Examining the Role of Self-Determination Theory in AI-Enhanced Personalized Blended Learning Environments for Primary School Chinese EFL Learners

Arfa Akram[1], Laraib Munsif[2], Musarrat Parveen[3], Sundas Sattar[4] and Awais Ur Rahman[5]

1) Bahauddin Zakariya University Multan, Pakistan
2) M. Phil Scholar, Shaheed Benazir Bhutto Women University Peshawar, Pakistan
3) M. Phil Scholar, Shaheed Benazir Bhutto Women University Peshawar, Pakistan
4) University of Sahiwal, Pakistan
5) Abdul Wali Khan University Mardan, Pakistan

Introduction

It is pertinent to mention here that EFL education in Chinese primary schools has emerged as an important focus of the last few decades due to rising globalization and development of economosaic(Cosmopolitic)eti fluence of China (Wang & Kirkpatrick, 2022; Li et al. , 2023). Today, Ministry of Education, China has laid policies to begin English learning from the third grade; this is an indication that learning should begin early in a childhood so as to learn the language and have the ability to communicate through it (Zhang & Liu 2024). However, many concerns still exist in EFL educational environment such as great class size, less opportunity to interact with real contexts, and curriculum stress on examinations (Chen et al. , 2023; Wu & Johnson, 2024). The literature review of the present study has also stressed on the fact that new strategies are being called for to tackle these issues. For example, Yang et al., (2023) stated that conventional paradigm C loses the interest of young readers and Zhao and Smith (2024) noted that more entertaining and user-centred learning approaches have to be established. In addition, Liu and Wang (2023) pointed out that the present EFL curriculum implemented in Chinese primary schools does not incorporate the sociocultural context and fails to provide authentic language practice to the learners which is essential for second language acquisition.

Self-Determination Theory, developed by Deci and Ryan (1985) and further elaborated in subsequent work (Ryan & Deci, 2020), posits that intrinsic motivation and psychological well-

being are fostered when three basic psychological needs are met: that are self-determination, self-organised competence and self-relatedness. In the educational domain, SDT has been particularly applied toward helping educators to facilitate the motivation, engagement as well as learning achievement of learners (Vansteenkiste et al., 2023; Johnson & Lee, 2024). Some of the current researchers have proposed the use of the SDT in language learning context especially in the EFL systems with a view of enhancing the instruction. For instance, Chen and Zhang (2023) established that speaking to students' self-regulated pedagogy learning to be more motivated and develop their language proficiency. Wang et al. (2024) has also observed that when teachers provided apppropriately challenging tasks and positive feedback,students' willingness to communicate in English had increased.

Recent advancement in information and communication technology specifically artificial intelligence has been proved as effective tool in education hence providing student with unique and individual needs favorable learning environment (Johnson et al. , 2024; Smith & Brown, 2023). During the use of blended learning which intermingles face to face and online learning, AI can adopt the abilities of numerous learning platforms, it can also give instant feedback and recommend relevant content (Li & Chen, 2024; Wu et al. , 2023). The use of AI in, EFL education is also viewed to hold the potential in meeting the learner's need to learn the second language, and enhance the learning process. For example, Zhang and Liu (2023) revealed that through the employ of AI based chatbots, students' spoken English easily could be enhanced, thanks to constant practice through the virtual teacher. Furthermore, Wang and Johnson in the study whereby the AI adaptive learning systems learned that it was easy to diagnose the specific areas that the individual students were struggling with in terms of grammar and vocabulary.

The CAR-SCT model, developed for this study, integrates four key elements derived from sociocultural theory and best practices in language education:The CAR-SCT model, developed for this study, integrates four key elements derived from sociocultural theory and best practices in language education:

1. Cultural Authenticity: Considering the students' cultural background in the choice of materials and tasks (Xu & Li, 2023).

2. Social Interaction: Enabling effective and authentic interaction and work (Chen et al. , 2024).

3. Language Utilization: Opportunities to use language actively in different settings (Wang & Smith, 2023).

4. Scaffolding and Guided Participation: Providing more intensive and progressive form of intervention with an aim of targeting discrete skills (Zhang & Johnson, 2024).

This model will endeavour to develop an integrated model of AI-assisted BL in EFL for the needs of primary school learners (Author, 2024). The CAR-SCT model extends prior work established in the literature, including Lantolf and Thorne's sociocultural approach to L2 learning, as well future developments in the communicative language teaching method by Richards and Rodgers 2023, but with the inclusion of AI personalisation elements.

As Liu et al. showed in their 2023 study, mixed approaches to teaching and learning with the help of artificial intelligence have recently received a lot of attention by academic researchers; however, the use of Self-Determination Theory in combination with blended learning and AI has not been the focus of many studies, especially with reference to the Chinese primary school EFL learners (Chen & Wang, 2024; Wang et al. , 2023 This study fills this void by exploring the role of the artificial intelligence (AI) in the delivery of the blended learning environment based on the CAR-SCT model that views learners' engagement and language skills improvement in light of the basic psychological needs that underpin the self-determination theory (SDT).

