Training readers and writers for a multimodal and multimedia society: Cognitive aspects

Edited by
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Training readers and writers for a multimodal and multimedia society: Cognitive aspects

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Editorial: Training readers and writers for a multimodal and multimedia society: cognitive aspects

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Editorial on the Research Topic
Training readers and writers for a multimodal and multimedia society: cognitive aspects

This Research Topic includes 10 articles belonging to the educational, psychological, and linguistic fields with researchers from different universities in Chile, China, and Spain. The articles have been published in the "Psychology of Language," "Educational Psychology," and "Cognition" sections of the journal Frontiers in Psychology, and the "Language, Culture, and Diversity" section of the journal Frontiers in Education.

Modern societies have made steady progress in creating a literate population. The majority of people can now access a wide range of resources using their reading and writing skills thanks to significant efforts, but are we really ready for the information age? Are educational institutions promoting information literacy? Are personal skills being considered? Are we really critical thinkers? This Research Topic provides an overview of the latest studies, covering issues from the individual to the group, from the skills of the subject to how best to develop them in the classroom.

Our main objective was to address a pressing issue facing modern global societies. It was suggested that the Research Topic explore this by providing a range of insights into critical literacy in general and reading and writing in particular. Research on writing processes, academic literacy, and analog and digital reading was therefore invited. This Research Topic also considered the cognitive processes of the subject in relation to building their mental lexicon and accessing information. This provides a glimpse into the world of people living in the post-truth era and immersed in literacy.

The articles published in this Research Topic have examined critical literacy from a variety of perspectives, providing a thorough examination of the contemporary heterogeneous cultural, linguistic, educational, and psychological environment, as outlined below. They are divided into four sections: reading, writing, foreign language teaching, and cognition.

In the first section, there are two studies that focus on the writing process. To investigate the effects of working memory updating training on primary school students' writing performance and ability, Gao, Li et al. conducted a study entitled "*The effect*

of working memory updating training on the Chinese writing ability of primary school students." Sologuren's research, on the other hand, describes the rhetorical-discursive organization of the laboratory report genre in this subdiscipline. It is entitled "*Student writing in the engineering curriculum: discursive rhetorical model of the laboratory report genre in Spanish*".

In the second section, three articles explore the cognitive and cultural dimensions of learning. Using conceptual metaphors as the guiding theory, Li and Lu's study, "*Conceptual metaphors and image construction of China in the space probe reports of China Daily: a social cognitive approach*," examines conceptual metaphors in China Daily news releases about Chang'e-5 and Shenzhou XIII from 2008 to 2021. The goal of de la Montaña Conchiña et al.'s research, "*Conceptions of geography and history as school disciplines: an approach from lexical availability*," aims to investigate how students at different educational levels perceive geography and history as academic subjects. Finally, Muñoz-Muñoz et al.'s paper, "*The influence of transmedia and extra-academic narratives on the formation of high school students' historical culture,*" focuses on the ways in which extracurricular activities might shape teenagers' perspectives.

Three papers discussing the reading process make up the third section. Gao, Yang et al.'s research, "*The influence of cognitive ability in Chinese reading comprehension: can working memory updating change Chinese primary school students' reading comprehension performance?*" examines two main areas: first, evaluating the central executive (CE) for predictive effects on Chinese primary school students' reading comprehension scores; and second, investigating the impact of CE training on Chinese primary school students' reading comprehension performance. In addition, González Ramírez and Pescara Vásquez's work, "*Dimensions of reading: a study of the beliefs of language and literature preservice teachers,*" seeks to examine the attitudes of preservice language and literature teachers toward reading. To conclude this section, the study conducted by Cui et al., "*Reading for gain or reading for fun: empirical evidence from China on the adoption mechanism of integrated children's books,*" using information technology, found that Reading for Gain includes a dual effect pathway based on the Hedonic Motivation System (HMS) and the Utilitarian Motivation System (UMS).

Finally, in the fourth section, there are two books on foreign language teaching. Guo's, "*Multimodality in language education: implications of a multimodal affective perspective in foreign language teaching,*" introduces this part. It offers a multimodal

affective technique to assess emotions in foreign language teaching situations. To conclude the Research Topic, Baaziz and de Vicente-Yagüe Jara's work, "*Didactics of written argumentation with Spanish as a Foreign Language (SFL) students at the university level in Algeria,*" investigates how a program that emphasizes the development of argumentation techniques has affected the quality of critical essays written by SFL students at the University of Algiers 2.

In summary, this Research Topic presents a global view that incorporates the study of critical literacy from a pluralistic research perspective. By doing so, we have provided a thorough analysis of the educational landscape that helps scholars address the issues, opportunities, and challenges that arise from the task of preparing writers and readers for a multimodal and multimedia society.

Author contributions

Funding

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Didactics of written argumentation with Spanish as a Foreign Language (SFL) students at university level in Algeria

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The general objective of this research is to investigate the impact of a program focusing on the development of argumentation techniques on the improvement of critical essays by SFL students at the University of Algiers 2. A quasi-experimental pretest-posttest study was carried out, where the indicators of textual levels obtained by the students were evaluated and compared, both before and after a learning intervention. The study involved 126 students studying SFL at the University of Algiers 2, whose essays were analyzed using Parodi and Núñez's (1999) analysis guidelines, in order to evaluate the students' argumentative competence at the three levels of microstructure, macrostructure and superstructure. Once the results were analyzed, statistically significant differences were observed in the indicators of the macrostructure, and superstructure. Furthermore, an improvement in the post-test means is observed in the indicators of these microstructure. Lastly, the intervention program strengthened students' argumentative abilities, which had a significant effect on their critical essays.

KEYWORDS

argumentation, essay, Spanish as a Foreign Language (SFL), microstructure, macrostructure, superstructure

1. Introduction

Education is the fundamental foundation for a country's progress; its goal is to develop students' skills so that they can be responsible citizens who actively engage in social life. Considering the continuous transformation of today's society, it is necessary to incorporate knowledge and skills in the university curriculum in order to provide students with the opportunity to develop their communication skills, which will enable them to function in the productive world and provide them with creativity and dynamism. In this context, Pipkin and Reynoso (2010) note that teaching argumentation is currently one of the fundamental topics of pedagogical reflection. However, traditional pedagogical models that focus on the accumulation of information and the repetition of formulas become very passive practices in the classroom and do not allow for interaction between subjects, which results in didactic tasks becoming meaningless. For this reason, the didactic development of argumentation must be recognized as a fundamental skill to replace the passive transmission of knowledge with an interactive discourse between teacher and student (Obando, 2007). Therefore, it is necessary to overcome the shortcomings of traditional pedagogical models, abandoning their behaviorist and decontextualized patterns in favor of an integrative model that pursues reflection and argumentative

interaction in strategic and contextualized situations. This methodological innovation in the didactics of argumentation is committed to learner autonomy and creativity, replacing the formal rigidity that has dominated the pedagogical scenario in traditional textual commentary.

In the same vein, Gómez Barriga (2012) argues that argumentation is a practice that can be found in different communicative contexts: at work, in everyday and academic conversations. In the university context, it constitutes a tool for the dissemination and generation of knowledge that contributes to the human and social development of the learner. Thus, Gómez Barriga (2012) asserts that the ability to produce arguments in all cultures is a key factor for success in politics, work, community, and family. There is an urgent need for the appropriate use of argumentation to express opinions in a climate of tolerance, respect, and consideration for the position of others, in order to reach agreements without reaching violent confrontations (Díaz and Mujica, 2007). For his part, Serrano (2008) emphasizes that the ability to argue enables students to act with good judgment in solving problems by presenting well-founded and convincing arguments.

Similarly, Ruiz et al. (2015) state that argumentation is a fundamental tool for the learning process, as it helps students to meaningfully understand the concepts addressed, in addition to promoting an interactive environment of academic debate and discussion. Specifically, Ruiz et al. (2015) propose a model of teaching argumentation that includes three types of relationships: epistemic (developing argumentation for knowledge construction), conceptual (the skill requires the use of dialogue, debate, criticism, decision making, listening, and respect), and *didactic* (language allows for the exchange of meanings and concerns).

According to the above, the argumentative text should be a frequently used resource throughout the teaching and learning process of students, and especially in the development of the subject of Spanish as a Foreign Language (SFL). Various studies have already focused on the study of the argumentative essay, providing theories and procedures for improving its practice in the classroom (Parodi, 2000; Díaz, 2002; Padilla et al., 2011; Bañales et al., 2015; Caro et al., 2018; Castro and Sánchez, 2018; Vicente-Yagüe et al., 2019, 2023; Baaziz, 2022; Caro and Vicente-Yagüe, 2022).

It should be noted that the production of argumentative texts is a cognitive process related to the operations of critical thinking, because it aims to identify a problem, understand, propose solutions, compare, contrast, analyze, evaluate, synthesize, establish causal relationships, and point out consequences. Díaz (2002) emphasizes that learning to write is at the same time learning to think critically and creatively, given that we develop our ability to think critically when we learn to write academic texts.

