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An Integrated Automatic Writing Evaluation and SVVR Approach to Improve Students' EFL Writing Performance

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Abstract: Writing is a challenging task for English Foreign Language (EFL) instruction. Based on artificial intelligence technology, Automatic Writing Evaluation (AWE) has received considerable attention from the EFL research community in recent years, since it can provide timely and personalized feedback to EFL writing learners. However, researchers have pointed out that while AWE can provide satisfactory feedback on vocabulary use and grammar, it is relatively inadequate at providing efficient feedback on organization, coherence, and content. Spherical Video-based Virtual Reality (SVVR) can provide a highly immersive and in-depth interaction learning environment that makes up for this shortcoming. Authentic experiences help enhance EFL writing learners' perceptions and understanding of context, and assist students in creating constructive internal connections between their personal experiences and the topic of their writing, thus improving their writing quality. Therefore, the current study proposed an approach which integrated SVVR and AWE to investigate its effects on EFL writing. To investigate the effectiveness of the proposed approach, a quasi-experiment was carried out in a university's EFL writing course. The experimental group (37 students) used the SVVR–AWE approach, while the control group (39 students) used the conventional approach with AWE. The results showed that the learning method not only considerably enhanced the students' EFL writing performance, but also raised their motivation, self-efficacy, and sense of presence, as well as reduced their EFL writing anxiety. Furthermore, interviews were performed and a thematic inductive qualitative analysis of the interview data was conducted to investigate the impact of this learning method on students' learning behaviors and perceptions.

Keywords: automatic writing evaluation; SVVR; EFL writing instruction; writing performance



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1. Introduction

As an international language, mastering English is crucial for people to communicate across national boundaries [1]. English, as an international language, plays an imperative role in international communication [1]. English writing, as an important form of language output, is not only an important means of expressing emotions and consciousness, but also indicates learners' level of comprehensive use of the language. English writing skills represent learners' proficiency at both the local level such as vocabulary, grammar, and sentence structure, and at the global level such as text organization, logical reasoning, and argumentation [2]. Therefore, writing in a foreign language is frequently an extremely challenging task for novice language learners [3]. In conventional EFL writing courses, the teaching mode is usually based on one-way teacher delivery [4]. Teachers are often faced with large class sizes, which makes them unable to take into account the learning status of each learner, and makes it difficult for students to receive timely and targeted feedback to improve their English writing skills [5]. Thus, timely, accurate, and personal feedback is essential to EFL writing instruction.

With the advancements in information technology and artificial intelligence, Automatic Writing Evaluation (AWE) has shown significant potential to improve the efficiency of EFL writing instruction [6,7]. Based on natural language processing technology, deep learning, and neural networks, AWE offers students multi-dimensional evaluation and feedback on grammar and vocabulary [5,8]. Some research shows that learning with AWE, EFL learners tend to practice more independently to improve their writing skills, and also learners' writing anxiety decreases significantly [9–11]. As for teachers, they also have more opportunities to focus on the high-level aspects of writing, thus increasing their teaching efficiency [5,12,13].

However, it has been noted that EFL writing learners face certain challenges in terms of linguistic usage and organizing written discourse [3]. Although AWE can improve writing accuracy, there are limitations in providing specific content feedback [8]. Writing is closely linked to authentic contexts, in which flexible and authentic contexts can link life experiences and previous knowledge of students [14] and thus inspire their writing. However, most EFL learners do not know how to describe their feelings due to a lack of real-life contextual experiences, which makes it difficult to write informative essays [15]. For EFL writing learners in particular, due to the constraints of limited time and budget, it is difficult for them to go abroad to have authentic experiences [16]; consequently, it is also difficult for them to express real feelings when writing. Therefore, it is necessary to incorporate appropriate technology to assist AWE-supported EFL writing activities.

With the constant development of technologies, VR technology that provides an immersive and interactive learning environment has attracted significant attention in the area of EFL education, especially low-cost and easy-to-edit Spherical Video-based Virtual Reality (SVVR) technology. SVVR refers to an immersive virtual experience in a VR environment using 360-degree photographs or videos of the actual context of learning [17], allowing users to observe from different directions with a high degree of immersion [18]. Researchers in EFL have attempted to apply SVVR technology to various aspects of English language teaching, such as speaking, reading, and writing, to provide learners with relatively realistic language learning situations and thus to enhance their learning experience [19,20]. In particular for EFL writing, the appearance of SVVR improved the traditional method of EFL writing instruction, stimulating learners' interest and motivation, and enhancing their understanding of the learning content [15,21]. For EFL writing courses, authentic language situations and learning experiences are important elements for learning, and Kolb [22] suggested that experiential learning can help learners create situations and enhance learning through repetitive practice and authentic experiences.

Therefore, the current study aimed to integrate SVVR and AWE into English writing to address both the basic-level issues of grammar, vocabulary use, and spelling, as well as to provide them with authentic contexts to address the higher-level issues of content organization, logical structures, and discourse coherence for EFL writing learners.

Consequently, this research proposed an EFL learning approach which integrates AWE and SVVR. A quasi-experiment was carried out to examine the impact of the proposed approach on EFL students' writing performance, motivation, self-efficacy, writing anxiety, and sense of presence. The research hypotheses are as follows:

Hypothesis 1 (H1): *The SVVR–AWE approach positively impacts EFL writing performance, compared with the conventional AWE (C–AWE) approach.*

Hypothesis 2 (H2): *The SVVR–AWE approach positively impacts EFL writing learning motivation, compared with the conventional AWE (C–AWE) approach.*

Hypothesis 3 (H3): *The SVVR–AWE approach positively impacts EFL writing self-efficacy, compared with the conventional AWE (C–AWE) approach.*

Hypothesis 4 (H4): *The SVVR–AWE approach positively impacts EFL writing anxiety, compared with the conventional AWE (C–AWE) approach?*

Hypothesis 5 (H5): *The SVVR–AWE approach positively improves the students’ sense of presence.*

2. Literature Review

2.1. AWE for EFL Writing

Advances in technology have led to the emergence of many technology-based feedback tools. AWE is a tool that uses latent semantic analysis and sophisticated natural language processing (NLP) techniques to provide learners with immediate automated feedback [23,24]. The working process of AWE consists in extracting linguistic, semantic, structural and rhetoric characteristics, after comparing students’ writing with an extensive informational database, and then to provide qualitative feedback on aspects of grammar, mechanics, and discourse [25]. AWE is usually used as an essay scoring tool to help learners improve their writing skills [26,27]. One direct benefit of AWE is to greatly reduce teachers’ scoring load and free them from the heavy, low-level error of writing revision, so that teachers have more time to provide higher-order feedback to students on their writing [28,29]. In addition, as AWE provides timely and quick feedback, it helps learners to improve the quality of their English writing by getting revisions at any time in any situation, which in turn increases their writing motivation and self-efficacy [30–32]. What is more, research has shown that AWE can provide learners with personalized comments on a variety of topics, thus enabling them to revise their essays in a targeted manner and improve their writing skills [8,33].