The importance of this study therefore lies in the subject of using findings to enhance the teaching practices and strategies, the educational technologies, and the policies that govern EFL education in the Chinese primary schools. This study seeks to make a thrust to the current research endeavours of enhancing English language learning in China and perhaps in other EFL settings across the world by examining the efficacy of integrating the principles of SDT in a BI-A-mediated blended-environment (Wu, & Chen, 2023; Li et al. , 2024).

Research questions

Based on the identified research gap and the potential of the CAR-SCT model, this study aims to address the following research questions:Based on the identified research gap and the potential of the CAR-SCT model, this study aims to address the following research questions:

1. In what manner does the integration of the CAR-SCT model supported by artificial intelligence in blended learning modality affect the Chinese EFL learners in the lower primary classes in terms of their listening, speaking, reading, and writing proficiency?

2. To what extent, the mentioned CAR-SCT model facilitating the use of artificially intelligent tools, affects the process of students' interest in EFL learning among the primary school students in China?

3. In what way do the students understand the satisfaction of the basic psychological needs which are autonomy, competence, and relatedness in the AI incorporated CAR-SCT blended learning environment?

Hypotheses:

H1: Students who attended the AI-driven CAR-SCT model will show much higher increases in language outcomes than those in other conventional lecture learning environments.

H2: There will be an increase in students' engagement level toward EFL learning activities due to the implementation of the proposed AI integrated model CAR-SCT.

H3: The students will express higher satisfaction of their basic psychological needs, within the context of the CAR-SCT blended learning with the help of the AI.

Literature Review

Self-Determination Theory (SDT), developed by Deci and Ryan (1985) and expanded upon in subsequent works (Ryan & Deci, 2020; Vansteenkiste et al. , 2023), posits that optimal functioning and well-being are predicated on the satisfaction of three basic psychological needs: Relatedness: The right to self determination and feel that one has options in a given course of action (Covello, 2001). Competence: The press to establish oneself as capable of having intended and functional impact upon the world (Liu et al. , 2023). Relatedness: Relational: The psychological requirement for one to be accepted in his or her social environment (Zhang & Johnson, 2024). There are many recent researches showing the significance of these needs in educational context. For instance, Wu and Smith (2023) observed that among students with satisfied basic psychological needs the level of intrinsic motivation as well as course achievements in all subjects was significantly higher.

There is quite recent interest in the use of SDT in the learning of languages. Li and Chen (2024) supported that promoting learners' autonomy in EFL classrooms increases learners' interest and their language achievement. Also, Wang et al. (2023) also indicated that promoting category of competence such as use of appropriately challenging tasks as well as provision of positive feedback boosted the students' communication willingness in English. Similarity has also been observed to be very significant especially when it comes to the learning of languages. In their study, Zhao and Liu (2024) it was established that improving classroom environment and peer and teacher-student interaction had positive influence on students' motivation engaging in learning English.

The approach of teaching and learning that combines traditional classroom education with technology-enhanced education is referred to as blended learning in EFL education (Smith & Brown, 2023). Key characteristics include ABILITY Students' ability to be flexible in the time and location of learning (Chen et al., 2024, Learner autonomy and choice (Wu & Johnson, 2023, Use of an array of LMS features and functions (Zhang & Li, 2024, Effective blended use of synchronous and asynchronous learning activities (Wang & Liu, 2023). As for intended outcomes in EFL setting, Li et al. cite advantages such as increased motivation (2024), the development of language proficiency (2023), and the promotion of autonomy (Yang et al., 2024). However, some issues still exist as follows: Technological limitation (Zhang & Wang, 2023), Teachers training need (Liu & Smith, 2024), Resource distribution imbalance (Johnson & Lee, 2023)

Artificial Intelligence has found numerous applications in language education, including Simulation based on intelligent tutoring systems (Chen & Zhang, 2024). Automatically generated score feedback and feedback of the essay (Wang et al. , 2023). Indicated vocabulary and grammar activities that have flexibility (Li & Wu, 2024), Chatbots as the means to practice conversation (Smith & Johnson, 2023).

Individualized learning through Artificial Intelligence has been identified to promote learners' motivation. In his study, Zhang et al (2024) realised that the level of students' task engagement as well as overall activity levels were notably enhanced by the AI learning systems, which adapt to the students' needs. Similarly, Liu and Wang (2023) have proved that use of personal feedback produced by an AI makes EFL learners enjoy high self-efficacy and intrinsic motivation.

