Exploring factors affecting communication in three-dimensional virtual worlds for second language learning: development and validation of a scale

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Abstract

Purpose – The use of three-dimensional virtual worlds (3DVWs) is increasingly becoming a common practice in language education to provide digital learning environments for second-language (L2) communicative classes. This study aimed to identify the key factors underlying communication in 3DVWs that can improve the communication skills of L2 learners.

Design/methodology/approach – To achieve this, exploratory factor analysis (EFA) and confirmatory factor analysis (CFA) were conducted to validate the identified factors affecting communication in 3DVWs. A self-reported questionnaire with 47 items on a five-point Likert scale was administered to 513 pre-service teachers, teachers and lecturers in the field of language education.

Findings – The results of the EFA revealed four factors that contribute to communication in 3DVWs, namely learner motivation, interaction pattern, language development and learner autonomy. CFA results provided support for the updated model, with statistically significant Chi-square results ($\chi^2 (df = 83) = 181.049, p < 0.001$) indicating a good fit between the model and the data.

Originality/value – The findings suggest that the four EFA-derived parameters are valid and can assist instructional designers and L2 instructors in creating 3DVWs that enhance L2 learners’ communication abilities. This study provides valuable insights for educators, instructional designers and researchers in the field of language education and technology-enhanced learning.

Keywords 3D virtual world, Second-language learner, Communicative skill, Exploratory, Confirmatory

Paper type Research paper

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1. Introduction

Three-dimensional virtual worlds (3DVWs) are a rapidly evolving field of computer-generated, multiuser environments that enable individuals to communicate and interact in real-time, regardless of geographical distance, through the use of avatars. This innovative technology has shown potential for a range of benefits for second-language (L2) learning, including improved communication through motion, voice, and text-based methods (Chen and Kent, 2020; Meadows, 2008). The versatility of 3DVWs for academic contexts and instructional purposes in higher education (Savin-Baden et al., 2010) has driven their increasing adoption in foreign language classrooms, with educators using platforms such as Second Life (SL) to enhance L2 proficiency, connect students with native speakers, and promote cross-cultural communication (Braun and Slater, 2014; Canto and Ondarra, 2017; Lan and Liao, 2018; Lan et al., 2018a; Yeh and Lan, 2018).

Several studies have explored the effectiveness of using 3DVWs in L2 learning. Chen and Kent (2020) found that a simulated immersive playground in 3DVW format enabled learners to use English for communicative and real-world purposes, engage in meaningful contexts, showcase their culture, and collaborate effectively. The European-funded initiative, EVIVA (Braun et al., 2020), evaluated the educational potential of two artificial worlds, including a 3DVW, where users interact through avatars. Jauregi et al. (2011) developed guidelines for interaction activities in 3DVWs for the EU project, NIFLAR, and found that the tasks designed for 3DVWs provided insight into activity design and contributed to a better understanding of student engagement in virtual environments.

Research has demonstrated that the use of 3DVWs can lead to improved L2 skills. For example, Lan et al. (2018a) found that English as a foreign language (EFL) students learnt words for sports more effectively by observing their own 3D avatars performing actions than by performing the actions themselves or doing nothing. Lan and Liao (2018) discovered that Chinese as L2 students perceived that the authentic-like situations in 3D virtual scenarios reduced their learning anxiety, motivated them to acquire knowledge, and enabled them to understand what they heard. Chen (2016b) found that L2 learners gained experiential learning experiences by performing real-world tasks in the target language facilitated by the unique qualities of 3DVWs.

Despite the growing body of literature on the use of 3DVWs for L2 learning, there remains a gap in research that employs factor analysis to analyse data collected from these environments. This study aims to address this gap by utilising factor analysis to examine data collected from a 3DVW, in order to gain a deeper understanding of L2 learning in virtual worlds, and explore specific ways in which this technology can be used to enhance L2 proficiency, connect students with native speakers, and promote effective communication.

1.1 Development and initial validation of the questionnaire

The current study aimed to develop and validate a questionnaire that evaluates the key components of 3D Virtual Worlds (3DVW) in language teaching and communication skill development. To achieve this, a comprehensive review of the existing literature was conducted, and ten lecturers and specialists were interviewed in one-on-one sessions (Young and Bryan, 2018). The development and initial validation of the questionnaire was carried out through a rigorous three-step process.

