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SMART BOARD-BASED ASSESSMENT OUTCOMES OF IMPLEMENTING OUTDOOR TRANSDISCIPLINARY LANGUAGE INSTRUCTION FOR PUPILS

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ABSTRACT

Aim/Purpose	The purpose of this research was to examine the potential outcomes of applying the outdoor transdisciplinary language instruction paradigm to primary school students' cognitive and emotional improvement with smart boards as an assessment tool.
Background	Traditional approaches to teaching English in primary schools do not give particular consideration to outdoor transdisciplinary learning for students' cognitive and emotional improvement, especially in terms of effective assessment. Hence, in this study, outdoor drawing was integrated with teaching English to create a transdisciplinary paradigm and smart boards were adopted in the assessment.
Methodology	A pre-test post-test quasi-experimental design using an equivalent control group was employed, in which learning performance, emotions (typically positive emotions), and reported satisfaction level were compared via an English vocabulary

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test, the Chinese version of PANAS, and a structured self-reported satisfaction instrument. E-prime 2.0 was used to register data for the three instruments and to complete the vocabulary identification phase while smart boards were adopted as an assessment tool to evaluate students' learning performance. The data collected were analyzed using an independent t-test and the non-parametric Mann-Whitney U test using SPSS 22.0.

Contribution: Unlike traditional research, which only utilized smart boards as presentation tools, this research provided evidence for the effective use of interactive technology as assessment tools for innovative language learning in primary school settings.

Findings: Results indicated that outdoor transdisciplinary drawing developed more positive emotions and higher satisfaction among students and showed significantly higher learning performance compared with indoor transdisciplinary drawing. Moreover, smart board-based assessment scores showed that students were more effectively engaged as compared to E-prime-based assessment.

Recommendations for Practitioners: The findings suggest that instructors should try to allow students to have more opportunities to explore language activities in school-based outdoor environments, which benefits their cognitive and emotional improvement. Moreover, using smart board-based assessments should be encouraged since more authentic performance could be elicited.

Recommendations for Researchers: This research mainly focuses on the effects of learning environments and assessment tools in transdisciplinary language instruction. Hence, researchers can employ an updated design to focus on the transdisciplinary setting to investigate more interesting outcomes.

Impact on Society: Schools should adopt more new interactive digital technologies to improve assessment for students' innovative learning in different contexts, which can help students develop more transversal skills, benefiting their employers and making them even more competent. More critically, government support is needed to encourage schools to use emerging technologies for educational reform in the classroom, and linkages between technology vendors and schools could be encouraged to provide subsidies and other measures to less financially able schools.

Future Research: Future research could explore the differences in the interaction effects of class type and learning environments on students' learning outcomes. In addition, longitudinal assessments to investigate the intensity of the experimental intervention could provide more interesting results on the long-term effects and suggest more sustainable use.

Keywords: smart board, place-based pedagogy, transdisciplinary language instruction, learning performance, positive emotions

INTRODUCTION

Knowledge in real life is interrelated and difficult to isolate. This is increasingly reflected in school-based subjects, where learning tends to focus on more integration between subjects. The trend is currently the mainstream for curriculum-related reforms in schools. A curriculum integration project in New Zealand schools by The New Zealand Council for Educational Research in 2018-19 showed that the majority of teachers who implemented curriculum integration confirmed that integrative learning enables students to build meaningful relationships between knowledge and was more engaging for students (McDowall & Hipkins, 2019). The Finnish National Board of Education (2016) had also seen the value of integration as it launched a new core curriculum in 2016 which focused on the reforms of values, learning environments, and pedagogical approaches, especially transversal competence areas "that cross the boundaries of and link different fields of knowledge and skills" (p.21). Z. T. Li and Wen (2020) pointed out the transition to integrated education from 'All-round Education' is the current trend for educational reform in China, indicating the need for an integrated curriculum for students. This is especially true in primary schools. All-round Education, in line with developing transversal competence in Finland, serves as China's modern educational policy, demanding reforms in teaching to focus on integration and transversal competences (e.g., aesthetic skills and physical fitness). Thus, curriculum-related reforms in China have begun to focus on developing students' competences. Classes at school must promote innovation in terms of teaching content, methods, etc.

In developing students' key competences, cognitive and emotional outcomes during teaching can be investigated. To maximize the effects of outcomes, the teaching strategies need to be more dynamically integrated, which means that two or more subjects need to be integrated into a lesson so that students experience more authentic learning and improve both cognition and emotions. According to Kaufman et al. (2003), three main types of integration exist in teaching, namely, multidisciplinary, interdisciplinary, and transdisciplinary teaching. Among the three, the transdisciplinary approach has the highest level of integration, since being transdisciplinary requires learners to undertake real-life problems or projects and apply knowledge and skills from multiple disciplines. For instance, the educational paradigm, called STEAM (science, technology, engineering, arts, and mathematics) education, typically represents a transdisciplinary approach that focuses on participatory processes (Polk, 2015) and problem-solving (Lawlor et al., 2015).

As highlighted above, being transdisciplinary refers to a teaching and learning approach, which focuses on learners' active involvement and motivation to address issues. Loibl et al. (2017) reviewed previously relevant research on the learning approach called PS-I, including two phases, that is, the problem-solving phase and the instruction phase (PS-I). Among the two phases, the instruction phase is designed to teach students relevant knowledge explicitly. Hence, transdisciplinary language instruction is defined as the language-teaching process which focuses more on collaboration and interactions that are student-centered and highlight problem-based learning (PBL), featured by integrating English with components of other subjects (Loibl et al., 2017). Nevertheless, if English classes adopt a transdisciplinary approach, the outcomes of interdisciplinary language instruction are highlighted and could focus more on learners' participation in learning and acquisition of useful skills. Additionally, an authentic real-life problem in English is often selected to demonstrate students' knowledge and realize the learner-centered exploration, accompanied by group collaboration, active discussion, and other strategies. Furthermore, in terms of creating a more authentic learning environment for transdisciplinary language instruction, school-based outdoor settings have the potential and provide advantages such as the availability of numerous resources and possibilities of a more sustainable assessment (Hill & Hannafin, 2001) as compared with traditional classrooms.