However, researchers have still raised some doubts about the use of AWE in EFL writing instruction. On the one hand, learners have expressed levels of distrust in the accuracy of AWE feedback. On the other hand, simply using AWE can lead to poor revision accuracy, and learners tend to focus on the length and complexity of the essay rather than on the quality of the writing [29], which makes it difficult for EFL writing learners to truly improve their writing. A previous study integrated a reflection-promoting approach into AWE-supported EFL writing instruction and found significant results [5]. Thus, if we want to maximize the effectiveness of AWE’s role in EFL writing instruction, we need to reconsider the design and arrangement of the teaching activities. According to experiential learning theory, experiential learning is a four-stage process for building knowledge, which consists of concrete experience, reflective observation, abstract conceptualization, and active experimentation [22]. It is significant to provide EFL learners with authentic language contexts in which they can understand concepts and engage in conceptual abstraction in an experiential process, which in turn promotes reflective observation to improve learning performance [34]. Therefore, it is necessary to provide immersive learning contexts to enrich the writing content of EFL writing learners when learning with AWE.

2.2. SVVR-Supported EFL Writing

Virtual reality (VR) is a new media technology that uses a computer to create an illusion of genuine presence or to replicate a three-dimensional virtual environment [35]. It offers a 360-degree immersive panoramic experience that gives users the impression that they are in a real setting [36]. SVVR is a fully immersive and less expensive and easy-to-implement VR virtual environment that uses primarily 360° photos or videos for immersive virtual experiences [37]. SVVR provides vivid multi-sensory stimulation and continually rotates the screen to encourage learners to look from various angles and orientations, boosting their sense of immersion [38,39]. In addition, SVVR can place learners in real scenarios at a lower cost by using diverse devices to experience virtual activities, such as cellphones, tablet computers, and Google Cardboard [40], and enhance their interactions in the learning environment [41]. SVVR has been used by many researchers in many educational contexts, such as English language learning [15], science [35], cultural courses [16], teacher professional development [42], engineering instruction [43], and medical training [40].

The appearance of SVVR has made a huge change in pedagogical practice, especially in EFL instruction, by providing authentic language learning contexts. For example,

Huang et al. [15] successfully enhanced students' writing performance in content and appearance, higher-order creative dispositions, and writing self-efficacy by implementing SVVR in a high school writing class. Chen et al. [14] applied SVVR to writing instruction and improved learners' behavioral engagement and deep writing skills, which resulted in better writing performance in terms of expressive language skills and creative thinking. Researchers have further indicated that SVVR is crucial for facilitating English writing, since it can provide learners with an authentic language learning context in which they can improve not merely their writing skills and engagement, but also their sense of accomplishment [15,44,45]. For instance, Chen et al. [46] showed that teaching with SVVR provided secondary school students with more opportunities to observe and reflect, considerably enhanced their writing skills, and changed how they saw themselves as "writers".

Thus, SVVR has great potential to provide students with authentic and interactive learning environments to enrich their writing content. Additionally, it is recommended to use the experiential learning theory to support learning activities when implementing VR-based learning environments [47]. As a result, the current study combined experiential learning theory [22] to develop an experiential learning model integrating SVVR and AWE, and applied it to EFL writing instruction to facilitate students' experience depth and EFL writing performance in terms of richness and completeness of writing content.

3. Integrated AWE and SVVR Approach for EFL Writing

Based on the experiential learning theory, the current study developed a learning environment which integrated AWE and SVVR to support EFL writing instruction (see Figure 1). In the stage of Concrete experience, learners can observe the learning content through SVVR. In the stage of reflective observation, learners need to respond to questions in the SVVR system. In the stage of abstract conceptualization, learners need to abstract what they have seen in the SVVR system and finish the writing task with the support of AWE. In the stage of active experimentation, learners can evaluate, revise, and rewrite with feedback from AWE. They can also view SVVR repeatedly for writing inspiration if they need to revisit the situation during the revision process.

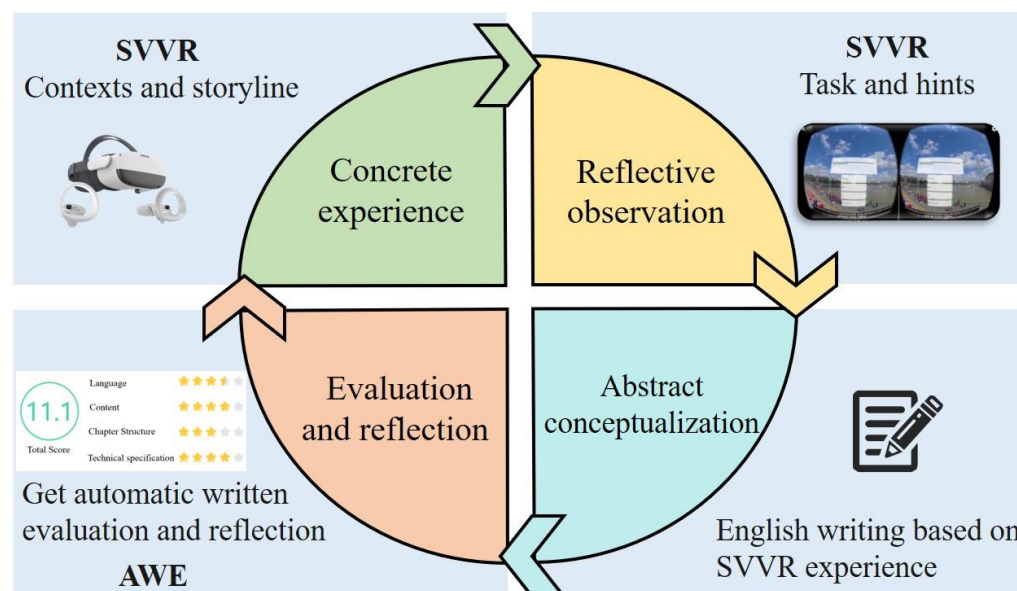


Figure 1. Experiential learning model for integrating AWE and SVVR.

The system architecture of the proposed SVVR–AWE learning environments is illustrated in Figure 2; it consists of teacher and student interfaces. For the teacher interface, an SVVR editor (UPTALE) was adopted by teachers to create, organize, and browse the learning content. For the student interface, students have access to the learning content in the SVVR system, and can switch between learning scenarios and respond to the questions

regarding the learning content. Student information, the state of the assigned learning tasks, and all the learning behavior are stored in the SVVR system.

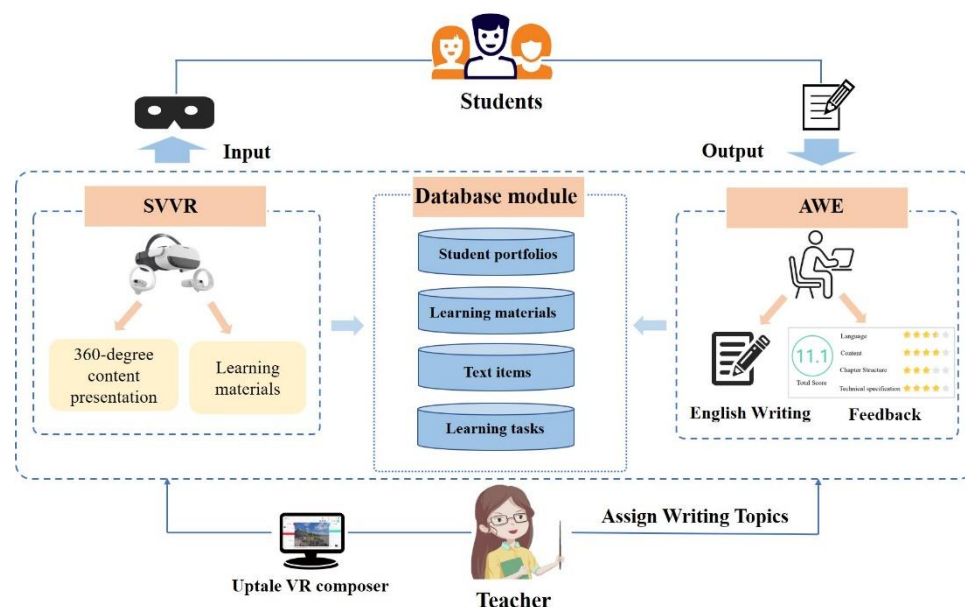


Figure 2. The system structure of the current study.