Study 1 involved the creation of survey items based on a review of published studies (Canto and Ondarra, 2017; Jarmon et al., 2009; Minocha and Reeves, 2010; Peterson, 2016; Yeh and Lan, 2018) and expert interviews. Study 2 was a pilot study that tested the initial validity of a pool of 50 items, which was narrowed down from the initial set, on 107 pre-service teachers, teachers, and lecturers. A principal components analysis (PCA) was conducted, revealing a five-factor solution for the 3DVW dimensions related to L2 communication development. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.897, and a significant Bartlett’s test of sphericity ($\chi^2(1081) = 21192.534; p < 0.001$) indicated the suitability of the items for factor analysis.
To further enhance content validity, a panel of five experts was consulted to evaluate the clarity and comprehensibility of the 50 items. This resulted in the removal of three items, resulting in a final questionnaire consisting of 47 items.

### 1.2 Initial indications of internal structure

The study further examined the construct validity of the questionnaire developed in Study 2 by using a sample of 1,026 pre-service teachers, teachers, and lecturers. The sample was randomly divided into two halves, with the second subsample of 513 participants selected to test the internal construct of the questionnaire. The approach of dividing a large sample in half for instrument development and replication is a common practice when sample size is sufficient (DeVellis, 2012). The dimensionality of the questionnaire was analysed through a principal factor analysis with varimax rotation, which yielded a five-factor solution with a KMO measure of sampling adequacy of 0.965 and a significant Bartlett’s test of sphericity ($p < 0.001$), indicating the suitability of the items for factor analysis.

Item analysis was conducted by examining item commonality, factor loadings, and the number of items per factor (Hair et al., 2019). After five items were deleted due to insufficient factor loading and the fifth factor was eliminated with only two items, four factors met the statistical retention criteria. The four factors were named Learner Motivation (LNM), Interaction Pattern (ITP), Language Development (LGD), and Learner Autonomy (LNA) based on a review of existing literature. A CFA was conducted with 40 items that had factor loadings of 0.32 and communalities of 0.30. The four factors demonstrated good internal consistency, with Cronbach’s coefficient alphas ranging from 0.786 to 0.972. Factor scores were generated using the regression method and standardised to have a mean of zero and a standard deviation of one. The intercorrelations between the factors ranged from 0.895 to 0.982, indicating both distinctiveness and interconnection between dimensions.

The results of the questionnaire revealed four dimensions – LNM, ITP, LGD, and LNA – that align with the key aspects of 3DVWs in L2 communicative classrooms identified in the literature review and will be discussed in the following section.

### 2. Factors of 3DVWs in L2 communicative classrooms

An exploratory study, conducted through a questionnaire, identified four key factors that shape the use of 3DVWs in L2 communicative classrooms. The application of 3DVWs in L2 instruction is a growing area of research, and the literature emphasises its potential to enhance language proficiency (Canto and Ondarra, 2017; Lan et al., 2019; Peterson, 2016). The interactive, immersive, and realistic features of 3DVWs make them an ideal tool for simulating real-life tasks that can be challenging to achieve in traditional classrooms.

However, the use of 3DVWs for L2 instruction poses a significant challenge, which is to design tasks that sustain student interest (Dörnyei and Kormos, 2000). Tasks that align with students’ motivation for learning and maintain their interest are crucial for increasing student engagement and active involvement. 3DVWs offer distinct opportunities for L2 instruction by enabling the simulation of real-world activities (Cooke-Plagwitz, 2009; Peterson, 2016) and interactive problem-solving tasks (Jauregi et al., 2011; Wang et al., 2012). Research suggests that these tasks improve student commitment and engagement, leading to increased motivation, autonomy, and communication (Chen, 2016a; Clarke and Dede, 2005; Dawley and Dede, 2014; Pellas, 2014; Peterson, 2010, 2012).