Environmental changes related to teaching foreign languages in schools have been drawing more practical attention. For instance, Forest School has been gaining popularity among English primary schools (Coates & Pimlott-Wilson, 2019). Various practices based on different outdoor learning environments make place-based pedagogy become a new way of learning connected to space (Miller, 2018). According to features of place-based pedagogy and the former definition of transdisciplinary language instruction based on PS-I (Loibl et al., 2017), outdoor transdisciplinary language instruction is conceptualized as the language-teaching process in outdoor environments focusing more on collaboration and interactions that are student-centered and highlight PBL, which integrates English with components of other subjects.

Furthermore, adopting the paradigm of teaching transdisciplinary English, which is featured by PBL, is often related to technology-based pedagogy and demands an updated assessment for learning outcomes. This is distinct from traditional classroom-based assessment practices that are largely dependent on traditional print media and less on digital technologies. Digital tools-based assessment seems to have advantages over traditional assessments, thus leading to more research in recent years. For instance, multimodal digital classroom assessments (MDCAs) can be used as a subset of classroom assessments, especially for students' formative assessments (Fjørtoft, 2020). For specific subjects, the use of a digitally formative assessment tool for measuring mathematics achievement and motivation in grade-three primary education was found to be effective via a randomized experimental design (Faber et al., 2017). Currently, teaching using smart boards is prevalent in schools in China. Smart board-based activities are commonly featured by 'touch-screen' interactions for an interactive learning experience. For instance, to assess if students memorize vocabulary well, a smart board can present a more dynamic stimulus for students to respond to. Additionally, smart boards can be updated quickly, and more personalized or customized functions can be added to empower students to obtain a more dynamic learning experience (Mun & Abdullah, 2016). This also suggests that there is a potential for using smart boards as an assessment tool, and hence this study investigates the use of smart boards for assessment in the outdoor transdisciplinary language instruction classroom.

LITERATURE REVIEW

TRANSDISCIPLINARY APPROACHES TO TEACHING ENGLISH

Previous research has seldom focused on the effects of teaching English in a transdisciplinary pattern. However, there has been some research done on investigating the integration of teaching English with various forms of art such as music (Akbary et al., 2018; Moradi & Zamanian, 2014). With drawing as a teaching element, research indicated that drawing could help individuals improve their sense of aesthetics and to enhance memory in educational settings (Wammes et al., 2019). However, the outcomes of integrating drawing in art with drawing in English language instruction (Adoniou, 2013; Altun, 2015) have not been investigated much, especially in primary school settings in China as more attention seems to be given to integrating other subject-related elements as compared to art. In physical education, Baena-Extremera et al. (2018) adopted a structural equation model (SEM) to prove that students' autonomy can contribute to their satisfaction in bilingual physical education as a typical integration of English and physical education. This means that students can achieve better learning outcomes if they can obtain more independent participation in the learning process. Yang et al. (2020) examined the effectiveness of digital storytelling (DST) on learning English as a foreign language in which DST was conducted as an interdisciplinary project and English was integrated with a computer course. The eight-week interdisciplinary curriculum was helpful to improve students' spoken English and creative thinking, in line with the findings by Ramalingam et al. (2022) that digital storytelling was effective in improving students' language speaking skills. Further, along with the emergence of STEAM education, a transdisciplinary approach that focuses on PBL (Quigley et al., 2019) has become more popular, which inspires educators to redesign and integrate science, art, and other subjects to effectively help students in primary schools develop practical skills. Apart from these, Hanks (2022) proposed that learners and teachers can work as co-researchers to explore praxis by integrating research, especially Action Research (e.g., Exploratory Practice) (Hanks, 2017), into language teaching and learning. Exploratory Practices (EP), which is defined as a sustainable approach for both language teachers and learners involved in the learning process to comprehend their own life in the language classroom (Allwright, 2005), demands more practices in the inquiry-featured transdisciplinary language instruction which focuses on PBL.

OUTDOOR PLACE-BASED PEDAGOGY FOR ENGLISH

Previous research in Scandinavian countries has suggested that outdoor settings make subject-related learning for young learners potentially more meaningful (Schwartz, 2014; Sjöblom & Svens, 2019) as staying outdoors was more an interest-oriented and experience-centered instructional strategy (Sheppard, 2011) and most likely helped learners engage in more active inquiry practices (Ireland et al., 2014) where more connections to students' life experiences were made and social interaction was encouraged (Tal, 2016). Learners staying outdoors are often surrounded by and provided with more abundant learning stimuli in nature, such as smells, colors in nature, different textures of plants, etc. Häggström and Schmidt (2020) found that direct encounters with the outdoor environment enhanced children's basic literacy and ecological literacy, which further helps to develop critical thinking, consistent with the effects of outdoor place-based learning (Schwartz, 2014). The above research indicated a place-based pedagogy started to impact the way of learning, which highlights a democratic and independent learning environment for learners (McInerney et al., 2011). Specifically, hands-on language activities outside of the classroom could positively lead to better learning outcomes (Uysal & Yavuz, 2015) as they could provide learners with concrete materials and physical activities such as walking, running, jumping, dancing, and climbing. Even school-based outdoor environments, though relatively artificially designed, also tended to be physically and mentally beneficial as research has found that exposure to nature just by walking through natural areas and even in rooftop artificial gardens could still have positive effects both physiologically and psychologically (Suenaga et al., 2020). Employing an action research methodology in a Year 7/8 outdoor-based English Writers Workshop course, Neville et al. (2021) found students enhanced their creative writing capacity and engagement with outdoor place-based learning. Similarly, Myhre and Fiskum (2021) used semi-structured group interviews in a lower secondary school in Norway as students went through a varied and sensuous learning experience for English as a second language (L2) in an outdoor environment. Students then reported increased confidence, real-life language use, and interesting ways of learning, while expressing more willingness to communicate in English. Referring to the philosophy of place-based pedagogy, learning in outdoor transdisciplinary language instruction has the potential to positively impact the learning process among students. This has been shown as pupils involved in a series of research relevant to literacy teaching and learning have brought positive outcomes in practices of place-based pedagogy such as in a Taiwanese place-based curriculum case study (Chan, 2022) and the investigation of place-based writing in a literacy and leadership development program (Lundahl, 2022).

Digital Tool-Based Assessment

With the extensive integration of various digital technologies in schools, updated assessments of learning from a digital approach have become increasingly essential. Hence, it may not be completely efficient to continue with conventional approaches to assess the outcomes of inquiry-featured transdisciplinary language instruction as PBL in schools is more related to the development of a variety of students' competences (Craig & Marshall, 2019). Parrado-Martínez and Sánchez-Andújar (2020) suggested some common categories of competences, including teamwork and cooperation competence, oral communicative competence, and creativity and innovation. There is a potential to improve these competences during a multi-sensory learning process.

