Applying Exergames in the Classroom for Learning Chinese

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Abstract

Applying computer games in second language learning (L2) has been proved to be very effective. The integration of learning styles and multiple intelligence theory may reduce students' learning curve and enhance their learning strengths in L2 learning. However, the traditional games used in L2 are either too simple to be attractive to adult learners or too complicated to be adopted in the classroom. In this paper, to apply bodily-kinesthetic intelligence, the authors used motion sensors to design a series of computer games for learning Chinese. It gives learners a new way to engage and interact so that it boosts learning efficacy. Based on the observation that gestures and speech show consistent or related meanings, engaging learners' kinesthetic intelligence has been shown to improve performance for foreign language learning. The authors designed several exergames for practicing Chinese characters and making sentences in classroom teaching and received positive feedback.

Keywords: Microlearning; exergame Kinect; Intel RealSense; kinesthetic

Introduction

Howard Gardner is the best-known for this theory of multiple intelligences. According to this theory, people have many different ways of learning. Gardner's theory had a particular impact in the field of education, where it inspired teachers and educators to explore new ways of teaching aimed at these different bits of intelligence (Cerruti, 2013). This theory can "validate educators' everyday experience: students think and learn in many different ways. It also provides educators with a conceptual framework for organizing and reflecting on curriculum assessment and pedagogical practices. In turn, this reflection has led many educators to develop new approaches that might better meet the needs of the range of learners in their classrooms." (Palmer, 2001).

Using the multiple intelligence concepts, we designed and implemented computer-aid language learning tools in teaching Chinese. Computer-assisted teaching is not new, and its apparent effect has been recognized in the teaching world. Computer-assisted instruction is diverse; the most popular one is the computer game, especially in language learning (Sykes & Reinhardt, 2013). Many teachers use ready-to-use or self-made games to enhance learning effectiveness. With simple logic and interfaces (using keyboard and mouse), most of these games are effective supplementary tools in classrooms. However, such computer games become less attractive to college students. First, the game logic is too simple; second, the interaction is tedious. Therefore, college faculty tend to use

traditional teaching methods rather than computer games in the classroom. However, it is suggested that computer games may be useful to language learning and instruction.

With the rapid development of computer hardware recently, video games have become very popular, and the interactions between computers and players are more diversified. According to the Entertainment Software Ratings Board statistics in 2021, the worldwide video game market value has reached over $155.89 billion in 2020. One of the important reasons is the innovation in human interaction and motion sensors introduced in computer technology, such as exergames, requiring participants to be physically active or exercise to play the game. Exergames often require motion sensors, such as Kinect/Azure from Microsoft (Kinect Azure website & Microsoft Kinect website), RealSense from Intel (Intel Conceptual Challenge, 2013), and PlayStation Move from Sony. These devices can detect the motion of humans and objects and introduce a new way of communication between humans and computers. Many educators have had the experience of not being able to reach some students until presenting the information in completely different teaching methods or providing new expression to the student. For example, one has a hard time understanding a concept through verbal explanation but probably easily understands it after seeing a picture. Because of these experiences, the theory of multiple intelligences resonates with many educators, and a one-size-fits-all approach to education will invariably leave some students behind. Motion sensors allow students to apply their bodily Kinesthetic intelligence in classroom learning. In addition, learning-based game development grows rapidly. For example, the learning-based games market value has reached $2.5 billion in 2015, and the growth rate has been 15.4% for the past few years. This paper introduces a design of simple and effective computer-based educational games using a motion sensor, including experimental analysis conducted in a US college, which improves foreign language learning in the classroom environment.

Microlearning, dealing with small learning topics and short-term learning activities, has been applied in language learning in the last decade. Microlearning refers to micro-perspectives in the context of education. For language learning, micro aspects refer to vocabularies, phrases, sentences, and grammar rules, which are essentially the focus of the second language curriculum in colleges. The microlearning concept has been adopted in many educational games for language learning. In the paper, the micro-learning concept is utilized to design an exergame for learning Chinese.