If we analyze the different educational contexts regarding the didactics of argumentation, the study by Camps (1995) in the Spanish context examines the different obstacles that hinder students in writing argumentative texts. First, he mentions the difficulty of understanding a text, taking into account aspects such as the author's intention, the recipient and the reader's own social situation. In addition, there is the difficulty of identifying their own opinions on different topics, understanding the counterargument, using concessions to defend an opposing thesis, and insufficient knowledge of linguistic resources.

In the Venezuelan context, the research by Sánchez and Álvarez (1999) on the development of written argumentative skills stands out; their results highlight the lack of argumentative structure in students' texts, as well as the absence of strategies for expressing their own opinions. Serrano and Villalobos (2008), for their part, verify the absence of discursive procedures in the production of written texts. Serrano's (2001) study points out inconsistencies at the superstructure level of the written texts produced by the students.

In the Chilean context, the study by Núñez (1999) shows results of low performance in structural development after analyzing the elaborated writing essays. Similarly, Parodi and Núñez (1999) research on the evaluation of argumentative writing production stands out, where the students' difficulties in elaborating their texts are discussed in relation to the three levels of textual competence.

In the Argentine context, Perelman (2001) addresses students' writing difficulties and mentions their problems with textual structuring, lack of knowledge of argumentative strategies to support opinions, and insufficient resources to connect the text. In the Mexican context, the work of Castro and Sánchez (2018) stands out; they report the following writing problems: ignorance of the function and value of textual quotations to support their arguments, imitation of the position of other voices without developing their own voice (giving their personal appreciation as an extension of the expert opinion to validate their own discourse), ignorance of the discursive resources that allow the author's positioning.

In the Algerian context, the study by Bellatrèche (2013), among the studies on the didactics of French at the University of Mostaganam, highlights the unsatisfactory argumentative competence of students in the three textual dimensions. Moreover, the results obtained by Belaouf (2016) show that students have difficulties at the linguistic level, at the level of coherence, and at the level of argumentative competence; the study confirms that the difficulties appear early in school and persist until university education.

The present research is aimed at the Algerian university context in the learning and teaching of Spanish as a Foreign Language (SFL). Considering that argumentation is a textual typology that should be worked on by students throughout their academic career, it is appropriate to carry out research in the two Spanish degree programs at the University of Algiers 2.

Therefore, the general objective of the present research is to study the effect of the intervention of a program focused on the development of argumentation strategies on the improvement of the development of critical essays by SFL students at the University of Algiers 2. This general objective is articulated by the following specific objectives:

- To compare the grades obtained by the students in the indicators of the microstructure level, before and after the didactic intervention.
- To compare the grades obtained by the students in the indicators of the macro-structural level, before and after the didactic intervention.
- To compare the grades obtained by the students in the indicators of the superstructure level, before and after the didactic intervention.

The proposed hypothesis is that the students will obtain better results in the written essays after carrying out a didactic intervention in their class sessions on the process of argumentative writing.

2. Research method

2.1. Design

A pre-experimental pretest-posttest study (Campbell and Stanley, 2005) was conducted to evaluate and compare indicators of students' writing levels before and after a learning intervention focused on discursive argumentation strategies for critical essay writing.

2.2. Participants

The study included 126 students enrolled in the second and third degrees of Spanish as a Foreign Language at the University of Algiers 2, between the ages of 19 and 22, as shown in Table 1. All students in both courses were included in the study without any special selection. A non-probabilistic purposive sampling procedure was used, based on convenience (Sáez, 2017).

2.3. Research instrument

The analysis guide by Parodi and Núñez (1999, pp. 74-77) was used to evaluate students' argumentative competence in the texts produced (Table 2). The instrument follows the classification of Van Dijk (1992), which explains three textual levels: microstructure, macrostructure, and superstructure. Microstructure is a set of interrelated and coherent propositions that make up the different sentences of a text. Macrostructure refers to a set of propositions that synthesize the overall meaning of the text and are necessary for textual coherence. The superstructure represents the way in which the information of the text is organized according to a scheme whose components are the thesis, a series of arguments, and a conclusion.

The indicators that correspond to each of the levels are articulated in three criteria that are scored on a scale of 1 to 3. The instrument allows us to evaluate the capacities achieved by the students and to measure their performance at each textual level, classifying their productions in the performance criteria established in the guideline. In short, it assesses the students' ability to organize and produce coherent and cohesive argumentative texts.

2.4. Procedure

The procedure of the present research is articulated in the didactic intervention program and in the two moments before and after the moment of written production of an essay by the students. Thus, first, the students in the 2nd and 3rd years must write an essay on "The

incorporation of ICT in university education" and "The university facing the online challenge of the coronavirus," respectively, which will be analyzed as a pretest; then, the program is applied in the classroom, whose sessions conclude with the writing of a new essay, which constitutes the posttest.

The didactic intervention program is presented in Table 3 and was validated by five expert judges who validated its content (degree of precision and conceptual, syntactic, and structural adequacy) with respect to the purpose of the research. The evaluations offered were discussed and agreed upon, with suggestions for improvement for its final version.

The program is divided into three phases: introductory phase, argumentative workshop, and final phase. Throughout the program, the cognitive, structural, and linguistic dimensions of written composition are addressed, including sessions with different aspects: text comprehension, planning, individual argumentative writing, revision and rewriting for self-evaluation and self-criticism, oral debates, and collaborative argumentative writing in groups for peer learning and fostering a cooperative environment. In addition, the didactic intervention carried out with the students was developed in a total of 20 sessions, throughout the academic year. Specifically, 10 sessions were dedicated to each of the courses, distributed in two sessions per week, during 5 months of the first semester of the course.

The study complied with the ethical guidelines of the University of Algiers 2 required for research on human subjects: informed consent, right to information, protection of personal data, guarantee of confidentiality, non-discrimination, free of charge, and the possibility of withdrawing from the program at any stage.

2.5. Data analysis

First, the corpus of texts written by the students was analyzed according to the criteria and indicators of the textual levels presented by Parodi and Núñez (1999, pp. 74-77).

Second, once the scores were calculated, the Kolmogorov–Smirnov normality test was applied to determine the relevance of using parametric tests. This test showed that the different indicators of textual levels ($p < 0.05$) were not distributed according to the normal distribution. Therefore, the Wilcoxon test was used to compare the scores obtained by the students before and after the didactic intervention.

3. Results

The results are presented according to the specific objectives, each of them related to three textual levels: microstructure, macrostructure, and superstructure. To this end, Table 4 shows the scores obtained for each of the indicators of the textual levels analyzed.

With respect to the first specific objective, which was to compare the students' scores on the microstructural level indicators before and after the didactic intervention, no statistically significant differences were observed in the thematic progression and inter-sentence relations in either of the two grades of the study sample. However, there was an improvement in the posttest means of the 2nd and 3rd grades for both indicators.

TABLE 1 Participants in the study.

Level	Gender	Number of students	Total
2nd	Masculine	5	71
	Feminine	66	
3rd	Masculine	7	55
	Feminine	48	
Total			126

TABLE 2 Written production analysis guideline.

Level	Indicators and criteria	
Microstructure	Thematic progression	
	Adequate maintenance of thematic progression, without breaks	3
	Maintenance of thematic progression with one break	2
	Maintenance of thematic progression with more than one break	1
	Inter-sentential relations	
	Coherent relations between sentences	3
	Inter-sentential relations with one break	2
	Inter-sentential relations with more than one break	1
Macrostructure	Topic	
	Adequate maintenance of the assigned theme	3
	Maintenance of assigned topic with one break	2
	Maintenance of assigned topic with more than one break/developed topic not relevant to the task	1
	Macro propositions with argument function	
	2 or more macro propositions with argument function consistent with each other	3
	2 or more macro propositions with argument function in the form of a list/only one macro proposition with argument function	2
	2 or more macro propositions, inconsistent with each other/no macro proposition with argument function	1
Superstructure	Thesis	
	Thesis included in the text and relevant to the task.	3
	Semi-explicit thesis	2
	Absence of thesis or thesis not relevant to the task	1
	Argumentation	
	An argument justified by supporting facts and consistent with each other	3
	An insufficiently justified argument	2
	Absence of argument/an unsupported argument	1
	Conclusion	
	Inclusion of argumentative conclusion	3
	Argumentative conclusion semi-explained or partially derived from the above	2
	Absence of argumentative conclusion/conclusion not pertinent to thesis or arguments	1

Therefore, in terms of microstructure, the students do not manage to overcome their initial difficulties, they remain in a low performance of the criteria. It is not possible to find a significant positive effect after the intervention, as it is verified the persistence of errors in their writing. The writings are incoherent and diffuse, due to several errors of nominal and verbal co-reference, particularly the lack of concordance between the number of the nominal element and the pronouns that substitute it, the lack of gender concordance, the lack of concordance between the number of the nominal element and the corresponding verb tenses or the use of incongruent verb tenses. Regarding the component of inter-sentence relations, there are numerous errors in the use of linguistic and semantic mechanisms.

Regarding the second specific objective, which focused on comparing the scores of the macro-structural indicators, statistically significant differences are found in the topic indicator for students in grade 3, although the improvement of students in grade 2 can also be observed. There are also statistically significant differences in the macro-propositions with argument function indicator for both classes of students.