As Robertson et al. (2019) indicated, technology can create an engaging formative assessment to enhance student learning. Using digital tools such as computer-based assessment (CBA) can usually detect and capture more subtle details and make the process more efficient during assessments. Specifically, Virinkoski et al. (2018) suggested CBA can help simplify the assessment process and efficiently identify if students require extra support while reading. In addition, computerized adaptive testing has been shown to work among primary school children for improving mathematical skills (Martin & Lazendic, 2018). With the advancement of new technologies, especially modern interactive media, the effectiveness of traditional paper-and-pencil assessment is often criticized. Accordingly, new technology-based assessments have increasingly started to gain more scientific attention. Ningsih and Mulyono (2019) suggested that PC-based Kahoot! and ZipGrade as digital assessment tools were proven to be effective in primary school classrooms. For example, via simulating immersive visual environments with various anxiety-evoking stimuli, VR has been adopted to reduce individuals' anxieties and fears, whose symptoms can be measured immediately (Diemer et al., 2014). Furthermore, digital technology such as the iPad has been used to aid the assessment of anxiety among students with Autism Spectrum Disorder (ASD) (Lefer et al., 2019).

As one of the most widely used digital technology currently, smart boards have been a critical tool for enhancing classroom involvement in primary schools. Previous research proved that using smart boards can effectively improve students' cognitive aspects in learning, such as creative thinking (Al-dalalah, 2021), higher-order thinking (Abdullah et al., 2020), and academic achievement (Akar, 2020). However, the investigation of using smart boards to effectively assess learning outcomes has been neglected (Robertson et al., 2019).

THEORETICAL FRAMEWORK

There are in total three theoretical frameworks related to this research, based on which three conceptual approaches exist; namely, learning performance, positive emotions, and reported satisfaction level. Such theoretical frameworks as inquiry-based learning, Attention Restoration Theory (ART) (R. Kaplan & Kaplan, 1989), and theory of behavior all help support the logic and practice of this research.

REPORTED SATISFACTION LEVEL AND INQUIRY-BASED LEARNING

The students' reported satisfaction level of the transdisciplinary language instruction session can be defined as the joy of fulfillment that learning activities and the experiential feelings that the session can provide (Kangas et al., 2017). Moreover, this definition is usually related to positive attitudes and emotions triggered by learning motivation (Topala & Tomozii, 2014). This means that students can feel more satisfied when feeling more motivated in the transdisciplinary language instruction session. In terms of motivating learners, transdisciplinary language instruction should be more engaging and more supportive for learners to get involved, physically and mentally. Fortunately, distinct from the other two integration approaches for teaching and learning English, namely, the multidisciplinary and interdisciplinary approach, the transdisciplinary approach typically focuses on PBL, requiring students to engage in collaboratively tackling challenging tasks. Therefore, being transdisciplinary is often considered a higher level of integrated learning, which is linked to the essence of STEAM education as a philosophy and approach (Holbrook et al., 2020). More specifically, this transdisciplinary approach is called inquiry-based learning, often engaging students in collaborative tasks that involve asking questions, planning ways to answer questions, offering new understandings, etc.. In detail, Pedaste et al. (2015) conducted a systematic literature review and then developed a synthesized inquiry-based learning framework consisting of five general phrases, namely, orientation, conceptualization, investigation, conclusion, and discussion, which can help ensure an effective inquiry-based learning process for instructional designers and teachers.

POSITIVE EMOTIONS AND ATTENTION RESTORATION THEORY

To evoke students' positive emotions, the individual should often feel less mental fatigue and stress. From this perspective, together with Stress Reduction Theory (SRT) (Ulrich, 1981; Ulrich et al., 1991), R. Kaplan and Kaplan (1989) proposed an Environmental Psychology theory called Attention Restoration Theory (ART) to explain how outdoor nature or landscapes can facilitate individual restoration from fatigue. ART posits our directed attention is restored when exposed to green nature which is soft and fascinating, thus helping us recover from mental fatigue. Specifically, even small-scale nature in neighborhoods or parks can exert restorative effects. More directly, SRT pointed out that natural settings make individuals enjoy a calming effect, which is accompanied by positive feelings. Numerous empirical research has provided strong support for the two theories. For example, Jiang et al. (2021) investigated how people driving at high speeds can be positively affected by landscapes using a simulation system. The result showed that greener landscapes generally more positive impact on drivers' mental status.

Learning Performance and Theory of Behavior

Technology-based assessments (TBAs) use digital technology in the design, delivery, and analysis processes to measure cognitive and skill-based performance, which can provide students with dynamic, focused, and situated knowledge (Mayrath et al, 2012). One type of TBA is formative assessment, which demands individualized feedback from modern technologies well-designed to support collecting data and analyzing complex processes, and providing formative feedback (Irons & Elkington, 2021). Clarke-Midura and Dede (2010) used immersive technologies to develop virtual performance assessments, concluding that assessment using digital media enables the use of measures based on performance via visualizations, simulations, data-analysis tools, etc., which includes visualization of data and information, and more invisible phenomena. Dalby and Swan (2019) proved that iPad technology can be used to enhance formative assessment in science and math classrooms. These valid practices in technology-based assessment, especially smart boards-based assessment, can be supported by B. F. Skinner's theory of behavior (Vargas, 2017), especially operant conditioning (Skinner, 1937), in which reinforcement schedules are very important for learning behaviors such as time-based schedules, including fixed and variable intervals (Staddon & Cerutti, 2003). While launching smart boards with precisely fixed interval reinforcement schedules, especially when those positive reinforcers are delivered, smart board-based assessments are posited to help students quickly establish a series of positive operant behaviors and outcomes. Moreover, the idea of making learning visible proposed by John Hattie in educational fields can also explain the positive potentials of technology-based assessments, especially using smart boards. As Hattie (2012) stated, visible teaching and learning occur when the learning process involves active, passionate, and engaging people (teachers, students, peers, etc.). In terms of practicality, when users touch the screen, colorful images and symbols can show up to visually support learning concepts (Solvie, 2004). Hence, smart boards can use various forms of attention-attracting media for learning, such as videos, images, programs, etc., thus creating a more abundant and positive learning or user experience, compared with conventional approaches.