3.1. Concrete Experience

The teacher briefly introduced the learning activities before the writing activity. Students were familiar with the SVVR system and experienced the spherical view under the guidance of the instructor. In the SVVR system, learners observe the descriptive information (including text, pictures, and videos) for certain writing topics to have the holistic perception and concrete experience of the writing topic. The learning environment at the stage of concrete experience is depicted in Figure 3.

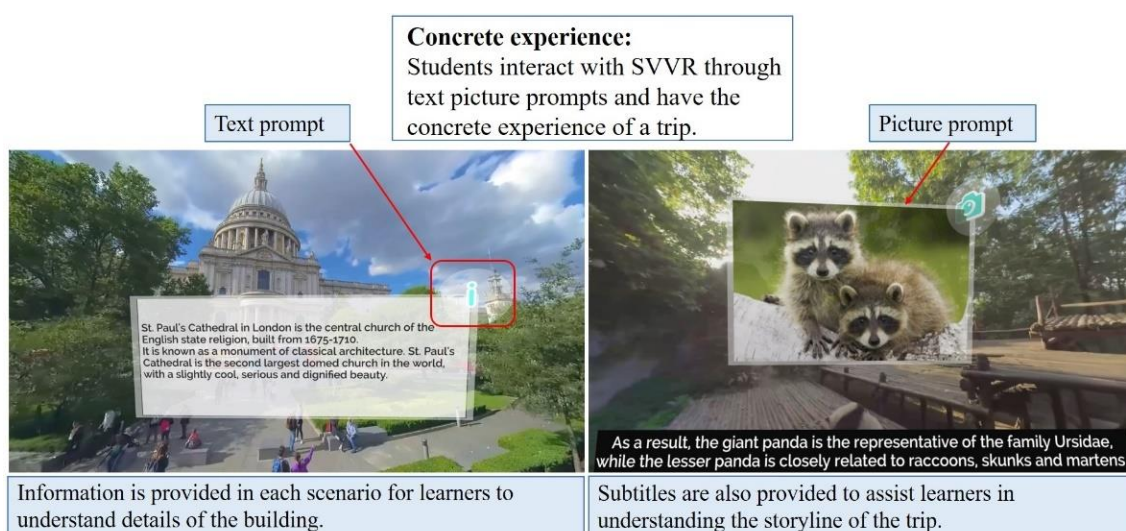


Figure 3. SVVR scenes in the “concrete experience” stage.

3.2. Reflective Observation

In the writing activities in SVVR, students need to observe the learning material in the system. Meanwhile, learners need to move the cursor and click the button to respond to the questions. Learners reflected on their writing skills by looking at images and answering questions through interactive text and image developed in the SVVR system (see Figure 4).

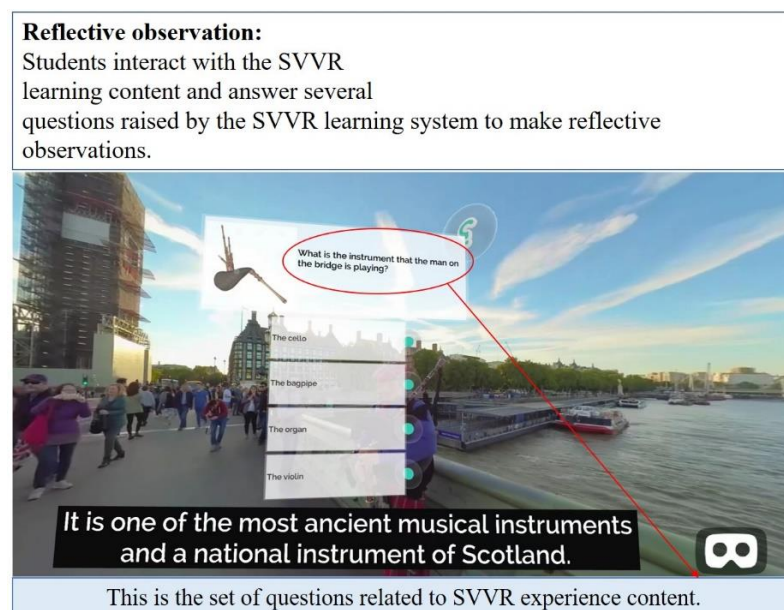


Figure 4. The SVVR scene in the “Reflective observation” stage.

3.3. Abstract Conceptualization

The participants further abstracted the observed information into concepts by combining the knowledge gained during the concrete experience and reflective observation stage with the writing tasks. At the same time, learners also need to provide the writing framework before writing on the AWE platform (see Figure 5).

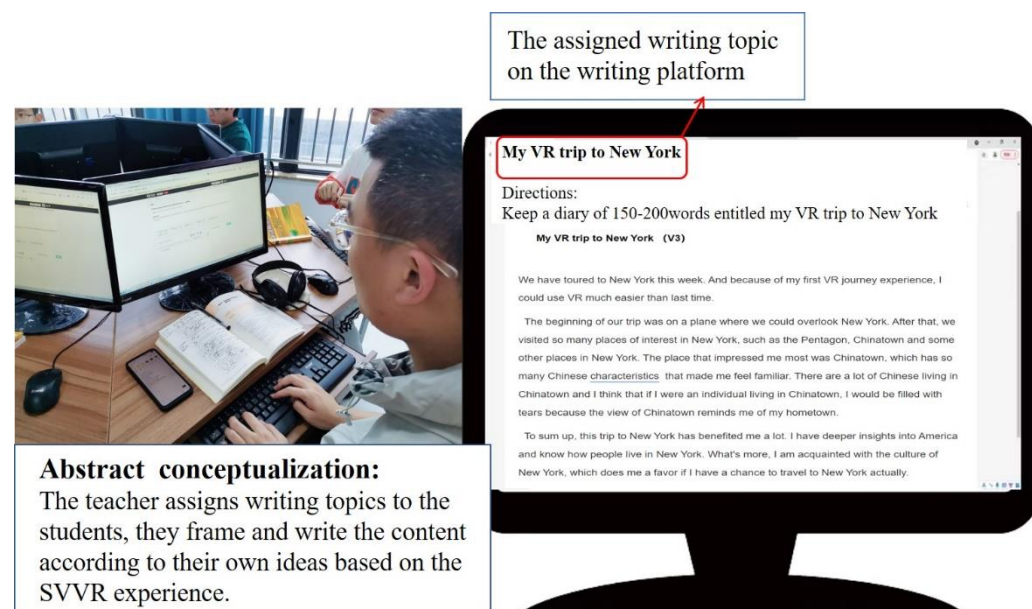


Figure 5. “Abstract conceptualization” stage with the AWE.