The use of 3DVWs and interaction as a feature of L2 acquisition is a rapidly growing field of research (Hartwick, 2018). 3DVWs provide a more natural learning environment than traditional online learning platforms and may promote interaction more effectively (Jarmon et al., 2009). Additionally, storytelling, role-playing, improvisation, and other action-based
activities have been found to enhance social interaction in 3DVWs (Wang et al., 2020). These virtual environments allow learners to engage with native speakers and undertake real-world tasks using avatars (Jauregi and Canto, 2012; Wigham et al., 2018). Research suggests that language proficiency can be achieved through social interaction and meaningful engagement with tasks in 3DVWs (Peterson, 2012). Therefore, incorporating 3DVWs in L2 instruction can be a promising strategy for facilitating language learning in a realistic and engaging manner.

3DVWs offer significant potential for enhancing language development by providing abundant opportunities for social interaction and collaboration (Jarmon et al., 2009). The communicative capabilities embedded in 3DVWs enable learners to engage in authentic and meaningful interaction with others, positively impacting their communicative competence (Canto and Ondarra, 2017; Jauregi et al., 2011). Learners’ exposure to rich linguistic input and authentic communication experiences in task-based interaction enhances their communicative competence (Coleman, 2002; Crookall, 2002).

Task-based language teaching and other pedagogical approaches that foster authentic communication and interaction between learners are necessary to effectively enhance L2 learners’ communicative competences (Lan et al., 2016). In addition, the design and implementation of 3DVWs should prioritise the promotion of learner autonomy by providing opportunities for learners to create their own learning materials and contexts (Yeh and Lan, 2018). Learner autonomy and motivation can be fostered by allowing students to have control over their learning experience and experiment with the language (Hafner and Miller, 2011; Lan, 2015; Mercer and Williams, 2014; Reinders, 2010).

The promotion of learner autonomy is a fundamental aspect of language learning and has been widely recognised as essential for enhancing learner motivation and engagement (Reinders, 2010; Mercer and Williams, 2014). When students exercise control over their learning, they are more likely to be motivated and increase their autonomy (Hafner and Miller, 2011). Therefore, is it crucial to design and implement educational materials and activities that inspire learners to transcend beyond the boundaries of the pedagogical setting and apply their newly acquired knowledge to real-life situations.

The use of 3DVWs has shown potential for enhancing learner autonomy and motivation in L2 instruction (Yeh and Lan, 2018; Lan, 2015). 3DVWs provide a rich and immersive environment for learning and offer authentic learning activities that encourage students to communicate with one another. Moreover, 3DVWs increase students’ motivation and desire to learn an L2, particularly when they are given opportunities to create their own learning materials and contexts.

This purpose of this study was to examine the factor structure of a questionnaire designed to assess the components of 3DVWs in L2 communicative classes. The research objectives were twofold: (1) to determine the fit of the previously discovered four-factor structure of the questionnaire with data from a large sample of participants and (2) to confirm the critical factors that contribute to the development of 3DVWs for L2 communicative classes. Building on the findings of the initial exploratory study, the study hypothesised that the four-factor structure would be replicated, and confirmatory item analysis would validate the four factors. The study aimed to provide empirical evidence in support of the use of 3DVWs in L2 instruction and to identify the key components that contribute to the effectiveness of 3DVWs in promoting language development and communicative competence.

3. Methods
The current study employed a descriptive quantitative methodology with EFA and CFA to investigate the factor structure and validate the previously developed questionnaire on the use of 3DVWs in L2 communicative classes in the Thai context. Adherence to institutional review board-approved ethical norms, including IRB approval and informed consent, ensured...
the protection of participants’ rights and confidentiality. The study’s results provide valuable insights into the effectiveness of 3DVWs in promoting language development and communicative competence in L2 instruction in Thailand.

3.1 Participants
The sample size for this study was carefully calculated using G*Power 3.1.9.7 software to achieve a sufficient sample size for conducting EFA and CFA. Multiphase sampling techniques were used to recruit a diverse sample of 513 pre-service teachers, teachers, and lecturers, with the goal of ensuring representativeness in terms of gender, profession, and geographic location. The sample consisted of 76.02% female and 23.98% male participants, with 74.46% pre-service teachers, 1.56% schoolteachers, and 23.98% university and college lecturers. Representation from all six regions of Thailand was ensured, with the majority of participants (58.29%) from the Bangkok Metropolitan area and others from the Northeast (15.98%), Central (12.28%), North (9.55%), South (2.28%), and East (1.56%) regions.