The data obtained from the macrostructure in the pretest show that most of the students have difficulties in thematic development due to the insufficient use of mechanisms for hierarchizing information and relating ideas, which hinders text comprehension. Regarding the students' use of macro-sentences, there are no arguments, but their use is limited to definitions or explanations of the topics of the given instructions. However, the post-test data show evolutionary differences, and an achievement is observed at all levels of performance, as the given topics are adequately developed with coherent arguments.

Finally, it is verified that in both courses there are statistically significant differences at all levels of the superstructure (thesis, argumentation, and conclusion). In the post-test, after the development of the didactic intervention, there are notable evolutionary differences, because an adequate development of the topics of the given instructions is demonstrated, in such a way that explicit theses are presented, supported with clear arguments, and converge in the enunciation of adequate conclusions.

As for the dimension of the superstructure in the pretest, the data showed that the students had enormous difficulties in formulating its components. Regarding the thesis, most of them were unable to state

TABLE 3 Didactic intervention program.

Phases	Sessions	2nd course	3rd course
Initial	1	Theoretical session	Theoretical session
	2	Argumentative production begins on the obligatory nature of vaccination against Covid 19	Initial argumentative production on euthanasia
Workshop	3	Analytical reading of text (Covid-19 denial) and collaborative revision of writings.	Analytical reading of text (Euthanasia: Covid-19 vaccine) and collaborative revision of writings.
	4	Thesis statements and argumentative debates	Thesis statements and argumentative debate
	5	Textual cohesion activities	Textual cohesion activities
	6	Text analytical reading: Influencers: a double reality for greenwashing	Text analytical reading: gender-based violence
	7	Text analytical reading: The Capital Punishment	Text analytical reading: The Capital Punishment
	8	Collaborative writing and textual revision	Collaborative writing and textual revision
Final	9	Argumentative production in a control situation	Argumentative production in a control situation
	10	Comprehension and written production in a test. Topic: The fakes news about Covid-19	Comprehension and written production in a test. Topic: Islamophobia

TABLE 4 Pre-test and post-test results for students in the 2nd and 3rd courses.

LEVEL	Indicators	Pre test				Post test			
		2nd course		3rd course		2nd course		3rd course	
		M	DT	M	DT	M	DT	M	DT
Microstructure	Thematic progression	1.02	0.62	1.2	0.65	1.3	0.52	1.4	0.66
	Inter-sentential relationships	1.1	0.81	1.2	0.45	1.6	0.34	1.7	0.47
Macrostructure	Topic	1.1	0.72	1.3	0.64	1.9	0.65	2.2*	0.56
	Macro-propositions with argument function	1.2	0.54	1.2	0.44	2.2**	0.85	2.4**	0.86
Superstructure	Thesis	1.1	0.67	1.2	0.61	2.8***	0.67	2.6***	0.56
	Argumentation	1.2	0.86	1.4	0.75	2.2**	0.86	2.4**	0.58
	Conclusion	1.1	0.53	1.2	0.32	2*	0.57	2.3*	0.46

$*p < 0.05$, $**p < 0.01$, $***p < 0.001$.

their position for or against the topic. Similarly, the writings showed deficiencies in the formulation of arguments and reasons to support the thesis. Likewise, the conclusion showed a lack of knowledge and poor command of how to present the final conclusion of the argumentative writing. On the contrary, the analysis of the texts produced after the didactic intervention shows a significant achievement in all the indicators of the superstructure.

4. Conclusion

After analyzing the results, it can be observed that after the intervention program focused on the development of argumentative writing strategies, a significant effect was obtained in the students' critical essays. The argumentative skills of the study sample were strengthened after the didactic intervention, as improvements and a positive effect were observed in the three textual levels. Although there was a slight improvement in the microstructure, it is the level with the most inconsistent indicators in the framework of writing competence. However, it is necessary to note that, given the lack of a control group in the design of this research, there may have been other variables that

influenced the observed improvements, in addition to the intervention program itself. This issue should be pointed out as a limitation of the study and leads the research on the didactics of argumentation towards other types of methodological designs that allow us to confirm the results obtained with the present study sample.

Written argumentation is considered a difficult task that involves various thought processes, from gathering the necessary information, to defending positions with valid evidence, to formulating pertinent conclusions. Therefore, it is of paramount importance for the teacher to support the learner through an active teaching process based on persuasive tasks so that the student achieves argumentative competence, in addition to insisting on the primordial value of reading in argumentative writing (Vicente-Yagüe et al., 2023). Thus, this study highlights the valuable recovery of the argumentative practice in the classroom and the pedagogical reconversion aimed at new approaches to writing based on critical reflection, overcoming academic models focused on the meaning of the text and the author's intention.

It is worth noting that, in recent years, several research studies carried out in different countries have shown the importance of

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

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Publisher's note

promoting the mastery and use of argumentation skills in university students, both orally and in writing. Their contributions constitute theories for the development of learners' skills and the improvement of their ability to persuade, argue and acquire a more complex language so that they are able to elaborate persuasive speeches for their interlocutors. It should be noted that several researchers have already pointed out that the successful completion of a written composition is not an easy task and requires a specific intervention that allows students to master the grammatical, linguistic and discursive processes of argumentation (Álvarez, 1995, 2001; Camps, 1995; Perelman, 2001; Díaz, 2002; Martínez, 2002; Obando, 2007; Matteucci, 2008; Serrano, 2008; Ramírez, 2010; Fernández Millán et al., 2021).

For this reason, the present study focuses on written argumentation, which is addressed in the university curriculum of the SFL degree at the University of Algiers 2. In fact, this skill is essential for the development of students' critical thinking and the promotion of skills that allow them to express their points of view on a given topic, to communicate and express their ideas and opinions in writing according to their own criteria, and to defend them with valid arguments (Parodi, 2000). In fact, its use is of paramount importance, since it allows them to access information, process it and take a stand in different situations that arise in their learning process (Vicente-Yagüe et al., 2019).

In this sense, it is appropriate to emphasize that the lack of studies on written composition in general and argumentative typology in the Algerian university classroom in particular justifies the need to develop studies in the classrooms themselves with a university sample through designs that include didactic interventions. A rethinking of university studies in SFL is necessary in order to incorporate efficient didactic proposals in all academic courses that address the mismatches in the three textual levels and allow addressing students' difficulties in the direction of developing their written argumentative competence. This type of research is necessary to promote students' argumentative discourse in the broad field of written production.

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The effect of working memory updating training on the Chinese writing ability of primary school students

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Objective: This study aimed to explore the effects of working memory updating training on primary school students' writing ability and performance.

Methods: A total of 46 fourth-grade Chinese primary school students were recruited; their performance in the Chinese character N-back training task, the Writing Ability Questionnaire, and a time-limited writing task was assessed.

Results: The paired-sample *t*-test revealed that working memory updating training significantly improved the experimental group's working memory level. After training, a repeated measures ANOVA revealed that the experimental group's performance on the Writing Ability Questionnaire improved and was higher than that of the control group. In the time-limited writing task, independent-sample *t*-tests revealed that the experimental group's writing fluency increased and was higher than that of the control group, while the latter's grammatical accuracy and complexity decreased and were lower than those of the former.

Conclusion: Working memory updating training can be used as auxiliary cognitive training to improve primary school students' working memory level, thereby promoting their writing development.

KEYWORDS

working memory, central executive, Chinese writing ability, updating, primary school

1. Introduction

Working memory is a memory system with limited capacity that provides individuals with a place to temporarily store information and is an important influencing factor in writing production (Baddeley, 1992). Working memory includes a phonological loop, a visuospatial sketchpad, a central executive, and episodic buffers. Among these functions, the central executive (consisting of updating, inhibition, and shifting) is the core component of working memory (Miyake et al., 2000). Working memory, particularly its updating, plays an important role in advanced cognitive processes (Zhao and Zhou, 2014).

Lower working memory levels are more likely to lead to writing problems (Baddeley, 2003; Thorell et al., 2009; Tagarelli et al., 2011; Wen, 2012; Archibald, 2017; Nielson and DeKeyser, 2019; Mavrou, 2020; Deldar et al., 2021; Vasylets and Marín, 2021; Li, 2022). Theoretical studies agree that there is intense competition for working memory resources during the writing process (Hayes, 2000; Kellogg et al., 2013). According to Skehan (1998), working memory resources have a competitive effect on the fluency, accuracy, and complexity of writing performance. Currently, a three-dimensional analytical architecture consisting of complexity, accuracy, and fluency is widely used in studies on the relationship between working memory and writing performance (Yi and Luo, 2013; Polio and Shea, 2014; Johnson, 2020). This is the writing performance construct used in this study.