3.4. Evaluation and Reflection

Learners would receive the feedback provided by the AWE. Based on the learning analytics, a certain tool or strategy to facilitate learners’ reflection is important when introducing technology in the teaching process [48]. Thus, learners are required to evaluate the feedback content and revise their writing after receiving the automatic feedback from AWE rather than passively view and accept the feedback. As shown in Figure 6, feed-

back included overall score, scoring dimensions, rubric, and specific grammar and word spelling issues.

Evaluation and reflection:

Students receive the AWE, including the total score, scores by different items, and advice to revise.

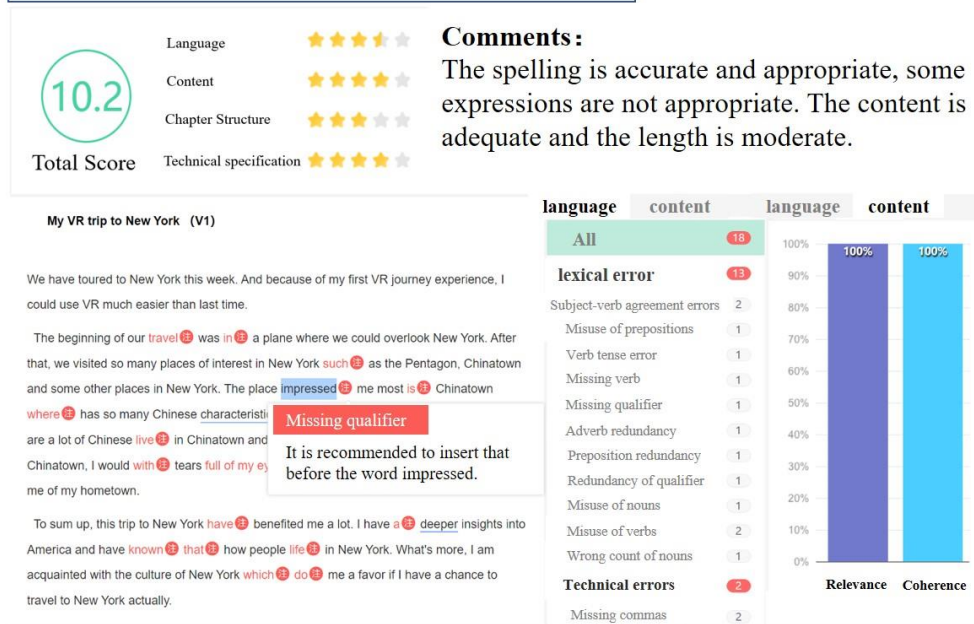


Figure 6. The feedback content of AWE.

4. Method

4.1. Participants

A total of 76 college students (average age = 20) from a university majoring in English were invited as participants. A total of 37 students were selected as the experimental group learning with the SVVR–AWE approach, while 39 students were the control group using the C–AWE approach. Both the experimental and control groups were taught by the same English writing teacher with more than 10 years of teaching experience. It should be noted that all the students participated in this research activity voluntarily. Before the experiment, participants were told the purpose of the experiment and notified of their rights to withdraw at any moment. Additionally, all of the participants' personal information was kept secure.

4.2. Experiment Procedure

To confirm the effectiveness of the proposed research method, the experimental process is shown in Figure 7. The experiment was carried out at a university's EFL writing course and lasted for 4 weeks. Before the experiment started, the instructor spent 20 min introducing the learning system and activities to the students. To ensure that all students started with equal English writing skills and knowledge, they were asked to complete an English writing pre-test and the questionnaires of writing motivation, self-efficacy, and writing anxiety.

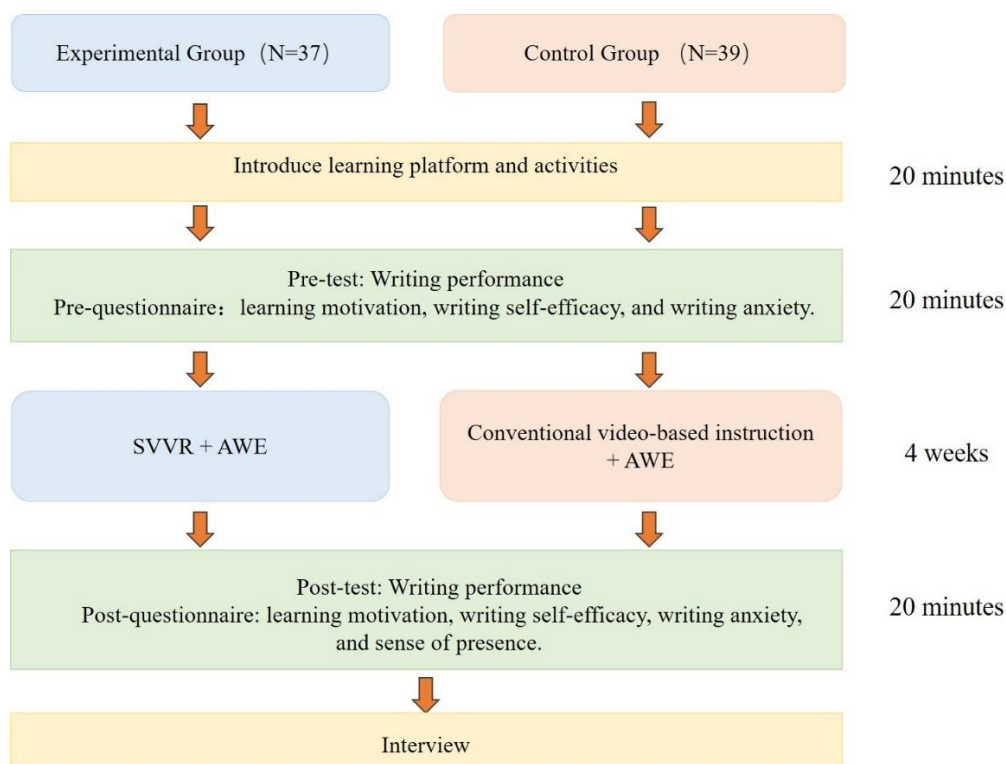


Figure 7. Experimental flow chart of the study.

In the following 4 weeks, students participated in the learning activities that covered four writing topics, respectively protecting animals, travelling in London, visiting New York, and an underwater world. Each week students were asked to describe what they saw and what they thought after learning in the SVVR system. The experimental and control groups of students were instructed to learn the content through SVVR and watch traditional videos, respectively. They were then subsequently instructed to write using the AWE platform. The experimental group could explore to learn in the SVVR system, while the control group would fill out the learning sheet with the same questions set for the experimental group after watching the video.

After the learning activities, students needed to take the post-test and post-questionnaire to investigate learners' conception of learning motivation, self-efficacy, writing anxiety, and sense of presence in the SVVR system. Several students were invited to take part in the interviews to collect their feelings about the learning approach.

4.3. Measuring Instruments

The measurement instruments used in this study included the EFL learning achievement test, the learning motivation questionnaire, the writing self-efficacy questionnaire, the EFL writing anxiety questionnaire, and the sense of presence questionnaire, as well as interviews about their learning experiences.

