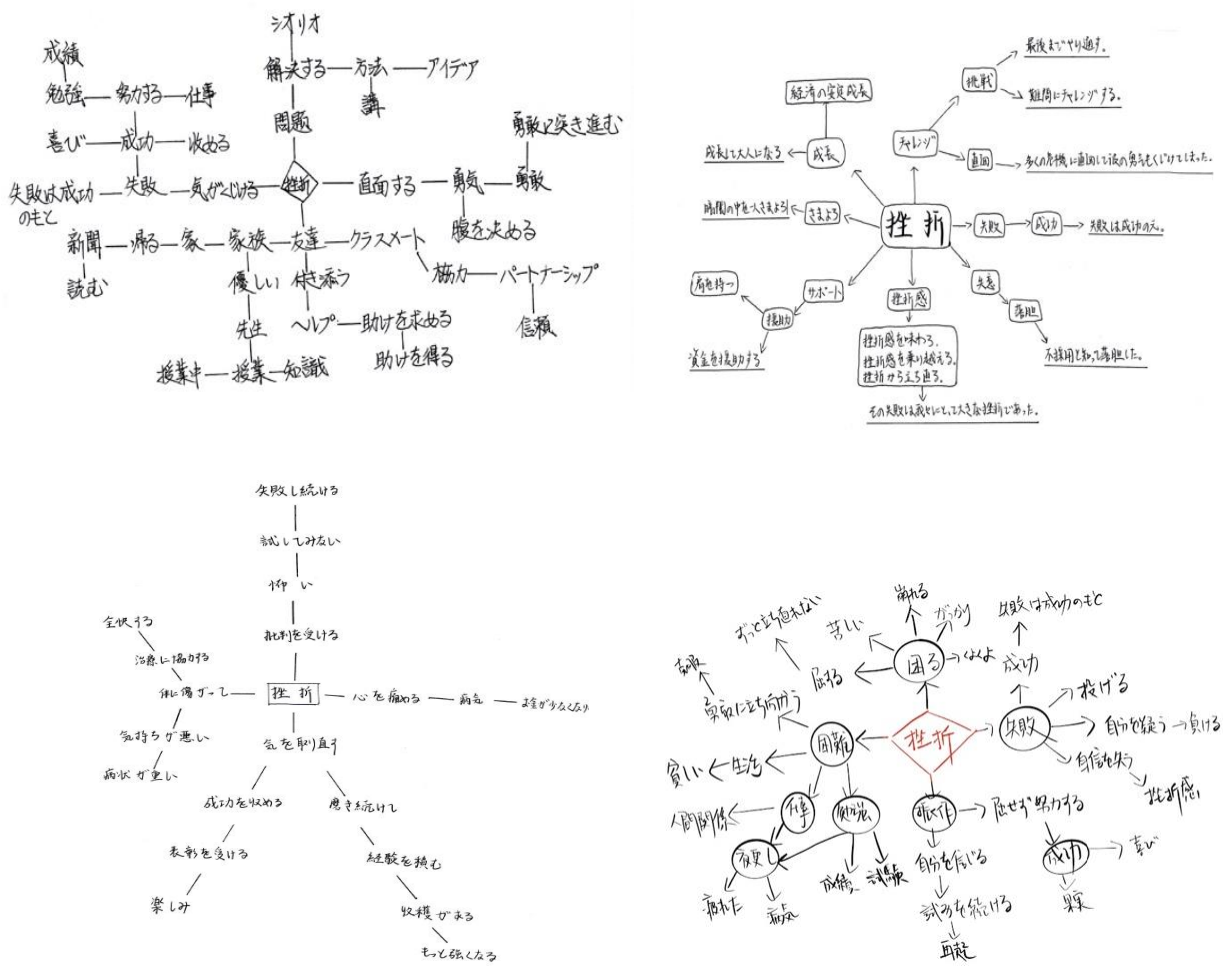


Figure 8. Samples of vocabulary association activity with mind mapping.

3.2.2 Association reading activity

Mind mapping assists to fracture the text passage into sentences and words to make them easier to understand. In the daily association reading activities, students find keywords and key sentences from the reading materials, and take a hierarchical or tree branch format to express the main idea of the article and keywords and key sentences of each paragraph. Association reading activity with mind mapping was carried out in the following steps: (1) First, give the students a few minutes to complete the quick reading and grasp the main idea; (2) Second, ask the students to read the article again, and guide them to draw the mind map according to the central idea of the article. The students draw mind maps within a given time limit of 30 minutes; (3) After having finished their own mind maps, students were required to change and discuss their ideas according to their different mind maps. Figure 9 shows the mind maps drawn by different students around the same article in daily association reading activities. Different mind maps drawn by students can show their different divergent thinking patterns in dealing with the same article. The students' mind maps will be presented, and the teacher will let them explain the content of the article based on their mind maps, which help to carry out more in-depth language learning and application.

In the mind maps of these students, the key points are highlighted, and each branch is also represented by graphics, using methods such as fonts, lines, and graphics to achieve personal style mind maps. Mind mapping can activate students' reading and thinking by forming a clear frame of the article structure in their minds. Students can diverge their thinking on the article topic and add content to their mind maps, which clearly show the article composition and the details of each part. Through mind mapping, students can better grasp the overall structural context and layout of the article, deepening their understanding of the content and allowing them to gather detailed information efficiently.

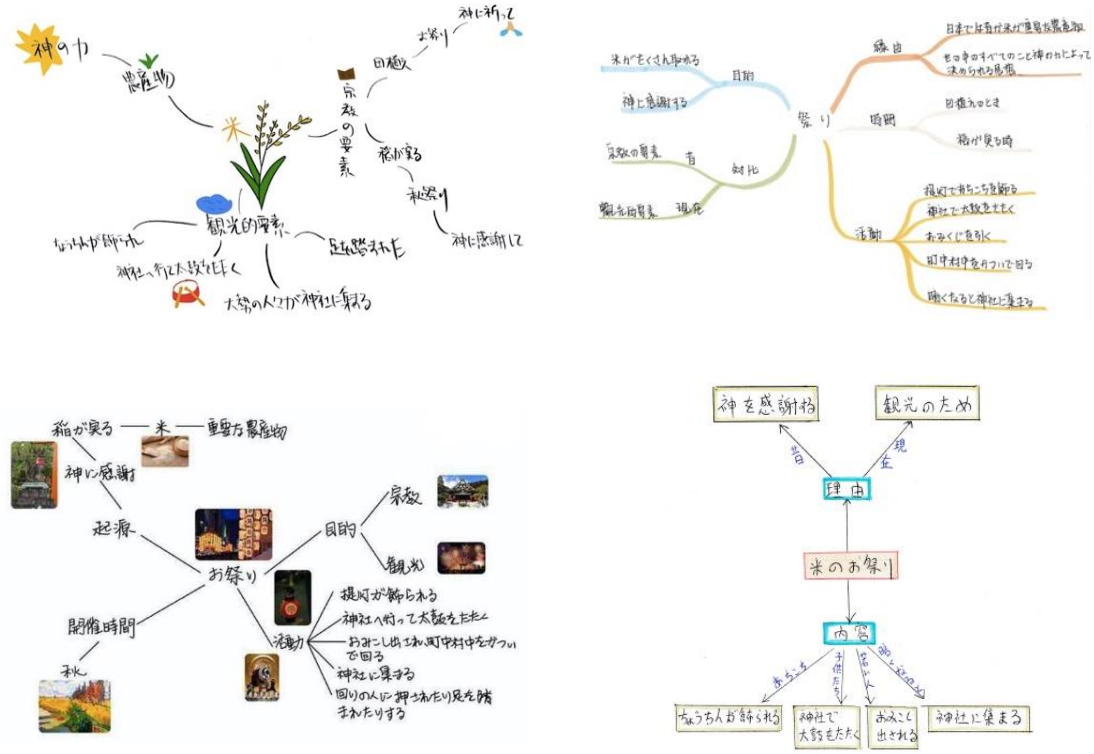


Figure 9. Samples of association reading activity with mind mapping.

3.2.3 Association writing activity

In the daily association writing activities, applying mind maps to the conception of writing contains following steps: (1) Ask the students to freely associate among the pictures given by the teachers in two minutes, and write down related keywords, and try to associate the keywords together to form a common topic; (2) Draw mind maps to sort out the various points that are most consistent with the relevance and importance of the article; (3) Start writing essay according to the mind map within a given time limit of 20 minutes. The mind map drawn by students' divergent thinking can make the framework of the essay more clearly, and make the students' essay writing thinking more cohesive and logical. Figure 10 shows the daily association writing activities with mind mapping by different students. In the process of drawing their mind maps, students can better recall and master the topic vocabulary and sentence expressions. Mind mapping can encourage the students to play with association and divergent

thinking in writing, turning a potentially boring thinking process into something fun and interesting.

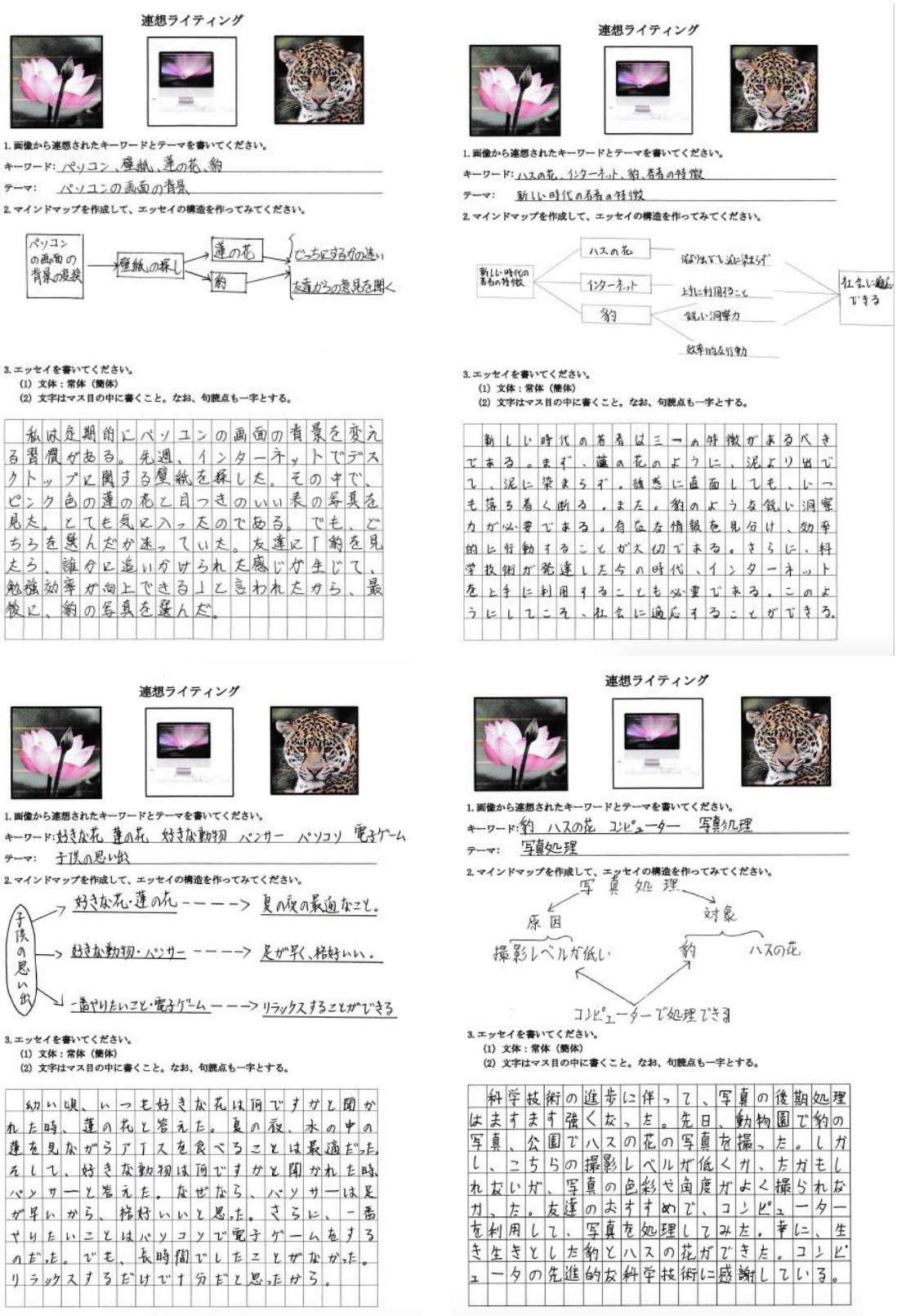


Figure 10. Samples of association writing activity with mind mapping.

3.3 Results and discussion

To clarify the creative pedagogy's effect on creativity, this study applied creative thinking test to gauge the students' creative thinking skills, Japanese language proficiency test to measure their language performance, and a motivation questionnaire to assess their learning motivation. ANOVA was conducted, with the post-test scores as the dependent variable, group membership as the fixed factor, and pre-test scores as the covariate, to examine whether the creative pedagogy intervention resulted in statistically significant differences between the two groups and whether the improvement in scores from pre- to post-test for the experimental group was statistically significant. The analyses were performed using SPSS statistical software version 25. The results showed that the creative pedagogy significantly improved the scores of the experimental group on the creative thinking test, the foreign language proficiency test, and the choice and executive motivation subscales. These findings suggest that the proposed pedagogy can help cultivate creativity in university foreign language classrooms.

3.3.1 Association-based activities effects on creative thinking skills

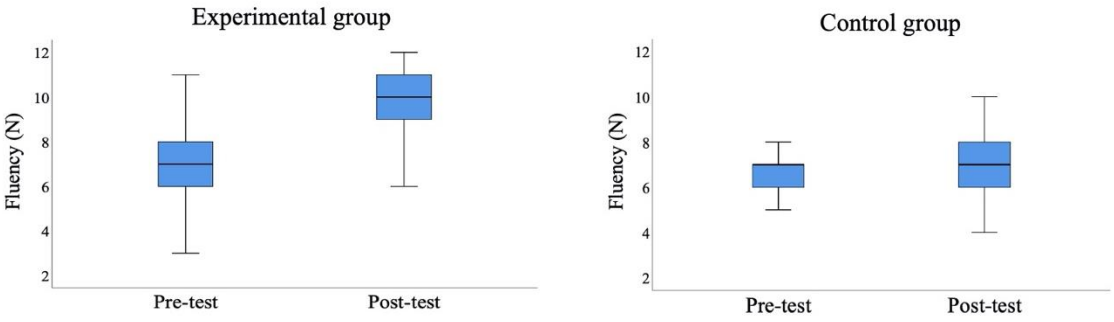
(1) Instrument

Alternative Uses Test (AUT) measures divergent thinking effectively by asking participants about different possible uses of the common objects within a specified time (Guilford, 1986). In this study, the stimulus for the creative thinking started with the AUT, to which the students respond by writing ideas. The theme in the creative thinking pre-test was "the uses of an empty beer bottle", and the theme in the creative thinking post-test was "the uses of an umbrella when it isn't raining". The students were required to elaborate on their ideas as thoroughly as possible within a time limit of 5 minutes. All the answer sheets were written in Japanese and graded by experienced Japanese

teachers and advanced psychology experts. Divergent thinking emphasizes fluency, flexibility, and originality (Guilford, 1986). These three factors were included in the creative thinking test. Fluency is related to the ability to generate relevant, meaningful ideas; flexibility reflects the ability to produce a variety of idea types; and originality is measured by unique or uncommon answers (Kim, 2006). In this study, the definitions of fluency, flexibility, and originality were summarized as follows: Fluency refers to the ability to produce a large number of ideas (simple sum of answers appropriate to the theme); flexibility refers to the ability to produce a wide variety of ideas (simple sum of different categories obtained by comparing the answers); and originality refers to the ability to produce unusual ideas (answers that are unique and uncommon, frequency of occurrence is low).

(2) Creative thinking skills

Based on the statistical comparison of the creative thinking skills for the two group (Figure 11), ANOVA analysis was conducted (Table 2). The results indicate that the mean scores of the experimental group improved more than those of the control group from the pre-test to the post-test. The effect of the creative pedagogy intervention reached a significant level in fluency, with a large effect size, F (1, 225) = 151.14, p < 0.001, η_P^2 = 0.403; flexibility, with a medium effect size, F (1, 225) = 18.64, p < 0.001, η_P^2 = 0.077; and originality, with a medium effect size, F (1, 225) = 10.64, p < 0.01, η_P^2= 0.045. The improvements in these three creative thinking skill subscales were all statistically significant.