Aim and Research Questions

The purpose of this research was to examine the potential outcomes of applying the outdoor transdisciplinary language instruction paradigm to primary school students' cognitive and emotional improvement with smart boards as an assessment tool. The research questions were as follows:

1. Can a school-based outdoor learning environment make students in transdisciplinary language instruction obtain more emotions (typically positive emotions) than indoor classroom learning?
2. Can the use of smart boards to assess the English learning process get better learning performance compared with other methods such as E-prime 2.0?

A pre-test post-test quasi-experimental design was adopted to explore Questions 1 and 2, in which relevant valid scales were administered to measure target dependent variables, including positive emotions and self-reported satisfaction levels, as well as learning performance (i.e., learning scores).

Methodology

Participants

Participants for this study consisted of student volunteers from eight classes in grade 2 at one primary school in southwest China. Thirty students (the students were randomly recruited from classes 2, 4, and 6, with 10 students from each class, including five females and five males; the average age was eight years old) served as the control group (the indoor transdisciplinary language instruction group), while 30 (from classes 1, 3, and 5, with 10 students from each class) were the intervention group (the outdoor transdisciplinary language instruction group).

Both the intervention group and the control group accomplished the 30-minute transdisciplinary language instruction session, integrated with thematic drawing. To address the possible Hawthorn effect, the project head teacher informed participants in the intervention group of the session (they would be taken to the school-based outdoor environment to finish one English lesson by two teachers) and told the students in the control group about the lesson (they would stay in the classroom to have one different English lesson by two teachers). This consent was designed to implement the intervention naturally. Since those two groups of participants followed the same consent procedure, the possible Hawthorn effect may have been minimized to a great extent. The experimenter was present only during the relevant assessment sessions.

STUDY DESIGN

The critical design of this study was a pre-test post-test quasi-experimental design, which consists of three main sessions, namely, Pre-test, Post-test session1, and Post-test session2. The learning environment (two types: Outdoor Group/Indoor Group) was chosen as the independent variable, and three key dependent variables include learning performance (i.e., vocabulary identification), emotions (typically positive emotions), and self-reported satisfaction level. Two groups of randomly selected students were respectively assigned to the Outdoor Group/Indoor Group to complete the transdisciplinary language instruction session. In the Pre-test, each group of 30 pupils was first required to finish the paper-based assessment, including both the Vocabulary Identification (VI) and the Chinese version of PANAS (mainly positive emotions), after which the transdisciplinary language instruction was implemented, including a 20-minute English phase by the assigned English teacher and a 10-minute art thematic drawing. Next, two groups continued to finish the Post-test session1, via the PANAS and structured self-reported satisfaction instrument in written form. Additionally, both groups were taken to simultaneously launch the PC-based VI assessment of acquired words via the behavioral software E-prime 2.0. In Post-test session 2, the 30-student intervention group, i.e., the Outdoor Group, was further divided into two equal sub-groups to finish another VI, in which half of the students were assessed by checking and responding via E-prime 2.0, and the other half using smart boards.

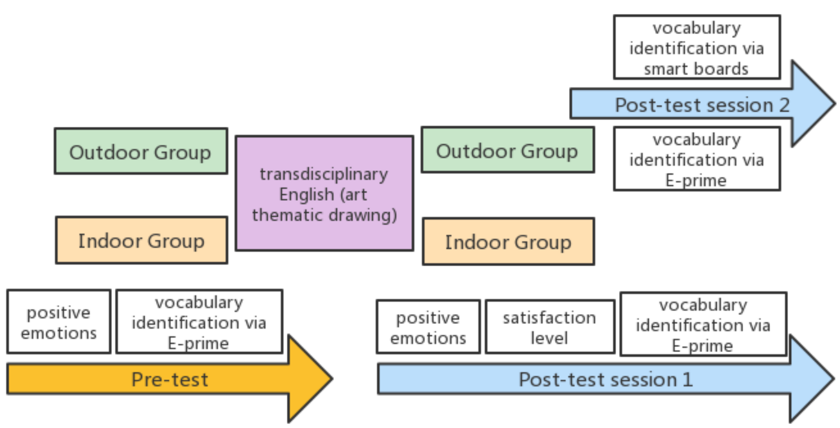

Figure 1. Pre-test post-test quasi-experimental design

RELATED PREPARATIONS

The baseline of learning performance

To effectively carry out the transdisciplinary language instruction phase and avoid possible effects of individuals' prior knowledge, both groups finished the cognitive pre-test for the target vocabulary which included four unfamiliar words and one common word: water. If students identified one word correctly, they would score one point. Hence, the total score of the learning performance ranged from 0 to 5 points. The final score was used to confirm if the baseline of the target vocabulary scores between the two groups showed any significant difference.

The selection of target English vocabulary for vocabulary identification

To guarantee the accurate use of the target English vocabulary, the English teachers at the school, who have more than 5 years of experience with first-grade professional titles and above, were invited as panelists to discuss the appropriate choice of related vocabulary for the transdisciplinary drawing-integrated English session. Considering students' age and the suitable learning intensity (i.e., session time), the professional group of English teachers agreed that the group of target vocabulary words finally included *sunlight, soil, fertilizer, leaf, and water* (as one common word).

PBL-based art thematic drawing in the transdisciplinary language instruction

The transdisciplinary language instruction session was implemented respectively by two teachers who were recruited for this purpose: an English teacher and an art teacher for the two groups (i.e., the control and intervention group) simultaneously. The procedures were as follows. Initially, for both groups, students were divided into a five-person sub-group and were firstly motivated to answer a practical question in their groups. The question was "How can trees grow healthily in nature?" Then, students from both groups participated in answering the question, thus motivating the students to learn. The English teacher for both groups used the same teaching module, in which students in each sub-group collaborated to learn vocabulary related to how trees grow in nature. After that, using those English words learned (i.e., *sunlight, soil and fertilizer, leaf,* and *water*), each sub-group together drew a thematic picture depicting how trees can grow healthily in nature within 10 minutes. The oral instruction was "The drawing session only needs the sub-group to use shapes and colors to express the topic with neither verbal English communication nor written texts.", which largely avoided the consolidation effect of recall learning. The art teacher only served as the supervisor for students to finish the thematic task and mostly watched the process.