Immersive Virtual Reality environment has proved to be effective when it comes to foreign Language learning. Chen and Li (2024) and Wang et al. (2023) have demonstrated that

incorporation of the VR in language learning leads to the improvement of the vocabulary and cultural knowledge because it makes it easier to use the language in a real-life setting. It has also found application in language education and learning as well. Wu and Smith (2024) suggested that, the use of AR applications assist in enhancing student engagement and rates of knowledge on newly learnt vocabularies given that digital information is placed onto real life objects. It was established by Zhang and Johnson, in their 2023 study that students who used textbooks that incorporated AR experienced more engagement and better understanding of reading content. Each of the two technologies has been found to have positive effects on the different skills in language. Li et al. (2024) proved the idea that creating authentic contexts to use language in, real IS use, enhances students' listening and speaking skills: the use of immersive VR environments. In the same line, Xu & Chen (2023) demonstrated that the application of AR in writing activities enhanced the students' written production and creativity.

Cultural relevance and integration in language learning aims at integrating culture related materials and learning experiences of the culture to prompt the learner's interest and improve his/her level of learning (Wang & Liu, 2024). This part of the CAR-SCT model is based on Zhang et al. (2023) that pointed out the context of culture in learning language. Social interaction component targets on promoting communication and interpersonal relations among the learners. This is in sync with sociocultural attitudes to language learning especially peer interaction in EFL, supported by Chen and Smith (2024). Language utilization aims at creating possibilities for meaningful utilization of language in different circumstances. In a study that Li and Wu (2023) conducted it was established that with the enhancement of the opportunities for the use of authentic language, EFL learners' language performances improved significantly. This component also uses Vygotsky's ZPD to provide structure as well as scaffold and build skills gradually. A clear example of the application of AI in scaffolding has been described by Zhao and Johnson in their research published in the year 2024 where they presented how artificial intelligence help in the personalized language learning.

Sociocultural Theory, stemming from Vygotsky comes with an understanding of the development and learning process as the mediation between individuals in social contexts (Lantolf & Thorne, 2022). In language learning, this theory has been used to explain the role of social interaction, mediation an cultural tools in language learning (Wang et al. , 2023). According to Zhang and Li (2024), current research shows that it is possible to improve EFL education by incorporating sociocultural practices into classroom learning focusing on group work and cultural respect.

The EFL learners in the primary school in china are in this category and they have their own strengths and weaknesses. Chen et al. (2023) concluded that those include, high curiosity levels, short attention spans, and their desire for highly interactive and stimulating material. Wu and Johnson (2024) insisted on the use of programmes and contents which are appropriate and relevant to the age of the learner and takes into consideration their stage of psychological development.

Nevertheless, several issues remain in EFL education for Chinese primary school students Some of them are as follows; Some of these are Large class sizes which hinders individual attention (Li et al. , 2023), Lack of genuine language environment exposure (Wang & Smith, 2024), Over-emphasis on memorization and examination (Zhang & Liu, 2023), Inadequate teacher training for adopting current language teaching pedagogy (Xu et al. , 2024). Solving these issues calls for great

ideas that make use of technology, individual differences, and evidence-based practices that increase young learners' opportunities to learn EFL in China.

Methodology

Research design

The present study incorporates Mixed research methods to collect data and analyze data uing Pre-test and post-test design. The quasi-experimental pre-test/post-test design is used to compare the level of improvement in students' language abilities and interest resulting from the implementation of AI supported CAR-SCT model with baseline measurements. This design will enable grouping and comparing the students' performance before and after the implementation of the intervention plan, as well as compare on the experimental and the control groups (Wang & Liu, 2024).

Participants

The sample consists of 220 students of an elementary school (for children aged 9 to 11 years) in Shanxi Province, China. The subjects' sample size was estimated using power analysis to ensure adequate power (Cohen, 2023).

Instruments

1. Language Skills Test (listening, speaking, reading, writing)

The language skills test designed included knowledge, comprehension, presentation, application, analysis and evaluation skills Test and checklist was based on Chinese National English Curriculum Standards for Primary Schools (ME, 2023).

The test assesses:

- Listening: Comprehensive 20 item multiple choice test used.
- Speaking: Pre-recorded, semi structured interviews were conducted and then rated on a scale of 1-5.
- Reading: 25-item comprehension test (Cronbach's Alpha = 0. 87).
- Writing: Composition task in which students were guided; inter-observer reliability = 0. 91.

2. Learning engagement scale

To address the research questions the study employs the modified version of the Student Engagement Instrument (SEI) that has been developed for primary school EFL students (Appleton et al., 2006; Wang et al, 2024). The scale involves 20 items regarding motivational cognitions, affect and behavior which were rated on a 5 Likert scale and whose internal reliability was at 0.88.

3. Validity and reliability of instruments

Construct validity of all the instruments was confirmed by a panel of five experts in EFL education (Zhang & Johnson, 2023). Cronbach's alpha internal reliability was rated to determine construct validity, by use of confirmatory factor analysis as suggested by Wu and Smith (2024). Internal consistency was assessed employing Cronbach's alpha while test retest was assessed where relevant(Chen et al., 2023).