3.2 Instrument
The 3DVWs in L2 communicative classes questionnaire was designed to assess the four fundamental elements (LNM, ITP, LGD, and LNA) of 3DVWs in L2 instruction. The questionnaire consisted of items rated on a 5-point Likert scale (strongly disagree to strongly agree), allowing participants to provide their opinions on what teaching Thai as a foreign language in 3DVWs entails. To ensure the questionnaire’s content validity, a thorough literature review was conducted and validated through interviews with 20 lecturers and specialists and consultations with five experts. The content validity of the questionnaire was critical in determining its adequacy and relevance to the population being studied. A comprehensive set of questionnaire items can be found in Appendix.

3.3 Procedure
The study followed ethical protocols approved by the institutional review board to administer an online questionnaire via Microsoft Forms, seeking the perspectives of 513 pre-service teachers, teachers, and lecturers on the essential elements of 3DVWs in L2 communicative classes. The participants were assured of anonymity and provided implied consent by completing the 15-min questionnaire. The authors employed a comprehensive literature review and expert consultations to ensure the content validity of the questionnaire, as content validity is critical in evaluating the measure’s relevance to the study population. The reliability of the questionnaire was established through EFA and further validated through CFA, following the guidelines (Chiang et al., 2023; Hooker et al., 2016; Hsu, 2010) for questionnaire development and validation. All data was de-identified to preserve participant confidentiality.

4. Findings
4.1 EFA results
The results of the principal component analysis with varimax rotation revealed the underlying structure of the 3DVWs for L2 instruction items in the survey. Four factors were identified, accounting for 67.515% of the items’ variance. The factor loadings, eigenvalues, and normality accounted for each factor are presented in Table 1, along with the alpha coefficients. The alpha coefficients indicate strong internal consistency, with Factors 1, 3, and 2 showing the highest reliability and Factor 4 showing the lowest. The use of a minimum eigenvalue of 1 and a minimum factor loading of 0.32 ensured that only items that met the criteria were used in the final solution.
The 40-item questionnaire yielded a four-factor model. The first factor, named “Learner Motivation,” accounted for 25 items that measure the level of learners’ motivation to learn within 3DVWs. The second factor, “Interaction Pattern,” consisted of six items that assess the ways in which learners interact with the tasks and content in 3DVWs. The third factor,
“Language Development,” included four items focused on developing effective communication skills through practice in 3DVWs. The fourth factor, “Learner Autonomy,” was composed of five items that gauge students’ responsibility and self-directed learning in 3DVWs.

The normality tests of the sample data showed that the means ranged from 3.331 to 4.345, and the standard deviations were between 0.783 and 1.168. The skewness and kurtosis values were also within the normal range, as skewness values ranged from $-0.252$ to $-0.989$ and kurtosis values ranged from $-0.636$ to 0.865 (George and Mallery, 2016). These results indicate that the data is normally distributed and suitable for factor analysis as it falls within the acceptable range of $\pm 2$.

4.2 CFA results
The results of the CFA indicated that the four-factor model of the questionnaire was an appropriate representation of the data, with a good fit to the observed data as indicated by the following fit indices (Kline, 2015):

1. Chi-Square Test of Model Fit ($\chi^2$ (df = 83) = 181.049, $p < 0.001$),
2. Tucker–Lewis Index (TLI) = 0.940,
3. Root Mean Square Error of Approximation (RMSEA) = 0.067,
4. Comparative Fit Index (CFI) = 0.957, and
5. Standardised Root Mean Square Residual (SRMR) = 0.053.

These results suggest that the questionnaire’s structure and the relationships among its items were well represented by the four-factor model, thus providing support for its reliability and validity (Brown, 2006). A visual representation of the factor loadings for each item can be found in Figure 1.