The current research has focused on exploring the relationship between working memory and writing ability (Skehan, 2002; Vanderberg and Swanson, 2007; Kellogg et al., 2013; Capodieci et al., 2019; NoackLeSage et al., 2019; Sangani and Jangi, 2019; Sartori et al., 2021; Grace Kim, 2022). For example, studies have found that Chinese English as a Foreign Language learners' working memory is strongly related to fluency and syntactic complexity in writing performance (Yi and Ni, 2015a). Another study found that Chinese English as a Foreign Language learners' working memory has a significant effect on accuracy and syntactic complexity (Yi and Ni, 2015b). Supporting this view, one study found an independent effect of working memory on the complexity and accuracy of writing performance (Jin and Wang, 2021). Moreover, Vasylets and Marín (2021) found that the relationship between working memory and writing performance differed among learners with different writing proficiency levels. Working memory was associated with writing accuracy for low-writing proficiency learners, while working memory was associated with writing complexity for high-writing proficiency learners. Additionally, Zabihi (2018) found that higher working memory levels directly predicted higher writing complexity and fluency scores but negatively affected writing accuracy scores in a study of intermediate- and upper-level English learners. However, little attention has been paid to whether writing performance varies with changes in working memory levels. Several studies have found that working memory training can have positive transfer effects on reading comprehension and fluid intelligence in early childhood and school-aged individuals (Loosli et al., 2012; Peng et al., 2014), thus providing new ideas for further exploration of the causal relationship between working memory and writing ability. Gao (2019) verified that updating training can steadily improve Chinese writing performance among Chinese primary school students. However, aspects of individual writing performance that are enhanced by working memory training have not been studied. Examining the role of children's working memory transfer as an auxiliary in writing can enrich and enhance the current methods and efficiency of teaching writing to school-aged children.

The purpose of this study was to bridge a significant gap in the literature by comparing changes in individuals' writing ability and performance before and after working memory updating training. To solve this problem, we trained fourth-grade primary school students in working memory updating and recorded their writing test scores and performance.

Based on the limited extant research, we propose three hypotheses. First, working memory updating training can enhance primary school students' working memory performance. Second, the increase in participants' working memory proficiency can promote their writing ability. Third, the improvement of working memory level enhances primary school students' fluency-related writing performance.

2. Materials and methods

2.1. Participants

A total of 46 Chinese fourth-grade primary school students participated in this study. Participants were divided into an experimental group and a control group based on their scores on the Writing Ability Questionnaire (He, 2006). In total, four participants were excluded from the experimental group due to absence from school; thus, 19 participants (eight boys and 11 girls) remained. A total of five participants were excluded from the control group; thus, 18 participants (six boys and 17 girls) remained. The participants' ages at the beginning of the experiment were 9–11 years old ($M = 10.02$, $SD = 0.49$). The difference in mean age between the two groups of primary school students was not significant [$t_{(35)} = 0.02$, $p = 0.99$]. The students were from a class in the same neighborhood school, having similar language use experiences and living environments; the participants in both groups were right-handed and had no similar experimental experiences. None of the students participating in the experiment had psychiatric, neurological, or developmental disorders, according to previous assessments by the medical and mental health departments of the school. This study was approved by the Research Ethics Review Committee of the College of Psychology of Xinjiang Normal University, China. The students' parents were informed of the entire process, and consent was obtained from the students, guardians, and school before the experiment.

2.2. Research design

Between-participants design was adopted in the study. Both groups participated in normal school activities in the same class. Additionally, the experimental group underwent 14 sessions of working memory updating training over 8 weeks. The control group did not receive specialized working memory training. Participants in both groups were administered a writing ability test and a time-limited writing task test before and after training. The participants' writing ability tests were reviewed, data from the time-limited writing task were collected, and working memory updating training was conducted in a double-blind experimental setting.

2.3. Stimulus materials

2.3.1. Updating training program

The experimental group performed an adapted Chinese-character N-back training task. Brain imaging studies have confirmed that the N-back task can sufficiently activate the brain regions associated with working memory and executive function (Richards et al., 2009). The training task was referenced to the N-back training task from previous studies (Zhao et al., 2013; Gao, 2019). The stimulus materials were referenced from the General Standardized Chinese Character List (State Council of the People's Republic of China, 2013), which was created by the Chinese Ministry of Education and the National Language and Character Work Committee, from which 500 Chinese characters were randomly selected as stimulus materials.

	Indicators	Measurement methods
Fluency	Number of characters written in a unit of time	Total number of characters divided by the time of writing
	Number of words written per unit of time	Total number of words divided by the time of writing
Accuracy	T-unit accuracy	Error-free T-units divided by the total number of T-units
Complexity	Average length of T-units	Total number of words divided by the total number of T-units
	Average length of sentences	Total number of words divided by the total number of sentences
	Proportion of compound sentences	Total number of compound sentences divided by the total number of sentences

2.3.2. Chinese writing tests and time-limited writing tasks

The Writing Ability Questionnaire was used to assess participants' writing ability. The questionnaire comprised four parts: reviewing, conceiving, expressing, and modifying abilities. The discrimination of each question was above 0.3, and the internal consistency coefficient (Cronbach's α) was $r = 0.81$.

The pre-test time-limited writing task was titled *My Vacation Trip*, and the post-test time-limited writing task was titled *A Day in My Life*. Both were paper-and-pencil tasks; the topics were related to the participants' daily lives and were of equal difficulty. None of these tasks had been performed by the participants in their usual studies.

The data recording method for the time-limited writing task was based on a previous study (Qi and Kim, 2022) in which the fluency, accuracy, and grammatical complexity of the participants' Chinese writing were recorded. As shown in Table 1, the term "fluency" refers to participants' writing speed, including the number of characters and words produced per unit of time. Accuracy and complexity introduced the concept of the revised T-unit to Chinese writing analysis (Qi and Liao, 2019). Consider a single sentence and a modified complex sentence as a T-unit. The clauses in the joint compound sentences were considered independent T-units. The term "accuracy" refers to the ratio of the number of error-free T-units to the total number of T-units in the participant's entire composition. The term "complexity" refers to the ratio of the average number of words contained in T-units, average number of words contained in sentences, and ratio of complex sentences to the total number of sentences in the composition. The two time-limited writing tasks were analyzed independently by two experimenters according to the study measures and verified by sampling with 93% sample consistency.

2.4. Procedures

2.4.1. Updating N-back training task

The experimental group's training procedure was presented on a computer. There were four difficulties in the training task: 1-back, 2-back, 3-back, and 4-back tasks. Each difficulty level comprised 15 + n trials. As Figure 1 illustrates, each trial had a response time of 3,000 ms, and the participant needed to judge whether the current presented character was consistent with the previous nth-presented character and responded with a key press. In total, 10 trials were inconsistent, while five were consistent. All the trials were randomly presented. The participants were trained for 15 min each time, 1–2 times per week, for a total of 14 sessions. The training was conducted in a school computer room. The participants were familiar with the computer room, which was well-lit and ventilated, away from the classroom, and with low noise. Each participant underwent training daily in a standard classroom. In total, four monitors were present throughout the experiment, and they provided continuous feedback to the participants. The participants were given a sticker as a reward at the end of each training exercise. The first training session was conducted during the 4th week of the semester. At this time, the students' learning conditions stabilized. The participants in the experimental group started with 1-back training for each training session. At the end of each difficult task, the program provided participants with feedback on their accuracy during the task. If the accuracy rate was higher than 80%, the participants entered the next difficulty level. If the accuracy rate was lower than 80%, the participants were given one chance to repeat the difficult task. If the accuracy rate of the second training was below 80%, the difficulty level was decreased by one. Moreover, the 4-back tasks did not have an endpoint. When the total training time reached 15 min, the program automatically ended, and the accuracy and reaction time of the participants' training were recorded.

2.4.2. Chinese writing tests and time-limited writing tasks

During the entire experimental stage, the two groups were administered a pre-training test and a post-training test, together with the Writing Ability Questionnaire and time-limited writing task. The pre-training test was conducted 1 week before the start of the working memory updating training. The post-training test was conducted 1 week after the completion of the updating training. The Writing Ability Questionnaire comprised 100 points and lasted for 60 min. The time-limited writing task collected only data on writing performance and lasted for 30 min. Both groups underwent the tests simultaneously.