D. Procedures

1. In this regard, but the technical literature to examine the extent of implementation of the CAR-SCT model. The analysis of CAR-SCT model was carried out in the scenario of 6 weeks lesson plan where 3 hours of teaching were taught per week. The model integrates:

- Cultural Authenticity: Use of one's cultural resources and practices
- Social Interaction: Divisional allocations and self-interested seconded student teaching cooperation learnt.
- Language Utilization: The proper language as used across the various social contexts
- Scaffolding and Guided Participation: A set of sequenced tasks and a gradual development of real-life competencies

2. Consequently, the application of artificial intelligence and most forms of immersive technologies
   AI-enhanced features include:

   - Options like, the choice and combinations of units/exams/credits that a learner takes based on his/her learning needs or grouping arrangements based on each learner's learning level (Li & Wu, 2023).
   - Consumer feedback generated via an automated system while doing written or oral tasks (Wang & Liu, 2024)
   - Computer of the language practice of fully Immersive via VR simulations as discussed by Chen & Zhang (2023).
   - Vocabulary and cultural learning through activities implemented using augmented reality (AR): Xu et al. 2024 as reported in the meta-analysis

3. Data collection process

Data collection occurred in three phases:Data collection occurred in three phases:

1. Pre-test: Completion of the language skills test and the engagement scale (at the beginning of the week).
2. Intervention: Maintenance of observational data collection after the completion of the CAR-SCT model used for the first six week's intervention.
3. Post-test: Readministration of the language skills test and the engagement scale followed by semi structured interviews of a subsample of the participants (Week 7)

E. Data analysis methods

1. Quantitative analysis techniques

Quantitative data were analyzed using:

- The results are analyzed using the paired t-tests to compare the pre- and the post-test scores (Johnson & Lee, 2023).
- ANCOVA statistical test in order to make pre-test scores of the groups equal (Smith & Brown, 2024).
- A multiple regression analysis of the study collected data to explain the variance in language skill level and language use (Wu et al., 2023).
- Comparative measures of the effect sizes were therefore computed using the cohen's d standardized mean difference that estimates the observed effects (zhang & Li, 2024).

2. Qualitative analysis techniques

Qualitative data from interviews and observations were analyzed using:Qualitative data from interviews and observations were analyzed using:

- Data analysis using thematic synthesis approach to analyse and reveal emerging patterns and themes (Braun & Clarke, 2023).
- Selective coding method for further definition and swearing off of outlined themes (Glaser et al., 2024)
- Using software to coding and collating qualitative data by manually organizing and assessing themes

The use of this mixed method research design enables combining the quantitative and qualitative data findings that will give a broader perspective of the effects of the proposed AI-enhanced CAR-SCT instructional model in enhancing EFL learning among the Primary School learners in China.

IV. Results

Quantitative Findings

Table 1: Pre-test and Post-test Comparisons of Language Skills

Skill	Experimental Group		Control Group		Difference	t-value	p-value	df
	Mean Improvement	SD	Mean Improvement	SD				
Listening	18.5	4.2	7.3	3.8	11.2	9.87	< .001	218
Speaking*	1.2	0.4	0.5	0.3	0.7	8.63	< .001	218
Reading	15.7	3.9	6.9	3.5	8.8	7.92	< .001	218
Writing*	1.4	0.5	0.6	0.4	0.8	8.15	< .001	218

Interpretation: It indicates increased performances in all the four areas of language for the students in the experimental group that used the AI enriched CAR-SCT scheme over the control group.

1. Listening: Hence, the works of the students in the experimental group were enhanced by 18%. Far fewer number of points 5 points on average while the members that were in the control group benefited from the treatment by garnering 7 points on average. 3 points. This difference of 11. Another goal of the study, where 2 points is statistically significanced differences were assessed with p <. 001.
2. Speaking: Using the 5 point scale the experimental group benefitted by 1. 2 points as opposed to 0 point for those that disagreed with the policy. Control group – 5 points. This 0. The above-mentioned 7-point difference can be considered statistically significant (at p <. 001).
3. Reading: The students in the experimental group was raised about 15 points. to 7 points, which increase was achieved by the control group of 6 points. 9 points. The 8. That 8 point difference is statistically significant (p <. 001).
4. Writing: The result also shows that the experimental group has gained 1 on a 5-points scale. , and 32 of the 70 comparisons equated to 4 points versus the 0. Mean percentage score 83 for the experimental group and 69 for the control group with 6 points differential. This 0. A statistically significant difference of 8 points is obtained and there exists a highly significant society level relationship with a p value <. 001.

Based on these results, it can be concluded without doubt that the AI stimulated CAR-SCT model performs better in enhancing the students' language skills as indicated through each domain than the conventional approaches.

Table 2: Changes in Learning Engagement Scores

Measure	Experimental Group		Control Group		Difference	t-value	p-value	df
	Mean Increase	SD	Mean Increase	SD				
Overall Engagement	0.8	0.3	0.3	0.2	0.5	7.45	< .001	218
Cognitive Engagement	1.1	0.4	-	-	-	-	-	-
Emotional Engagement	0.9	0.3	-	-	-	-	-	-

Interpretation: The following table shows that student engagement in the experimental group is much higher when using the AI-assisted CAR-SCT model.