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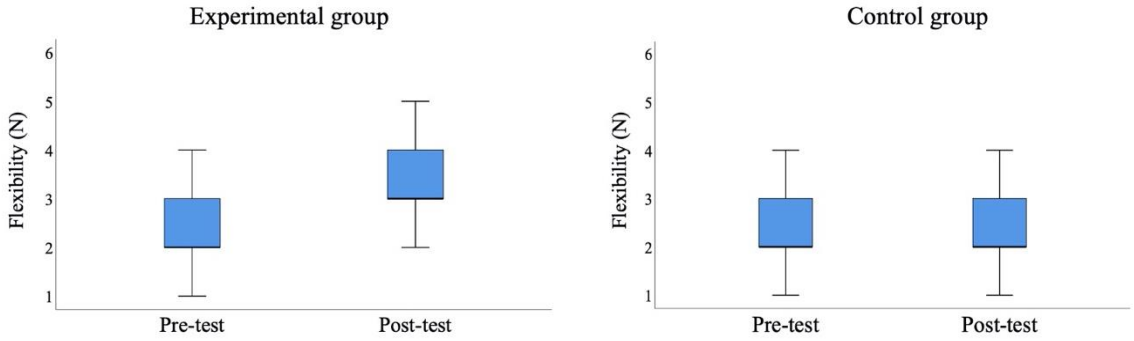

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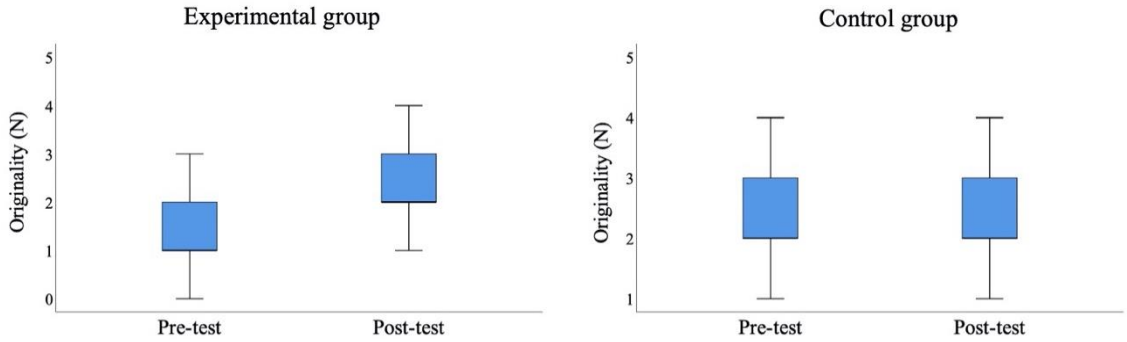

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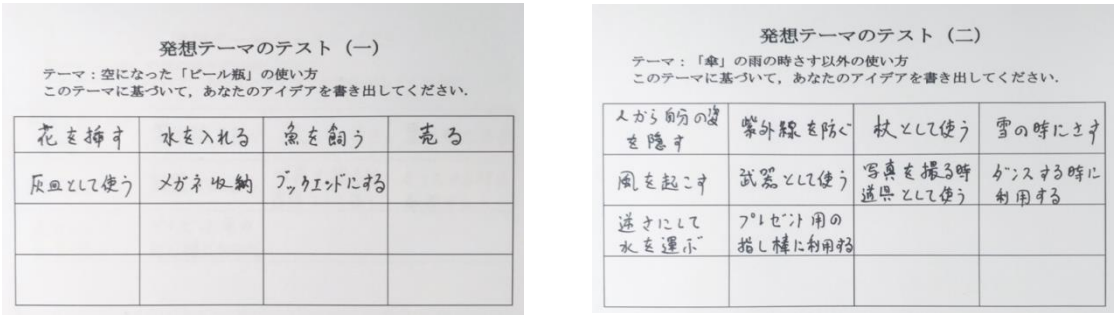
Figure 11. Statistical comparison of creative thinking skills for the two groups. (a) Fluency; (b) Flexibility; (c) Originality.

Table 2. ANOVA results of creative thinking skills.

Item	Group	N	Pre-test		Post-test		*df*	*F*	*p*	η_P^2
			M	SD	M	SD				
Fluency	EG	115	6.98	1.57	9.65	1.53	1	151.14***	0.000	0.403
	CG	112	6.87	1.28	7.10	1.27				
Flexibility	EG	115	2.49	0.95	3.30	0.87	1	18.64***	0.000	0.077
	CG	112	2.23	0.74	2.39	0.72				
Originality	EG	115	1.27	0.80	2.35	0.81	1	10.64**	0.001	0.045
	CG	112	1.23	0.68	1.42	0.59				

(Note. EG–Experimental Group; CG–Control Group. *p<0.05; **p<0.01; ***p<0.001.)

An example of answers by a student from the experimental group on the AUT is shown in Figure 12. The student wrote the answers in the Japanese language. In the pre-test, ideas written according to the prompt "the uses of an empty beer bottle" were "to store water," "to keep a fish," "to sell," "to use as an ashtray," "to store glasses," and "to use as a bookend." The number of ideas (fluency) was 7, the variety of ideas (flexibility) was 2, categories: "container" and "recycling," and unusualness of ideas (originality) was 1, "to use as a bookend." In the post-test, ideas on "the uses of an umbrella when it isn't rainy" were "cover your body from others," "to shield against ultraviolet rays," "to use as a cane," "to use when it is snowing," "to wind up," "to use as a weapon," "to use as a tool when taking pictures," "to use as a prop when dancing," "to carry water upside down," and "to use as a pointer for a presentation." The number of ideas (fluency) was 10, the variety of ideas (flexibility) was 3, categories: "health appliances," "play equipment," and "weapon," and the unusualness of ideas (originality) was 2, "to carry water upside down" and "to use as a pointer for a presentation." In the post-test, this student wrote more ideas in different categories than in the pre-test, and the unusualness of ideas increased.



(a) (b)

Figure 12. An experimental group student's answers to the creative thinking test. (a) Creative thinking pre-test; (b) Creative thinking post-test.

In traditional foreign language classrooms, there are less enlightenment and guidance to students, and less communication and discussion between teachers and students. For answering questions, a traditional lecture often advocates uniformity and standardization, but does not advocate extensiveness, multi-level, or diversification. Traditional teaching process would lead to form a regular thinking mode, which limits the development of students' creative thinking skills. Breaking the traditional classroom teaching model is the key to stimulating students' creativity. This study proposed the creative pedagogy of association-based activities with mind mapping in the classroom, which enables students to fully demonstrate their own thoughts while using foreign language, so that they can have a broad space for creative thinking.

Following the intervention, the experimental group's scores for the creative thinking post-test were higher than those for the creative thinking pre-test. Significant between-group differences were also observed in the creative thinking skill subscales. Notably, the effect size for fluency was large. The results indicate that the creative pedagogy intervention can promote creative thinking skills, which is consistent with the findings of Lin (2011), Siraj-Blatchford et al. (2002), and Ulger (2016), noting that participants who received creative training while engaging in activities have demonstrated a significant improvement in creativity, especially in terms of creative thinking skills. Creative activities often provide opportunities to improve students'

creative thinking. Association plays an important role in divergent thinking. Students who have participated in association-based activities are more likely to think creatively to generate ideas. The results confirm the effectiveness of association-based activities in enhancing the creative thinking skills of university foreign language learning students. Divergent thinking is a way of thinking about problems from multiple angles and aspects, and mind mapping is a graphic technique for expressing divergent thinking. Mind mapping is a visual thinking structure diagram that can provide students with a platform to think about problems from multiple angles. In this study, association-based activities with mind mapping created a free learning atmosphere and independent learning opportunities for students, and guided them to think about problems from multiple angles, and expanded their thinking perspectives. It enabled students to use known information as the starting point of thinking, based on the knowledge and experience they have mastered, to use associations to speculate and imagine, and to think from different angles and different directions, thereby have promoted the development of students' divergent thinking skills.

3.3.2 Association-based activities effects on language proficiency

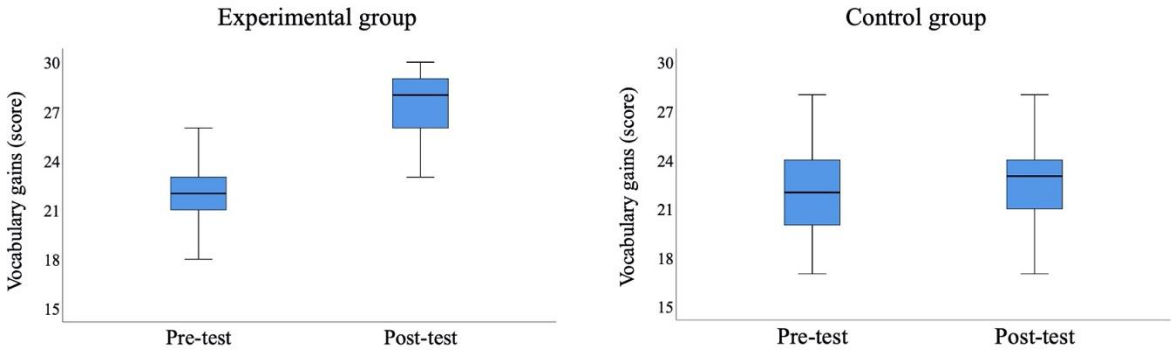
(1) Instrument

In this study, the students' language proficiency was measured with a Japanese language proficiency test on vocabulary, reading comprehension, and writing. First, in the vocabulary part of the test (accounting for 30% of the total score), students were to complete sentences by choosing the best answer from four words or phrase options within 10 minutes. Second, in the reading comprehension section of the test (accounting for 40% of the total score), the students read five Japanese articles and completed the test within 50 minutes. Each article had approximately 500 words and was followed by two reading comprehension multiple-choice questions. The students also had to write down the keywords and main sentences from each article. Finally, the writing part of

the test (accounting for 30% of the total score) required the students to determine the title of the composition based on the pictures given and write a composition of about 200 words within 30 minutes. The composition needed to be fluent in the language, appropriate in word choice, reasonable in structure, appropriate in style, and persuasive. The difficulty levels of the Japanese language proficiency pre-test and post-test were similar but not identical.

(2) Language proficiency

The statistical comparison (Figure 13) and ANOVA results (Table 3) show that both groups received higher mean scores on the post-test. However, experimental group received higher mean scores than the control group did, and the differences were statistically significant, with a medium effect size in each case: vocabulary, F (1, 225) = 23.08, $p < 0.001$, $\eta_P^2 = 0.093$; reading, F (1, 225) = 2.03, $p < 0.01$, $\eta_P^2 = 0.029$; writing, F (1, 225) = 1.60, $p < 0.05$, $\eta_P^2 = 0.027$; and total score, F (1, 225) = 8.69, $p < 0.01$, $\eta_P^2 = 0.037$.



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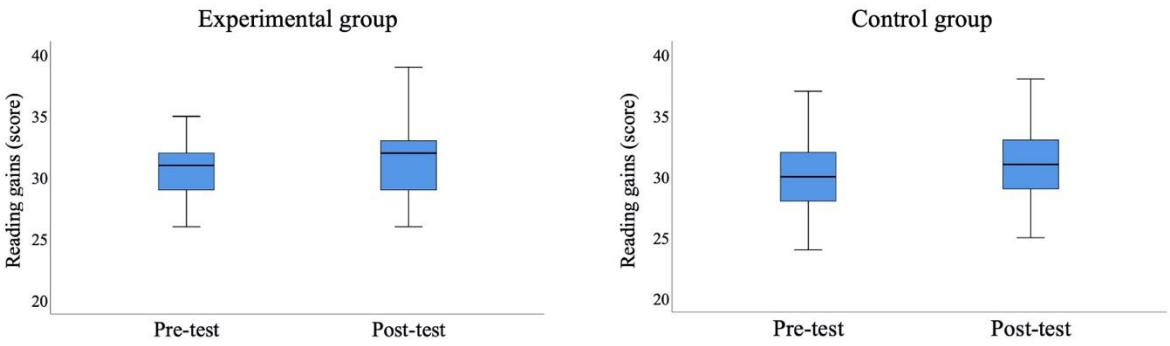

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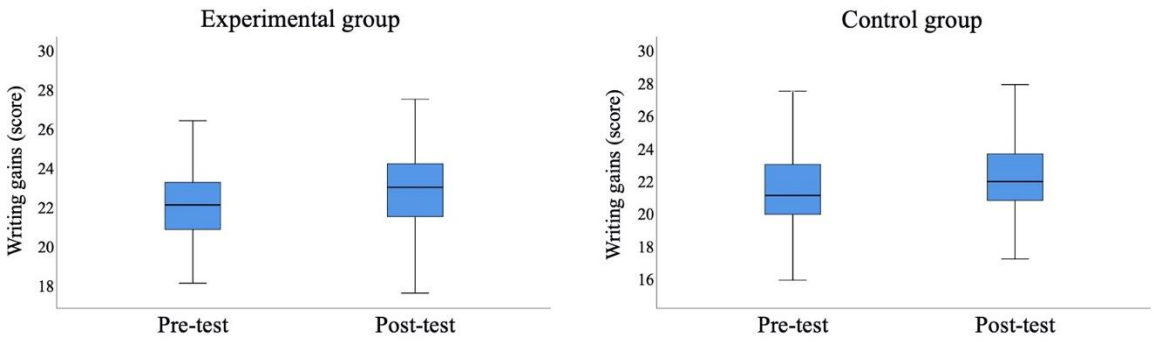

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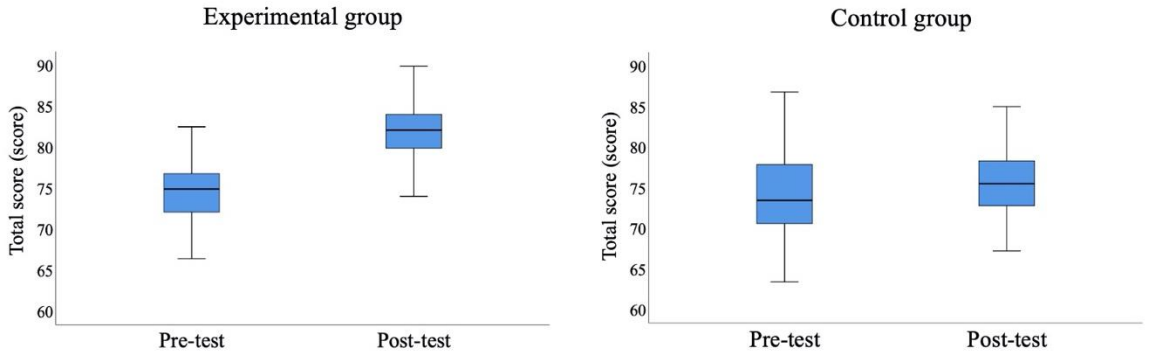


(**d**)

Figure 13. Statistical comparison of language proficiency for the two groups. (a) Vocabulary; (b) Reading; (c) Writing; (d) Total score.

Table 3. ANOVA results of language proficiency.

Item	Group	N	Pre-test		Post-test		*df*	*F*	*p*	η_P^2
			M	SD	M	SD				
Vocabulary	EG	115	21.70	1.79	23.70	1.86	1	23.08***	0.000	0.093
	CG	112	22.06	2.57	22.62	2.44				
Reading	EG	115	30.64	2.15	33.27	2.54	1	2.03**	0.006	0.029
	CG	112	30.49	3.03	31.18	2.73				
Writing	EG	115	22.25	1.97	24.92	2.13	1	1.60*	0.030	0.027
	CG	112	21.51	2.67	22.05	2.19				
Total score	EG	115	74.60	3.73	81.90	3.40	1	8.69**	0.004	0.037
	CG	112	74.06	4.61	75.84	4.26				

(Note. EG–Experimental Group; CG–Control Group. *p<0.05; **p<0.01; ***p<0.001.)

The significant increase in the experimental group's mean total score indicates that the creative pedagogy intervention can enhance students' Japanese language proficiency. This indication is similar to the observation by Fisher (2004) that the cultivation of creativity can improve students' academic performance and rekindle their learning motivation. In contrast to learning through rote memorization or repetition, a well-designed learning process can improve students' access to their foreign language knowledge, which can enhance their language proficiency. The creative pedagogy presented in this study is an innovative teaching mode for facilitating students' creative use of a foreign language. In the daily association-based activities with mind mapping, students choose a certain knowledge as a starting point for free association of related knowledge, which guided them toward relevant information around a central theme, improve their systematic understanding, and broaden the scope of their knowledge. This process can not only help students have a firm grasp of what they have learned, but also help them build connections between knowledge. In the process of using mind maps to draw knowledge structure, students can clarify the knowledge context quickly and visualize disordered knowledge. The visual thinking framework can deepen students' understanding of knowledge, and stimulate their various new ideas. In addition, the association-based activities enabled students to study in various forms instead of learning by rote, which was conducive to creating a playful, student-centered learning environment and mobilizing their initiative to learn. Therefore, students' foreign language learning can change from passively receiving knowledge to actively exploring it. Association-based activities can guide students toward relevant information around a central theme, improve their systematic understanding, and broaden the scope of their knowledge. Creative pedology may have a positive impact on memory and thinking. When students are interested in the association-based activities, they tend to be proactive in completing the activity, which can encourage them to participate in the learning process more actively and perform better. Thus, association-based activities can play an important role in improving students' language proficiency.