We predicted that the performance level of the working memory updating training task would increase significantly in the experimental group after training. Meanwhile, participants in the experimental group exhibited higher writing ability test scores and improved writing performance compared with those in the control group. We used SPSS 20.0 software for all data analyses. Paired-samples *t*-tests of mean performance on the first 5 days of updating training and mean performance on the last 5 days of updating training for the experimental group were
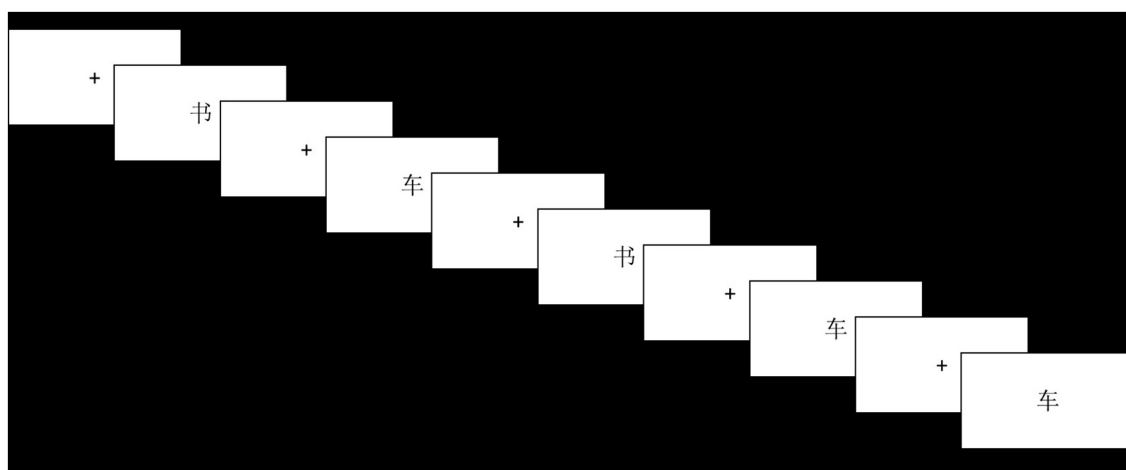
FIGURE 1
N-back training task.
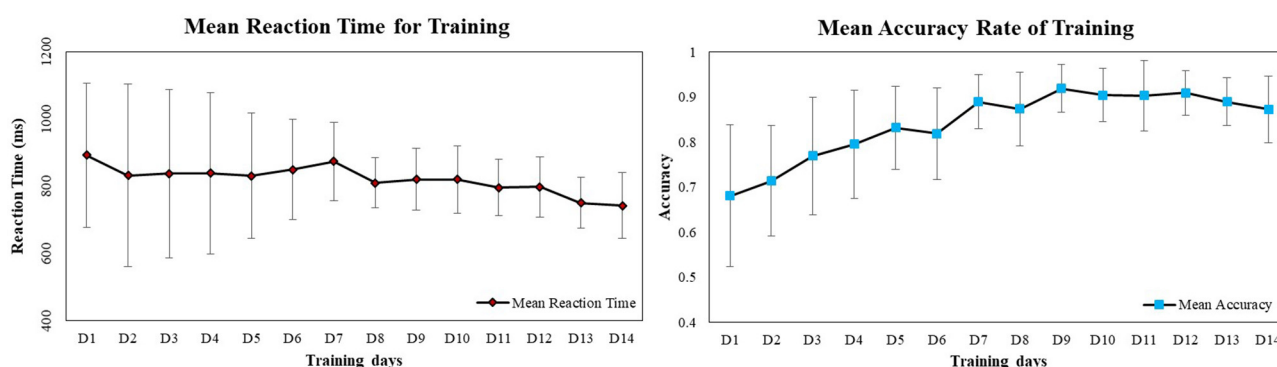
FIGURE 2
Mean reaction time and accuracy rate of training in the experimental group.

used to examine the changes in performance on the working memory updating training task for the experimental group. A 2 (subject type: experimental group vs. control group) × 2 (time: pre-test vs. post-test) repeated-measures ANOVA was used to examine the differences in the Chinese writing ability test scores between the two groups of subjects before and after training. An independent samples t-test was used to test the difference in the change in writing performance (post-training performance minus pre-training performance) between the two groups.

3. Results

3.1. Working memory updating training

As shown in Figure 2, the paired-sample t-test of the mean scores of the first 5 days of updating training and the mean scores of the last 5 days of updating training in the experimental group revealed that working memory updating training enhanced the working memory performance (Hypothesis 1). The mean accuracy

of the last 5 days of training was higher than that of the first 5 days of training [$t_{(18)} = 6.24$, $p < 0.001$, Cohen's $d = 1.81$, $r = 0.67$]. There was no significant difference in training reaction time [$t_{(18)} = -0.75$, $p = 0.46$, Cohen's $d = 0.94$, $r = 0.42$]. These results suggest that working memory updating training enhances working memory performance.

3.2. Chinese writing tests

A 2 (participant type: experimental vs. control group) × 2 (time: pre-test vs. post-test) repeated-measures ANOVA with both groups' Writing Ability Questionnaire scores revealed an increase in the experimental group's writing ability. As shows in Table 2, the interaction effect between participant type and time was significant [$F_{(1,35)} = 12.20$, $p = 0.001$, $\eta_p^2 = 0.26$]. A simple effects analysis revealed no significant difference between the pre-test scores of the two groups [$F_{(1,35)} = 0.26$, $p = 0.61$, $\eta_p^2 = 0.01$]. The experimental group scored higher than the control group on the post-test [$F_{(1,35)}$

TABLE 2 Mean pre- and post-training Writing Ability Questionnaire scores for both groups.

Groups	Pre-training ($M \pm SD$)	Post-training ($M \pm SD$)
Experimental group	33.84 ± 8.06	64.65 ± 12.48
Control group	35.11 ± 7.00	56.48 ± 8.74

$= 5.26, p = 0.03, \eta_{\mathrm{p}}^2 = 0.13$]. A simple effect analysis was conducted on both groups' pre- and post-test scores; the experimental group's post-test scores were higher than the pre-test scores [$F_{(1,35)} = 267.34, p < 0.001, \eta_{\mathrm{p}}^2 = 0.88$]. The control group's post-test scores were higher than the pre-test scores [$F_{(1,35)} = 121.87, p < 0.001, \eta_{\mathrm{p}}^2 = 0.78$]. The results indicate that teaching enhances writing ability and that an improved level of working memory can promote teaching effectiveness (Hypothesis 2).

3.3. Chinese writing performance

As shown in Table 3, independent sample t-tests for the change in writing performance (post-test performance minus pre-test performance) revealed a significant increase in writing fluency in the experimental group compared with the control group. The number of characters per unit of time increased and was higher in the experimental group than in the control group [$t_{(35)} = 2.95, p = 0.006$]. The number of words per unit of time increased and was higher in the experimental group than in the control group [$t_{(35)} = 3.03, p = 0.005$]. In terms of accuracy, the T-unit accuracy decreased and was lower in the control group than in the experimental group [$t_{(35)} = 2.65, p = 0.01$]. In terms of complexity, the average length of the T-units in the control group decreased and was lower than that in the experimental group [$t_{(35)} = 4.78, p < 0.001$]. The average sentence length in the control group decreased significantly compared with that in the experimental group [$t_{(35)} = 2.88, p = 0.007$]. The proportion of compound sentences decreased in both groups, but there was no significant difference between the groups [$t_{(35)} = 1.22, p = 0.23$]. The results indicate that the experimental group participants' writing fluency increased while maintaining their original accuracy and complexity. The control group exhibited increased writing fluency at the expense of accuracy and complexity (Hypothesis 3).

4. Discussion

This study examined the effects of working memory training on primary school students' writing using Chinese character N-back training, the Writing Ability Questionnaire, and a time-limited writing task. The results showed that working memory updating training improved primary school students' performance on the working memory task (H1) and the Writing Ability Questionnaire (H2). Additionally, the experimental group's writing performance showed a developmental pattern of increased fluency and maintained accuracy and complexity (H3).

The first and second findings indicate that working memory updating training and school teaching worked simultaneously

for both groups of participants. Both groups scored significantly higher on the post-training writing test than on the pre-training test; however, in the post-training test, the experimental group scored significantly higher than the control group. This suggests that working memory updating training, as an auxiliary to normal teaching, can accelerate the development of individual writing skills. Our results are consistent with previous research suggesting that working memory training improves individual writing proficiency, but that working memory training cannot replace the role of teaching (Mo et al., 2018; Agha et al., 2022). The experimental results indicated that participants' writing ability improved through working memory training.

The third finding showed that the experimental group's writing fluency was significantly higher than that of the control group. This suggests that working memory training enhances individual writing fluency. These experimental results are similar to those of previous studies using working memory levels to predict writing performance in intermediate- and upper-level English learners (Zabihi, 2018). We filled the gap in the literature regarding the effect of working memory training on writing performance. Our experiment used working memory training to confirm the effect of working memory on writing performance. To the best of our knowledge, this is the first study to show that writing performance exhibits a developmental pattern of increased fluency while maintaining original accuracy and complexity through working memory training.

Writing is a complex process; it requires not only retrieving and transforming linguistic information from long-term memory into written form but also supervising the entire writing process and checking logical relationships in writing production. The entire writing process calls upon a large number of cognitive and linguistic resources (Li and Roshan, 2019). Working memory for temporary processing and storing information is important for supporting a successful writing process.

In elementary, low-level writing, learners pay more attention to word and syntactic processing, which are susceptible to working memory (Weigle, 2005). At this stage, each word occupies one unit of working memory. A high load on working memory for long periods leads to a decrease in the ability of the updating to continuously regulate and review working memory content during the writing process, which in turn leads to an increase in the error rate during the writing process. Learners with high levels of updating have significant learning advantages in these aspects of the writing process. They can allocate cognitive resources more effectively, balance the integration of meaning and form in the writing process, and perform multiple rounds of material analysis. They can even redistribute the remaining cognitive resources to help them reach advanced writing levels faster. In contrast, learners with low levels of updating have no choice but to engage in low levels of data-driven processing of writing information in situations where working memory is running under a high load and have no more resources to allocate to other parts of the writing process. On the one hand, this high load leads to an increased probability of mistakes in spelling and grammar, which are dominated by updating. On the other hand, it also reduces the degree of sentence-paragraph-chapter linkage in writing, thereby decreasing the overall quality of writing output.

TABLE 3 Changes in writing fluency, accuracy, and complexity between the two groups.