Theoretical foundation of exergames for language learning

Exergames need additional human input and have a natural advantage on the freedom and comfort of use. In 1983, the Harvard Graduate School of Education Psychological Developmental scientist Howard Gardner found that human learning abilities are different from earlier research. Its rationale is Gardner's theory of multiple intelligence (Gardner, 1993). This was later called the theory of multiple intelligences or learning styles. Human learning styles include:

- Linguistic intelligence ("word smart")
- Logical-mathematical intelligence ("number/reasoning smart")
- Spatial intelligence ("picture smart")
- Bodily-Kinesthetic intelligence ("body smart")
- Musical intelligence ("music smart")
- Interpersonal intelligence ("people smart")
- Intrapersonal intelligence ("self smart")
- Naturalist intelligence ("nature smart")

One has his/her own learning styles according to his/her learning intelligence. Traditional computer games may apply different bits of intelligence, for example, spatial intelligence, musical intelligence,

linguistic intelligence, and logical intelligence, people with learning intelligence could learn more efficiently through these computer games. In this project, the authors are interested in applying bodily-kinesthetic intelligence in second language learning. Body-kinesthetic intelligent learners are good at using the whole body to express thoughts and feelings and the capacity to use hands to produce or transform things deftly. These people cannot survive for long sedentarily, and they like using hands to build things, love outdoor activities, talking with people, and using gestures or another body language. They can think through what the body feels when they learn. Bodily-kinesthetic intelligence enables us to apply a motion sensor as a teaching aid during second language acquisition (Beaudin et al., 2007). During traditional teaching, instructors always pay attention to linguistic intelligence and logical-mathematical intelligence in learning while ignoring the use of students' other abilities to learn effectively. How to maximize teaching results? Gardner's theory provides the foundation for this project. Using students' kinesthetic intelligence, the authors designed a few simple exergames and applied them in the classroom as teaching aids.

Using students' kinesthetic intelligence, the authors designed a few simple exergames and applied them in the classroom as teaching aids. These games are a good fit for vocabulary and sentence practice for pronunciation of new words, writing Chinese characters, restructuring sentences, and so on. The main benefits of the games are as follows:

Engagement: Unlike traditional PC games, the exergames require body movement. It creates a positive classroom learning environment. Learning new vocabulary is usually boring, and hence the exergames help to demolish boredom and increase retention in the classroom. They enhance language acquisition through their own activities. (Erradi, 2013).

Interaction: Compared to most other traditional PC games, the exergames are more realistic and more immersive. It easily piques students' learning interest, especially those students who have bodily-kinesthetic intelligent learning characteristics. Different from traditional PC games, more than one student can play the game with exergames at the same time. Students can compete with each other in the classroom, and hence it promotes learning interests. It encourages the student to participate in the game-based exercises. (Logsdon, 2021)

Related literature

Various forms of gaming have been shown to be effective tools to augment language learning, including game-enhanced and game-based second language teaching and learning (Sykes & Reinhardt, 2013). *Game-enhanced second language teaching and learning* (L2TL) indicates vernacular, commercial games, which have not been designed for educational purposes but can be applied as supplemental learning tools for L2TL (Viberg & Grönlund, 2012). Game-enhanced L2TL have been produced all over the world, in different languages. They are regular games, which cover a variety of genres (i.e., Action, Adventure, Role-playing games, and Strategy games), in different types (i.e., Traditional, Casual, and Social), played by a single user, multiplayer, or massively multiplayer. They are running in various technology platforms, including personal computers, game consoles (i.e., Microsoft Xbox and Nintendo Wii), and mobile platforms (i.e., Tablets and Smartphones). The games can be run as a stand-alone version or multi-players via the network (internet). They could be free to download/play, with one-time registration/purchase cost for one copy, or requires a monthly subscription fee.

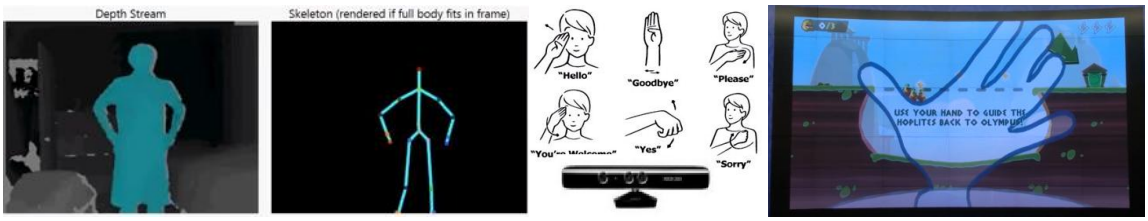
The Game-based L2TL is defined as "games and game-inclusive synthetic immersive environments that are designed intentionally for L2 learning and pedagogy" (Sykes & Reinhardt 2013). These games can be classified into two categories: traditional games and Microlearning-based games. The traditional game-based L2TL includes adventure-based games (i.e., Mentira) (Mentira Website). Game-based L2TL, on the other hand, includes games designed and developed for L2TL. Tacticle