It is noteworthy that these findings indicate that the questionnaire developed for the study effectively measures the essential elements of 3DVWs in L2 communicative classes, as identified through the literature review, interviews with experts and specialists, and consultations with five experts. This contributes to the field of language education by providing a valid and reliable tool for measuring the effectiveness of 3DVWs in L2 communicative classes.

5. Discussion
The current study is the first to examine the underlying factors of 3D Virtual Worlds (3DVWs) for enhancing L2 learners’ communicative capabilities, utilising an instrument based on a comprehensive review of relevant literature. The findings highlight that motivation, interaction, communication, and autonomy are crucial factors in the effectiveness of 3DVWs in L2 communicative classrooms.

The presence of these factors is significant for L2 instructors and practitioners, who can use the information to develop 3DVWs that engage learners effectively. According to Mount et al. (2009), the degree of engagement depends on the learner’s motivation to participate. The study’s results demonstrate that most learners have positive experiences with 3DVWs, and interaction stimulates high motivation and interest. Jauregi et al. (2011) further found that integrating 3DVWs with native speakers enhances the motivation of L2 learners, especially for those with low proficiency levels.

The immersive, interactive, and realistic nature of 3DVWs allows learners to imitate real-world tasks in target language environments, encouraging learner autonomy and
goal-oriented efforts. Dörnyei and Kormos (2000) suggest that these environments result in greater motivation and sustained task interaction. Education in virtual environments has the potential to be a novel teaching and learning technique that enables students to interact from any location at any time (Park and Seo, 2013). With the pervasive and dynamic nature of 3DVWs, learners can interact with other speakers worldwide, negotiate meaning spontaneously, and adjust their linguistic output, thus enhancing their interaction and communication competence (Jauregi et al., 2011).

The use of 3D Virtual Worlds (3DVWs) in L2 instruction provides students with opportunities to engage in authentic-like communication tasks outside of the traditional classroom setting (Blake, 2000). Studies have shown that the interactional spaces of 3DVWs are beneficial for L2 learners’ language development as they provide opportunities to experiment with social norms and engage in meaningful learning activities (Jauregi et al., 2011; Steinkuehler, 2006; Cooke-Plagwitz, 2008). Research also suggests that the authentic-like circumstances provided by 3DVWs can reduce anxiety and increase motivation among learners (Lan and Liao, 2018). The use of avatars in 3DVWs can also enhance communication and promote learner autonomy (Ibáñez et al., 2011).

The study of Kim (2014) shows that students’ speaking proficiency, including vocabulary, sentence complexity, pronunciation, and confidence, improves in 3DVWs. Digital environments increase learners’ autonomy by allowing them to work individually and interact with peers. Cho and Lim (2017) suggest that autonomy in learning activities leads to intrinsic motivation, and 3DVWs can be used to increase students’ autonomy, resulting in more self-directed effort and active participation.

The findings of this study highlight the importance of motivation, interaction, communication, and autonomy in the effectiveness of 3DVWs in enhancing L2 learners’ communicative capabilities. The results provide a foundation for L2 instructors and
practitioners to develop 3DVWs that effectively engage learners and support the acquisition of communicative competence.

6. Conclusion and limitation
The results of this study provide meaningful contributions to the field of L2 education by emphasising the critical role of motivation, interaction, communication, and autonomy in enhancing the communicative abilities of L2 learners through the use of 3DVWs. Previous studies have demonstrated that 3DVWs, with their immersive and interactive nature, have the potential to improve motivation, interaction and communication between learners, as well as foster learner autonomy (e.g. Ibáñez et al., 2011; Jauregi et al., 2011; Lan and Liao, 2018).

Moreover, the use of 3DVWs for authentic problem-solving tasks has been shown to enhance L2 learners’ communicative abilities, negotiation of meaning, and interaction and communication competence (e.g. Canto and Ondarra, 2017; Coleman, 2002). This study has expanded the understanding of the features and benefits of 3DVWs for L2 education and their future design, providing valuable insights for instructional designers, practitioners, and educational institutions to make informed decisions in the implementation of virtual environments for L2 education.