		Post-test minus pre-test		t	Cohen's d	r
		Experimental group	Control group			
Fluency	Number of characters written in a unit of time	5.54 ± 4.63	1.37 ± 3.92	2.95**	0.97	0.44
	Number of words written per unit of time	1.44 ± 1.43	0.11 ± 1.22	3.03**	1	0.45
Accuracy	T-unit accuracy	0.00 ± 0.13	−0.14 ± 0.20	2.65*	0.83	0.38
Complexity	Average length of T-unit	0.65 ± 1.28	−1.46 ± 1.40	4.78**	1.57	0.62
	Average length of sentences	−0.37 ± 4.09	−4.72 ± 5.06	2.88**	0.95	0.43
	Proportion of compound sentences	−0.07 ± 0.20	−0.14 ± 0.15	1.22	0.4	0.19

*p < 0.05. **p < 0.01.

This study confirmed that the improvement in participants' working memory performance through training promoted their writing performance. This finding supports previous research suggesting that working memory limits the process of writing output (Kellogg, 1996). This also supports the previous view that there is competition for cognitive resources, especially working memory resources, in the writing process (Skehan, 2002).

Updating's critical role in writing may be due to the fact that children first learn about writing systematically at the primary school level as well as their lack of proficiency in content during writing output. Children must repeatedly check the vocabulary and syntactic structures selected while writing. Furthermore, they must check what has been produced, as well as spelling, grammatical, and structural mistakes in writing. These writing output processes require a certain level of updating as a basis for ongoing conditioning and checking the content of newly entered working memory. An increased level of updating enhances the stability of the level of continuous regulation during individual writing and reduces the error rate under a high working memory load. It also promotes the performance of low-level learners and beginners in primary processing (e.g., wording). To some extent, it optimizes the monitoring system in the process of written language output, improves the efficiency of the reading and editing processes, and enhances the performance of the participants' language writing process. This conjecture was verified through our experiments.

As the teaching cycle progressed, the pattern of writing performance development in both groups revealed that improved working memory promoted increased fluency in the writing process and maintained previous levels of accuracy and complexity. In other words, individuals with high working memory proficiency produce more words and make fewer errors per unit of time in their writing. Therefore, based on the developmental differences between the two groups, we conjecture that both improved their writing fluency during normal educational activities. However, the experimental group's ability to monitor the writing process and maintain accuracy and complexity was enhanced, owing to the improved level of working memory. In contrast, the control group showed a significant decrease in accuracy and complexity because of further intensification of the working memory load while enhancing writing fluency, which increased the competition for working memory resources during the writing process.

Working memory updating training can enhance frontal middle gyrus activation, which is associated with writing (Westerberg and Klingberg, 2007). Thus, as the level of working memory increases, individuals gain access to more working memory resources to process and integrate writing processes. Individuals can maintain stability during high working memory loads while improving their capacity to monitor the writing process. This would compensate for the high error rate caused by students' weak connections to knowledge points and their unfamiliarity with the writing process at the primary level. This suggests that working memory updating training can be used as an auxiliary to writing education to accelerate the acquisition of individual writing skills.

Additionally, the retention of the effects of working memory updating training has been validated in previous studies. Peng et al. (2014) and Gao (2019) used working memory updating training to track the retention effects of working memory training for toddlers and primary school students, respectively, and found that working memory updating training continued to have a stable transfer effect on fluid intelligence and writing achievement 6 months after the end of training. This suggests that the transfer effect of working memory updating training is more pronounced in early childhood and school-age children. This view is indirectly supported by studies based on tracking primary school students showing that working memory is consistently a significant predictor of writing ability at the primary school stage (Guan et al., 2019; Rocha et al., 2022).

5. Limitations and prospects

Participants from the same group (class and community) were selected to balance their writing abilities, language experiences, and living environments. This similarity in teaching processes, writing strategies, and experiences may have led to similar developmental patterns in writing performance among individuals. These drawbacks may also explain the controversial results of current research on the relationship between working memory and writing. Additionally, the balance of participant proficiency allowed us to analyze only the differences in participants' writing performance and failed to provide in-depth statistical test results. Future studies should examine large sample sizes across various regions to balance the effects of participants' educational environment, writing strategies, and learning motivation. Alternatively, multiple small-sample studies should be conducted, strictly matching the factors of participants' educational environments, writing strategies, and learning motivation to examine working memory's

effects on individual writing performance in different teaching modes. Ultimately, this will provide persuasive evidence for the numerous debates among researchers in this field.

6. Conclusion

This study confirms that an improvement in working memory can promote primary school students' Chinese writing performance. The participants showed a developmental pattern of writing performance in which fluency increased and previous accuracy and complexity were maintained. The three pieces of evidence we provide suggest that working memory training is an effective supplement for primary school students. Combined with the currently limited literature on the effects of working memory training on writing ability, these findings suggest that future research on working memory and writing ability should focus on the specific effectiveness of working memory training on writing, rather than simply assessing the relationship between working memory proficiency and writing ability. Working memory is one of the most important factors influencing the writing process, and future studies should provide a comprehensive understanding of writing development.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by the Research Ethics Review Committee of the College of Psychology, Xinjiang Normal University. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

JG did the validation, data analysis, writing the original manuscript, writing-review and editing, and supervision. SW did the experimental design, supervision, and manuscript revision. GL did the experimental program design. ZY, TW, and FL did the data collection and calculation.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyg.2023.1163132/full#supplementary-material

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Conceptual metaphors and image construction of China in the space probe reports of *China Daily*: a social cognitive approach

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The success of Shenzhou XIII and Chang'e-5 mission became a milestone in China's aerospace history and represented China's latest attempt to contribute to international space industry, which greatly promoted the China's national image. However, rare studies have examined the image construction in aerospace field. Thus, this study takes conceptual metaphors as the guiding theory and studies conceptual metaphors in China Daily news release on Chang'e-5 and Shenzhou XIII from 2008 to 2021. It focuses on the types of metaphors used, the semantic features of the metaphors, and the characteristics of Chinese images in aerospace field. It is found that China Daily widely uses conceptual metaphors in its news release on space probe, which mainly includes 11 conceptual metaphor categories such as "endeavor," "great significance," "time" and "journey," and 20 types of conceptual metaphor subcategories, all of which are working together to construct the image of China in aerospace industry, which is characterized with the following features: a dream-building action with lofty goals, an enterprising action which represents the prosperity and progress of China, an exploratory action that is constantly forging ahead and pursuing, a leading action that opens a new chapter and leads a new journey, a braving action which dares to be the first to live in the space, and an achieving action to create a community with a shared future for mankind.

KEYWORDS

conceptual metaphor, national image, space probe, image construction, *China Daily*

Introduction

The Chinese space probe program began in the 1950s and launched the first satellite on April 24, 1970. After that, in 1971, manned space engineering was propounded. In 1992, according to the "three-step" development strategy, China's manned space project was implemented, and till 2010, the manned space station project was officially launched. On October 16, 2021, the Shenzhou XIII mission launched on a Long March 2F carrier rocket and started the longest manned flight in space.

On November 22, 2000, the State Council issued the white paper "China's Aerospace," which put forward the goal of space exploration focusing on lunar exploration. Two years later, a national cooperative engineering system framework was established to improve the carrying capacity and meet the needs of deep space exploration. It included a three-step lunar exploration program ("orbit, land, and return") named Chang'e lunar probe, which was projected to be completed in 2020. On November 24, 2020, China launched the Chang'e-5 spacecraft to collect and return samples from the moon, which was the first space expedition from any country to bring back lunar samples in decades.

The success of the two missions became a milestone in China's aerospace history and represented China's latest attempt to contribute to the international space industry, which greatly promoted China's national image. However, rare studies have examined image construction in the aerospace field. At present, scholars greatly concentrate on the construction of national image, and its linguistic construction has also attracted special attention (Sun, 2009), especially the cognitive linguistic construction (Hu, 2011; Li, 2011). Among them, conceptual metaphor is a commonly used technique (Liang, 2013, p. 113). Therefore, by undertaking the analysis, the current study has two specific goals: (1) to investigate the mechanism of the conceptual metaphors in the case of space probes by the series reports of *China Daily*, and (2) to explore the national image of China that is constructed by these metaphorical words in the aerospace news reports.

The significance of this study lies in investigating the conceptual metaphors used in the news series of space probe. First, it identifies the metaphor words in the news texts and summarizes the semantic features of these metaphors. Then, based on these semantic features, it systematically examines the national image of China constructed by the aerospace news reports. Finally, the result of this project will also provide a reference for journalists to know and improve the national image in future news reports.

Literature review

Literature review of national image

Initial studies of images can be traced back to the work of Kenneth Boulding (Davies et al., 2021, p. 70), who regards image as "the subjective knowledge of the world which governs people's behavior" from the aspect of the international political field (Boulding, 1956, p. 5–6). Nimmo and Savage (1976) extended the meaning of "image" and believed that image is a human construct imposed on an array of perceived attributes projected by an object, event, or person. Every object has its image, as well as an image perceived by others. Individuals, organizations, and even countries have images. These images are of vital importance since they influence the process through which one deals with others. For a country, this image impacts many arenas, such as the military, politics, economics, and tourism, to name but a few.