Language and Culture Training Systems (Johnson & Valente, 2009) and Role-play-based games (i.e., Middworld (Middworld website), Zon (Zon website), and Lost in Middle Kingdom (Doe, 2014). Each game is only used to learn one or two second languages. For example, Mentira is for Spanish; Zon is for Mandarin; MiDDWorld is for French and Spanish. Most of the games have been designed for L2TL research purposes, and only demos have been developed for preliminary experiments or proof of concept. Croquelandia is only a research prototype; Zon is underdeveloped, and it is not available now. Tacticle is restricted and only available for purchase by primarily military entities. The traditional game-based L2TL has complicated logic, and hence it may not suit classroom activities, which only aim to enhance students learning, such as new vocabulary and grammar. In addition, these games are required users with intermediate second language proficiency, so they are not suited for entry-level learners.

Many mobile applications have been developed to help second language learning using Microlearning (Viberg and Grönlund 2012). However, only a limited number of games are available. Researchers from Microsoft developed a few Microlearning applications for second language learning, including adaptive flashcard-based games for second language Microlearning on a mobile platform (Edge & Landay, 2012) and a simple mobile game to help Mandarin learners train the tonal sound system of Chinese (tone is considered as one of the most difficult parts of Chinese) (Edge et al. 2012). Erradi et al. designed a mobile game to learn vocabulary (Erradi et al., 2013). Though the studies showed that the games are effective for language learning, the design of the game interfaces is poor. In addition, some simple online language-learning games are available, but most of them are designed for young kids, and few games are attractive to college students. The design of the interface and gameplay need to be improved for college users.

The recent emergence of consumer 3D depth-sensing devices such as the Microsoft Kinect and Azure Kinect (Kinect Azure website & Microsoft Kinect website), Intel RealSense (Intel Conceptual Challenge 2013), and Leap motion (Leap Motion website) brings the prospect of new and immersive gaming experiences previously impossible with traditional input modalities such as the mouse, keyboard, joystick, and gamepad. These devices have created a new class of games known as “exergames” - computer games with a physical exercise component, which became more and more popular from kids to adults. The gestures that people produce when they talk do play a part in communication, and they do provide information to co-participants about the semantic content of the utterances, although there clearly is variation about when and how they do so (Kendon, 1972). Because skeletons and gestures can be identified and tracked by the motion sensors, sign languages - dynamic gestures characterized by continuous hand motions and hand configurations, can be recognized using Kinect (Chai et al., 2013; Gameiro et al., 2014; Yang ,2015; Zafrulla et al., 2011). Exergames can be applied in the classroom, either as a new way to deliver new content or as classroom exercises to enhance students' learning/understanding. They could be designed with a single-player or with multiplayer. Engaging learners’ kinesthetic intelligence has been shown to improve performance for foreign language learning.

Applying multiple intelligences increases engagement and learning efficacy and provides teachers a better understanding of students' knowledge and skills (Darling-Hammond, 2010). Therefore, the 3D sensors promise to create kinesthetic games to help learners acquire second languages through constructions grounded in 3D space and body motion. *“No more monologue by the teacher aimed at the students who don’t retain half of what they hear. No more boredom in the classroom.“ Language is no longer the barrier; physical impairment is no longer a shortcoming.* Interactive *schooling is the way of the future.”* (Reinhardt & Sykes, 2012) Both multiple intelligences and learning styles can work together. They can form a powerful and integrated human intelligence and learning model, which respects and celebrates diversity. In addition, the model can also provide students tools to utilize different learning styles and learning standards (Silver et al., 1997).



(a) **(b)**

Figure 1. (a) A depth image and the skeleton detection captured by a motion sensor; and (b) Sign language recognition (with gesture recognition) using a motion sensor. (3) an exergame using Realsense

Motion sensors provide real-time motion capture, image recognition, microphone input, voice recognition, community interaction, and other features. Motion sensors often capture the 3D motion and voices of players. Therefore traditional game control is no longer necessary. In other words, students can play an exergame by using gestures in the classroom. Though it's designed for game consoles, it is also widely used for the research community, for example, Computer Vision, Robotics, and Education. It allows teachers and researchers to make the classroom atmosphere more active and enhance teaching efficacy.