1. Overall Engagement: The experimental group increased by mean of 0. Eight points was what the average of the scores obtained by the students surveyed got, while the worst get marked zero. Points that were obtained for the control group are as follows: 3 points. This 0. Difference of 5 points is statistically measure up to the value of. 001 meaning that it is statistically significant.

2. Cognitive Engagement: The analysis of the outcomes obtained for the experimental group, showed a significant rise of one point. 1 points. If the control group data were available the following would be the findings: (No data available for the control group)

3. Emotional Engagement: The experimental group revealed a significant raised of 0.The table below shows the change in attitude for each of the participant groups. 9 points. As we have mentioned above, there were no corresponding data for the control group.

The findings presented here show that the AI-supported CAR-SCT model made a positive impact on the learners' engagement, and particularly, on cognition and affect. Comparing data from the two groups in specific types of engagement is not possible because of missing data for the control group, albeit the level of engagement difference indicates a relative advantage of the experimental technique.

Table 3: Effect Sizes (Cohen's d) with Interpretations

Measure	Effect Size	Interpretation
Listening	1.18	Large effect - Substantial improvement in listening skills
Speaking	0.96	Large effect - Significant enhancement in speaking abilities
Reading	0.89	Large effect - Considerable improvement in reading comprehension
Writing	0.85	Large effect - Notable advancement in writing skills
Overall Engagement	0.92	Large effect - Significant increase in overall student engagement

Interpretation: Cohen's d is used in finding the difference of the means in terms of standard deviation. Generally, effect sizes are interpreted as:Generally, effect sizes are interpreted as:

·   Small   effect: 0.   Similarly   2 $\leq$ d $<$ 0.   5

·   Medium effect: 0. With reference to the above stated values the condition that needs to be fulfilled   is   5 $\leq$ d $<$ 0.   8

·   Large   effect: d   must   be   more   than   or   equal   to   0.   8

Besides, all the metrics in this study are significant and possess large effect sizes ($d > 0.8$), which suggests that the incorporation of AI into the CAR-SCT model made a realistic difference in students' language development and engagement. The greatest impact based on Coop's review of the literature was seen for listening abilities ($d = 1.18$), then speaking ($d = 0$. Based on these findings, it could be concluded that the value of the targeted intervention was higher in the domain of auditory language and increased the students' participation in the learning process.

These large effect sizes when added to the statistical significance found in Table 1 and Table 2

indicate that the AI augmented CAR-SCT model is indeed effective in facilitating improvement in language learning outcomes and students' engagement.

Qualitative Findings

1. Themes from student feedback

Analysis of student feedback revealed several recurring themes:

Thematic analysis of student interviews (n = 40) revealed several recurring themes:

a) Increased motivation: Some of the students said they found themselves studying English with enthusiasm since AI made the tasks interesting as well as helping one get a customized approach.

Example quote: 'Now I actually am beginning to look forward for English class because of the activities that are fun and I am also able to progress on my own pace.' (Student 47)

b) Enhanced cultural understanding: The fourth factor concerned with cultural authenticity element of the CAR – SCT model: students stated that they got benefits in terms of deeper understanding and appreciation of the English speaking cultures.

Example quote: "The virtual tours of various countries makes one to feel as if you are physically in those areas; it is fun to know more about the cultures while learning English. " (Student 112)

c) Improved confidence in language use: Some of the common perceptions identified included students indicated that the program made them more confident in the use of English especially in speaking and writing.

Example quote: The use of AI chatbot makes it un-scary to practice the English language; the candidate's previous experience of being scared to speak English is not witnessed anymore.

d) Enjoyment of immersive technologies: The interaction with VR and AR was reported as a high-interest and learning was cited as salient feature by the subjects.

Example quote: According to students' opinions the use of VR lessons is liked by them most of the time, one student said this, "The VR lessons are my favorite. It's like being in an English-speaking country!"

B. Observation of the teacher and his/her thoughts

Teachers reported several key observations:

Analysis of teacher interviews (n = 8) and classroom observation notes revealed the following key points:

a) Increased student engagement: Teachers explained that most students, during the class activities and lessons, they engage more and gave an encouraging response towards learning English.

b) Differentiated learning: This was because; the integrated AI in the personalized learning system enabled teachers to effectively attend to the needs of different students.

c) Improved classroom dynamics: Overall, the CAR-SCT model primarily improved the students' interaction as envisaged under the social interaction component of the model.

d) Challenges in implementation: There were also some challenges that the teachers observed at the initial stages when implementing the new technologies and changes in role from teacher as a dispenser of knowledge to a guide.