4.3.1. Rubric of English Writing Performance

The writing test in this study was selected and revised by expert English teachers with extensive experience in teaching English. The test aims to examine students' mastery of chapter structure, vocabulary use, spelling and grammar, and content of EFL writing. In reference to Fu et al. [49], the rubrics for English writing performance adopted in the current study include five dimensions: organization of content, linguistic accuracy, originality, fluency, and elaboration. Students' writing was assessed by two experienced instructors who had been instructing English writing for a long time. The organization of content refers to the coherence and logic of the writing. Linguistic accuracy indicates

the correct usage of grammar and spelling. Creativity means whether there is innovation in content or expression. Fluency refers to producing more ideas. Elaboration refers to developing ideas with a great deal of details. Both the pre-test and post-test yielded total scores of 40 points, comprising 15 points for the organization of the content, 10 points for linguistic accuracy, and 5 points each for originality, fluency, and elaboration. Two expert English teachers scored according to the rubric, and the internal consistency was 0.83.

4.3.2. Learning Motivation

Six questions (three for intrinsic motivation and three for extrinsic motivation) were concluded in the learning motivation questionnaire that was developed by Wang and Chen [50]. A statement such as, “I like course content that genuinely challenges me so I can learn new things,” is an example of intrinsic motivation. “The most satisfying thing for me right now is getting a good score in this class” is one item for extrinsic motivation. The survey used a 5-point Likert scale and had a satisfactory Cronbach’s α of 0.81.

4.3.3. Writing Self-Efficacy

A modified version of the writing self-efficacy questionnaire from Bruning et al. [51] was used. The 16 items are divided into three categories: ideation, conventions, and self-regulation. The survey used a 5-point Likert scale, where 1 was the lowest and 5 was the greatest. Higher scores indicate that students show higher levels of self-efficacy to learn in EFL writing. The three questionnaire dimensions’ respective Cronbach’s α scores were 0.92, 0.91, and 0.91.

4.3.4. English Writing Anxiety

The English writing anxiety questionnaire was modified from the measure developed by Cheng [52]. It consists of nine items such as “When writing in English, I often worry that I will make language mistakes”, “When writing in English, I often feel my heart pounding”, and “When practicing writing English compositions, I often give up easily”. The survey used a 5-point Likert scale with an acceptable Cronbach’s α of 0.85.

4.3.5. Sense of Presence Questionnaire

The measure created by Hwang et al. [53] was modified for the sense of presence questionnaire. It consists of five items, such as, “To what extent were there times during the experience when the field became the reality for you, and you almost forgot about the real world?” and “During the time of the experience, did you often think to yourself that you were just standing in the conference hall or classroom wearing a VR helmet or did the field overwhelm you?” The survey used a 5-point Likert scale, where 1 was the lowest and 5 was the highest with a Cronbach’s α of 0.71.

4.3.6. Interview Outline and Coding Scheme

The interview questions used in this study’s interviews were adapted from Hwang et al. [54]. Seven questions were included in the outline for the semi-structured interviews, and 24 students (12 from each group, coded as E1-E12 and C1-C12) were invited to the interview. The purpose of the interviews was to investigate the advantages and disadvantages of the proposed learning approach from the students’ perspectives. In order to conduct a thematic inductive qualitative analysis of the interview data, Atlas.ti.22.1.4 was adopted. The results of the interviews provide additional evidence to interpret the out-comes of this study and are expected to inform future improvements in methodology. Listed below are the interview questions:

- (1) What do you believe you have benefited from learning English writing using this method the most? Which aspect did you learn the most about? Give us a specific illustration, please.

- (2) How is this method for learning EFL writing different from EFL writing classes you have previously taken (or expected)? Do you think it's effective? Why? Do you agree with the way it is used? How does it help you?
- (3) What are the advantages of this learning approach in general?
- (4) What aspects of the learning process (such as the functionality or interface design) could be improved? Please give us an example.
- (5) Would you like to have the opportunity to learn to use this method again in the future? Which courses might it be applied to? Why do you believe these courses are appropriate for this strategy?
- (6) Would you recommend other students to use this learning approach? Why, in your opinion, do they need to learn in this manner? Or would they prefer to learn this way?
- (7) Would you advise other educators to adopt this teaching strategy? Why do you think they need to use this teaching strategy? Or would they be open to adopting this in-structional strategy?

5. Results

5.1. Analysis of Learning Outcomes

In order to assess the effect of the proposed SVVR–AWE learning approach on students' EFL writing performance, a one-way ANCOVA was used in this study. The post-test scores were used as independent variables, while the pre-test scores were used as covariates. According to the test of homogeneity regression, there is no significant difference between the two groups' EFL writing performance ($F = 0.67, p > 0.05$), indicating that ANCOVA analysis could be conducted. The results are displayed in Table 1; a statistically significant difference between the experimental and control group was found ($F = 8.61, p < 0.05$), and the partial eta-squared (η^2) was 0.11 [55], representing a medium effect size. Meanwhile, the adjusted average score of the experimental group was 33.63 ($SD = 2.31$) with the standard error of 0.36, which was higher than the adjusted average score of the control group with 32.17 ($SD = 2.49$) and the standard error of 0.35. Therefore, hypothesis 1 is accepted. According to the findings, students who used the SVVR–AWE approach outperformed those who used the C–AWE approach in the EFL writing course.

Table 1. The ANCOVA results for Learning performance.

Group	N	Mean	SD	Adjusted Mean	Std. Error	F	η^2
Experimental group	37	33.65	2.31	33.63	0.36	8.61 **	0.11
Control group	39	32.15	2.49	32.17	0.35		

** $p < 0.01$.

Additionally, a series of ANCOVAs were carried out using the pre-test scores of each aspect of EFL writing performance as the covariate and the post-test scores of each aspect of English writing performance as the dependent variable to identify which aspects of EFL writing performance benefited from the suggested learning approach. The examination of the hypothesis of homogeneity of regression slopes revealed that the assumptions were not violated: organization of content ($F = 0.04, p > 0.05$), linguistic accuracy ($F = 2.33, p > 0.05$), originality ($F = 2.17, p > 0.05$), fluency ($F = 1.41, p > 0.05$), and elaboration ($F = 3.07, p > 0.05$). In order to find the differences in the five dimensions between the two groups, a series of ANCOVAs were used. The ANCOVA result is shown in Table 2.

In the aspect of organization of content, students in the experimental group scored significantly higher on EFL writing than those in the control group after excluding the influence of the pre-test, ($F = 9.46, p = 0.003 < 0.01$), with a medium effect size ($\eta^2 = 0.12$) [55]. The experimental group's adjusted mean was 13.31 ($SD = 0.94$), while the control group's adjusted mean was 12.70 ($SD = 0.95$). The findings demonstrated that students who learned using the proposed SVVR–AWE approach had a greater capacity for organization of content than students who learned using the C–AWE approach.

Table 2. The ANCOVA results of writing performance in the four dimensions.