Instruments

The Chinese version of PANAS

To effectively measure students' emotional experiences during the transdisciplinary language instruction session, the positive and negative affect schedule (PANAS) (Watson et al., 1988) was adopted to measure all the experienced emotions. To further better measure the target emotions for those primary school students in grade 2, who may not comprehend the meaning of all the emotional words in PANAS so well, the experimenter strategically used the same oral explanation of emotional words for both groups before the pre-test. In the Chinese version of PANAS adjusted by H. Li et al. (2003), there were in total 10 emotion adjectives, and five positive and five negative words, with a Cronbach Alpha of 0.82. The Cronbach Alpha for positive emotions was 0.85 while for negative emotions was 0.83. For the report of this study, positive emotions were mainly reported to represent students' emotional experiences. The Likert response for each emotion word ranged from 1 to 5, meaning "not at all" to "extremely". Therefore, the possible total score of positive emotions ranged from 5 to 25 points. The scores of negative emotions had the same range.

Structured self-reported satisfaction instrument

For measuring students' reported satisfaction levels of transdisciplinary language instruction, the self-structured reported satisfaction instrument was adapted from the research by Kangas et al. (2017), in which the connection between student satisfaction and teacher engagement in a playful learning environment (PLE) was explored. The investigation was closely related to the features of transdisciplinary learning. Hence, referring to the satisfaction survey items which collected data about the playful learning environment, the teacher, group participation, learning content, etc., four dimensions related to the satisfaction of the transdisciplinary language instruction session were constructed, namely, art-based drawing, attractiveness of the English topic, outdoor learning/indoor learning, and group discussion. Each dimension was scored on a five-point Likert scale, which ranged from very unsatisfactory, a bit unsatisfactory, neutral, a bit satisfactory, and very satisfactory. Correspondingly, each dimension was indicated using points 1 to 5. In the end, the indoor or outdoor group used one version of the structured self-reported satisfaction instrument since one item asked about the reported satisfaction level regarding different learning environments (i.e., outdoor/indoor environment).

To ensure the reliability and validity of the two scales, a pilot test was administered for a smaller sample. For validity, four experienced teachers and two administrators were invited to accomplish and discuss the clarity and number of items. According to their professional suggestions, some items were redesigned. In terms of reliability, these two scales were administered among 20 students in another school from the same district. The data collected data was analyzed using SPSS 22.0. The Cronbach Alpha for the Chinese version of PANAS and the structured self-reported satisfaction instrument was calculated with the values of 0.712 and 0.741 respectively, which indicated the adequate reliability of those scales.

Data Collection

In the post-test sessions 1 and 2, the data registration of participants' responses in terms of vocabulary-learning outcomes was obtained using a psychological behavioral software called E-prime 2.0 to visually present vocabulary pictures to students in sequence, along with which the attached pronunciation was played for the participant to correspondingly judge the audio as wrong or right. Then the button was pressed to continue (Figure 2). Students' responsive signals were finally registered as the corresponding value, 0 or 1. If the response was correct, one point was registered, otherwise, zero points would be registered. Therefore, the total values of vocabulary identification ranged from zero to five points.

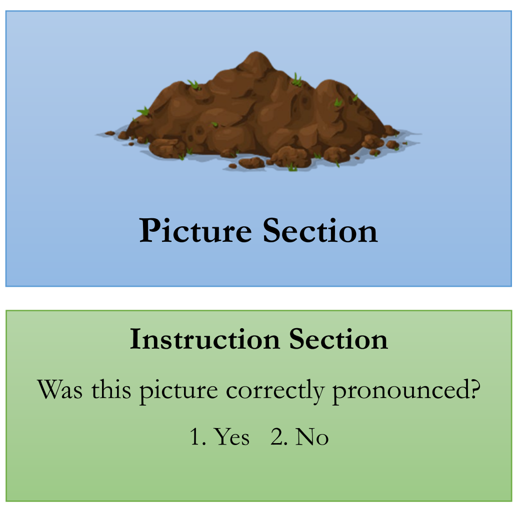

Figure 2. The design window of E-prime 2.0-based procedures

Concerning the brand of smart boards in post-test session 2, Hite Vision was used, and the product was a 19B Intelligent Interactive Flat Panel with enhanced viewing and writing experience. This version had the Touch Response Time (Single Point) ≤10 ms. Similar to using E-prime, smart board-based tasks were also featured by viewing the picture along with one certain pronunciation, followed by requesting a judgment task. The difference was the pictures were in the GIF version, which meant a more dynamically interactive mode. Additionally, when the task was done, participants received a cartoon-based happy face or sad face. This aimed to evoke students' competitive motivation for subsequent identification. The right or wrong responses were registered in the setting, similar to using E-prime.

Ethical Considerations

This study was based in a primary school, therefore demanding consideration of informed consent, confidentiality, and clarification about possible harm and benefits. Before the transdisciplinary language instruction session, the content of this study was explicitly explained to the two groups of students and the participating teachers. Students were informed that they could withdraw from the study if they so choose and that the study was completely confidential without any potential harm. In addition, written informed consent was signed by each participant.

Statistical Analysis

Based on the pre-test post-test quasi-experimental design, SPSS 22.0 was launched to finish an independent t-test and then the non-parametric test, i.e., the Mann-Whitney U test was used to compare differences of several dependent variables between different learning environments, by which the differences of learning performance (i.e., vocabulary identification) between E-prime and smart boards were compared.

Results

While exploring the Tests of Normality of data in SPSS 22.0, the output showed that the pre-test and post-test learning performance (i.e., vocabulary identification) and the post-test RSL did not meet the condition of normal distribution (Shapiro-Wilk test $p<0.001$), but the score of the pre-test (Shapiro-Wilk test indoor group $p=0.066>0.05$, outdoor group $p=0.208>0.05$) and post-test (Shapiro-Wilk test indoor group $p=0.215>0.05$, outdoor group $p=0.185>0.05$) of positive emotions were normally distributed (Tables 1 and 2).