For the definition of the national image, Martin and Eroglu (1993) thought that national image refers to the combination of all descriptive, inferential, and informational faith that a person has toward a particular country. And that impression is mainly reflected in the aspects of politics, economy, and science and technology. Kunczik (1997) argued that national image is the representation that a person holds of a given country, what a person believes to be true about a nation and its people. The domestic scholar (Sun, 2002) pointed out that national image refers to the external and internal public's understanding and evaluation of a particular country in terms of its politics, economy, society, culture, and geographical conditions. The national image is fundamentally determined by the comprehensive national strength of the country, but it cannot be simply equated with the actual condition of that country. National image is the comprehensive reflection of a

country's soft power and hard power, thus, there is no doubt that national image can be constructed from many aspects.

At present, the construction of a national image has attracted increasing attention, and its language construction has also attracted the special attention of scholars (Sun, 2009, p. 60–83). In foreign linguistic field, Doorslaer (2010) discussed the construction of national image in the translation of news terms in new media using the theory of iconology; Young (2012), based on the Hofstede's five cultural dimensions, conducted a qualitative research on Russian culture from the perspectives of the Russian people, government, culture, tourism and products, and discussed how the state should take "identity as the national image"; Lee and Kim (2013) made some analysis on how the translation of the South Korean tourism influenced the national image; Adeyemi (2017) studied semiotic resources in resisting Nigeria's negative stereotypes in the international community, especially the country's national image in the Western media; Pieta (2018) demonstrated that Poland was portrayed as both a friend and an enemy when its literary texts was translated into Portuguese and investigates how the role of different versions of literary texts influenced the construction of the national image.

In the domestic linguistic field, the studies on national image mainly focus on constructing the image of China and various research approaches have been used, such as the translation strategy (Hu, 2010, 2014; Wang, 2012; Lu, 2013; Yuan, 2014), multimodal discourse analysis (Pan and Zhang, 2013), cognitive analysis (Liang, 2013; Liu, 2017), corpus linguistics (Hu and Li, 2017; Yu and Chen, 2019), rhetoric theory (Hu and Xue, 2010), critical discourse analysis (Liu and Yu, 2014; Li, 2017; Pan and Dong, 2017), narrative analysis (Ren, 2017; Zhu et al., 2019), and cultural discourse analysis (Wang, 2017). For the examination of perceived national images, we can see that the expression of a national image widely depends on different linguistic devices. Among them, metaphor deserves our attention (Liang, 2013, p. 115).

Literature review of national image and metaphors

Human thought processes are largely metaphorical. This is what we mean when we say that the human conceptual system is metaphorically structured and defined. Metaphors as linguistic expressions are possible precisely because there are metaphors in a person's conceptual system. In addition, conceptual metaphors are grounded like our everyday interaction with the world. That is, conceptual metaphor has an experiential basis (Lakoff and Johnson, 1980, p. 7, 9; Vyvyan and Melanie, 2006, p. 295). Thus, it can be seen that metaphorical linguistics are reflections of an underlying conceptual association based on people's daily experiences. According to cognitive semanticists, metaphor is a conceptual mapping between the source and target domain. The source and target domains are always unidirectional. Kövecses (2002; p. 20) put it, "target domains are abstract, diffuse and lack clear delineation; as a result, they 'cry out' for metaphorical conceptualization", and found that the most common source domains for metaphorical mappings include domains relating to the HUMAN BODY (the heart of the problem), ANIMALS (a

sly fox), PLANTS (the fruit of her labor), FOOD (he cooked up a story), and FORCES (don't push me!). The most common target domains included conceptual categories like EMOTION (she was deeply moved), MORALITY (she resisted the temptation), THOUGHT (I see your point), HUMAN RELATIONSHIPS (they built a strong marriage), and TIME (time flies). According to Raymond and Gibbs (2011), the range of abstract conceptual domains that appear to be structured in some manner by conceptual metaphor is immense and includes emotions (Kovecses, 2000), the self (Lakoff and Johnson, 1999), morality (Johnson, 1993), politics (Lakoff, 1996; Musolff, 2004), science concepts (Brown, 2003; Larson et al., 2006), illness (Sontag, 1978; Gibbs and Franks, 2002), psychoanalytic concepts (Borbely, 2004), legal concepts (Winter, 2002), mathematics (Lakoff and Núñez, 2002), and certain cultural ideologies (Goatly, 2007). Thus, this study mainly adopts the domains, such as cultural ideologies (traditional culture), morality (strivers, share, and leadership), time (time), human relationships (family), journey (journey), and some other abstract concept domains (music, chapter, significance, and difficulty) to contract the metaphor typologies.

In recent examples of scholarship on national image and metaphors, Liang (2013) investigated the special role of the metaphor in image construction, sorted, and analyzed the collected corpus of a large number of news reports referring to the country's name. It is found that in the current news report discourse construction of the national image, the shaping of the national image of conceptual metaphor at the cognitive level was mainly reflected in four aspects, namely, animalization and personification, solidification and temporary, nationality and ideology. Pan and Zhang (2013) identified and interpreted metaphor and metonymy in *China's national image promotion: perspectives*, analyzed the interaction mode between them, discussed their different roles in forming cohesion and coherence of multimodal discourse, and revealed the cognitive mechanism of multimodal discourse. Guan (2018) made a systematic study on how to construct the Russian national image in the Russian national image propaganda film based on the theory of multimodal metaphor. Liang (2018), using the theory of framing theory and conceptual metaphor, analyzed 124 reports in the China column of the *Economist* in 2016, and discussed the attitude of British media toward China's economy. Fitnat (2021) researched the use of metaphors among students and teachers to determine the images they had in their minds regarding a specific set of developed countries. It was concluded that there is a strong relationship between metaphor creation and age, and that metaphor production increases rapidly as the students get older and more knowledgeable. It was also determined that metaphor quality and production rate decreases as teachers' professional seniority increased. Musolff (2021) explores the nation as a body metaphor in the specific cultural context and concluded that "Scenarios thus serve as the background against which the new concept or argumentative application can be analyzed in relation to the historically situated communicative context".

However, research on the construction of the national image in the aerospace field using the conceptual metaphor theory is rare. Only one recent example of study, Li (2016), based on the theory of conceptual metaphor, examines the characteristics of metaphor mechanism in the news reports in the case of space probes and analyzes the changes of metaphor used in different social and historical backgrounds. Studies on the construction of the national image in the aerospace field are still rare. Hopefully, this article may lead to further research into this topic.

Corpus and methodology

China Daily was established in 1981 as the national English-language newspaper. It serves more than 330 million readers all over the world and is a default choice for people who read about China in English.[1] This article collects 460 news reports of Chang'e 5 and Shenzhou XIII as the corpus data. And then based on the conceptual metaphor theory, it identifies the metaphors used in these news reports, examines the semantic features of these metaphors, and investigates the national image of China constructed by *China Daily*.

Data of the research

On the *China Daily* website, 330 news reports are collected with "Chang'e-5" as the subject keyword. The time selected is from September 24, 2008 to January 29, 2021. A total of 130 news reports are collected with "Shenzhou XIII" as the subject keyword. The time selected was from October 10, 2011 to April 16, 2022. The years 2008 and 2011 were the earliest times when *China Daily* reported on Chang'e-5 and Shenzhou XIII. The years 2021 and 2022 were the time that Chang'e-5 and Shenzhou XIII successfully completed the mission, respectively.

Research questions

This article aimed to answer the following three questions:

(1) What conceptual metaphors are used in the news reports of Chang'e 5 and Shenzhou XIII in *China Daily*?
(2) What are the semantic features of these conceptual metaphors?
(3) What kinds of national image are constructed by the news series of *China Daily*?

Criterion for metaphors

The metaphor was characterized by the schematic form: A is B, as in *Achilles is a lion*. As a consequence, metaphor has been identified since the time of Aristotle with implicit comparison. In other words, while metaphor is based on the comparison of two categories, the comparison is not explicitly marked (Vyvyan and Melanie, 2006, p. 293). Thus, in this article, if the concept in one domain can be expressed by the concept in another domain, we can suppose that the conceptual metaphor is produced. The explicit metaphor can be expressed as "XXX (one concept)" is "A", otherwise, if the "XXX (one concept)" is replaced by "A",

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the "A" is the implicit metaphor. In this article, the explicit metaphors refer to some examples such as "Chang'e-5 is one of the most complicated and challenging **missions** in China's aerospace history"; and the implicit metaphors include "TT&C missions of the **Shenzhou** and **Tianzhou** spacecraft series, **Tianhe** core module, **Chang'e** lunar probe series, and **Tianwen**-1 Mars probe have been completed successfully."

Data analysis

Conceptual metaphor in the case of the chang'e-5 by series reports

The Antconc software was employed to extract the sentences with keywords. Such words as "Chang'e; lunar exploration; lunar sample; moon probe project" were treated as keywords and were used to search for the conceptual metaphor sentences in the corpus of 330 news reports. As a result, 506 statements using conceptual metaphors have been found. After identifying and sorting the conceptual metaphors in these sentences, the main conceptual domains and the number of metaphors are given in Table 1.