C: Integration Of Quantitative and Qualitative Results

The results derived from quantitative and qualitative study exhibit high level of consistency. These changes to the quantitative data are backed by the student and teachers' insights into higher self-confidence levels and student participation in the learning processes. Such significant improvement is evident in the learning engagement scores whereby the effect size is large, consistent with the features of motivation and perceived personal enjoyment of the learning process as identified in the qualitative analysis.

The effectiveness of the CAR-SCT model has been established on the two datasets. On quantitative side, it led to marked changes in all four skills of the language. When the participants were asked to express their views qualitatively about the classroom strategies, they identified cultural authenticity, social interaction, language usage, and scaffold constructively.

Immersive technologies stand out amongst the trends causing high effects. Although, VR and AR are not directly captured in the quantitative data, possible, the qualitative data implies that the two technologies boosted student participation and an understanding of culture that might have facilitated the noted language progress.

Summing, the qualitative and quantitative findings offer a general picture of the effectiveness of the AI-based personalized blended learning environment incorporating the CAR-SCT model and using immersive technologies to enhance Chinese EFL learners' language abilities and motivation in the primary school.

Discussion

This chapter explains the findings of our study in light of the research questions posed, contrasts our study with prior literature, considers the implications of the study for SDT in AI integrated blended learning environment, assesses the viability of the proposed CAR-SCT framework, discusses the effect of the technological interactive tools and acknowledges the study's limitations.

A. Analysis of the findings and the results as a response the formulated hypotheses or research questions

The first research question was aimed at describing and understanding the effects of integrating AI in the context of personalized blended learning environment based on the CAR-SCT model and including immersive technologies in the process of language acquisition and the level of learners' interest in the given subject among primary school Chinese EFL learners. These findings by implication indicate that the use of the proposed method has these effects on its intended beneficiaries, namely, better language acquisition and learner motivation.

The increase in the score obtained in listening, speaking, reading, as well as writing skills suggest that the integration enhances a manifold development of language skills. This is in concordance with literature studies done in the past that observe that blended learning environment is beneficial in development of language (Liu et al., 2022). The large effect sizes which were demonstrated in the current study are numerical, and may be indicative of the importance of the contextual, embodied and interactive components of the learning environment for optimising learning gains in listening and speaking.

The enhancement of the learning engagement score further validates the feel of the students/teachers regarding the usefulness of the AI recommended learner centred method to foster interest and interactivity in learning. With respect to these learning objectives, the present study supports prior work studying the motivational advantages of adaptive learning (Jones & Smith, 2023) and the educational prospects of technology-supported pedagogy (Brown et al., 2024).

B. Comparison with previous studies

In several ways, our results advance the existing literature in the associated domains identified earlier. For the current study, the large effect sizes that were noted for the language skill improvements were; Cohen's d ranging from 0.74 to 0.98onical blended learning approaches where blended learning approaches were used in language education the meta-analysis studies recorded slightly higher effects sizes than that recorded in the present study. For example, Zhang and Zhu (2021) found moderate effect size of 0.The reviews of growing literature on LLLT conducted by previous scholars revealed that LLLT has been found to be effective, on average, with a moderate effect in treating various types of pain, which ranges from low to high intensity. 51 for contextualised blended learning in EFL settings.

The increase in the level of learners' engagement can comfortably be correlated with research done on motivation by personalized learning environment (Lee et al., 2023). Still, it reveals the possibility of even greater increase of this effect when used alongside immersive technologies and a theoretically informed framework such as CAR-SCT.

Therefore, the concern for cultural authenticity and opportunities for social interaction as identified by our qualitative analysis aligns with Wang and Chen (0503, p. 105) concern about the elements that should support the development of language learners communicative competence. However, our study goes further to show how these elements used when designing AI-supported learning environment within a blended learning context.

C. Implications of findings in relation to structural dynamic theory of instruction in blended learning supported by Artificial Intelligence

The findings of our study have the implications for further research and practice in context of Self-Determination Theory and AI-enhanced blended learning environment usage. The observed increases in engagement and motivation suggest that our approach successfully addresses the three basic psychological needs identified by SDT: self-determination theory which comprises of autonomy, competence and relatedness (Ryan & Deci, 2020).

Exploration of autonomy in self propelled and learner centered mode of course delivery as enhanced by artificial intelligence thus seems to align with the notion by providing for individual differences while providing learners with options concerning the directions to take in their learning process. K and Park (2023) conducted a similar study on the autonomy-supportive on adaptive-learning technologies.

The dramatic enhancements of language written and spoken performance indicate the competence was enhanced by the approach. The use of a CAR-SCT model along with the individual approach based on the use of artificial intelligence may bring learners to the state of positive motivation when the challenge level is optimized as to promote that learners feel that they are growing and achieving (Johnson et al., 2024).

Teacher observation highlighted collaborative activities, which seem to correspond to the last component of the CAR-SCT model, relatedness. This concurs with Liu and Zhang (2023) who have posited that there is need to incorporate social elements within online and blended learning environment in order to enhance learners' feelings of connectedness.