Writing Performance	Group	N	Mean	SD	Adjusted Mean	Std. Error	F	η^2
Organization of content	Experimental	37	13.32	0.94	13.31	0.14	9.46 **	0.12
	Control	39	12.69	0.95	12.70	0.14		
Linguistic accuracy	Experimental	37	7.43	0.80	7.46	0.13	1.90	0.03
	Control	39	7.23	0.87	7.21	0.12		
Originality	Experimental	37	4.57	0.56	4.50	0.10	4.82 *	0.06
	Control	39	4.13	0.77	4.19	0.10		
Fluency	Experimental	37	4.24	0.55	4.24	0.10	0.07	0.001
	Control	39	4.21	0.66	4.21	0.10		
Elaboration	Experimental	37	4.08	0.60	4.13	0.09	4.41*	0.06
	Control	39	3.90	0.60	3.86	0.09		

** $p < 0.01$, * $p < 0.05$.

In the aspect of originality, students in the experimental group scored significantly higher on EFL writing than those in the control group after excluding the influence of the pre-test, ($F = 4.82$, $p = 0.03 < 0.05$), with a medium effect size ($\eta^2 = 0.06$) [55]. The experimental group's adjusted mean was 4.50 ($SD = 0.56$), while the control group's adjusted mean was 4.19 ($SD = 0.77$). The findings demonstrated that students who learned using the proposed SVVR–AWE approach had a greater capacity for originality than students who learned using the C–AWE approach.

In the aspect of elaboration, students in the experimental group scored significantly higher on EFL writing than those in the control group after excluding the influence of the pre-test, ($F = 4.41$, $p = 0.04 < 0.05$), with a medium effect size ($\eta^2 = 0.06$) [55]. The experimental group's adjusted mean was 4.13 ($SD = 0.60$), while the control group's adjusted mean was 3.86 ($SD = 0.60$). The findings demonstrated that students who learned using the proposed SVVR–AWE approach had a greater capacity for elaboration than students who learned using the C–AWE approach.

However, there was no significant difference between the experimental and control groups in terms of linguistic accuracy and fluency.

5.2. Analysis of Learning Motivation

The assumption of homogeneity of variance in the groups was satisfied with the results of the pre- and post-test of students' learning motivation ($F = 1.09$, $p > 0.05$). As a result, it was implied that the rest of the tests could proceed under the assumption that the regression coefficients for the two groups were homogeneous. In Table 3, the ANCOVA result is shown. Students in the experimental group had significantly higher learning motivation than those in the control group after controlling for the effects of the pre-test ($F = 4.56$, $p = 0.04 < 0.05$), with a medium effect size ($\eta^2 = 0.06$) [55]. Meanwhile, the ad-justed means and standard error of the experimental group were 23.84 ($SD = 3.31$) and 0.44, whereas those of the control group were 22.52 ($SD = 2.90$) and 0.43. Therefore, hypothesis 2 is accepted. According to the findings, students who used the SVVR–AWE approach had higher levels of learning motivation for EFL writing than those who used the C–AWE approach.

Table 3. The ANCOVA results for Learning motivation.

Group	N	Mean	SD	Adjusted Mean	Std. Error	F	η^2
Experimental group	37	24.19	3.31	23.84	0.44	4.56 *	0.06
Control group	39	22.18	2.90	22.52	0.43		

* $p < 0.05$.

5.3. Analysis of Writing Self-Efficacy

The assumption of homogeneity of variance in the groups was satisfied with the results of the pre- and post-test of students' writing self-efficacy ($F = 0.00$, $p = 0.99 > 0.05$).

As a result, it was implied that the rest of the tests could proceed under the assumption that the regression coefficients for the two groups were homogeneous. In Table 4, the ANCOVA result is shown. Students in the experimental group had significantly higher writing self-efficacy than those in the control group after controlling for the effects of the pre-test ($F = 4.68, p = 0.03 < 0.05$), with a medium effect size ($\eta^2 = 0.06$) [55]. Meanwhile, the ad-justed means and standard error of the experimental group were 55.39 (SD = 8.53) and 1.27, whereas those of the control group were 51.55 (SD = 9.61) and 1.24. Therefore, hypothesis 3 is accepted. According to the findings, students who used the SVVR–AWE approach had higher levels of writing self-efficacy for EFL writing than those who used the C–AWE approach.

Table 4. The ANCOVA results for Writing Self-efficacy.

Group	N	Mean	SD	Adjusted Mean	Std. Error	F	η^2
Experimental group	37	55.84	8.53	55.39	1.27	4.68 *	0.06
Control group	39	51.13	9.61	51.55	1.24		

* $p < 0.05$.

5.4. Analysis of English Writing Anxiety

The assumption of homogeneity of variance in the groups was satisfied with the results of the pre- and post-test of students' English writing anxiety ($F = 1.09, p = 0.30 > 0.05$). As a result, it was implied that the rest of the tests could proceed under the assumption that the regression coefficients for the two groups were homogeneous. In Table 5, the ANCOVA result is shown. Students in the experimental group had significantly lower English writing anxiety than those in the control group after controlling for the effects of the pre-test ($F = 5.17, p = 0.03 < 0.05$), with a medium effect size ($\eta^2 = 0.06$) [55]. Meanwhile, the adjusted means and standard error of the experimental group were 26.77 (SD = 5.42) and 0.57, whereas those of the control group were 28.58 (SD = 4.77) and 0.55. Therefore, hypothesis 4 is accepted. According to the findings, students who used the SVVR–AWE approach had lower levels of English writing anxiety for EFL writing than those who used the C–AWE approach.

Table 5. The ANCOVA results for English writing anxiety.

Group	N	Mean	SD	Adjusted Mean	Std. Error	F	η^2
Experimental group	37	26.03	5.42	26.77	0.57	5.17 *	0.07
Control group	39	29.28	4.77	28.58	0.55		

* $p < 0.05$.

5.5. Analysis of Sense of Presence

According to the results of the sense of presence questionnaire (Table 6), almost all of the students in the experimental group confirmed that they perceived themselves to have a high level of involvement in SVVR (the total mean value was 4.51, and the standard deviation was 0.50). Therefore, hypothesis 5 is accepted. This indicated that the learners had a strong sense of presence when learning in the SVVR system.

Table 6. The participants' perceived presence.

No.	Dimensions	Mean	SD
1	I had a sense of immersion in this learning activity.	4.57	0.50
2	The virtual scenes at the event seemed more like real places to me.	4.57	0.50
3	When I look back on the experience later, I feel that the scene is like a place I have visited, not just an image.	4.51	0.51
4	During the event, the virtual experience of the scenario made me feel strongly.	4.51	0.51
5	During the experience, I often forget that I am only wearing the virtual device for the activity.	4.38	0.49

5.6. Interview Results

In the current study, the Atlas.ti.22.1.4 software was adopted to conduct the thematic inductive qualitative analysis to understand the relationship between the main ideas raised in the interviews. In this study, the interviewers focused on learners' learning experiences with the SVVR–AWE approach. By comparing and reflecting on the interview records, we summarized the benefits of the SVVR–AWE approach. The researcher who analyzed the interviews organized the learners' responses into the following four dimensions: enhanced learning experience, improved writing ability, optimized learning process, and improved teaching. As shown in Figure 8, the Atlas.ti network presents the learning experience of the experimental group for the SVVR–AWE approach. As shown in Figure 9, the Atlas.ti network presents the results of the learning experience of the control group for the C–AWE approach.