Table 1. Tests of normality for LP and PEs of the two groups

Categories		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	*Df*	*Sig.*	Statistic	*Df*	*Sig.*
pre-test of LP	indoor	0.488	30.000	0.000	0.492	30.000	0.000
	outdoor	0.473	30.000	0.000	0.526	30.000	0.000
pre-test of PEs	indoor	0.170	30.000	0.027	0.935	30.000	0.066
	outdoor	0.181	30.000	0.013	0.953	30.000	0.208
posttest of LP	indoor	0.344	30.000	0.000	0.755	30.000	0.000
	outdoor	0.457	30.000	0.000	0.554	30.000	0.000
posttest of PEs	indoor	0.113	30.000	.200*	0.954	30.000	0.215
	outdoor	0.177	30.000	0.017	0.951	30.000	0.185
increased PEs	indoor	0.251	30.000	0.000	0.854	30.000	0.001
	outdoor	0.539	30.000	0.000	0.180	30.000	0.000

Note: LP = Learning Performance; PEs = Positive Emotions

Table 2. Tests of normality for RSL of the two groups

Categories		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	*Df*	*Sig.*	Statistic	*Df*	*Sig.*
RSL of art-based drawing	indoor	0.376	30.000	0.000	0.690	30.000	0.000
	outdoor	0.539	30.000	0.000	0.180	30.000	0.000
RSL of the attractiveness of the English topics	indoor	0.521	30.000	0.000	0.350	30.000	0.000
	outdoor	0.488	30.000	0.000	0.492	30.000	0.000
RSL of outdoor learning/indoor learning	indoor	0.241	30.000	0.000	0.867	30.000	0.001
	outdoor	0.528	30.000	0.000	0.347	30.000	0.000
RSL of group discussion	indoor	0.423	30.000	0.000	0.626	30.000	0.000
	outdoor	0.495	30.000	0.000	0.461	30.000	0.000

Note. RSL = Reported Satisfaction Level.

Therefore, this study uses both a non-parametric test (Mann-Whitney U test) and an independent t-test to compare differences in all the dependent variables, emotions (typically positive emotions), and reported satisfaction levels between the intervention and control group (indoors and outdoors).

Table 3. The baseline of learning performance between the two groups

	Group	N	Mean Rank	Median	Sum of Ranks	Mann-Whitney U	Z	Sig(2-tailed)
pre-test of LP	indoor	30.000	31.000	1.000	930.000	435.000	-0.311	0.756
	outdoor	30.000	30.000	1.000	900.000			

The Mann-Whitney U test was launched to compare the differences in the familiarity of target vocabulary between the students of the two groups. The indoor group (N=30) had a mean rank of 31.00, and the outdoor group (N=30) had a mean rank of 30.00. But the results did not find a statistically significant difference between the outdoor (Median=1.000) and indoor (Median=1.000) group (U=435.000, Z=-0.311, p=.756), indicating that those chosen English words were valid and no cognitive difference was found, and the baseline of students' learning performance was almost the same for the latter intervention.

Table 4. Differences in positive emotions and RSL between the two groups

	Group	N	Mean	SD	t-test	*Df*	*Sig*
pre-test of PEs	outdoor	30.000	15.500	2.432	5.339	58.000	0.000
	indoor	30.000	12.600	1.714			
posttest of PEs	outdoor	30.000	18.530	2.403	6.706	58.000	0.000
	indoor	30.000	14.730	1.964			
increased PEs	outdoor	30.000	3.030	0.183	3.896	30.233	0.001
	indoor	30.000	2.130	1.252			

The independent t-test was used to compare the differences in emotional assessment (typically positive emotions) between the two groups. Results showed that the pre-test for positive emotions for the outdoor group (M=15.50±2.432) was significantly higher than that of the indoor group (M=12.60±1.714), T=5.339, p<0.001. Similarly, the post-test of positive emotional assessment for the outdoor group (M=18.53±2.403) was significantly higher than that of the indoor group (M=14.73±1.964), T=6.706, p<0.001.

Since the baseline of positive emotions for the indoor and outdoor groups was different, a further comparison of the changes in positive emotions between the two groups was carried out. Results showed that the increased positive emotions for the outdoor group (M=3.03±.183) were significantly higher than that of the indoor group (M=2.1±1.252), T=3.896, p<0.001, meaning that the outdoor transdisciplinary language instruction session enabled students to experience more positive emotions than those indoors.

Table 5. Differences in various dimensions of RSL between two groups

	group	N	Mean Rank	Median	Sum of Ranks	Mann-Whitney U	Z	Sig(2-tailed)
posttest RSL for art-based drawing	indoor	30.000	25.670	5.000	770.000	305.000	-3.074	0.002
	outdoor	30.000	35.330	5.000	1060.000			
posttest RSL for the attractiveness of the English topics	indoor	30.000	31.900	5.000	957.000	408.000	-1.003	0.316
	outdoor	30.000	29.100	5.000	873.000			
posttest RSL for out-door/indoor learning	indoor	30.000	19.300	4.000	579.000	114.000	-5.5	0.000
	outdoor	30.000	41.700	5.000	1251.000			
posttest RSL for group discussion	indoor	30.000	28.700	5.000	861.000	396.000	-1.08	0.280
	outdoor	30.000	32.300	5.000	969.000			

The Mann-Whitney U test was adopted to compare the differences in RSL. Results showed that some dimensions of RSL (i.e., art-based drawing and outdoor/indoor learning) between the two groups were significantly different. RSL of art-based drawing for the outdoor group (N=30, mean rank=35.33, Median=5.00) was significantly higher than that of the indoor group (N=30, mean rank=25.67, Median=5.00), U=305.000, Z=-3.074, p=.002<0.05. RSL of outdoor learning for the outdoor group (N=30, mean rank=41.70, Median=5.00) was significantly higher than the RSL of indoor learning for the indoor group (N=30, mean rank=19.30, Median=4.00), U=114.000, Z=-5.5, p<0.001. However, for RSL concerning both attractiveness of the English topics and group discussion, RSL for the outdoor group (N=30, mean rank=29.10, mean rank=32.30, Median=5.00) and indoor group (N=30, mean rank=31.90, mean rank=28.70, Median=5.00) did not saliently differ from each other, U=408.000, Z=-1.003, p=.316 and U=396.000, Z=-1.08, p=.280.

Table 6. Differences in learning performance between the two groups via E-prime 2.0

	group	N	Mean Rank	Median	Sum of Ranks	Mann-Whitney U	Z	Sig(2-tailed)
posttest of LP	indoor	30.000	19.930	4.000	598.000	133.000	-5.131	0.000
	outdoor	30.000	41.070	5.000	1232.000			

The Mann-Whitney U test was launched to compare the differences in the scores of identifying students' learning performance (i.e., vocabulary identification) between the indoor and outdoor groups.

Results showed that the mean rank of students' learning performance between the indoor group (N=30, mean rank=19.93, Median=4.00) and the outdoor group (N=30, mean rank=41.07, Median=5.00) significantly differed from each other (U=133.000, Z=-5.131, p<0.001, two-tailed), indicating that the outdoor group significantly remembered and learned much better than the indoor group.