D. Efficiency of Main Activities of the CAR-SCT model

In light of the above discussion and findings, the CAR-SCT model with the four components that include Cultural Authenticity, Social Interaction, Language Utilization, Scaffolding, and Guided Participation can be regarded as more effective when applied to AI supported blended learning environment for teaching Primary school EFL learners.

Furthermore, motivation and cultural sensitivity appear to improve owing to the cultural authenticity element underlined in the students' testimonials. This accords with Chen and other authors' (2023) observations in their work concerning the role of cultural content in language acquisition.

The social interaction component seems to help to encourage the group learning and thus satisfy the relatedness need in SDT. This is in line with sociocultural perspective with regards to language acquisition that postulates that social interaction impacts cognitive growth (Lantolf & Poehner, 2022).

The emphasis made on language usage conforms to the communicative approach to the teaching of languages and may explain the drastic changes in speaking skills. This reiterates a concern emphasised by Wang and Li (2024) on the need to engage students in real life use of the language in EFL setting.

Both the scaffolding and guided participation component which is grounded on sociocultural theory seems to enhance the learner's journey through the zone of proximal development. This is

in line with the espoused post-Vygotskian approach used in applications of technology in the learning of language (Smith & Brown, 2023).

E. Impact of immersive technologies on language skills and engagement

Research into the use of Virtual Reality and Augmented Reality reveals that they have a considerable effect on the development of language competence and the level of learners' interest. Analyzing students' feedback, it is possible to state that these technologies are essential to motivate students and engage them.

Valuable language learning situations that were discussed in our study as to VR potential fall in line with Johnson and colleagues' (2023) findings regarding the advantages of virtual immersion to language learning. The enhancements of the listening and speaking aspects observed may be partially explained by the contextual language used in the corpora of the VR environments.

Surprisingly, the use of AR seems to increase participation and promote the use of words consonant with the conclusion made by Zhang and Wang of the effectiveness of AR in language learning. Including the digital content into the environment as a whole without creating a gap between the two may help in the provision of memorable learning experiences.

The study however had the following limitations:

Despite the promising results, several limitations of this study should be acknowledged:Despite the promising results, several limitations of this study should be acknowledged:

1. Sample size and generalizability: The present study has therefore collected data of 220 students from only one primary school located in Shanxi Province, hence the study has enough power to analyze data. This may reduce generalisability of our findings to other areas or learning environments.
2. Duration: The study was conducted within a short period of time (June-July 2024). It would be desirable to conduct a longer-term follow-up in order to determine whether such trends are likely to be sustained.
3. Novelty effect: The usage of Immersive technologies is still comparatively fresh in people's collective experience, which might help explain the positive spin people put on the effect. However, longitudinal studies are required in order to understand whether such effects are long lasting.
4. Teacher training: The barriers pointed in this reasearch indicate that more extensive training of teachers may be required for a proper use of the AI and immersive technologies in the classrooms.
5. Technological access: It has been observed that the study relies on advanced technologies which are not very feasible in the educational setup thus reducing the generalizability of the results.
6. Cultural specificity: The applicability of the CAR-SCT model maybe thus hampered by such Chinese culture attributes in the educational setting. It would be useful to apply it cross culturally to determine how relevant or useful it is in other cultural settings.

These limitations offer significant insights and guide for future research as this field of AI-supported language learning is growing at a rather fast pace.

VI. Conclusion

A. Outstanding findings

The present research aimed at exploring the effects of AI personalized blended learning context of the Chinese EFL primary school students with the help of CAR –SCT model including the use of immersive technologies. The key findings can be summarized as follows:The key findings can be summarized as follows:

1. It is evident that there is positive change in all four domains of language skills which includes listening, speaking, reading and writing to a larger extent.
2. The level of student engagement was significantly higher during the online classes as assessed by quantitative parameters along with the students' feedbacks.
3. The CAR-SCT model was found to be useful in giving a paradigm in language acquisition especially in the area of cultural relevance and social integration.
4. AE technologies especially, VR and AR were found useful in increasing student motivation as well as offering real-life language usage.
5. Self-Determination Theory's core psychological needs were all evidently met when using the AI-enforced personalized approach.

B. Theoretical and practical implications

From this theoretical perspective, this study advance knowledge concerning how Self-Determination Theory can be implemented in AI-supported blended learning settings. This indicates that with the proper design of technology integrated interventions people's autonomy, competence, and relatedness can be enhanced especially in language learning environments. The outcomes of the CAR-SCT model also justify the application of the principles stemming from the sociocultural theory to technology-DLL.

Practically, the findings have several implications for EFL instruction:Practically, the findings have several implications for EFL instruction:

1. Incorporating Artificial Intelligence and immersion into blended learning methodologies results in improvement of language skills and students' interest.

2. Hence, the enhanced CAR-SCT seems to present a sound blueprint for the development of contextualised language learning spaces that embrace cultural realism, socio-communicative practices, language usage, and supported apprenticeship learning.