The overview of the study

Our study is based on the multiple intelligences theory. This theory represents different intellectual abilities and learning styles. They have been categorized in a number of different ways: visual, auditory, and kinesthetic, impulsive and reflective, right brain, and left brain. Our games are designed using the kinesthetic learning ability. In the study, the following research question is asked:

- Does applying exergames in the classroom contribute to Learning Chinese?

Method

Participants

There are two groups' students who participated in the research. They are all freshmen in the level 1 Chinese class in a US college. To make a fair comparison, the authors selected students from two classes at the same level.

Table 1. Participants in the experiment

	Male	Female	Teaching with the exergames	Language level
Class 1	11	18	Yes	1
Class 2	14	8	No	1

Table 2: Participants of the experiment (Ethnic differences)

Race of the students	Asian	African–American	Hispanic	White
Class 1 using exergames	5	6	14	4
Class 2 w/o exergames	3	10	7	2

Tools

The tools that were used to play these games are PC, motion sensor, and game software. The authors have developed the game software on Windows 10, using C# programming language, with a Microsoft Kinect for the motion sensor. The game runs on a PC, either a laptop or a desktop PC.

Procedure

After a new lesson has been finished, the author lets students practice in two steps: first, set up the device (connect Kinect, game software with PC) and free up space (1.6X2 meters) in the front of the classroom; second, explain the rules of the game and let students try. Usually, the instructor calls one or more students for the first round. Then other students will voluntarily play the games. The authors selected two classes with the same language level. The authors used the exergames in one class and another class without the exergames.

The authors gave the same quiz to two classes till the authors finished teaching each topic. Below is two sample quiz questions:

a) Write a number according to the audiotape (playing audio including the following 10 numbers):
{13, 57, 82, 40, 65, 91, 24, 33, 7, 0}

b) Write Chinese characters according to English words below:
{old brother, younger sister, has/have, who/whom, family}

The full credit of each quiz is 2 points for each question, and the total is 40 points for 20 questions.

The games have been designed using Microlearning concepts, which only cover small topics and fit classroom needs. In this project, the authors have designed and developed exergames using a motion sensor for undergraduate students learning Chinese. Combining the knowledge of computer vision and the technologies in exergame, the authors designed a series of games using 3D motion sensors with body motion tracking and gesture recognition. The exergames can be split into two categories, generic-purposed exergames, and specialized games.

Generic exergame has been designed for learning Chinese vocabulary and sentences. Figure 2 includes two examples. Figure 2a is an in-class competition-based game for language learners as a group-based activity while reviewing new vocabulary. The logic of the game is simple. There are a number of pairs of cards in the game. A pair of corresponding words in English and Chinese (for example, “Hello” and “Ni Hao”), or a pair of corresponding questions and answers can be hidden under a pair of cards (for example, “我们明天一起去打篮球” and “We will play basketball tomorrow.”). All of the cards are positioned randomly every time. The students use hand gestures to flip cards and match two cards in the same pair. They have to understand the meanings of the cards and also memorize their locations. The game also includes an interface to allow teachers to prepare new vocabulary or questions and answers. The authors used the game to practice two topics: “greetings” and “family members”.

Figure 2b shows an exergame for practice Chinese vocabulary and phrases and the idea borrowed from the well-known game “FruitNinja”. In this example, students are expected to use hand gestures to cut the green fruit. They need to understand the questions (“削下面水果的颜色：绿色”) and find out the green fruit, and it tests if students memorize colors in Chinese. Note that the game can be used to test other vocabulary and phrases as well.

(a) (b)

Figure 2. Two Microlearning exergames have been designed (a). A card-based exergame to match Chinese vocabulary; (b). An exergame for practice Chinese, and the idea borrowed from the well-known game “FruitNinja”.