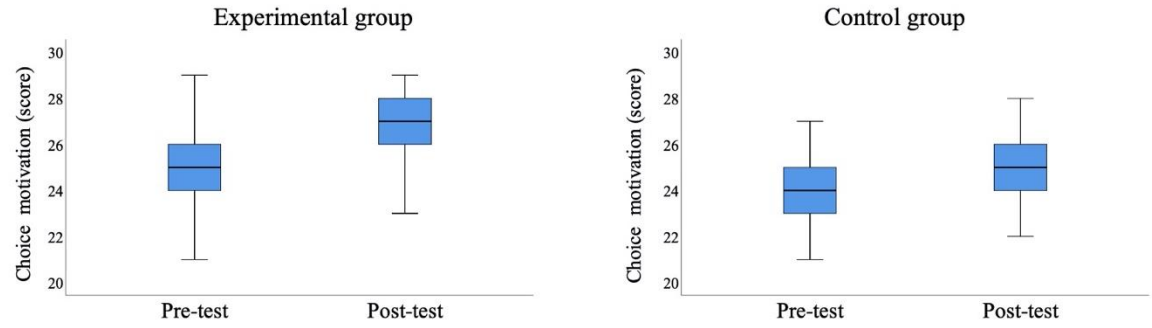
3.3.3 Association-based activities effects on learning motivation

(1) Instrument

A motivation questionnaire was administered to clarify whether a creative pedagogy could motivate and interest students. According to Dörnyei (2001), motivation in language learning is modeled as a three-step process involving choice motivation (which requires fostering a fun, supportive atmosphere during the lecture), executive motivation (which requires instructors to make learning exciting and enjoyable), and increased motivation (which requires increasing learner satisfaction). Based on this research, the motivation questionnaire in this study consisted of three subscales, each of which had six items: choice motivation (e.g., study in a free and fun classroom atmosphere), executive motivation (e.g., deepening understanding and leading to the acquisition of new knowledge), and increased motivation (e.g., a sense of accomplishment) (Liu et al., 2019). All answers were evaluated as follows: agree = 5, slightly agree = 4, uncertain = 3, slightly disagree = 2, disagree = 1. There was also a free description section in the questionnaire where the students could elaborate on their ideas: “What do you think of the teaching method in this classroom?”

(2) Learning motivation

The learning motivation results for the two groups are shown in Figure 14 and Table 4. The experimental group’s mean scores were significantly higher than those of the control group in the post-test in two categories. The effect size for both choice motivation and executive motivation were medium: choice motivation, F (1, 225) = 9.70, $p < 0.01$, η_P^2 = 0.041; and executive motivation, F (1, 225) = 7.06, $p < 0.01$, η_P^2 = 0.031. In the case of increased motivation, the improvement was not statistically significant, with a small effect size, F (1, 225) = 2.57, $p > 0.05$, η_P^2 = 0.011.



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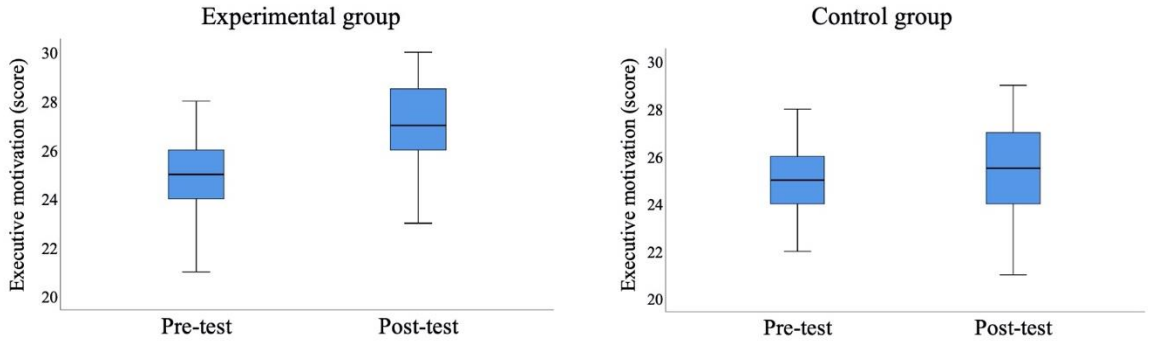

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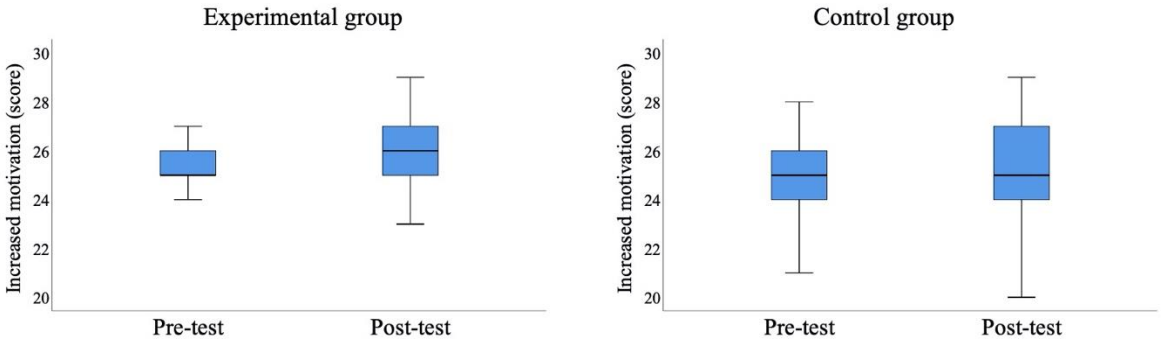

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Figure 14. Statistical comparison of learning motivation for the two groups. (a) Choice motivation; (b) Executive motivation; (c) Increased motivation.

Table 4. ANOVA results of learning motivation.

Item	Group	N	Pre-test		Post-test		*df*	*F*	*p*	η_P^2
			M	SD	M	SD				
Choice motivation	EG	115	24.92	1.86	26.63	1.47	1	9.70	0.002**	0.041
	CG	112	24.21	1.35	24.90	1.36				
Executive motivation	EG	115	25.10	1.57	26.93	2.00	1	7.06	0.008**	0.031
	CG	112	25.17	1.38	25.39	1.74				
Increased motivation	EG	115	25.14	1.23	26.23	1.58	1	2.57	0.111	0.011
	CG	112	24.91	1.46	25.33	1.92				

(Note. EG–Experimental Group; CG–Control Group. *p<0.05; **p<0.01; ***p<0.001.)

The following comments by students came from the free description section, which reflected a positive attitude towards the creative pedagogy. First, this pedagogy appeared to help students develop and elaborate on their ideas more effectively. Students' comments included: "It was different from the previous lecture, rather than remembering by rote, I could remember by thinking;" and "I obviously felt that association-based activities could help me generate more creative ideas." Second, students found the mind maps to be effective tools in learning. The students responded: "In the vocabulary association activity, I can imagine lots of words and sentences that can be connected, which can help me learn vocabularies comprehensively;" "In the association writing activity, mind mapping can help me to think effectively to relate the main idea with its elaboration;" and "Mind mapping helps me to organize ideas, even if the article had a large number of words, contained a large amount of information, or had a complex structure, it's easier to capture key information and analyze it." Finally, the association-based activities stimulated the students' interest and improved their enthusiasm and initiative. The students commented: "My learning satisfaction was increased;" "It inspired my interest and enthusiasm in learning;" and "I hope this teaching method will be maintained all the time, and I want to recommend this classroom activity to other universities."

Students used mind maps to draw their own knowledge structure diagrams. In the mind mapping process, students gave full play to their own associations to conduct independent exploration of knowledge and form a knowledge structure diagram that conforms to their own way of thinking. Mind maps drawn by the students themselves can show their thinking processes and help them enjoy thinking, thereby enhancing their enthusiasm and learning motivation. The results of the motivation questionnaire showed that association-based activities created an active classroom atmosphere, made learning exciting and enjoyable, and increased student satisfaction. On the motivation questionnaire, most students positively evaluated all question items, and the feedback from the free description section was generally positive. Many students expressed their interest in the association-based activities, which differed from those used in the previous traditional classes. Mind maps drawn by the students themselves can show their thinking processes and help them enjoy thinking, thereby enhancing their enthusiasm and learning motivation. The results show that creative pedagogy can provide learners with a supportive environment that enables them to improve their motivation while learning content. Therefore, language educators should strive to present the classroom as an interesting place where students can learn with eager enjoyment (Lightbown & Spada, 2013).

Significant between-group differences were obtained in the learning motivation subscales other than increased motivation, possibly because the implementation period of creative pedagogy was relatively short. If the implementation had occurred over a longer period, the between-group differences might have been statistically significant. Learning motivation has been shown to have a positive influence on learners' language proficiency (Oxford & Shearin, 1994). To develop learners' language proficiency in foreign language education, teachers should creatively enhance their students' learning motivation (National Advisory Committee on Creative and Cultural Education [NACCCE] 1999). A longer intervention period may have not only further enhanced the students' learning motivation but also better stimulated the experimental group's acquisition of language proficiency.

3.4 Summary

A creative educational environment can cultivate creativity in foreign language learning university students. This study reformed the traditional foreign language classroom model and applied daily creative activities to enhance students' creativity. The creative pedagogy presented in this study has illustrated the feasibility of using association-based activities with mind mapping, not only resulted in the development of students' creative thinking skills but also improved their language proficiency and learning motivation. Data and findings from this study will contribute to undergraduate foreign language teaching and learning processes and offer directions for creative pedagogy in the field.

In addition, this study has several implications for undergraduate foreign language education. Foreign language learning university students should be encouraged to participate in association-based activities with mind mapping in everyday learning to cultivate their creativity. Teachers can emphasize creative activities in their teaching techniques, design mind maps for foreign language textbooks, and provide overviews of the appropriate forms to teach vocabulary, reading, and writing. This teaching method can help students learn a foreign language efficiently and enhance their creative thinking skills.

In this chapter, we have investigated the creative pedagogy's effectiveness through traditional testing methods: Alternative Uses Test (AUT) to measure creative thinking skills, foreign language proficiency test to measure language performance, motivation questionnaire to measure learning motivation. The traditional tests can provide analytical data, but whether the scores of these tests are related to creative problem solving ability has not been fully confirmed. In addition, it's more convincing if the students' learning outcomes can be observed through their biometric data. In the next two chapters, we will apply modern science and technology, including EEG investigation and eye tracking detection, to present more accurate numerical results to

prove the effectiveness of creative pedagogy on students' creative thinking skills and foreign language performance.

Chapter 4 EEG investigation on creative thinking skills

Content

- **Research outline**
- **Materials and methods**
- **Results and discussion**
- **Summary**

Chapter 4
EEG investigation on creative thinking skills

Besides using Alternative Uses Test (AUT), in this chapter, an EEG investigation was taken for testing students' creative thinking skills, which provided biometric data to further verify the effectiveness of creative pedagogy. Divergent thinking is a dynamic process. EEG experiments can be used to record the change process to deepen the understanding of divergent thinking. In recent years, the development of EEG and brain function imaging has provided powerful technical support for the study of the neural basis of creativity, including the alpha band activity in divergent thinking. We used EEG to consider an assessment technique of creative thinking with biometric data. Participants' EEG signals were measured by Emotiv Epoc+ equipment in this study. The brain wave images and the divergent thinking task data of the experimental group and the control group were compared and analyzed, and the alpha band power of divergent thinking task was investigated. The results show that the experimental group had significant higher alpha band power in anteriofrontal lobe, frontal lobe, frontocentral lobe, and temporal lobe, especially in the anteriofrontal lobe area, and the alpha band activity of the right cerebral hemisphere was more active. It indicated that students who have received creative pedagogy had stronger divergent thinking skills, and the creative pedagogy used by this study can effectively develop students' divergent thinking skills.

4.1 Research outline

Many scholars have studied the relevant brain regions in the process of creative thinking task. Most studies have shown that creative thinking is the product of multiple brain regions, and there are similarities and differences in the key brain regions

involved in specific tasks (Razoumnikova, 2000; Razoumnikova, 2007; Sun et al., 2016; Zabelina & Andrews, 2016; Shen et al., 2010). Flaherty (2005) proposed a three factors model of brain anatomy, noting that creative thinking was caused by the network connection function of front lobe, temporary lobe and limbic area. Among them, frontal lobe is responsible for the generation of creative ideas. In the process of creative thinking, the anteriofrontal lobe is interrelated with divergent thinking (Dietrich & Kanso, 2010). During the divergent thinking task, both sides of the brain of highly creative participants had significant activation of the opposite anteriofrontal lobe (Carlsson et al., 2000; Wu et al.,2015; Razoumnikova, 2000). Fink et al. (2010) improved the novelty of participants' responses by increasing cognitive stimuli, and found that the activation of the medial anteriofrontal lobe cortex plays an important role in generating novel ideas. Liu et al. (2015) used the poetry creation task to find that different brain regions were activated in the generation and revision processes of creative ideas, and the medial anteriofrontal lobe was activated in both processes.

There are four kinds of EEG in human beings: alpha band, beta band, delta band, and theta band. Among these, the alpha band is a more subconscious EEG. When EEG is presented as alpha band, imagination, creativity and inspiration continue to flow out, judgment and understanding of things is greatly improved, and at the same time, the body and mind will present a sense of stability, happiness and relaxation. Alpha band synchronization can reflect an active cognitive process (Klimesch et al., 1999). Jausïovec (2000) used EEG technology to investigate the alpha band power in the divergent thinking task. The results showed that highly creative participants had higher alpha band power, especially in front lobe areas. Fink, et al. (2006) investigated the alpha band synchronization of participants on the divergent thinking task by using the event related desynchronization (ERD) method. The results showed that the answers with higher novelty are accompanied by stronger alpha band synchronization. More creative ideas are related to stronger alpha band power increase. In addition, Jung-Beeman et al. (2004) pointed out that compared with non-insight solutions, insight

solutions have a higher level of alpha band power, and the most prominent one is the right cerebral hemisphere cortex.

At present, in the foreign language education, the effect of creative pedagogy is measured by traditional divergent thinking test. To our knowledge, no study appears to exist that has analyzed EEG correlates of creative pedagogy in the foreign language education. Based on the previous researches, this study mainly focused on the research question that what is the difference between the alpha band power of experimental group and control group, and then elaborated on the development effect of creative pedagogy on divergent thinking. We mainly analyzed task-related alpha band power while participants worked on different divergent thinking tasks.

4.2 Materials and methods

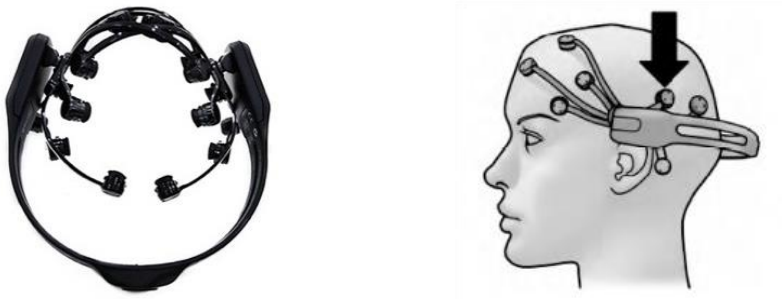
4.2.1 Participants

We selected 20 students from each group. All participants gave their informed consent for inclusion before they participated in the experiment. Experimental group students received creative pedagogy to develop their divergent thinking training in their usual classrooms, mainly consisting of carrying out association-based activities with mind mapping for 8 weeks. After completing the divergent thinking training, the two groups of students participated in the divergent thinking tasks for EEG data collection.