Table 7. Differences in learning performance via E-prime 2.0 and Smart Boards

	new-group	N	Mean Rank	Median	Sum of Ranks	Mann-Whitney U	Z	Sig(2-tailed)	Exact Sig. [2*(1-tailed Sig.)]
posttest of LP	indoor	15.000	11.500	4.000	172.500	52.500	-3.247	0.001	.011[a]
	outdoor	15.000	19.500	5.000	292.500				

Within the post-test of the rate of accuracy of identified English vocabulary (i.e., Leaning Performance), the independent t-test was used to compare if there was a difference in the rate of accuracy between using E-prime 2.0 and smart boards. The histogram showed that the distribution of the score of identifying vocabulary using E-prime 2.0 and a smart board looked similar. The median for using E-prime 2.0 and a smart board was 5 and 4. Moreover, the results showed that the scores of identified English vocabulary for the outdoor group between using E-prime 2.0 (N=15, mean rank=11.50, Median=4.00) and smart boards (N=15, mean rank=19.50, Median=5.00) significantly differed from each other (U=52.500, Z=-3.247, p=.011 (Exact Sig. [2*(1-tailed Sig.)])<.05), suggesting that the assessment outcomes using smart boards were significantly better than using E-prime 2.0 for students in the outdoor group.

DISCUSSION

By investigating how different environments of transdisciplinary language instruction may impact students' emotional experience and satisfaction in the pre-test post-test quasi-experimental design, the findings indicated that school-based outdoor learning environment made students in the transdisciplinary language instruction obtain more positive emotions and higher reported satisfaction levels, compared with traditional indoor classroom-based learning. This provided more practical evidence for the positiveness of place-based pedagogy as a way of learning which is engaged in space (Miller, 2018). First, even though students experienced positive emotions both indoors and outdoors, students' positive emotions while staying outdoors were significantly higher than indoors. From the perspective of ART (S. Kaplan, 1995), natural outdoor environments tend to have the interior richness of characteristics necessary for restorative experiences. In essence, S. Kaplan (1995) suggested that if the outdoor environment is featured by being away, fascination, extent, and compatibility, nature can form and maintain directed attention to help decrease individuals' mental fatigue. This means directed attention is the key to learners' effectiveness, which influences selection, emotions, perception, action, etc. Aside from this, Stress Reduction Theory (SRT) by Ulrich (1981) and Ulrich et al. (1991) highlighted that natural settings make individuals enjoy a calming effect, simultaneously accompanied by positive feelings. Johansson et al. (2011) found that simply walking on a park street can saliently increase positive emotions and decrease feelings of pressure, which may be due to using stimulus-abundant outdoor space, where students are more likely to access rich materials and satisfy their curiosity.

Furthermore, behind the increased positive emotions in nature, some cognitive mechanisms exist. S. Kaplan (2001) proposed that a more active engagement with the environmental experience by using mental strategies; namely, avoiding unnecessary costs in terms of expenditure of directed attention, and enhancing the effect of restorative opportunities, would support positive restorative outcomes.

As Hoigaard et al. (2012) found, even for teachers more engagement in the teaching experience would help them experience more emotional support. Using experimental paradigms, Pasanen et al. (2018) in Finland found that participants in the restoration-enhancement group had better-sustained attention after walking in nature, while both the restoration-enhancement and awareness-enhancing groups reported improvements in positive emotions. To further explore the mechanisms of nature's elevating positive emotions, Ballew and Omoto (2018) launched structural equation modeling (SEM) to conclude that absorption emerged as a critical mediator and that awe and other positive emotions were fostered when people feel immersed in their natural surroundings. Moran (2019) surveyed prisoners at a large medium-security prison in the UK, suggesting that in stressful contexts even nature-related photographic images not only enable restorative effects but also bring calmness and contribute to self-reflection. Other research even provided physiopsychological evidence to show lower frustration, engagement, and arousal, and higher meditation when moving into the natural space (Aspinall et al., 2015). This indicated the relevant cognitive and physiopsychological factors may interplay to cause or strengthen the positive feedback from staying in outdoor nature.

As for the relatively higher reported satisfaction level for the outdoor art-based drawing than the indoor version, as mentioned before, this may be due to the evoked learning motivation by the PBL of the transdisciplinary language instruction outdoors. Since the process required students not only to collaborate with other students as a team but to also finish a series of automatic discussions with each other, these outcomes in place-based pedagogy are distinct from classroom-based learning. Traditionally in the classroom, teachers would unconsciously have the key role to lead the learning, especially in public schools in China. Many teachers do want to make a change to practice place-based pedagogy but various factors make this relatively challenging as class management, such as physical settings and the number of students in one class, would need to change.

Based on the above discussion, different stakeholders in primary school education in China should consider their responsibilities to improve the learning quality among students. Firstly, outdoor learning environments for primary schools need to be appropriately designed and constructed. In addition, indoor learning environments, e.g., traditional classrooms, also need to be redesigned so that they can naturally enable students to obtain potentially positive learning experiences, thus promoting place-based pedagogy. This is in line with Barrett et al. (2017) study which analyzed the impact of the physical design of classrooms on the learning progress (i.e., reading, writing, and math) of pupils aged from 5 to 11 years via the Holistic Evidence and Design (HEAD) study, and showed that students' writing progress was strongly linked to several natural factors, including classroom-based natural elements (wooden furniture and plants), window views of nature, and directly reaching an outdoor space from the classroom. Secondly, for a realistic situation, where each classroom in public schools has relatively more students than in private schools, local governments may have to take more careful consideration on the enrolment in the schools to avoid the high demand for certain schools. Providing the number of schools according to the density of different communities could help alleviate the stress of "large classrooms". Furthermore, the curriculum reform should appropriately consider place-based pedagogy and how to structure integrated learning of different subjects (e.g., interdisciplinary and transdisciplinary learning) to improve students' key competences so that students can benefit from an "All-round Education".

Of particular importance is that the findings indicate that using smart boards for assessment has significantly higher scores than using the smart board for presentation alone with E-prime 2.0. As Harlan and Rivkin (2000) suggested, children are more likely to foster engagement and build knowledge in a learning environment with opportunities to interact, physically and mentally. Smart boards have various characteristics to motivate students to learn (Smith et al., 2005), which is because their features enable visual, audio, and tactile modalities, and entertainment-related elements (Şad, 2012). These functions mean that various dynamic resources, including images, animations, audio, or videos can be shared to create a more interactive learning process. This process motivates students to use their senses, one of which is the sense of touch. The sense of touch among students in the assessment phase using smart boards was fully activated, usually along with a series of physical movements. This proved to be an advantage of using smart boards to make students more attentive and actively involved in the assessment with a huge touchscreen that provides electronic images for learners to interact with (Preston & Mowbray, 2008).