Specialized Exergame is designed for a challenging and important concept. Figure 3 shows an example of a game for the students to learn direction concepts since it is a very important topic. The authors display a big map with street names and some landmarks on the screen; students follow the direction given by the teacher to get to a destination. They use hand gestures to drag and drop the avatar into the right place on the map. The game tests student listening skills (e.g., left, right, east, west, north, south) and reading skills (e.g., street names or sign names in Chinese.) Students finish the exercise and learn knowledge in a virtual environment. Because the motion sensor is utilized for the user interface (a tool to control the exergame), similar simple games can be easily developed and utilized in the classroom to improve classroom engagements and participation.

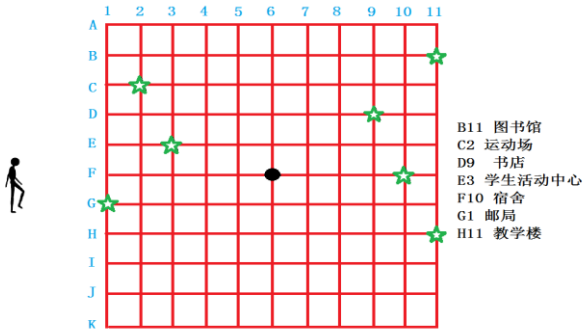


Figure 3. Microlearning games of direction

During the class, after explaining the instructions, the instructor will implement different activities to Analysis. Every student has to complete four quizzes to evaluate the effectiveness of the proposed exergames. In addition, students are required to complete the survey at the end of the semester. Both quiz scores and surveys are used for analysis. For the quiz questions, we analyzed their listening and writing comprehension separately and applied independent samples t-test in statistical analysis to study whether the proposed exergame affects the student learning in listening and writing comprehensions.

Results and Discussion

The chart below (Figure 4) shows the average scores of quizzes, reflecting the learning efficacy after applying the exercises in listening and writing. It is generally admitted that listening is easiest, and writing is the most difficult in Chinese learning. The statistics show that exergames help the students in both listening and writing, especially in writing. Table 3 shows the statistical analysis of listening

comprehension in the quizzes by comparing scores of listening questions between two classes, with and without using exergames. Though the average score of the class using the exergames improves, the result is not significant at the 0.05 level.

Table 3 shows the statistical analysis of writing comprehension in the quizzes by comparing scores of writing questions between two classes, with and without using exergames. The result is significant at the 0.05 level. It is probably because the proposed exergame requires the students to memorize Chinese numbers' meaning and what the Chinese characters look like.

Table 3. Statistical analysis of listening comprehension in the quizzes

	Mean	Standard deviation	t	Sig (2-tailed)
Class1 (game)	82.3	14.3	1.23	0.108
Class2 (no game)	76.8	16.7		

Table 3. Statistical analysis of writing comprehension in the quizzes

	Mean	Standard deviation	t-test	Sig (2-tailed)
Class1 (game)	84.8	17.9	2.60	0.011
Class2 (no game)	70.7	19.5		

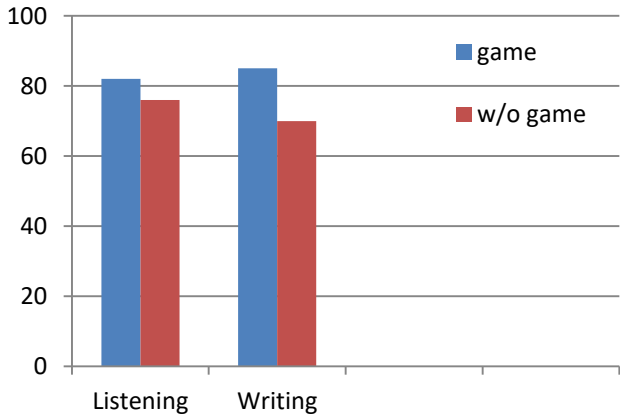


Figure 4. Average scores of all quizzes

The authors also asked the students in group 1 to finish a survey after the study. There were 29 students who participated in this survey. Since one student did not complete the survey questions, the authors collected only 28 valid survey sheets. From the survey, the authors found:

The games are attractive. Almost 80% of the students like to play and want to play more. It shows that students are interested in playing games in the classroom. Even though they had to walk to the front in the classroom and show body movement in front of others, they showed their interest in playing the game. About 90% of the students found this kind of game easy to play. It does not require any playing skills and training so that the players can focus on the content of the game. The study also shows the exergames are effective to different learning concepts. The authors believe the reason is that the students enjoyed and focused more on the procedure of learning, which is the key to exergame-based learning, and it motivates us to design more interesting and meaningful exergames.