4.2.2 Apparatus

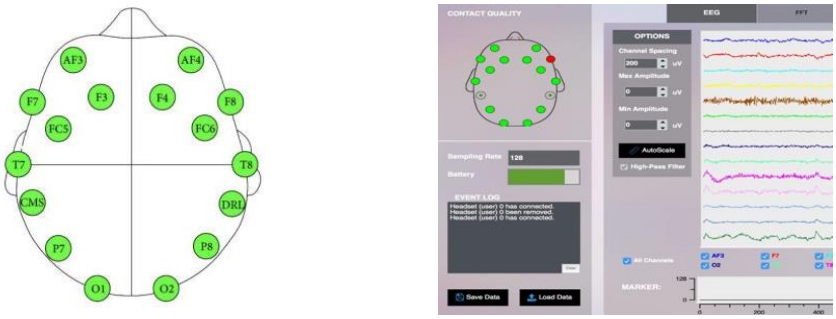
The experiment used the Emotiv Epoc+, which is produced by Emotiv systems, a neurotechnology company in San Francisco, California (Figure 15 (a)). It is a wireless Bluetooth EEG recorder that can collect 14 channels EEG signals and transmit the signals to the computer through wireless transmission. The 14 EEG channel names based on the international 10/20 system are: AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8, AF4. The distribution of the reference sensors is symmetrical, the odd number is on the left and the even number is on the right. Anteriofrontal lobe (AF3,

AF4), frontal lobe (F3, F4, F7, F8), frontocentral lobe (FC5, FC6), temporal lobe (T7, T8), parietal lobe (P7, P8), occipital lobe (O1, O2). In addition, CMS / DRL noise reduction configuration is also used in the device (Figure 16 (a)). EEG signal is filtered between 0.2 Hz and 43 Hz, and a 50 Hz notch filter is added to avoid power line pollution. The sampling frequency of all EEG signals is 256 times per second. The reference sensor has a black rubber cover. Place the sensors on the bone behind each earlobe. The two front sensors should be on the hairline approximately or 3 inches wide above the eyebrows (Figure 15 (b)). Press and hold the 2 reference sensors (above and behind the ear) for about 20 seconds, then Emotiv Epoc+ will begin to collect EEG signals (Figure 16 (b)).



(a) **(b)**

Figure 15. Emotiv Epoc+ equipment and wearing method.
(a) Emotiv Epoc+ equipment; (b) Emotiv Epoc+ wearing method.



(a) **(b)**

Figure 16. Emotiv Epoc+ reference sensors location distribution and signal display.
(a) Reference sensors location distribution; (b) Emotiv Epoc+ signal display.

4.2.3 Procedure

(1) Divergent thinking tasks

In this experiment, the EEG of the two groups in the process of completing divergent thinking tasks was compared and analyzed. There are four kinds of divergent thinking tasks which emphasize association. Insight (IS) task: give an unusual scene description, and ask participants to explain the causes and consequences of this scenario; Utopian situations (US) task: participants were instructed to put themselves in a utopian situation and to think of their own unique ideas or solutions; Alternative uses (AU) task: provide daily necessities and let participants say as much as possible about the unusual uses of daily necessities; Vocabulary association (VA) task: give a word and let the participants associate it with other words (Table 5). Separate measurement method was adopted, and sound insulation wall was installed in the closed classroom. After each participant entered the classroom, staff explained the purpose, significance and process of the experiment. Participants will rest for 5 minutes. During the experiment, participants tried not to have large body movements or communicate with others.

Table 5. Items in the divergent thinking tasks.

Divergent thinking tasks	Items
Insight (IS)	（1）The phone in the office kept ringing, but no one answer the call. （2）Person A is standing, person B is smiling and person C is crying.
Utopian situations (US)	（1）If there is no night, every day is daytime, what kind of life would it be like? （2）If all animals could speak and communicate with people, what would the world be like?
Alternative uses (AU)	（1）Brick （2）Plastic wrap
Vocabulary association (VA)	（1）Japanese words that begin with ‘は’ （2）Japanese words ending in ‘む’

(2) EEG data acquisition

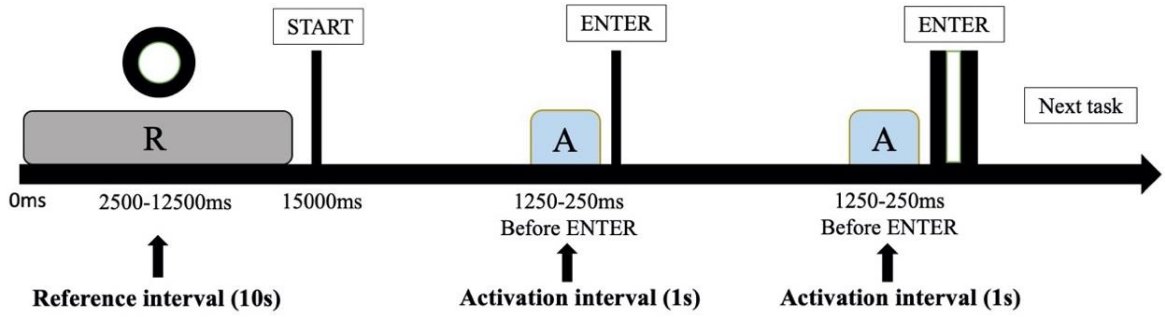
Figure 17 shows the schematic diagram of the EEG data acquisition. The participant sits on a chair facing the PC and performs the divergent thinking tasks while wearing the Emotiv Epoc+, and the EEG data at that time are recorded. The Emotiv Epoc+ sends data to the PC via the bluetooth driver. It is accessed by the EmotivPRO integrated software inside the PC. Data packets are sent every second, and by analyzing the acquired packets, numerical data of the alpha band can be retrieved. The averaged alpha band power using Fast Fourier Transformation (FFT) were calculated.

Figure 17. Schematic diagram of the EEG data acquisition.

(3) EEG data analysis process

The divergent thinking task starts with the presentation of the '○' symbol (Figure 18). Participants are required to pay close attention to the '○' symbol for a duration of 15 seconds. After the '○' symbol disappears, the divergent thinking task will be displayed on the computer screen. The participant then reads the introduction of each task, and after having an idea, they will press "enter" on the computer keyboard. At this time, the words "please answer" will be displayed on the computer, and the participants will begin to describe their ideas after reading. Participants were asked to express their ideas in as much detail as possible, which was recorded by the experimenters. Once the narration of ideas is completed, participants press the "enter" button again to confirm their ideas. After 5 seconds, the next task description will appear on the computer screen again. Each task needs to be completed within 3 minutes, and this process will be

repeated until the last divergent thinking task is completed and EEG data collection is completed.



(Note. R–Reference; A–Activation.)

Figure 18. Schematic diagram of the EEG data analysis.

As was shown in Figure 18, in the process of participants performing divergent thinking tasks, this experiment will select two time periods of EEG signals for data analysis: Reference (pre-stimulus) interval (10 s): The 10s time period when paying attention to the‘○’symbol (2500ms-12500ms); Activation interval (1s): The 1s time period before the enter button is pressed (1250-250ms before enter). Each divergent thinking task has two items, so there will be two activation intervals. This experiment will take the average of the EEG signals in the two activation intervals for analysis.

In the reference interval and activation interval, alpha band power (μV^2) was calculated by filtering the EEG signals with FFT filters. In order to investigate the changes of the task-related power (TRP) in the alpha band (Pfurtscheller, 1999), in each divergent thinking task, the (log-transformed) power in the activation interval minus that during the reference interval according to the formula as follows:

$$TRP_i = \log (Pow_i \ \text{activation}) - \log (Pow_i \ \text{reference})$$

If the alpha band power decreased from reference interval to activation interval, the TRP value is negative; If the alpha band power increased from reference interval to activation interval, the TRP value is positive (Pfurtscheller, 1999).

4.3 Results and discussion

4.3.1 TRP values in the divergent thinking tasks

Based on the statistical comparison in Figure 19, *t*-test was conducted (Table 6). The results show that the TRP in the alpha band of the two groups were both positive, which proved that the alpha band power of the two groups increased from the reference to the activation interval. In addition, the experimental group displayed significant stronger alpha band power increased than the control group in the IS task, ($t = 2.786$, $p < 0.05$), AU task, ($t = 3.197$, $p < 0.01$), and VA task, ($t = 5.086$, $p < 0.001$). In the case of US task , the difference was not statistically significant, ($t = 1.705$, $p > 0.05$).

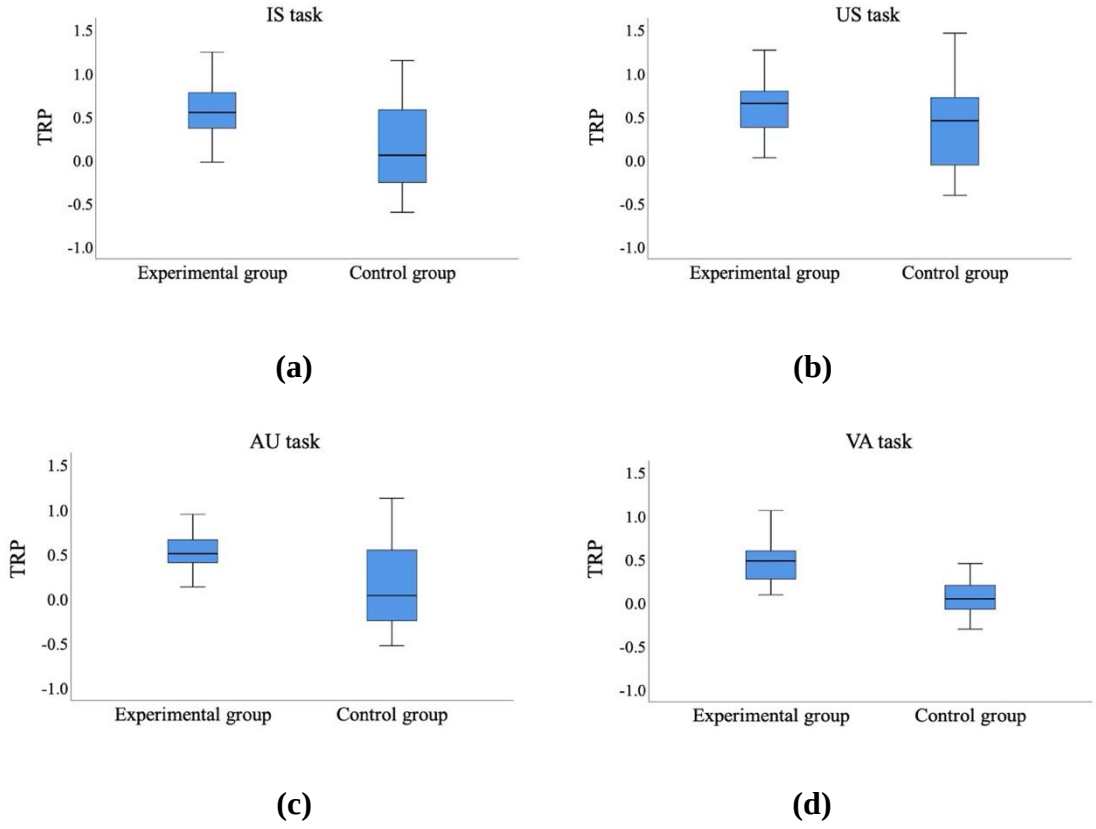


Figure 19. Statistical comparison of TRP in the divergent thinking tasks for the two groups. (a) TRP in IS task for the two groups; (b) TRP in US task for the two groups; (c) TRP in AU task for the two groups; (d) TRP in VA task for the two groups.

Table 6. The *t*-test results of TRP for the two groups.

Divergent thinking tasks	Experimental Group		Control Group		*t*	*p*
	M	SD	M	SD		
IS task	0.596	0.339	0.194	0.056	2.786*	0.012
US task	0.601	0.343	0.382	0.498	1.705	0.104
AU task	0.581	0.345	0.157	0.515	3.197**	0.005
VA task	0.501	0.293	0.095	0.273	5.086***	0.000

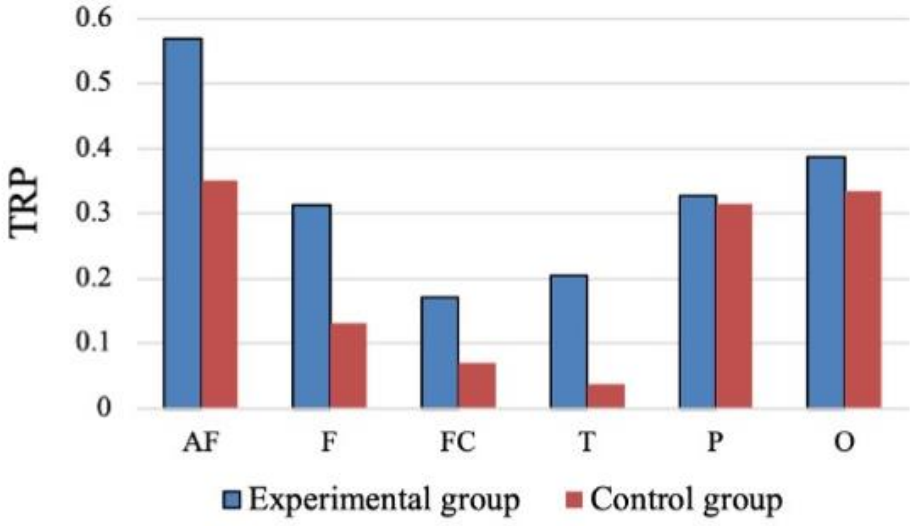
(Note. M–Mean; SD–Standard Deviation; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.)

The EEG data in this experiment indicated that both experimental group and control group showed an increase in TRP value. Divergent thinking was usually accompanied by an increase in alpha band power from the reference to the activation interval. The difference of alpha band power increased in the divergent thinking tasks of the two groups indicated that the alpha band power might check the promotion of the divergent thinking skills after the creative pedagogy. In the US task, the TRP value of experimental group was not significantly higher than that of control group, this may be due to the higher image thinking ability, intuition and understanding required for the description of US task. Both groups had similar imagination when performing divergent thinking, so there was no obvious difference between the two groups.

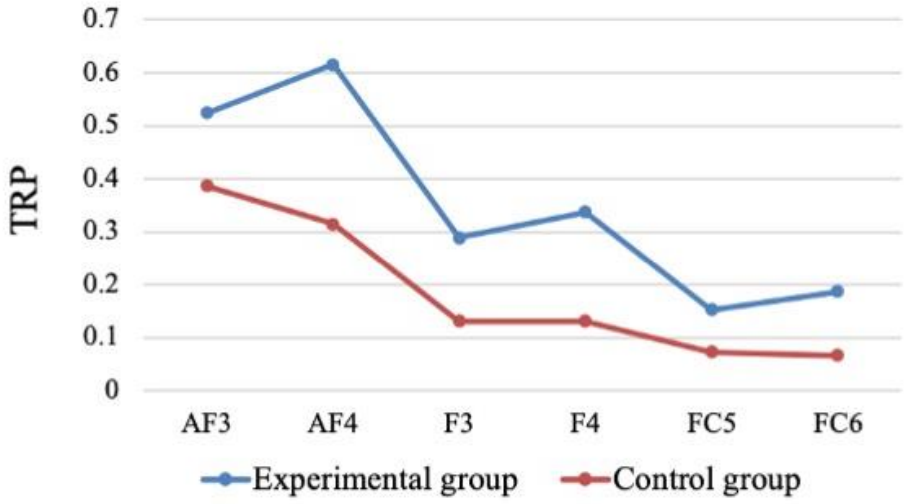
4.3.2 TRP values in different positions

Figure 20 (a) shows that the alpha TRP values of the whole brain area were all positive, which proved that the alpha power increased from the reference to the activation interval. The alpha TRP value of experimental group was higher than that of control group, and the differences were mainly concentrated in anteriofrontal lobe (AF), frontal lobe (F), frontocentral lobe (FC), and temporal lobe (T) areas. In addition, the TRP values of the AF areas in both groups were higher than other areas, and the experimental group displayed higher TRP value over AF areas than the control group. Moreover, in this experiment, we not only limited the detection of the differences of TRP values in the whole areas in both groups, but also made the investigation of the

differences of TRP values in the left and right cerebral hemisphere in both groups respectively.



(a)



(b)

Figure 20. TRP results for the two groups. (a) TRP from anterior to posterior regions for the two groups. AF, anteriofrontal; F, frontal; FC, frontocentral; T, temporal; P, parietal; O, occipital; (b) TRP in the left and right cerebral hemisphere for the two groups. Left cerebral hemisphere: AF3, F3, and FC5; Right cerebral hemisphere: AF4, F4, and FC6.

The results show that the TRP value of the right cerebral hemisphere in the AF, F, and FC areas was higher than that of the left cerebral hemisphere in the experimental group. However, there was no significant difference between the right and left cerebral hemisphere in the control group, and in the AF and FC areas, the left cerebral hemisphere was a little higher than that of the right cerebral hemisphere (Figure 20 (b)).

(1) TRP values in AF areas

The alpha TRP values of both groups were higher in the AF areas than other areas. In addition, compared with control group, experimental group had more task related synchronization of alpha activity. AF areas plays an important role in the development of creativity, especially for divergent thinking (Shamay et al., 2011; Crone & Dahl, 2012). The AF lobe regions of highly creative participants were significantly activated (Rutter et al., 2012). AF areas play an important role in the development of creativity and divergent thinking because the areas involve cognitive control functions (Miller & Cohen, 2001). In the process of cognition and thinking, alpha band power produced by AF area will increase, which will lead to in-depth analysis of the reading information (Carlsson et al., 2000). AF areas mainly calm and relax people in order to produce new, unique or original ideas. Dietrich (2004a) proposed that creativity requires cognitive ability (such as memory, concentration or cognitive flexibility), especially cognitive flexibility, which is regarded as the core connotation of divergent thinking, that is, breaking the conventional mode of thinking, adopting new thinking strategies, or establishing unique connections with stored knowledge. These cognitive abilities are usually attributed to the AF areas of the brain. The experimental group showed higher cognitive ability than control group, and has more prominent alpha activity in AF areas, which indicated that the development of their divergent thinking skills.