In essence, the smart board-based assessment makes students engage in active learning, which reflects the educational idea of visible learning by John Hattie. As Hattie (2012) suggested, visible learning occurs when active, passionate, and engaging individuals participate in the learning process. Active learning is defined as course activities-centered learning in which all the students are involved besides watching, listening, and taking notes (Felder & Brent, 2009), in which students' long-term cognitive retention (Rahn & Moraga, 2007) and learning interests (Meitner et al., 2005) can be maintained. As Jang and Tsai (2012) suggested, the use of IWBs (Interactive Whiteboard) enhanced learners' interactions. Emotionally speaking, Jwaifell and Gasaymeh (2013) indicated smart boards made learning more enjoyable and fun. Besides the emotional benefits, the establishment of the active learning process should be based on reinforced behavioral patterns, which can be explained by operant conditioning (Skinner, 1937), in which reinforcement schedules are very important for active learning. While launching smart boards loaded with abundant and positive reinforcers, smart boards are most likely to help establish efficient operant behaviors. For example, a series of physical behaviors such as jumping and touching can be quickly fostered when the screen stimuli appear at the right time, which can further enhance the assessment of students' learning performance, along with the impact of positive emotions evoked during the process.

The development and use of new digital technology-based assessment approaches are highly demanded (Cope et al., 2011). For example, Shi et al. (2018) designed a quasi-experimental study recruiting first-year college students to learn English respectively following interactive whiteboard-based and traditional lecture-based instruction for some time, which found that the interactive whiteboard-based instruction cultivated higher levels of academic self-efficacy among students. Similarly, Fjørtoft (2020) designed a formative experiment to improve multimodal digital classroom assessments (MDCAs) by using digital devices including mobile phones. In terms of using tablet devices as an assessment tool, Hautala et al. (2020) administrated a computerized game-based assessment (GBA) to primary school students and found that the GBA can assess students' reading skills reliably.

This research proved that smart boards facilitate active learning which is featured by multi-senses, including touch, seeing, etc. However, the reality is multi-sensory learning, typically the sense (modality) of touch, to create active learning is commonly underrated in classroom-based learning settings. A related program, called active learning using a smart board program, has been proven to have the attributes of effectively enhancing primary school students' learning (Mun et al., 2019). Likewise, tools such as smartphones have been proven to serve as effective assessment tools (Marinšek & Slana, 2014). Long before the COVID-19-affected era of education, technology was widely considered as having an irreplaceable role in facilitating teaching and learning in various contexts. Since the pandemic keeps negatively impacting traditional learning, educational technology tools unprecedentedly serve as effective helpers to cope with the issue of social distancing or lockdown for learning. Such online tools as Google Meet and Zoom have started to become globally adopted for companies, governmental institutions, and schools. Teaching subjects in schools such as English practice still lacks investigation into implementing an outdoor transdisciplinary approach, especially about the potentially effective use of new technology for assessment. Future attempts are suggested to launch the use of more multi-modality-based digital technology such as smart boards for assessing students' learning outcomes for different kinds of curricula, including formative and summative assessments. Furthermore, schools should adopt more new interactive digital technologies to improve the assessment of students' innovative learning in different contexts, which can help students develop more transversal skills, benefiting their employers and making them even more competent. More critically, government support is needed to encourage schools to use emerging technologies for educational reform in the classroom, and linkages between technology vendors and schools could be encouraged to provide subsidies and other measures to less financially able schools.

CONCLUSION

This research mainly investigated two key research questions: (1) Can a school-based outdoor learning environment make students in the transdisciplinary language instruction obtain more emotions (typically positive emotions) than indoor classroom learning? (2) Can the use of smart boards to assess the English learning process get better learning performance compared with other methods such as E-prime 2.0? By employing a pre-test post-test quasi-experimental design, in which three main sessions were implemented, namely, Pre-test, Post-test session1, and Post-test session2, this study managed to answer the above research questions. The Pre-test finished measuring students' positive emotions and the baseline of learning performance while students' post-test positive emotions and reported satisfaction level of the transdisciplinary language instruction were finished in the Post-test session 1. The Post-test session2 was about comparing the effects of using smart boards and E-prime to assess students' learning. Finally, the results showed that transdisciplinary language instruction outdoors not only notably helped students obtain more positive emotions and higher satisfaction but also led to significantly higher learning performances compared with transdisciplinary language instruction indoors. More importantly, using smart boards motivated students to more effectively engage in the assessment than in E-prime-based assessment. Hence, this study to some extent brings insights into the positive future of place-based transdisciplinary subject-based learning and the effectiveness of using modern interactive technology as assessment tools.

Although it is demonstrated that the positive outcomes of using smart boards as an effective assessment tool and that place-based pedagogy should be promoted in the school environment, there are still some limitations. First, more attention could be exploring the interaction effects of class type and learning environment type on students' learning outcomes since this study mainly focused on the effects of environment type and the use of smart boards. Specifically, this study found that the outdoor group indicated higher reported satisfaction levels than the indoor group, suggesting that class type and learning environment may have interaction effects on students' learning outcomes. Moreover, longitudinal assessments may be taken into consideration to find more sustainable and long-term effects, which can help investigate the intensity of experimental intervention, since only a single assessment in this study was finished for students' learning outcomes during the transdisciplinary language instruction session. Therefore, a series of transdisciplinary language instructions indoors and outdoors may be designed in the future, followed by multiple assessments using different tools such as paper or smart boards to compare the retention rate of vocabulary to be memorized. Thus, this may bring more insights into the durability of implementing different types of instruction based on the mixed effects of using effective tools and learning environments.

Furthermore, analyzing drawing works (e.g., in this study, the growth of trees) finished by students in the transdisciplinary session is very promising. Smolarski et al. (2015) designed a pre-test and post-test control group to compare various emotional expressions via different drawings, concluding that any kind of drawing helped improve students' moods and positive emotional expression and appeared to be significantly highest among all conditions. Therefore, future work should try to analyze students' drawings, for example, using thematic analysis, since artwork may help educators delve into details and find more qualitative explanations for students' learning.

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