(2) How to improve our game and utilize it in Chinese language learning. As we know, exergame is one of the computer-based games. But it has its unique feature: players move their bodies to complete the game. Hence the game should be designed with the following characteristics:

a. They should be fun. Not all students have the same learning styles. How do the authors attract students to play exergames if they are not bodily-kinesthetic intelligence learner? The answer is that the game should be fun and interesting.

b. They should be challenging. The games should have abundant content that challenges the students but can also be understood and utilized easily. If the games are too simple, students will lose interest quickly.

c. A moderate length of game practice: Students need to walk to a specific place to play an exergame. It takes 1-2 minutes to get ready to play. Our students played entry-level games which took 3-4 minutes to finish. Once a student completed one round, the next round started with the next student.

Table 3. Participants of the Survey

Numbers	Grade	Language level	Valid survey
29	Freshmen	1	28

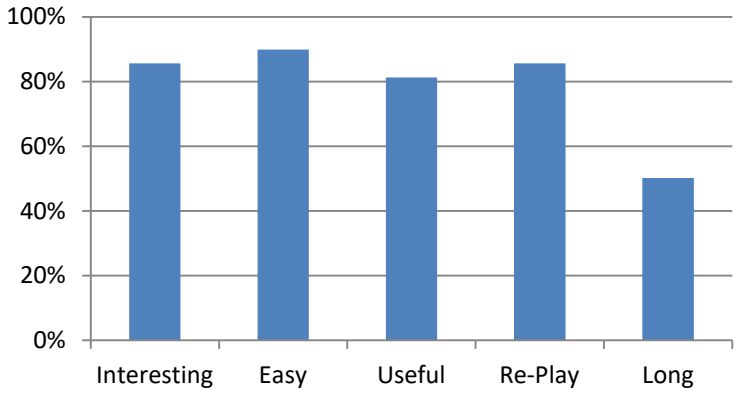


Figure 5. Survey Results

Video games are supplemental teaching tools. It provides multiple training aspects for learners and attracts more learners with different learning habits. The games are not expected to replace teachers' instructions. Nevertheless, it is a good method to encourage students to be engaged and active classroom atmosphere. In the future, the authors would design an easier implemented interface for instructors to modify games' contents according to their requirements. For example, for vocabulary games, instructors are allowed to modify the games and add new vocabulary easily according to the curriculum, without modification of the programming. Engaging learners' kinesthetic intelligence has been shown to improve student learning of different subjects, especially in vocabulary learning.

Conclusion and Future Research

In this paper, the authors have designed and implemented exergames using motion sensors. The preliminary experiments show that the games help improve learning Chinese vocabulary. The authors believe the experiment proved that engaging learners' kinesthetic intelligence could improve student learning effectiveness, especially in vocabulary learning. Currently, the authors are

performing more comprehensive experiments. In the future, the authors would improve the game design so the games could maximally use the advantages of motion sensors, and gameplay could be improved

Human learning abilities are diverse. Different learning styles indicate different ways to interact with the world. Each person favors certain learning styles. This is significant because when one prefers a specific learning style, it affects his or her success. Since bodily-kinesthetic intelligence is just one of them, the proposed exergames make use of this intelligence. Compared to traditional language teaching, based on the audio and video design for teaching activities, it opened up a new field of an activity design. With the continuous improvement of motion sensors, there will be more people playing the Exergame. According to a US technology blog site Business Insider, motion sensors were selected as one of the 10 most important electronic products of this century. With the popularity of motion sensors and exergames, it is more convenient and potential to apply them for L2 teaching in the classroom.

As a classroom teaching aid, the exergames also have some limitations. First, for kinesthetic intelligent learners, the effect using exergames in the classroom is obvious. During our exergames practice in the classroom, the authors found some students were willing to use this type of game, and in the subsequent classroom test, the result is significant. But not all students belong to the kinesthetic intelligence learning type. The teacher might expect some students to have no interest in playing such games, although this does not affect exergames in the role of a teaching aid. Secondly, there were no ready-to-use L2 exergames in the market; existing exergames are not easy to be adopted to the college curriculum. The authors are planning to develop a series of games on one topic to help students acquire the Chinese language through constructions grounded in space and motion.

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