(2) TRP values in F and FC areas

F and FC areas are frontal brain regions, which are crucial for the involvement in divergent thinking (Carlsson et al., 2000; Dietrich, 2004a). The alpha TRP value of the

experimental group was higher than that of the control group, which proved that the F and FC areas were more actively involved in divergent thinking and were fully utilized when the experimental group performed divergent thinking tasks.

(3) TRP values in T area

The T area is an important part of the brain's memory generation. The difference between the two groups in this area indicated that the experimental group paid more attention to connecting memories formed by different sensations, and promoted the completion of divergent tasks.

(4) TRP values in P and O areas

Both groups had high alpha TRP value that was similar in the P and O areas. The P lobe is somatosensory area. Both groups had high alpha TRP values in the P area, which indicated that the sensory experience of completing the divergent thinking tasks in both groups was strong, and there was a certain amount of pressure and anxiety. The O lobe is visual processing area. The increase of the alpha TRP value in the O area is a cognitive suppression of the interference information by the visual system (Sauseng et al., 2005; Klimesch, Sauseng & Hanslmayr, 2007). When performing divergent thinking tasks, both groups visually processed the divergent thinking tasks presented on the computer to effectively suppress interference information. In summary, multiple brain regions were involved in the divergent thinking process, and there were similarities and differences in the key brain regions. The similarities in P and O lobe areas showed a common phenomenon in the process of completing tasks, and the differences between the two groups in AF, F, FC, and T lobe areas indicated the experimental group significantly activated in divergent thinking, and this might be created by higher divergent thinking skills.

(5) TRP values in right cerebral hemisphere

There are more activations in the right cerebral hemisphere cortex, which plays an important role in the execution of divergent thinking tasks (Carlsson, et al., 2000; Razoumnikova, 2000; Fink, 2006). However, precious researches mainly detected the whole right cerebral hemisphere cortex's role in the divergent thinking tasks. In this study, we particularly focused on investigating the experimental group students' TRP values in the AF, F, and FC areas in the right cerebral hemisphere. As was shown in Figure 20 (b), the TRP values of the AF, F, and FC areas in the right cerebral hemisphere of the experimental group was significantly higher than on the left side, whereas the control group showed no significant difference between right and left cerebral hemispheres, and they had a little higher TRP value in the left cerebral hemisphere in the AF and FC areas. The results show that the association-based activities presented in this study could effectively improve the experimental group students to generate more alpha activity in the right cerebral hemisphere cortex, which played an important role during completing the divergent thinking tasks and enhanced their divergent thinking skills.

4.4 Summary

This study used Emotiv Epoc+ to collect EEG signals. The TRP values of the two groups in divergent thinking tasks were compared and analyzed to provide convincing data support for different divergent thinking states of the two groups. The above results of EEG and brain function imaging show that the key point of brain mechanism of divergent thinking is the anteriofrontal lobe, and higher divergent thinking skills are related to the increase of alpha band power of anteriofrontal lobe. The alpha band power in the anteriofrontal lobe areas of the experimental group significantly increased, and was higher than the control group. In addition, the alpha band power of the right cerebral hemisphere was higher than the left cerebral hemisphere. These data can prove that association-based activities can improve the effectiveness of divergent thinking skills, and promote the development of students' creativity. The results show that the

creative teaching method of association-based activities with mind mapping can effectively improve students' creative thinking skills.

In this study, all the participants used Emotiv Epoc+ equipment to participate in the experiments for the first time, their mentality may not be the natural state in ordinary times, and the biometric data collected in the experiments may be affected. In the future, we should increase the measurement times to make the participants get more used to the EEG signals and eye movement indicators collecting equipment and thus keep a natural mentality.

Chapter 5 Eye tracking detection on foreign language proficiency

Content

- **Research outline**
- **Materials and methods**
- **Results and discussion**
- **Summary**

Chapter 5
Eye tracking detection on foreign language proficiency

In this chapter, we used eye tracking sensors to explore the creative pedagogy's effects on students' reading ability. We analyzed eye movement indicators, including fixation-related indicators (number of fixations, fixation frequency, and mean fixation duration), regression count, saccade amplitude, and pupil diameter. In addition, the analysis of heat maps and fixation trajectory maps, which are specific tool for visualization of eye movement data and intuitive analysis of reading process, were explained. The results show that the number of fixations, fixation frequency, mean fixation duration, and regression count in the experimental group were all lower than in the control group, and the pupil diameter was larger than in the control group. The heat map and fixation trajectory map show convergence, mostly focusing on the position of keywords and key sentences, with relatively large saccade amplitude and more information obtained by one gaze. Moreover, they had a higher skipping reading rate, which enhanced reading speed to obtain information accurately and quickly. These empirical results indicate that the association-based activities was an effective method for improving students' reading ability.

5.1 Research outline

Reading material includes words, grammar, expressions, sentence patterns etc. Reading ability is significant in foreign language learning, which comprehensively reflect foreign language proficiency as a whole (Nuttel, 1982). In this study, students' foreign language proficiency evaluation focused on the measurement of their reading ability. To comprehensively test reading ability, it is necessary to analyze the cognitive process of reading effectively and study the real-time understanding process of

discourse comprehension. Therefore, in addition to the traditional reading comprehension testing, we applied an eye tracker to test students' reading abilities by visualizing the cognitive processing of text understanding and the reading process directly. The association reading activity with mind mapping requires students to consciously find keywords and key sentences from the article and draft the structural framework of the whole article, which allows them to fully grasp the main content of the reading article and therefore realize the goal of quickly understanding the general idea of the article and therefore improve reading efficiency. Mind mapping is a cognitive process, thus it is of great practical significance to study how mind mapping training affects students' reading process. In this study, the eye tracking research method was used to investigate eye movement characteristics of students in the process of reading. The results show that there are differences in the eye movement indicators for the two groups. Participants of different reading levels have different cognitive processing levels during the reading processing, and the eye movement indicators can be used as a means of detection (Rayner & Sereno, 1994).

Eye movement indicators can reflect cognitive process in the reading process, and this is an important research area of psycholinguistics and reading psychology (Rayner, 1998). Eye tracking sensors represent a human–computer interaction technique for recording online reading behavior, showing eye movement indicators during reading and providing sufficient data support for the reading comprehension process. It can be considered as a tool for biometric measures (Aurora & Lorenzo, 2020). It was used to record eye movement indicators in real time, going on to map the eye movement indicators to the reading process that can effectively analyze the reading ability and provide a variable with psycho-ecological validity for reading research (Keith & Charles, 2003; Liversedge & Findlay, 2000)

The reading process is the course of cognitive processing of visual information, and eye tracking is the most effective method of studying cognitive processing of visual information (Hai, 2000). There is a definite corresponding relationship between reading process and eye tracking (Mancheva et al., 2015); the eye tracking research method has an important role and position within the study of reading process. Reading ability has

a significant influence on reading process; however, there is no fixed standard for the measurement or evaluation of reading ability. The study of the influence of reading ability on reading process can be attained by studying the differences of reading ability and cognitive processing. Reading ability is interrelated to the mode of eye movement, and through eye movement indicators the cognitive process of the differences in reading ability can be explained (Just & Carpenter, 1980). Through the study of eye tracking, we can understand the direction and times of eye movement during the process of reading, which can then provide a theoretical basis for the proposition of reasonable reading teaching methods to improve reading efficiency and learning effects (Ikeda & Saida,1978; Balota et al., 1985; Wu & Shu, 2001). Many previous studies have focused on researching eye indicators during the reading process, such as fixation-related indicators, saccade amplitude, regression, and pupil diameter (Zhan, 2013; Zhan, Liang & Ma, 2014). Fixation-related indicators can best reflect the reading characteristics of participants, such as number of fixations, fixation frequency, and mean fixation duration. Saccade amplitude can accurately show the reading efficiency and cognitive processing ability of reading materials. Regression can effectively reflect the process of reprocessing the reading materials. Pupil diameter's change is closely related to fixations, gaze, and other specific reading eye movements, which can analyze the psychological changes in people's reading process (Zambarbieri & Carniglia, 2012; Rivas-Lalaleo et al., 2017; Krieber et al., 2016). Readers who have high speed in reading tend to produce fewer fixations when reading sentences and texts, along with a shorter fixation duration, a larger scanning range, and a smaller range of regression (Rayner, Slattery & Bélanger, 2010; Everatt & Underwood, 1994; Häikiö et al., 2009). High level readers have shorter fixation duration and smaller regression count than ordinary readers (Ashby, 2005; Jared, Levy & Rayner, 1999). Rayner et al. (1994) found that, as the difficulty of the article increases, the cognitive processing becomes more complex and difficult. The saccade amplitude generally becomes shorter, while the regression count increases significantly, and the mean fixation duration becomes longer. Van Gerven et al. (2002) stated that, the greater is the effort in cognitive processing, the greater is the change in scope of pupil diameter. Previous studies provide a basis for explaining the relationship between eye movement indicators and cognitive processing in reading. However, at present, in regards to research on the effect of mind mapping training in reading teaching methods, previous studies mostly use reading tests or questionnaires to evaluate reading ability or identify reading difficulties

(Marton & Booth, 1997; Bahareh & Abbas, 2015; San, 2013; Andriani, 2017), while there are few studies on eye movement in the process of reading from the perspective of visual cognitive processing.

As indicated above, these assessments only present the results of reading comprehension and cannot explain the real-time process of text comprehension, thus it is difficult to objectively measure and evaluate reading ability. As a step toward filling this gap, to make the research more convincing and the results more precise, this study adopted the method of using an eye tracking experiment to study the different eye movement characteristics between the experimental group and the control group of students in the reading process from the perspective of visual cognitive processing, which can then go towards explaining the effect of the association-based activities on reading ability.

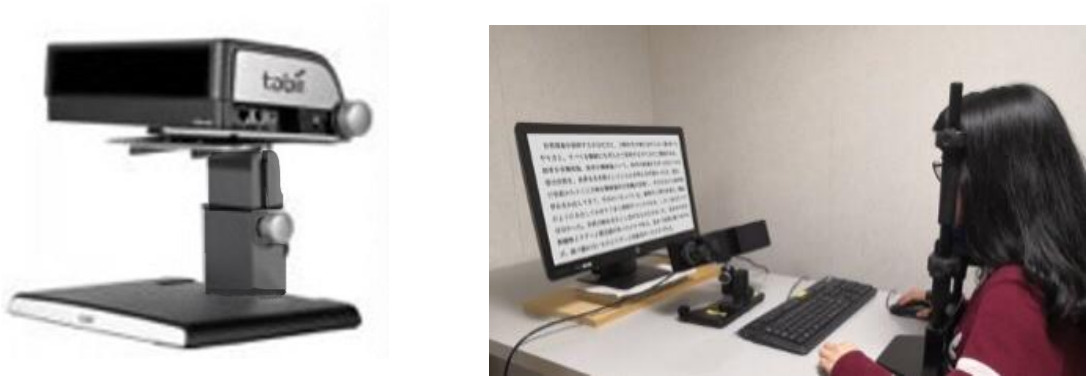
5.2 Materials and methods

5.2.1 Participants

We selected 20 students from each group. All participants gave their informed consent for inclusion before they participated in the study. Experimental group students received creative pedagogy to develop their foreign language proficiency, mainly consisting of carrying out association-based activities with mind mapping for 8 weeks. After the creative pedagogy, the two groups of students participated in the eye tracking experiment, which require them to read the reading materials that were the Japanese International Proficiency Test N2 exam reading comprehension simulation test materials. The number of words in each article is approximately 500, and the basic frame is 16 lines × 30 characters. The reading article contains Kanji, Hiragana, and Katakana, ensuring a comprehensive examination of Japanese reading ability.

5.2.2 Apparatus

The experiment used the Tobii T120 eye tracker, which is produced by Tobii in Stockholm, Sweden, with a sampling frequency of 1000 Hz and a resolution of the test machine display of 1024 × 768 pixels. Figure 21 (a) is the Tobii T120 eye tracker, and Figure 21 (b) is the participant’s physical eye movement test.



(a) **(b)**

Figure 21. Tobii T120 eye tracker equipment and eye movement test.
(a) Tobii T120 eye tracker equipment;(b) Participant's physical eye movement test.

5.2.3 Procedure

(1) Eye movement recording

Figure 22 shows the schematic diagram of eye movement data acquisition. The procedure consists of the five steps.

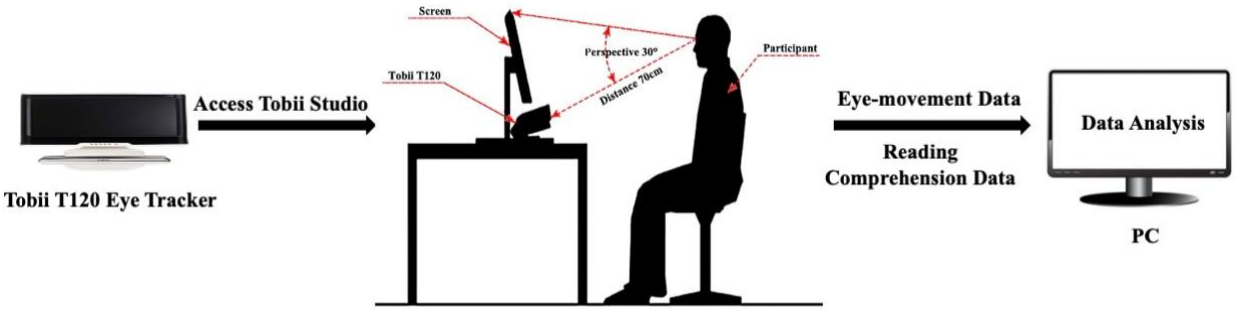


Figure 22. The schematic diagram of eye movement data acquisition.

I. Give instructions to the participants about how to do the experiment. The participant's eyes and the Tobii T120 eye tracker screen always at a distance of 70 cm, which is approximately at a perspective of 30°.

II. Ask the participants to read four Japanese articles that are displayed randomly on a PC screen, one after another. The time given for reading is unlimited.

III. Record eye tracking data during reading. The data of eye movement indicators are imported into Tobii Studio software.

IV. Follow each article with two reading comprehension multiple-choice questions and a requirement to write down the keywords and key sentences to measure their reading comprehension rate and reading efficiency, which participants must do immediately after reading.

V. Analyze the obtained eye movement data and reading comprehension data.

(2) Eye movement indicators

Among all kinds of eye movement indicators, fixation-related indicators, regression count, saccade amplitude, and pupil diameter are the most reported data in eye tracking studies and recognized as primary indicators playing critical roles in identifying students' reading abilities (Zhan, 2013; Zhan, Liang & Ma, 2014). Moreover, heat maps and fixation trajectory maps can provide an intuitive view of eye movement indicators and visualize the reading process (Zhang & Ye, 2006; Beymer et al., 2005). Therefore, in this study, these eye movement data were used for analysis.

I. Fixation-related indicators

Fixation indicates the position where eye remains still for a certain time period (Chamberlain, 2007; Dong et al., 2018), which can reflect reader's cognitive processing of reading materials (Holmqvist et al., 2011). Number of fixations, fixation frequency, and mean fixation duration are all general fixation-related indicators. Number of fixations is the number of gaze points while gazing at a certain area of interest (unit: number); fixation frequency is the number of gaze points per second (unit: times/s); and mean fixation duration refers to the average time that the eye remains still at each gaze point of a certain area of interest (unit: s). Compared to reading simple materials,

reading difficult materials has significantly more fixations, and the fixation frequency and mean fixation duration would be higher (Radach & Kennedy, 2004).

II. Regression count

Regression refers to the reading process that move in the opposite direction to the reading materials (Chamberlain, 2007; Dong et al., 2018). The reason of regression eye movement may be that readers have difficulty in understanding the article (Rayner, 1998). Regression count is the number of regressions per second (unit: times/s).

III. Saccade amplitude

Saccade is the rapid movement between fixations (Chamberlain, 2007; Dong et al., 2018). Saccade amplitude refers to the distance at which the gaze point moves from one fixation to another (unit: °/s). The saccade amplitude can reflect the amount of information obtained in a single gaze, showing the reading efficiency and processing difficulty. The longer is the saccade amplitude, the more information would be obtained in a single gaze, making the reading speed faster (Irwin, 1998).