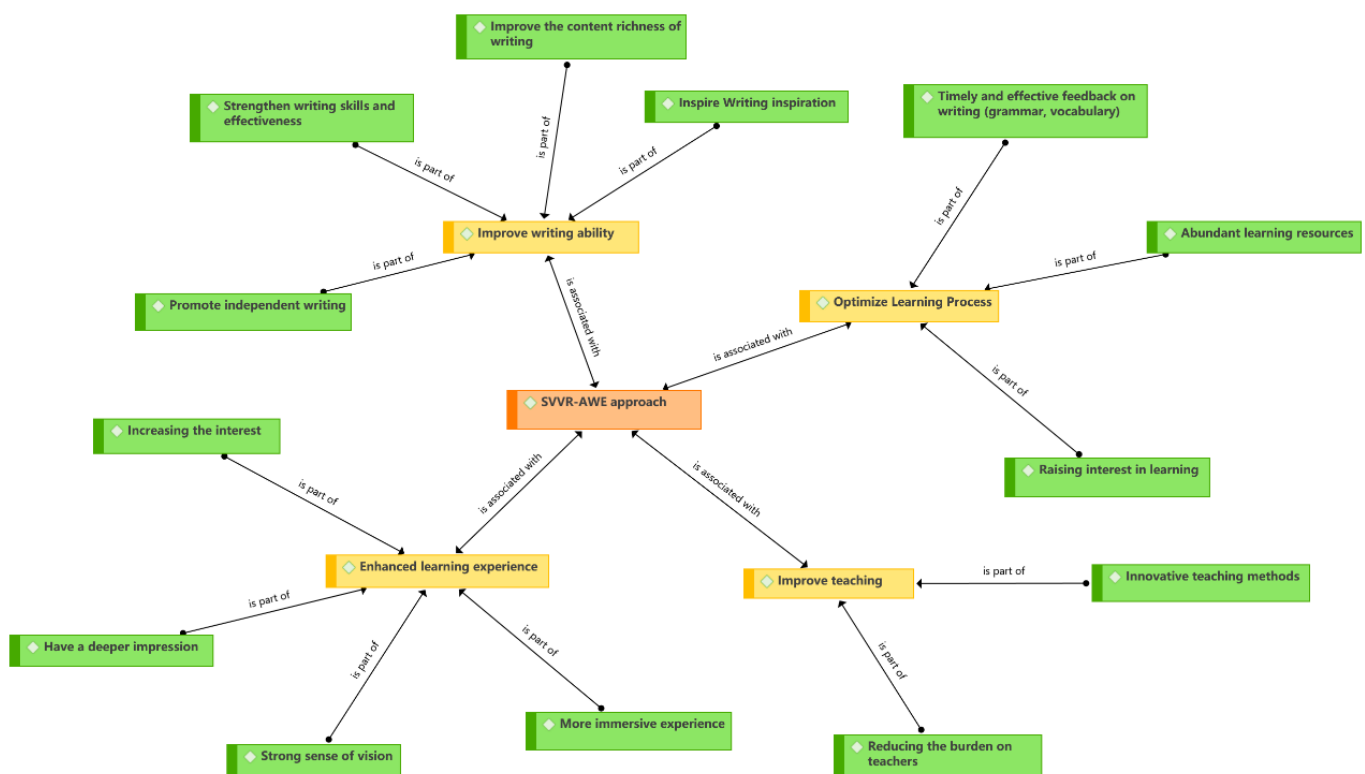


Figure 8. An explanation of the learning improvements made by students in the experimental group.

In terms of enhanced learning experience, after comparing the results of the interviews of the two groups, it was found that students who experienced SVVR felt a strong sense of experience, and they found the course more interesting and impressive than students in the control group. For example, the majority of participants interviewed said, “Learning through SVVR is more immersive, we get more information, and can click on the answers to the questions, thus remembering many points in more detail, which helps a lot in organizing the writing content” (E12). Another participant reported, “SVVR offers a visualization of the way of expressing in words, which gives us a better recall process when writing” (E07).

In terms of improving writing ability, almost all participants in the experimental group said that the SVVR–AWE approach could improve the content richness of their writing. In addition to helping with writing content, learners not only improved their writing skills and efficiency through the two technologies but also developed the ability to write independently. For example, one participant said, “I think writing might be a little more vivid compared to the previous way of delivering instruction because it allows us experience in SVVR and provides us with some great materials, such as the London trip. Probably because I have not really been to that place, I can’t describe some specific

attractions, but SVVR will give me a more profound impression” (E11). Some learners also said, “The usage of AWE can improve our writing skills and promote independent writing; it can point out mistakes and make us clearer and more specific to correct them” (C08).

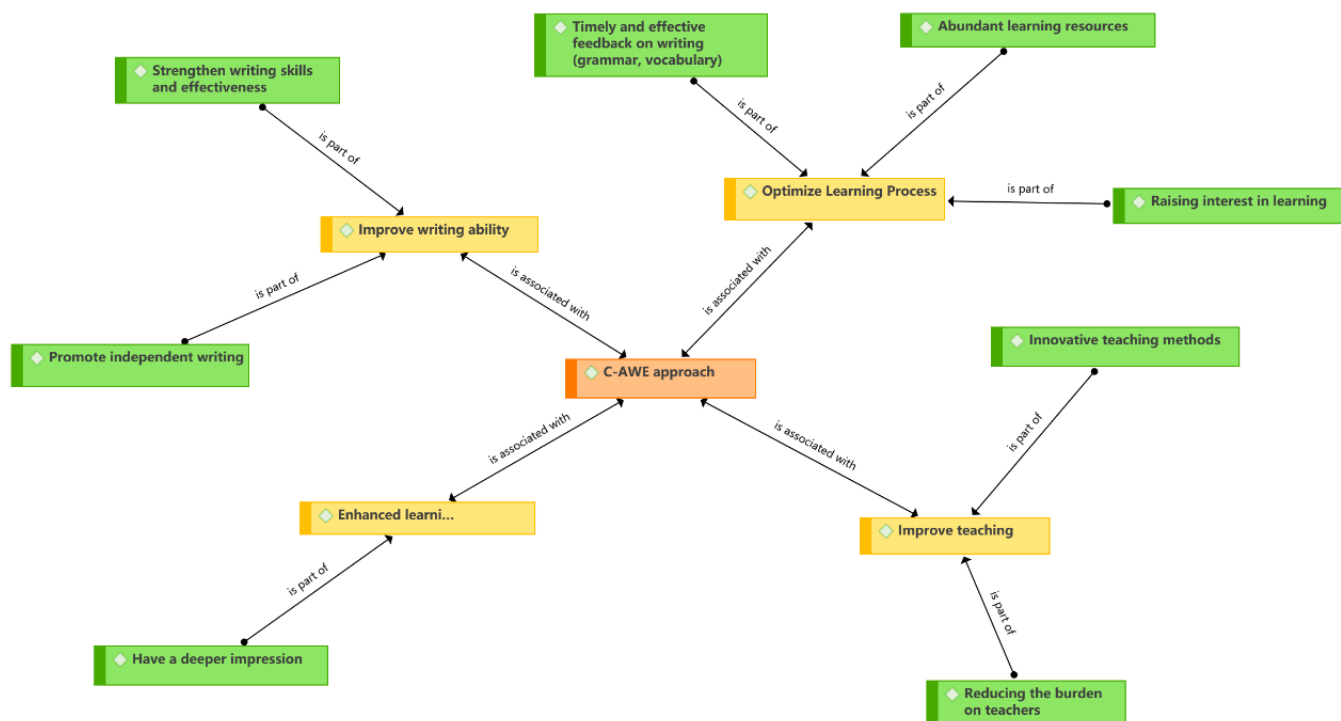


Figure 9. An explanation of the learning improvements made by students in the control group.