However, it is important to acknowledge the limitations of this study. One key limitation is the reliance on self-reported data, which may be biased by social desirability effects. Additionally, the sample of participants, mostly pre-service teachers and experienced lecturers, may not fully reflect the larger population of 3DVW users. These limitations must be kept in mind when interpreting the results. In order to further address these limitations, future studies could gather data through additional methods, such as observations or interviews, and include a more diverse sample in terms of age and proficiency level. Furthermore, replicating this study with a larger sample size would provide further evidence to support the relationship between 3DVWs and L2 communicative ability.

References


Factors affecting communication in 3DVWs


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Appendix

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**Factor 1: learner motivation (LNM)**

Q11 The 3DVWs provide L2 learners with feedback on their responses
Q37 At the conclusion of each lesson, L2 learners take a test to gauge their development
Q48 Learners can review previously studied material as necessary
Q10 The 3DVWs must enable L2 students to participate with lessons, such as by responding to questions
Q6 The utilisation of hypermedia makes 3DVWs more engaging
Q29 Learners are informed of the evaluation results immediately following each task in the 3DVWs
Q5 The utilisation of multimedia makes 3DVWs more engaging
Q27 The 3DVWs incorporate both L2 and international phonetic alphabets in their content and activities
Q34 Collaborating with others in the 3DVWs improves the communication abilities of L2 learners
Q32 Using games or gamification assists L2 students in concentrating on the content of the 3DVWs
Q33 Using simulations assists L2 students in concentrating on the content of the 3DVWs
Q15 In the 3DVWs, L2 learners acquire an L2 in a context-relevant manner
Q36 The 3DVWs are created to resemble real-world environments
Q18 The 3DVWs are proper for practising L2 writing/typing proficiency
Q12 The 3DVWs facilitate interaction between L2 learners
Q14 The 3DVWs offer possibilities for L2 students to collaborate
Q31 There are mini tests for students to complete periodically throughout the study of the 3DVWs
Q7 The content of 3DVWs emphasise the development of reading abilities
Q50 Learners can choose content in ascending order of difficulty
Q13 The 3DVWs facilitate interaction between L2 learners and digital artefacts
Q17 The 3DVWs are proper for training L2 reading comprehension
Q38 Instructors play a crucial role as facilitators in teaching content within the 3DVWs
Q30 Learners are informed of the evaluation results following all tasks in the 3DVWs
Q21 Using 3DVWs, L2 learners are able to communicate or interact with native speakers
Q22 The study and activity time in the 3DVWs are shorter than 60 min

**Factor 2: interaction pattern (ITP)**

Q24 Learning content and engaging in activities in the 3DVWs are synchronous (at the specified time)
Q1 A narrative video is used as the content of 3DVWs
Q3 The content of 3DVWs must be described by instructors
Q28 The 3DVWs’ content and activities appear only in L2
Q2 A descriptive text is used as the content of 3DVWs
Q41 The 3DVWs is used as the main medium in learning activities
Q25 Learning content and engaging in activities in the 3DVWs are asynchronous
Q9 The content of the 3DVWs must be described by instructors
Q8 The content of 3DVWs emphasise the development of listening and speaking abilities
Q19 The 3DVWs are proper for enhancing L2 oral proficiency
Q46 The 3DVWs are utilised throughout the entire lesson plan
Q23 The study and activity time in the 3DVWs exceed 60 min
Q23 The study and activity time in the 3DVWs exceed 60 min

**Factor 3: language development (LGD)**

Q20 The 3DVWs are proper for practising L2 listening comprehension
Q9 The content of the 3DVWs emphasise the development of writing and typing skills
Q8 The content of 3DVWs emphasise the development of listening and speaking abilities
Q19 The 3DVWs are proper for enhancing L2 oral proficiency

**Factor 4: learner autonomy (LNA)**

Q40 The 3DVWs are developed such that students can study without an instructor
Q25 Learning content and engaging in activities in the 3DVWs are asynchronous
Q4 In the 3DVWs, there is no lecture, but rather communication skills practice
Q46 The 3DVWs are utilised throughout the entire lesson plan
Q23 The study and activity time in the 3DVWs exceed 60 min

Table A1.
Survey items

Source(s): Authors’ own work