IV. Pupil diameter

Pupil diameter is an eye movement indicator used to infer the size of "cognitive processing" and "cognitive load", which is often used in the field of education (unit: mm) (Van Gerven, et al., 2002). The size of pupil diameter is closely related to the degree of psychological effort in information processing. When the psychological load is large, the range of pupil diameter will be larger (Heo et al., 2014; Bang, Heo & Choi, 2014). In addition, it is also closely related to people's emotions. For example, when people see things of interest, their pupil diameter will increase (Heo et al., 2014; Bang, Heo & Choi, 2014).

V. Heat map

Heat map representing fixation duration and fixation location have been shown to be a better representation of visual processing (Henderson, 2003). It is a visual form that displays visual behavior features by superimposing eye movement data of multiple participants, thus reflecting the distribution of the visual trajectory and visually displaying key areas of visual attention on the interface. In addition to representing the

concentration trend and dwell time of watching on the same page, it can also express eye movement patterns as they are superimposed on the same interface (Wang & Liu, 2018; Rayner, 2009). Figure 23 is a schematic diagram of a heat map. The focused area is represented by a spectrum of red–yellow–green, with red showing the area of most focus and green showing the area of least focus.

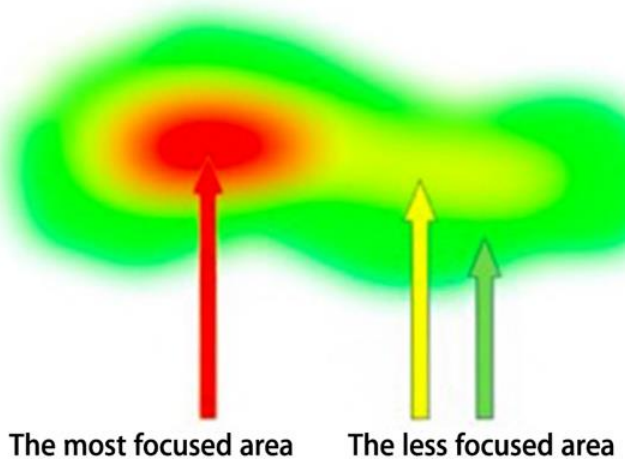


Figure 23. Schematic diagram of a heat map.

VI. Fixation trajectory map

Figure 24 is a schematic diagram of a fixation trajectory map. Circles in the fixation trajectory map indicate the number of fixations; the size of the circle indicates the fixation duration; and the lines between the circles indicate the saccade amplitude. By examining the fixation trajectory map, the complete reading process can be observed.

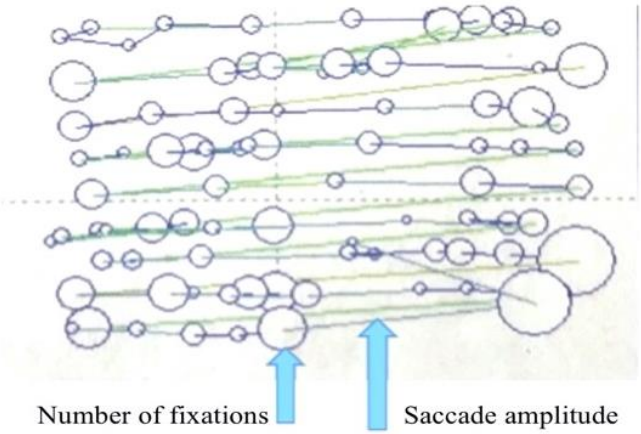


Figure 24. Schematic diagram of a fixation trajectory map.

(3) Reading comprehension indicators

To measure reading comprehension rate and reading efficiency, each article was followed by questions that participants needed to answer after eye tracking. Reading comprehension indicators were used for analysis, which are divided into four aspects: reading time, reading speed, reading comprehension rate, and reading efficiency (Zuo & Yang, 2006; Bai, Li & Yan, 2008). Reading time refers to the time (in min) spent reading the entire article; reading speed refers to the number of words (words/min) read per minute; reading comprehension rate refers to the number of questions answered correctly divided by the total number of questions; and reading efficiency refers to reading speed times the reading comprehension rate.

5.3 Results and discussion

5.3.1 Eye movement indicators analysis

Based on the statistical comparison in Figure 25, *t*-test was conducted (Table 7). The results show that the number of fixations, fixation frequency, mean fixation duration, and regression count were all significantly lower for the experimental group compared to the control group (number of fixations, $t = 13.375$, $p < 0.001$; fixation frequency, $t = -4.094$, $p < 0.001$; mean fixation duration, $t = 2.663$, $p < 0.05$; regression count, $t = 8.062$, $p < 0.001$). In terms of the saccade amplitude, the experimental group was significantly higher than the control group ($t = -6.473$, $p < 0.001$). The pupil diameter in the experimental group was larger than that in the control group, although there were no significant differences ($t = 1.961$, $p > 0.05$).

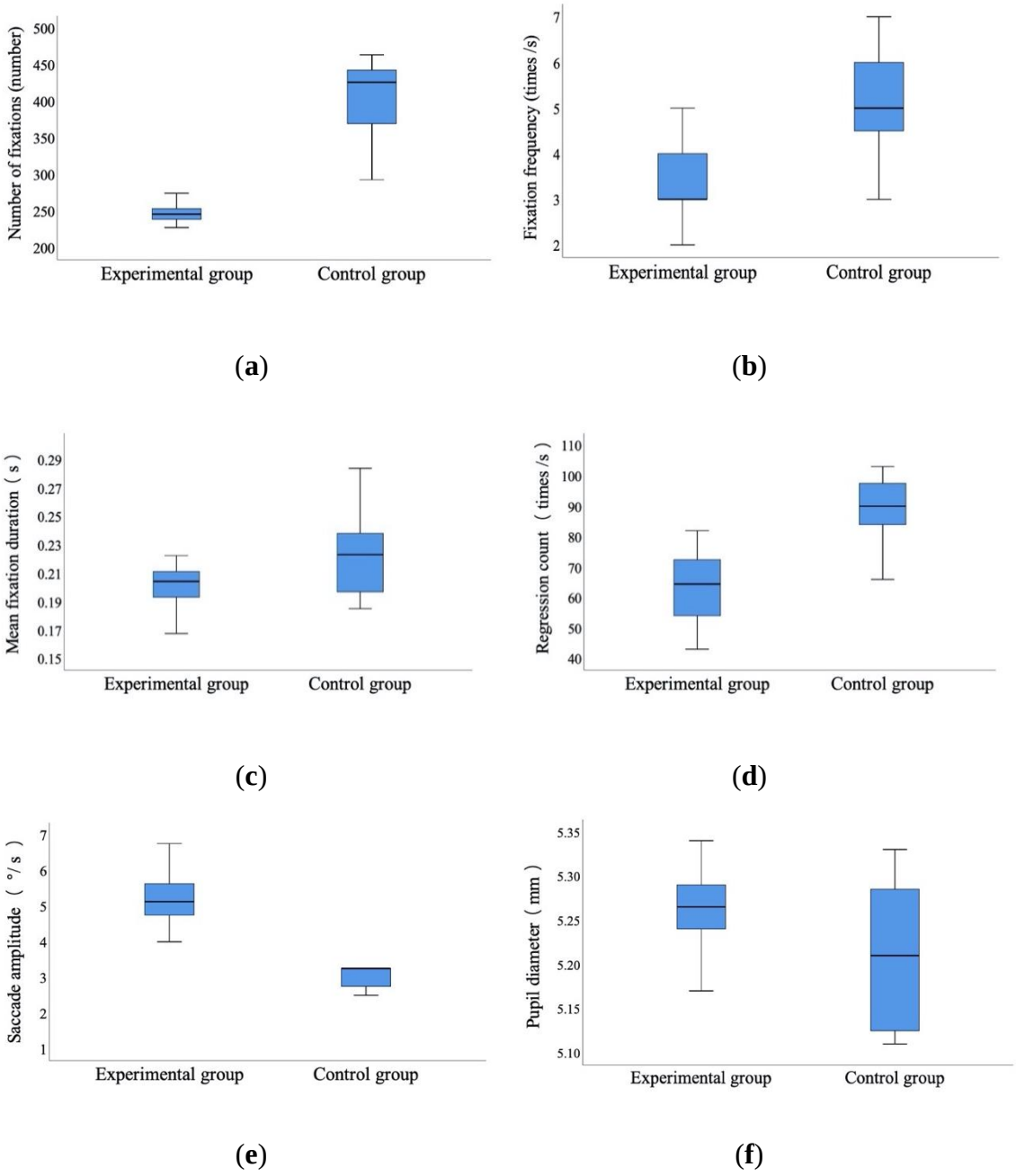


Figure 25. Statistical comparison of eye movement indicators for the two groups. (a) Number of fixations; (b) Fixation frequency; (c) Mean fixation duration; (d) Regression count; (e) Saccade amplitude; (f) Pupil diameter.

Table 7. The *t*-test results of eye movement indicators for the two groups.

Eye Movement Indicators	Experimental Group		Control Group		*t*	*p*
	M	**SD**	**M**	**SD**		
Number of fixations	250.91	19.16	404.70	47.78	13.375 ***	0.000
Fixation frequency	3.60	1.19	5.10	1.12	−4.094 **	0.001
Mean fixation duration	0.20	0.01	0.22	0.03	2.663 *	0.015
Regression count	63.15	11.80	90.00	8.94	8.062 ***	0.000
Saccade amplitude	5.06	0.93	3.34	1.01	−6.473 ***	0.000
Pupil diameter	5.25	0.06	5.21	0.08	1.961	0.065

(Note. M–Mean; SD–Standard Deviation; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.)

These eye movement indicators can reflect the understanding and information processing of the article when reading. From the perspective of fixation, a high number of fixations and fixation frequency indicate the difficulty in interpreting the fixated information (Ehmke & Wilson, 2007), and shorter mean fixation duration indicates a higher work efficiency (Van Orden et al., 2001). As skills improve, more information can be extracted around the point of fixation, making eye movements more effective overall (Holmqvist, 2011). Readers who have difficulty in understanding tend to re-read and have more regressions (Kuperman & Van Dyke, 2011; Rayner, Ardoin & Binder, 2013). Saccade amplitude can reflect task difficulty; longer saccade amplitudes are more exploratory (Tatler, Baddeley & Vincent, 2006). Pupil diameter provides a quantitative index for measuring the psychological load of information processing and can be used as an indicator of cognitive processing intensity. In general, the greater the effort of cognitive processing is, the greater the memory load is, and thus the greater the pupil diameter will be (Van Gerven et al., 2002).

The number of fixations and fixation frequency were lower in the experimental group than in the control group. The number of fixations and fixation frequency can reflect the comprehension and information processing of the subjects, which indicates that the experimental group can understand the reading materials easily.

The mean fixation duration in the experimental group was shorter than the control group. The length of the mean fixation duration is related to the semantic extraction of the observed words. The mean fixation duration of the experimental group was 0.20 s,

which can show that the main content of the reading materials can be extracted in a short time and the reading speed can be improved.

The regression count of the experimental group was significantly less than of the control group. Generally, regression is produced when there are difficulties and errors in understanding the reading content. The regression count of the control group was 90 times/s, which could infer that there were some difficulties in extracting and processing the information of reading materials, which requires repeated processing to achieve the goal of understanding the content of reading materials.

Saccade amplitude can reflect reading efficiency and processing difficulty. The saccade amplitude of the experimental group was significantly larger than that of the control group, which indicates that the experimental group could obtain a larger amount of information from the reading material and had a higher level of reading efficiency, while the saccade amplitude of the control group was small, indicating difficulty in processing reading materials.

The pupil diameter of the experimental group was larger than that of the control group. This indicates that the experimental group paid more attention to the information processing when reading materials, and their effort of cognitive processing was higher than that of the control group. In addition, it is possible that, after the creative pedagogy, the experimental group was more confident in their reading comprehension and had positive emotions regarding the completion of the reading task. The difference between the two groups did not reach a significant level, which may be due to the fact that the reading materials were not difficult and did not cause excessive psychological load on either group.

The reason the two groups have the above differences in these eye movement indicators is that the cognitive processing level of students with different reading ability will be different during the reading process. The association reading activity with mind mapping can effectively improve the reading comprehension rate, while reducing the total reading time, the number of fixations, fixation frequency, mean fixation duration, and regression count and increase the saccade amplitude and pupil diameter, which can help the students to complete reading comprehension more quickly and accurately.

5.3.2 Heat map analysis

The visual focused areas were compared by detecting the mean fixation duration and fixation location in heat maps. As presented in Figure 26, in this experiment, four Japanese reading articles were delineated into two specific visual areas: Text Area 1 (first specific visual area) — the area of the “keywords and key sentences” section — and Text Area 2 (second specific visual area) — the area of other parts.

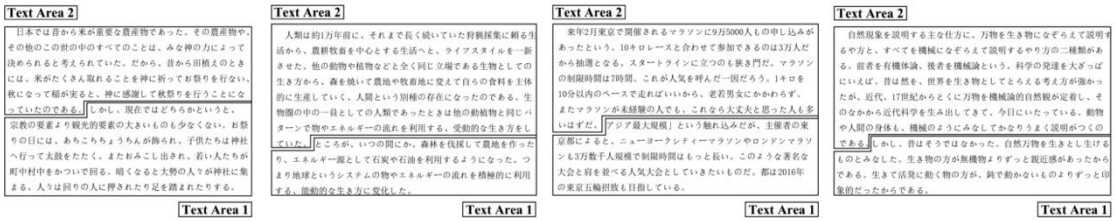


Figure 26. Text Areas 1 and 2 in four Japanese reading articles.

Figure 27 depicts heat maps of all participants for the four Japanese reading articles. For the heat maps of the experimental group, the red hotspot particles were large, and the hotspots were convergent, mainly concentrated in Text Area 1, the keywords and key sentences, and appeared rarely in other parts of the material. In terms of the heat maps of the control group, the red hotspot particles were discrete, and the hotspot areas were less concentrated.

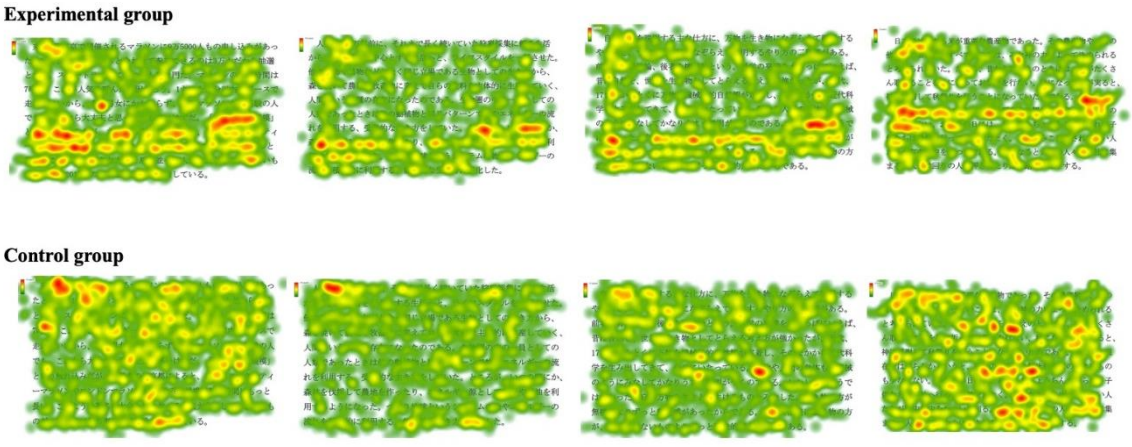


Figure 27. Heat map of the two groups in four Japanese reading articles.

The results are shown in Figure 28 and Table 8. The experimental group’s mean fixation duration on Text Area 1 of four Japanese reading articles were significantly

higher than that on Text Area 2 ($t = 6.543$, $p < 0.001$). On the other hand, there were no significant differences in the control group's mean fixation duration on Text Areas 1 and 2 of four Japanese reading articles ($t = -0.526$, $p > 0.05$).

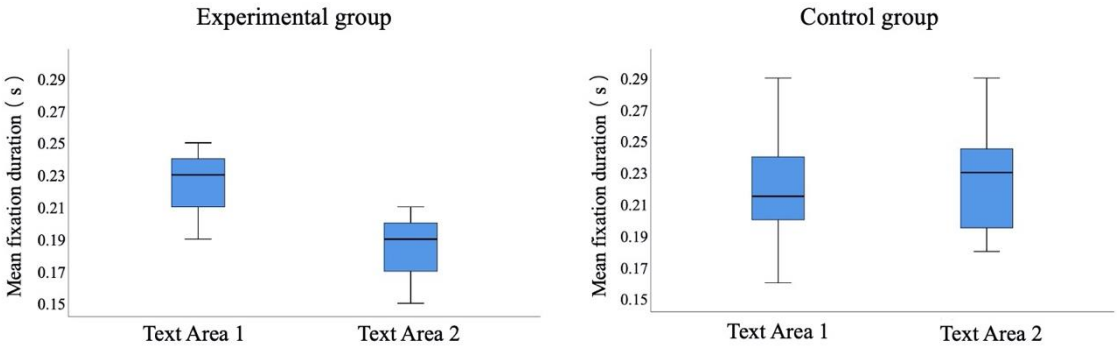


Figure 28. Statistical comparison of mean fixation duration on Text Areas 1 and 2 for the two groups.