In terms of optimizing the learning process, SVVR increased the interest of EFL writing learners because it provided abundant learning resources, and AWE gave learners some timely and effective personalized feedback, thus making the whole instruction process more efficient. The majority of interviewees acknowledged that such a learning approach would optimize the learning process in both experimental and control groups. During the interviews, most of the participants in the experimental group mentioned that the learning approach had improved their interest in learning. For example, one participant mentioned, “The learning approach has given me a lot of novel ideas for writing and I would be more willing to write, otherwise I might feel bored if I was just given a topic as in the conventional way” (E02). Another participant also said, “In the learning process, many new technologies are used, which are different from the conventional instructional way, and the knowledge previously learned is quite limited, while SVVR allows us to learn more about the learning resources” (E07). Moreover, another participant said, “AWE does not help a lot with the content and framework of writing, but it helps with grammar and vocabulary since it provides more timely and effective feedback” (C09).

In terms of improving teaching, some interviewees said that the learning approach is a novel way of teaching, which not only reduces the burden on teachers but also increases the efficiency of teaching. Some participants said, “The corrections made by the system are relatively objective and easy to understand. Integrating SVVR with AWE is not only novel, but it can reduce the teacher’s burden” (E07). Another participant said, “The application of this learning approach allows the teacher to spend more time on communicating with students and providing more individualized guidance for students” (C11).

6. Conclusions

Previous research has indicated that the application of AWE in EFL writing can improve EFL writing efficiency, but it lacks certain assistance in content and organization. The use of SVVR in writing activities has been shown to improve performance in writing

content and increase self-efficacy [15]. However, no research combined SVVR with AWE to explore its effects on learners' EFL writing performance.

Therefore, the present study proposed an approach that integrates SVVR and AWE to investigate the effects on EFL writing performance, motivation, writing self-efficacy, writing anxiety, and sense of presence. The experimental results showed that the SVVR–AWE approach significantly improved learners' EFL writing performance, learning motivation, and writing self-efficacy, and reduced their writing anxiety compared to the C–AWE approach. The study results indicated that integrating SVVR and AWE can have a positive impact on EFL writing, not only improving writing accuracy but also facilitating the richness and completeness of writing content for high-quality writing.

7. Discussion

In terms of learning achievement, students who adopted the SVVR–AWE approach showed better learning achievement than those who adopted the C–AWE approach. This finding is similar to the previous studies, which applied SVVR to EFL writing to help learners have better content and appearance in writing [14], and it was found that learning with AWE benefits learners in terms of their linguistic expression and creative thinking in writing [45]. In this study, the SVVR–AWE approach significantly improved learners' writing performance in the areas of organization of content, originality, and elaboration compared to the C–AWE approach. This may be because the application of SVVR can guide learners to experience the writing context, thus increasing the content richness and efficiency of their writing [56]. As for linguistic accuracy and fluency, nothing between the two groups differed significantly; a possible reason may be that both groups used AWE, resulting in no significant difference in the basic linguistic expressions of the two groups.

With regard to learning motivation, students who adopted the SVVR–AWE approach showed higher motivation than those who adopted the C–AWE approach. The result indicates that during the writing process, the relatively authentic language context in SVVR could inspire students to create ideas for their writing, which helped them to complete the writing task more successfully, thus enhancing their learning motivation in EFL writing [57]. Furthermore, as the interview results indicated, compared to the C–AWE approach, students who adopted the SVVR–AWE approach could increase their learning interests and have a deeper impression of the learning context, thus enhancing their learning experience. Scholars have indicated that allowing learners to perceive and understand a certain language context before writing can help improve their learning motivation [45]. Thus, this study appropriately integrated SVVR and AWE, which not only engaged learners in organizing what they observed and learned but also enabled them to connect writing topics to real-life contexts. This finding exactly echoes the statement in a previous study, which mentioned that simply using AWE may result in low-quality feedback, and introducing other technologies or strategies may help them perceive the meaning of the learned content better [7].

In terms of EFL writing self-efficacy, students learning with the SVVR–AWE approach had better writing self-efficacy than those learning with the C–AWE approach. Possible reasons for this may be that learners can enrich their ideas through SVVR. Compared to the conventional method, learners enhanced their perceptions and understanding through authentic contextual experiences and were able to elaborate on the content of their writing, thus increasing their confidence in writing [35]. This outcome is in line with the study of Huang et al. [15], which showed that the application of SVVR on writing helps to improve learners' writing self-efficacy. Self-efficacy is an imperative element in EFL writing instruction [58]. Appropriately integrating technology into instruction can help learners increase their learning experiences and enhance their authentic experiences, which can have a favorable effect on their level of self-efficacy [59].

In terms of EFL writing anxiety, students who learned with the SVVR–AWE approach had lower writing anxiety than those who learned with the C–AWE approach. This may be because, through the immersive experience of SVVR, learners remember the situations

they experience through recalling, which helps them to have some basic statements for describing when writing. In addition, learning in the SVVR system gives learners a relaxing learning environment, which may result in lower writing anxiety. Similar to what was found in the findings of Chien et al. [19], adopting SVVR in EFL writing instruction significantly reduced learners' writing anxiety, which also has a positive effect on learning performance. It is noted that AWE's provision of timely and personalized feedback also gives learners sufficient support to reduce their learning anxiety [60].

As for sense of presence, using the SVVR–AWE approach can enhance the learners' sense of presence. According to the questionnaire results and interview analysis, almost all students in the experimental group felt that they had a high level of engagement and a good immersion experience in SVVR. This finding is consistent with a previous study which found that virtual reality environments allow learners to feel a strong sensory fidelity in terms of visual and auditory aspects, and a strong sense of immersion, thus facilitating deep interactive behaviors [53,61]. Therefore, it can be inferred that by presenting authentic language situations, learners can have a sense of presence and thus engage in independent learning to improve their learning outcomes.

There are several practical and pedagogical implications of the current study for EFL writing instruction. From the practical perspective, the current study provided a technological solution for creating authentic language environments for EFL writing and helped teachers organize writing instruction activities in a technology-enhanced environment. The pedagogical implication from the study is that introducing AWE in EFL writing instruction should consider both individual learners' differences in understanding the feedback and also the learning activities' design, which effectively combined the advantages of AWE and SVVR.

Although this study found a positive effect of the proposed learning approach, there are still some limitations that need to be improved on in future studies. First, due to course limitations, this study was conducted for only 4 weeks, but writing is a core competency that needs to be developed over time. Second, the sample size of this study was small; future learning studies are recommended to expand the sample size.

In addition, adopting SVVR in the learning process may cause dizziness for some students, which may interrupt the learning process. Furthermore, the SVVR content was sometimes not well-organized, which led to passive learning.

In future studies, we will extend the experimental period reasonably according to the requirements of the curriculum and increase the number of study subjects appropriately. In addition, we need to pay attention to the SVVR content organization and the way to appropriately integrate AWE into the learning process. We suggest that researchers use other different learning strategies to support AWE to help students learn more effectively, such as gamification. Future research could also apply SVVR in different aspects of EFL (e.g., speaking, reading, listening, etc.) to help students improve their EFL learning performance and higher-level thinking skills. We also recommend that researchers further analyze students' personal qualities, such as their level of knowledge and cognitive style.

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