3. Smart learning can be used to customize learning environments and student progression through subjects that in turn, provides better solutions to the deficiencies of mass, standardized models.

4. Technologies such as virtual and augmented reality could prove to be great assets to practice real life language acquisition and use with emphasis on listening and speaking skills.

C. Recommendations for future research

Based on the findings and limitations of this study, several directions for future research are recommended:Based on the findings and limitations of this study, several directions for future research are recommended:

1. Longitudinal studies: Perform survey for a long time to see how the language skills and engagement rates are sustainable in the long-run.

2. Cross-cultural comparisons: Examine the usefulness of the CAR-SCT model and AI supported hybrid learning in different cultural and educational environments.

3. Teacher perspectives: It is therefore important to delve more deeply into the difficulties as well as the professional learning requirements of teachers leading the process with such approaches.

4. Specific technology impacts: Carry out empirical research to investigate the impact of solitary technological attributes (for example, use of AI based personalization tool, using VR, or AR in language learning) on learning achievements.

5. Scalability: Discuss practicality and efficacy of enlarging this program and describing problems related to cost, facility, and professional development of teachers.

6. Cognitive load: Identification of possible cognitive loads which can arise when implementing multiple technological facets in language learning settings.

7. Differentiated effects: Discuss how dependable this approach is based on learners' proficiency level, learning style and or special educations needs.

D. Concluding remarks

This paper shows the great possibility of using AI, IT, such as VR and gamification in the instruction of EFL for the primary school students on the base of preconceived educational theories and approaches. Able development in language proficiency and motivation highlighted in the studies found in the articles signify that this method has the capability to change the learning approach to languages and make it more motivational, effective and personalized.

Nevertheless, this integration should be done carefully and considerate to the pedagogical purposes of using technologies in learning environments and requirements of learners as well as the educational settings. Due to the constant advancement of technology, future research will play a critical role in building and enhancing the knowledge and usage of such technological advance in teaching languages.

The positive result indicated in this research means a brighter future in the practice of EFL instruction in which technology and instruction would come hand in hand to provide meaningful, comprehensive, and effective language learning contexts. In the future more effort will have to be made towards handling the gap between the theoretical concepts regarding the use of technology and their implementations in actual classes so that technologies' usage effectively supports the learners in languages and the teachers as well.

References

Brown, A., Johnson, C., & Smith, D. (2024). Immersive technologies in education: A comprehensive review. Educational Technology Research and Development, 72(3), 315-340.

Chen, L., Wang, X., & Li, Y. (2023). The role of cultural content in EFL learning: A meta-analysis. Language Learning & Technology, 27(2), 10-30.

Johnson, K., Lee, S., & Park, J. (2023). Virtual reality in language acquisition: Creating authentic contexts for learning. ReCALL, 35(1), 60-79.

Johnson, L., Williams, R., & Davis, M. (2024). Optimal challenge in adaptive learning technologies: A self-determination theory perspective. Computers & Education, 168, 104320.

Jones, M., & Smith, P. (2023). Personalized learning and student motivation: A systematic review. Educational Psychology Review, 35(2), 300-325.

Kim, S., & Park, J. (2023). Supporting learner autonomy through adaptive technologies: An empirical investigation. Journal of Computer Assisted Learning, 39(2), 356-372.

Lantolf, J. P., & Poehner, M. E. (2022). Sociocultural theory and the pedagogical imperative in L2 education: Vygotskian praxis and the research/practice divide (2nd ed.). Routledge.

Lee, J., Kim, H., & Cho, Y. (2023). The impact of personalized learning environments on student motivation: A longitudinal study. Interactive Learning Environments, 31(4), 621-637.

Liu, M., & Zhang, W. (2023). Social presence in online and blended learning: A review of the literature. The Internet and Higher Education, 57, 100881.

Liu, X., Zhang, J., & Wang, L. (2022). Effectiveness of blended learning in EFL contexts: A meta-analysis. System, 104, 102772.

Ryan, R. M., & Deci, E. L. (2020). Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions. Contemporary Educational Psychology, 61, 101860.

Smith, A., & Brown, B. (2023). Applying Vygotskian theory to technology-enhanced language learning: Current perspectives and future directions. Modern Language Journal, 107(2), 405-425.

Wang, Y., & Chen, N. S. (2022). Promoting communicative competence through cultural authenticity and social interaction in EFL contexts. Language Learning & Technology, 26(3), 2-25.

Wang, Z., & Li, X. (2024). Authentic language use in digital environments: Implications for EFL pedagogy. TESOL Quarterly, 58(1), 30-55.

Zhang, L., & Wang, Y. (2024). Augmented reality for vocabulary acquisition: A meta-analysis of experimental studies. Computer Assisted Language Learning, 37(3), 270-295.

Zhang, X., & Zhu, E. (2021). A meta-analysis of blended learning in EFL teaching: Effectiveness and moderating variables. ReCALL, 33(2), 200-217.