Table 8. The *t*-test results of mean fixation duration for the two groups.

Group	**Text Area 1**		**Text Area 2**		***t***	***p***
	M	**SD**	**M**	**SD**		
Experimental group	0.223	0.023	0.183	0.017	6.543 ***	0.000
Control group	0.222	0.032	0.224	0.034	−0.526	0.605

(Note. M–Mean; SD–Standard Deviation; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.)

The experimental group's most focused areas were the keywords and the key sentences, and the control group's reading process was fragmented. The results show that different reading teaching methods had different reading effects, and they affected the students' most focused areas on the reading materials. Through creative pedagogy, the students could create associations on keywords and key sentences, establish memory links, and use relevant hierarchical diagrams to integrate the language knowledge in the reading materials (Bahareh & Abbas, 2015; San, 2013). The students in the experimental group were able to grasp the keywords and key sentences for reading, which promoted the grasp of the structure and the understanding of the main idea of the article. In the case of the control group, the students were taught in the traditional reading teaching classroom, and teacher-centered teaching was conducted, which did not require students to do the practices to find key words and key sentences

in the reading materials. Thus, the eye movement characteristics on the heatmaps for the two groups were also different.

5.3.3 Fixation trajectory map analysis

Figure 29 is the fixation trajectory map for all participants in four Japanese reading articles.

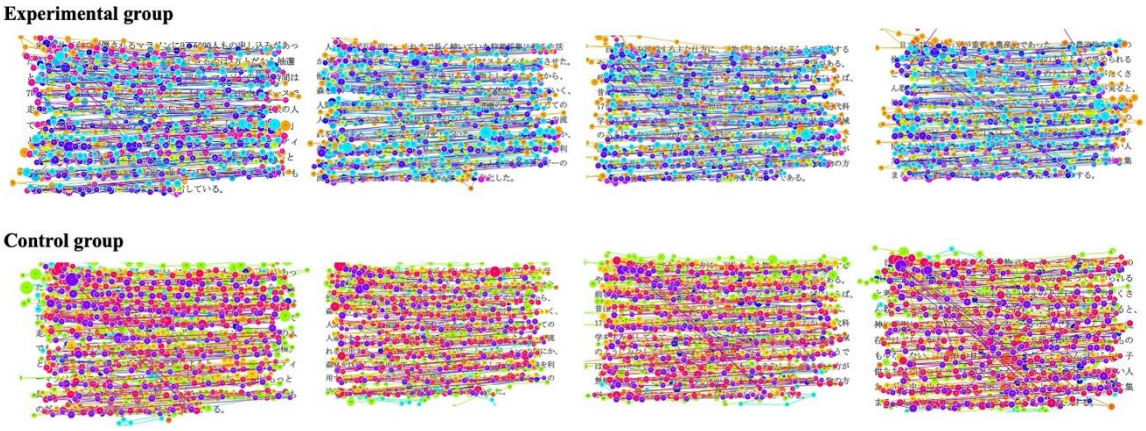
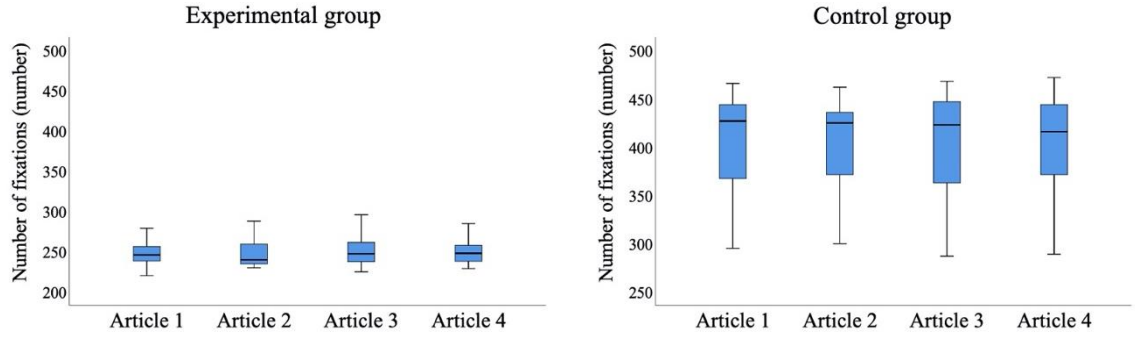
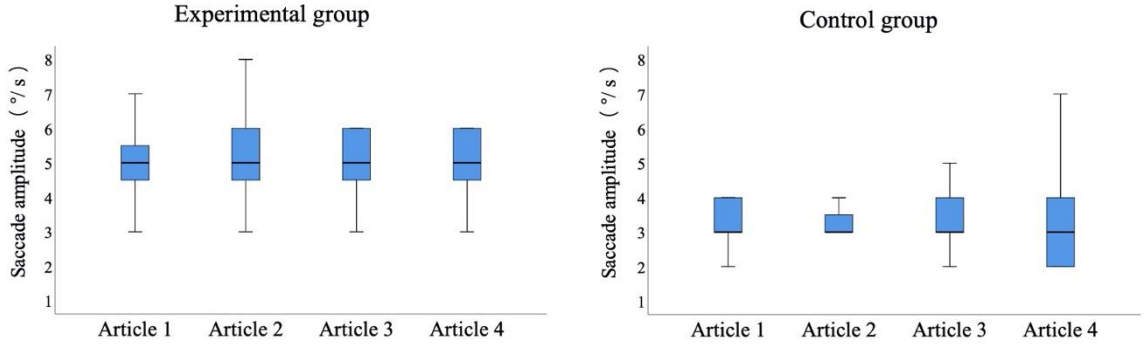


Figure 29. Fixation trajectory map of the two groups in four Japanese reading articles.

Number of fixations and saccade amplitude results for the two groups are shown in Figure 30 and Table 9. It indicated that the experimental group's gaze moved more quickly and the number of fixations was lower: the average number of fixations of the four Japanese reading articles was 250.91. The saccade amplitude was larger: the average saccade amplitude of four Japanese reading articles was 5.06 °/s. In contrast, the control group read each sentence (from first to last) carefully. The speed of eye movement between words and sentences was slow and the number of fixations was higher: the average number of fixations of the four Japanese reading articles was 404.70. The saccade amplitude was smaller: the average saccade amplitude for the four Japanese reading articles was 3.34 °/s.



(**a**)



(**b**)

Figure 30.Statistical comparison of the number of fixations and saccade amplitude on four Japanese reading articles for the two groups. (a) Number of fixations; (b) Saccade amplitude.

Table 9. Number of fixations and saccade amplitude for the two groups.

	Group	Article 1	Article 2	Article 3	Article 4	Average
Number of fixations	Experimental group	250.50	248.70	252.85	251.60	250.91
	Control group	405.60	404.95	402.55	405.70	404.70
Saccade amplitude	Experimental group	4.95	5.15	5.15	5.00	5.06
	Control group	3.40	3.25	3.45	3.25	3.34

As mentioned in the *t*-test of Table 7, the number of fixations was significantly lower for the experimental group as compared to control group ($t = 13.375$, $p < 0.001$). In terms of the saccade amplitude, the experimental group was significantly higher than the control group ($t = -6.473$, $p < 0.001$). The results show that the experimental group's reading process was relatively smooth, and the overall grasp of the article was

good, which could save reading time and improve reading speed. On the other hand, the control group had some difficulty in reading the article, which would lead to increasing reading time and decreasing reading speed.

During the reading process, people obtain information through fixations and transferred the fixations through saccades. The saccade amplitude changed due to the difficulty of reading materials. Saccade amplitude in fixation trajectory map indicates the skipping phenomenon. The greater is the saccade amplitude, the more words are skipped (Hutton, 2008). However, in the previous studies, although saccade amplitude data was obtained, little researches focused on the analysis on the skipping phenomenon. In this study, we detected skipping reading rate for the two groups. During the reading of Japanese articles, when gazing, readers usually see between two and five (mostly three and four) characters (Osaka, Koga & Nakazawa, 1993). In this experiment, skipping was defined as five words or more sight moving, or new line sight moving. Figure 31 shows the proportion of the skipping phenomenon in the entire line of sight movement data during the reading process of four Japanese articles in both groups. The results show that the skipping rate in the experimental group was high, at almost 70%, while, in the control group, it was low, at almost 30%. Skipping depends on the difficulty level of the entire article; the lower is the difficulty level of the reading material, the higher is the skipping rate (Hutton, 2008). It indicated that the difficulty level of the reading materials for the two groups was different, and the two groups showed different skipping rate. Reading materials were relatively less difficult for the experimental group, which may be related to the creative pedagogy's effects. Through mind mapping, the attention and time used on the reading unit can be reasonably allocated, and key points can be selected for reading to improve students' reading efficiency (Marton & Booth,1997), which will reduce the reading processing difficulty and make reading process more smoothly to a certain extent. Therefore, the saccade amplitude of the experimental group was larger, and the skipping rate was higher than that of the control group.

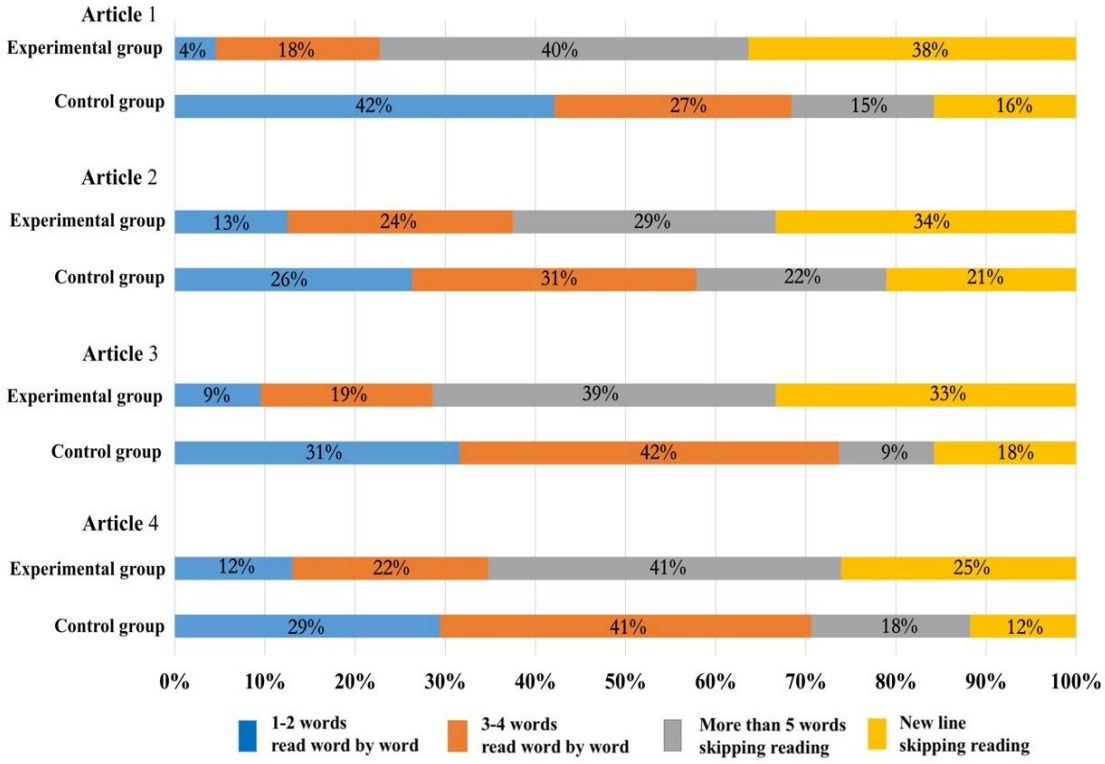


Figure 31. Proportion of skipping reading in the two groups.

5.3.4 Reading comprehension indicators analysis

To further investigate the reading ability of the two groups, reading comprehension indicators analysis was conducted. As presented in Table 10, the *t*-test results show that there were significant differences in the reading comprehension indicators between the two groups. By comparing with the control group, in the experimental group, the reading time was significantly shorter ($t = 6.075$, $p < 0.001$); the reading speed was significantly faster ($t = -5.674$, $p < 0.001$); and the reading comprehension rate and reading efficiency were significantly higher ($t = -3.035$, $p < 0.01$; $t = -5.822$, $p < 0.001$).

The results further confirm the considerable reading effect of creative pedagogy, which can save reading time, improve reading speed, enhance reading comprehension rate and reading efficiency, and thus promote students' reading ability to a certain extent. Mind mapping can activate students' reading skills to form a clear article structure frame in head. It can clearly show the structure of articles, so that students can more clearly understand and grasp the specific details of each paragraph and analyze the structure and content of the article in detail. Through mind mapping, students will

have a clear grasp of the overall structural context and layout of the article, as well as deepen their understanding of the content of the article and obtain detailed information efficiently. It can improve their ability to analyze micro-details of the article.

Table 10. The *t*-test results of reading comprehension indicators for the two groups.

Reading Comprehension Indicators	**Experimental Group**		**Control Group**		***t***	***p***
	M	**SD**	**M**	**SD**		
Reading time	1.25	0.25	1.90	0.34	6.075***	0.000
Reading speed	250.90	52.87	163.52	30.89	−5.674***	0.000
Reading comprehension rate	0.81	0.14	0.66	0.16	−3.035**	0.007
Reading efficiency	200.32	49.03	109.26	38.67	−5.822***	0.000

(Note. M–Mean; SD–Standard Deviation; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.)

5.4 Summary

By eye tracking analysis, the reading process can be inspected in-depth. In this study, we used eye tracking sensors to record eye movement indicators in real time, which provides a quantitative assessment and data evidence of creative pedagogy's effectiveness on reading ability. The results suggest that there are significant differences between the experimental group and control group's eye movement indicators during the reading processes. Their different eye movement indicators reflect their different states as parts of the process of information input and information extraction. Students in the experimental group were found to understand the reading materials more promptly, showing fewer fixations, fewer regressions, longer saccades, and larger pupil diameter, which measured creative pedagogy effectiveness on reading ability from the perspective of analysis data to evaluate the association-based activities on foreign language proficiency more comprehensively.

This study only applied six eye movement indicators to describe and explain the reading process. It may give limited implication to the correlation between the improvement of reading ability and the eye movement indicators. More eye movement indicators could be considered for further investigation and verification, such as

refixation rate, landing position, and first fixation duration. In addition, in future work, we look forward to recognizing students' cognitive and emotional status according to their eye movement indicators in order to have a more comprehensive and in-depth understanding of the cognitive process of reading.

Chapter 6 Conclusion

Content

- **Contribution**
- **Future research direction**

Chapter 6
Conclusion

Based on the findings obtained from previous researches and the practical lecture analysis, we presented a future creativity cultivation model in the foreign language classroom (Figure 32), which help students improve their creativity, including creative thinking skills, foreign language proficiency and learning motivation.

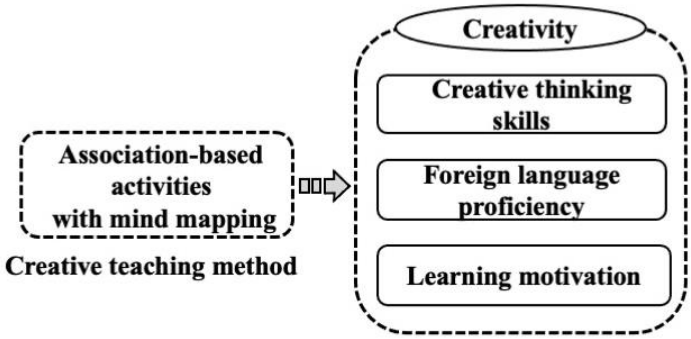


Figure 32. Creativity cultivation model in foreign language classrooms.

Creative teaching method of association-based activities with mind mapping, a topic on which there is little previous research in foreign language education, is the creative pedagogy proposed in this study. This teaching method enabled students to stimulate divergent thinking through associations. Meanwhile, it enlivened the classroom atmosphere to enhance their learning interest and foreign language ability. This kind of teaching model has changed the past teaching methods that simply explained vocabulary and grammar in foreign language classrooms, and filled the blank of creative teaching in foreign language education.

Moreover, in order to evaluate the effectiveness of the creative pedagogy, this study used a combination of traditional methods evaluation and biometric data analysis to optimize the evaluation method of creative teaching. Besides creative thinking test for exploring students' creative thinking skills, EEG investigation was applied for

checking their divergent thinking skills when they were doing divergent thinking tasks; In addition to the language proficiency test for testing students' foreign language performance, eye tracking detection was used for recording their reading process to investigate their reading ability. The results showed that this combination assessment method can provide more convincing evidence data for the evaluation effects. As was shown in Figure 33, we presented a creativity assessment model that can be applied for the future creativity assessment in foreign language classrooms.

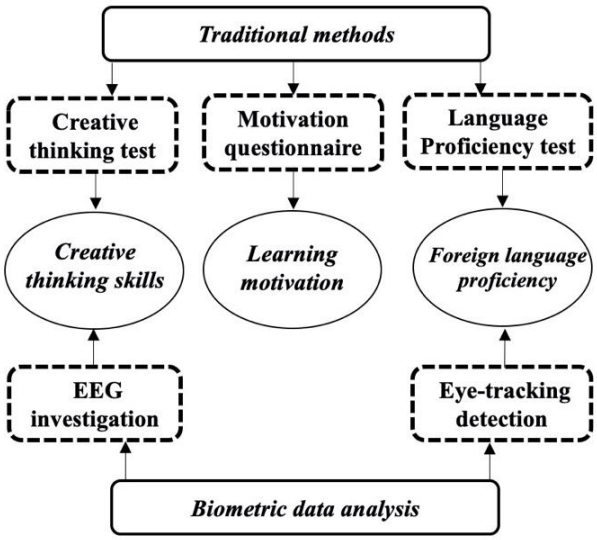


Figure 33. Creativity assessment model in foreign language classrooms.

6.1 Contribution

6.1.1 Academic contribution

An important criterion for measuring the quality of talents in current society is the level of creativity. How to cultivate students' creativity in foreign language classrooms is an important issue in the foreign language education. The foreign language education in universities shoulders the mission of cultivating creative foreign language talents. This requires that students should not only be taught foreign language knowledge, but more importantly, their creative thinking skills and pioneering and enterprising ability should be cultivated to adapt to the development of society. The main academic

contribution of this study is the construction of the creativity cultivation and assessment in foreign language classrooms in the universities.

This study provided theoretical support for creativity cultivation in the field of foreign language education in colleges and universities. Through the research and practice of association-based activities with mind mapping, this study explored whether it is suitable for creative teaching in foreign language classrooms in colleges and universities. The creative pedagogy that presented in this study can emphasize the subjectivity of students, fully mobilize their enthusiasm and initiative in learning, and transform their learning style from “knowledge accumulation type” to “knowledge exploration type”.

Association-based activities in the daily foreign language classroom training can get the simultaneous development of “foreign language understanding and creative thinking”, “foreign language proficiency and learning ability”, and “foreign language knowledge and enthusiasm for learning”. The teaching process was student-oriented, which helped them express and communicate ideas and thoughts creatively and freely, and to stimulate their interest in learning foreign languages and improving learning effects. This creative pedagogy provided students with creativity-focused classroom activities, so that students’ creativity can be fully developed. The EEG investigation and eye tracking detection experiments were used to verify the teaching effect, which provided a more effective basis for creativity assessment. Overall, this study presented a new way for cultivating students’ creativity, including creative thinking skills, foreign language performance, and learning motivation, and provided an effective theoretical basis for creative foreign language teaching.

6.1.2 Practical contribution

At present, foreign language teaching in universities provides little space for students to carry out creative learning, which directly affects the cultivation and development of their creativity. This study explored the theory and practice of foreign

language classroom teaching methods that promote the creativity development of students, which emphasized on the combination of learning and thinking in teaching process. The association-based activities with mind mapping advocates heuristic and participatory teaching, stimulate students' creative thinking skills and learning motivation. Moreover, the effectiveness of this creative pedagogy was evaluated by combining traditional testing methods with modern science and technology.

In foreign language education research and practice, exploring creativity development methods and evaluation approaches can provide support and guidance for cultivating creative foreign language talents. By constructing a new type of teaching model and exploring its evaluation system, this study provided an effective reference for creative teaching design and implementation of foreign language education. It is hoped that it will be popularized and applied to foreign language courses in other colleges and universities.

6.1.3 Original contribution to knowledge science

Knowledge science is a problem-oriented interdisciplinary field. This study set a joint study area of foreign language education and experimental technology for carrying out creativity cultivation and assessment.

Pedagogical content knowledge is essential to the creative foreign language teaching. This study discussed the construction and application of creative pedagogy, which used association-based activities with mind mapping for the foreign language classroom. This creative pedagogy created association atmosphere, cultivated association situations, and encouraged students to use mind mapping for association training. It supported and encouraged students to express novel and unique ideas, and cultivated their creative thinking skills.

This study also developed a set of teaching evaluation and assessment system to test the teaching effect produced by implementing creative pedagogy. The effectiveness was mainly verified from three aspects: creative thinking skills, learning motivation,

and foreign language proficiency. The results indicated that association-based activities with mind mapping is an effective way of creative teaching, which can help cultivate creativity in university foreign language classrooms.

In addition, in order to further verify the effect of creative pedagogy, besides traditional methods, this study proposed innovative creativity assessment of biometric data analysis, including EEG investigation and eye tracking detection, for the creative evaluation methods from the perspective of brain sciences. EEG investigation measured the difference in creative thinking skills between the two groups students by comparing their EEG signals. Eye tracking detection evaluated the impact of creative pedagogy on foreign language proficiency by detecting their reading ability. Biometric data analysis in this study was an innovation in creative evaluation methods in the field of foreign language teaching, which can make full use of analysis data to verify the effectiveness of creative pedagogy.

6.2 Future direction

Although this study achieved its aims in both theoretical and applicational level, certain limitations should be noted.

I. The creative pedagogy intervention was implemented for eight weeks. This length of time was sufficient to investigate the effectiveness but was short to generalize the results. Future research should be conducted with a longer period for the creative pedagogy intervention, and the results should be analyzed further. In addition, all the participants in this study were second-year students who had a basic level of Japanese language. For the students who had intermediate/advanced level of foreign language learners, and who learn different foreign language, further investigation and verification are required to confirm whether the creativity outcomes can also be achieved under the creative pedagogy presented in this study.

II. The present study focused on the cultivation of creativity in vocabulary and literacy learning. All five skills of listening, speaking, reading, writing, and translation

are significant in foreign language teaching and learning processes. Future research should be conducted on the use of the creative pedagogy intervention on listening, speaking, and translation learning processes to see whether it results in more comprehensive forms and methods for students' creativity cultivation.

III. In order to provide biometric data analysis, this study conducted EEG investigation on creative thinking skills and eye tracking detection on foreign language proficiency. Although the sample size was sufficient to clarify the effectiveness of creative pedagogy, it is still a small number for the generalization of the results. In the future, it is necessary to conduct the experiments with larger number of participants and to analyze the results further. Moreover, in this study, we haven't applied biometric data for further analyzing students' learning motivation. In the future studies, we will consider other signals to measure students' learning motivation status in the foreign language classroom. On this basis, we can make more accurate biometric data analysis on creativity outcomes.

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Research accomplishment

1. The paper published in journal

Ting Liu, Takaya Yuizono; Mind Mapping Training's Effects on Reading Ability: Detection Based on Eye Tracking Sensors; *Sensors*; *20*, *4422*, 15 pages, 2020. (Doi:10.3390/s20164422; Indexed by Scopus, SCI; Impact factor: 3.275; SJR Q1)

2. Conference proceedings

(1) International conference proceedings

- Ting Liu, Takaya Yuizono; Developing Innovation Skills in Second Language Education-Cultivation of Creativity and Intercultural Communicative Competence-; *The 13th International Conference on Knowledge, Information and Creativity Support Systems (KICSS-2018)*; pp.47-52; November, 15-17, 2018, Pattaya, Thailand.

- Ting Liu, Takaya Yuizono; Eye Movement Characteristics in Reading Foreign Language Text Based on Mind Mapping Training; *The 5th International Conference on Education (IICE Hawaii-2020)*; Oral presentation, January, 10-12, 2020, Honolulu, Hawaii, USA.

(2) Domestic conference proceeding

Ting Liu, Takaya Yuizono; Proposal of Curriculum for Foreign Language Education to Cultivate Creativity; *The 40th Research Conferences of Japan Creativity Society*; pp.97-100; September, 11-13, 2018, Osaka, Japan.

Appendix 1

Association-based Activity Teaching Plan

Association-based Activity Teaching Plan

Teaching Content	This practical lecture will apply a creative pedagogy that uses association-based activities with mind mapping for the foreign language classroom. Association-based activities are a learning process to select a knowledge as a starting point for associating related knowledge in the process of drawing a structure diagram, which could help students firmly grasp the knowledge they have learned, and help them to establish connections among knowledge and perform a flexible transfer of the knowledge. As an effective tool of associative thinking, mind mapping can help students to associate ideas, develop creative thinking skills and potential. It can also facilitate creative thinking through invigorating the classroom atmosphere during the learning process. Association activities with mind mapping can encourage students to think creatively. ***1. Vocabulary association activity*** Starting from the central word presented on the worksheet, students add related words (phrases or sentences) around the central word to draw mind maps within a given time limit of 5 minutes. ***2. Association reading activity*** Draw the mind map according to the central idea of the article, and use association and continue to add more detailed information to the mind map within a given time limit of 30 minutes. ***3. Association writing activity*** The teachers distribute some pictures that seem to be no relationship among them, and students are asked to write the keywords of each picture, and associate pictures to get writing topic. Then, the students will draw mind maps on the writing topic, and summarize the contents in order to write an essay within a given time limit of 20 minutes. In the process of drawing a mind map, students can use colored pens, pictures, etc., to highlight the key points, which can make the mind map more clearly presented and impressive; After having finished the mind map, students were encouraged to change and discuss their ideas according to their different mind maps.

Teaching Objectives	The key words of teaching objectives are creative thinking skills, Japanese language proficiency and learning motivation. ***Objective 1*** (After vocabulary association activity) Remember multiple different words in the creative thinking process according to mind maps, and an inclusive language database is formed. In addition, increasing interest in learning to develop good divergent thinking habits and improve comprehensive vocabulary ability. ***Objective 2*** (After association reading activity) Diverge students' thinking on the article topic and add content to their mind maps from different perspectives, to establish a clear foreign language knowledge structure, and stimulate their divergent thinking skills in reading, which would carry out more in-depth language learning and application. ***Objective 3*** (After association writing activity) Students show their ideas and some new creative content focusing on the writing theme in the form of a mind map, and finally edit and adjust, outline the structure and main content of the article, which encourage them to play with association and divergent thinking in writing, turning a potentially boring thinking process into something fun and interesting.
Teaching Procedure	***First week*** Practical lecture 1: Vocabulary association activity 1: Associate vocabularies with mind mapping (Select vocabularies from Lesson 1 in the text book). Practical lecture 2: Association reading activity 1: Write the reading material into a mind map (Select reading materials from Lesson 1 in the text book) Practical lecture 3: Association writing activity 1: Based on mind mapping, write an essay according to the pictures that were distributed by the teacher (One of the pictures is related to Lesson 1 in the text book). ***Second week*** Practical lecture 4: Vocabulary association activity 2: Associate vocabularies with mind mapping (Select vocabularies from Lesson 2 in the text book). Practical lecture 5: Association reading activity 2: Write the reading material into a mind map (Select reading materials from Lesson 2 in the text book) Practical lecture 6: Association writing activity 2: Based on mind mapping, write an essay according to the pictures that were distributed by the teacher (One of the pictures is related to Lesson 2 in the text book).

	Third week Practical lecture 7: Vocabulary association activity 3: Associate vocabularies with mind mapping (Select vocabularies from Lesson 1 in the text book). Practical lecture 8: Association reading activity 3: Write the reading material into a mind map (Select reading materials from Lesson 1 in the text book) Practical lecture 9: Association writing activity 3: Based on mind mapping, write an essay according to the pictures that were distributed by the teacher (One of the pictures is related to Lesson 3 in the text book). ***Fourth week*** Practical lecture 10: Vocabulary association activity 4: Associate vocabularies with mind mapping (Select vocabularies from Lesson 4 in the text book). Practical lecture 11: Association reading activity 4: Write the reading material into a mind map (Select reading materials from Lesson 4 in the text book) Practical lecture 12: Association writing activity 4: Based on mind mapping, write an essay according to the pictures that were distributed by the teacher (One of the pictures is related to Lesson 4 in the text book). ***Fifth week*** Practical lecture 13: Vocabulary association activity 5: Associate vocabularies with mind mapping (Select vocabularies from Lesson 5 in the text book). Practical lecture 14: Association reading activity 5: Write the reading material into a mind map (Select reading materials from Lesson 5 in the text book) Practical lecture 15: Association writing activity 5: Based on mind mapping, write an essay according to the pictures that were distributed by the teacher (One of the pictures is related to Lesson 5 in the text book). ***Sixth week*** Practical lecture 16: Vocabulary association activity 6: Associate vocabularies with mind mapping (Select vocabularies from Lesson 1 in the text book). Practical lecture 17: Association reading activity 6: Write the reading material into a mind map (Select reading materials from Lesson 1 in the text book)

	Practical lecture 18: Association writing activity 6: Based on mind mapping, write an essay according to the pictures that were distributed by the teacher (One of the pictures is related to Lesson 6 in the text book). ***Seventh week*** Practical lecture 19: Vocabulary association activity 7: Associate vocabularies with mind mapping (Select vocabularies from Lesson 1 in the text book). Practical lecture 20: Association reading activity 7: Write the reading material into a mind map (Select reading materials from Lesson 1 in the text book) Practical lecture 21: Association writing activity 7: Write an essay according to the pictures (One of the pictures is related to Lesson 7 in the text book). ***Eighth week*** Practical lecture 22: Vocabulary association activity 8: Associate vocabularies with mind mapping (Select vocabularies from Lesson 8 in the text book). Practical lecture 23: Association reading activity 8: Write the reading material into a mind map (Select reading materials from Lesson 1 in the text book) Practical lecture 24: Association writing activity 8: Based on mind mapping, write an essay according to the pictures that were distributed by the teacher (One of the pictures is related to Lesson 8 in the text book).
Teaching Text book	LIU, L.G., & Gong, W., et al. (2016). The new classic Japanese basic course (Book 4), Foreign Language Teaching and Research Press.

Appendix 2

Association-based Activity Questionnaire

Association-based Activity Questionnaire

Dear all,

Thank you very much for taking the time to fill out this questionnaire. The purpose of this questionnaire is to analyze the impact of association-based activities with mind mapping on your learning motivation.

This questionnaire is anonymous. All data are for research analysis only. There is no right or wrong answer, as long as it reflects your true thoughts.

Thank you for your cooperation and support!

Part 1: Single-choice question

Please select your opinion on the association-based activity with mind mapping accepted in this semester.

1. Study in a free and fun classroom atmosphere
   • Agree • Slightly Agree • Uncertain • Slightly Disagree • Disagree
2. Improve learning enthusiasm
   • Agree • Slightly Agree • Uncertain • Slightly Disagree • Disagree
3. Increase the fun of learning
   • Agree • Slightly Agree • Uncertain • Slightly Disagree • Disagree
4. Make learning content easier to understand
   • Agree • Slightly Agree • Uncertain • Slightly Disagree • Disagree
5. Improve thinking skills
   • Agree • Slightly Agree • Uncertain • Slightly Disagree • Disagree
6. Make language expression more clearly
   • Agree • Slightly Agree • Uncertain • Slightly Disagree • Disagree
7. Deepen understanding and leading to the acquisition of new knowledge
   • Agree • Slightly Agree • Uncertain • Slightly Disagree • Disagree
8. Student-centered teaching
   • Agree • Slightly Agree • Uncertain • Slightly Disagree • Disagree
9. The knowledge learned in the class is impressive
   • Agree • Slightly Agree • Uncertain • Slightly Disagree • Disagree

10. Active learning in the class

• Agree • Slightly Agree • Uncertain • Slightly Disagree • Disagree

11. Improve concentration in the learning process

• Agree • Slightly Agree • Uncertain • Slightly Disagree • Disagree

12. Enhance teacher-student interaction

• Agree • Slightly Agree • Uncertain • Slightly Disagree • Disagree

13. A sense of accomplishment

• Agree • Slightly Agree • Uncertain • Slightly Disagree • Disagree

14. Improve comprehensive foreign language ability

• Agree • Slightly Agree • Uncertain • Slightly Disagree • Disagree

15. Promote the formation of clear learning goals

• Agree • Slightly Agree • Uncertain • Slightly Disagree • Disagree

16. Enhance learning confidence and satisfaction

• Agree • Slightly Agree • Uncertain • Slightly Disagree • Disagree

17. Association-based activity will keep continue

• Agree • Slightly Agree • Uncertain • Slightly Disagree • Disagree

18. Association-based activity can be extended to other universities

• Agree • Slightly Agree • Uncertain • Slightly Disagree • Disagree

Part 2: Free description section

What do you think of the association-based activity with mind mapping in the foreign language classroom?

Thank you for sharing your opinions with us!