The table and Figures 1, 2 above show that there are mainly 11 conceptual domains and 18 conceptual sub-domains in the series of news by the case of Chang'e-5 aerospace. The characteristics of these conceptual metaphors will be discussed as follows:

The conceptual metaphor domain "Traditional culture (Chang'e, Yutu/Jade Rabbit, Shenzhou, Tiangong, Tianwen, Queqiao)" is the most widely used metaphor in the series reports. These metaphors are from Chinese poems and myths, which express Chinese people's yearning for the moon and the spirit of exploration for the truth. Thus, this conceptual metaphor domain highlights that Chinese people look forward to exploring the moon since the ancient time.

"Strivers" is also found to be a key semantic domain in these news reports, in which "Mission" as the sub-domain is the most widely used metaphor, and the sub-domains "Goal" and "Spirit" also exist. The most widely used metaphor word is "mission", which appears 712 times, and the "exploration" occurs 454 times. These metaphors emphasize that Chinese people advance bravely and modestly. The "Strivers" metaphor domain shows that China's aerospace industry is in the primary stage of rising and continuous exploration. The sub-domains "Goal (start, goal)" and "Spirit (spirit)" are positive, optimistic, and enterprising, which show that China is full of confidence in future for the space industry.

The conceptual metaphor "Significance" was ranked third, in which the conceptual metaphor "Achievement" is the key semantic domain, and the sub-domains "Power (lift, power, and emphatic)," "Action (leap)," and "Fruit (fruit)" are also found. The most widely used metaphors "success/successful/successfully" appear 278 times. These conceptual metaphors express the high evaluation of the completion of the space mission of chang'e-5, which has historic and strategic significance in China's space industry.

The conceptual metaphor domain "Time" includes sub-domains of "Time period (develop and upcoming)" and "Point of time (era, moment, and timeline)". This conceptual metaphor domain evaluates the current achievements and future

development of China's aerospace industry. It shows that chang'e-5 is of great significance to China's aerospace industry and has made great contributions in promoting the development of China's aerospace industry. The conceptual metaphor domain "Journey" includes sub-domains of "journey (Long March, step, phase, stage, course, and on its way/pave the way)" and "Landmark (milestone, landmark, and roadmap)", which shows that China's aerospace industry is still "on the way" and has a lot of room for development. The sub-domain "road sign" is symbolic and directional, which shows that the successful completion of the mission of Chang'e-5 is of great symbolic significance in China's aerospace history and plays a directional role in the development of the aerospace industry in future.

It also uses the conceptual metaphor domain "Difficulty (challenge/challenging, complicated, and overcame)", which expresses that the Chang'e-5 is complex, challenging, and a big breakthrough in China's technology. The words in the "Family (home/backup/safely/homecoming)" domain are warm and concerned. It marks that China contains humanistic feelings even in the technological field. The "Leadership (heads and lead)" domain shows that the aerospace industry in China has been at the forefront of the world and leads the development of aerospace science in the world. The "Share (share/willingness)" domain points out that China is willing to share the technological fruit with other countries and builds a community of shared future for mankind in the aerospace field. The last two domains "Chapter" and "Music (trilogy and rehearsal)" investigate that Chang'e-5 greatly promotes the development of the Chinese aerospace industry and China has a good wish for the space industry.

Next, the conceptual metaphor domains can be divided into three categories, and domains in each category and their word frequency are listed as follows:

1. Chinese aerospace industry is going upward (2,079): Chang'e-5 is mission (1,228) > Chang'e-5 is journey (656) > Chang'e-5 is goal (103) > Chang'e-5 is landmark (45) > Chang'e-5 is point of time (32) > Chang'e-5 is spirit (15).

2. China has a good wish for the space industry (1,743): Chang'e-5 is traditional culture (1,638) > Chang'e-5 is family (69) > Chang'e-5 is share (32) > Chang'e-5 is music (4).

3. Chang'e-5 is of great significance (1313): Chang'e-5 is achievement (624) > Chang'e-5 is time period (301) > Chang'e-5 is power (181) > Chang'e-5 is difficulty (121) > Chang'e-5 is leadership (62) > Chang'e- 5 is chapter (16) > Chang'e-5 is action (5) > Chang'e-5 is fruit (3).

Conceptual metaphor in the case of the Shenzhou XIII by series reports

The Antconc software was also employed to extract the sentences with keywords. Such words as "Shenzhou, astronauts/taikonauts, and space industry" were treated as keywords and were used to search for the conceptual metaphor sentences in the corpus of 130 news reports. As a result, 437 statements using conceptual metaphors have been found. After identifying and sorting the conceptual metaphors in these

TABLE 1 Main conceptual domains and the number of metaphors.

Domains	Sub-domains (5,135)	Words (occurrence)	Frequency (%)
Traditional culture	Traditional culture (1,638)	Chang'e (1,323); Yutu/Jade Rabbit (129); Shenzhou (69); Tiangong (58); Tianwen (41); Queqiao (18)	31.90
Strivers	Mission (1,228)	Mission (712); exploration (454); attempt (21); prototype (21); endeavor (20)	23.91
	Goal (103)	Start (46); goal (42); dream (14); wake-up call (1)	2.00
	Spirit (15)	Spirit (15)	0.29
Significance	Achievements (624)	Success/successful/successfully (276); achieve/achievement (85); historic (82); breakthrough/breakthroughs (39); complete (35); strategic (30); feat (21); contribute (20); accomplish/accomplishment (17); fulfill (15); highlight (4)	12.15
	Power (181)	Lift (108); power (72); emphatic (1)	3.52
	Action(5)	Leap (5)	0.10
	Fruit(3)	Fruit (3)	0.06
Time	Time period(301)	Develop (295); upcoming (6)	5.86
	Point in time(32)	Era (17); moment (14); timeline (1)	0.62
Journey	Trip(656)	Long March (427); step (76); phase (71); stage (53); course (15); on its way/pave the way (14)	12.78
	Landmark (45)	Milestone (24); landmark (19); roadmap (2)	0.88
Difficulty	Difficulty (121)	Challenge/challenging (66); complicated (41); overcame (14)	2.36
Family	Family (69)	Home (39); backup (20); safely (8); homecoming (2)	1.34
Leadership	Leadership (62)	Heads (53); lead (9)	1.21
Share	Share (32)	Share (29); willingness (3)	0.62
Chapter	Chapter (16)	Chapter (16)	0.31
Music	Music (4)	Trilogy (2); rehearsal (2)	0.08

FIGURE 1
Macro-level semantic domains of conceptual metaphors.
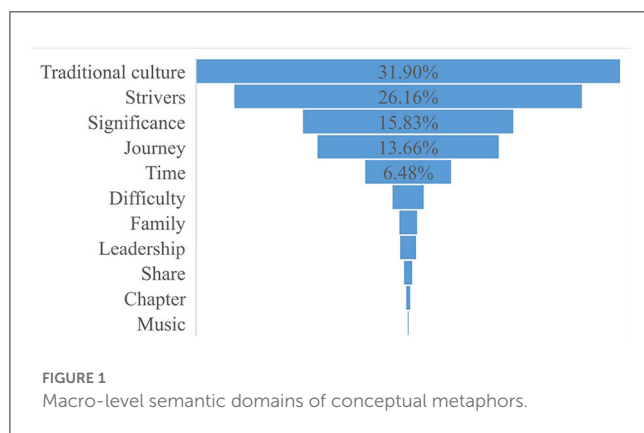
sentences, the main conceptual domains and the number of metaphors are given in Table 2.

The table and Figures 3, 4 above show that there are mainly seven conceptual domains and 18 conceptual sub-domains in the series of news by the case of Shenzhou XIII aerospace. Then, the characteristics of these conceptual metaphors will be discussed.

Similarly, the "Traditional culture (Shenzhou/Tiangong/ Tianhe/Tianzhou/Tianwen/Wentian/Mengtian/ Chang'e/culture)" domain is most widely used metaphor in the series reports. These

metaphor words are from Chinese ancient poems and myths, which express that Chinese people dream about exploring space and having a good longing for space.

The "Strivers" domain is second among all the metaphor domains, which is similar to the news reports of Chang'e-5 and shows the Chinese spirit of persistence and enterprise.

The conceptual metaphor "Significance" is also a key semantic domain in these news reports, in which the "Meaning" sub-domain is the most widely used metaphor, and "Achievements (accomplish/accomplishment, achieve/achievement)" and "Action (stride, seize)" are also used to speak highly of Shenzhou XIII, which make a great contribution to Chinese aerospace industry. The achievement of Shenzhou XIII is innovative and extraordinary.

The "Journey" metaphor is also used. It includes "Trip (Long March, Journey, travel, trip, voyage, level, foundation, and closed the gap)," "Occupants (occupants)," and "Landmark (milestone)". These metaphor words are beautiful, pleasant, and directive and show that Shenzhou XIII is exploratory and tentative.

The "Family (home and backup)" metaphor is also utilized and it plays the same role as mentioned earlier. "Leadership (leading, guidelines, and forerunners)" and "Hero (hero)" metaphors show that the Chinese aerospace industry is the leader in the world and Chinese aerospace workers are wise and brave and make great contributions to the aerospace industry. The "Age (age)"

FIGURE 2
Micro-level semantic domains of conceptual metaphors.
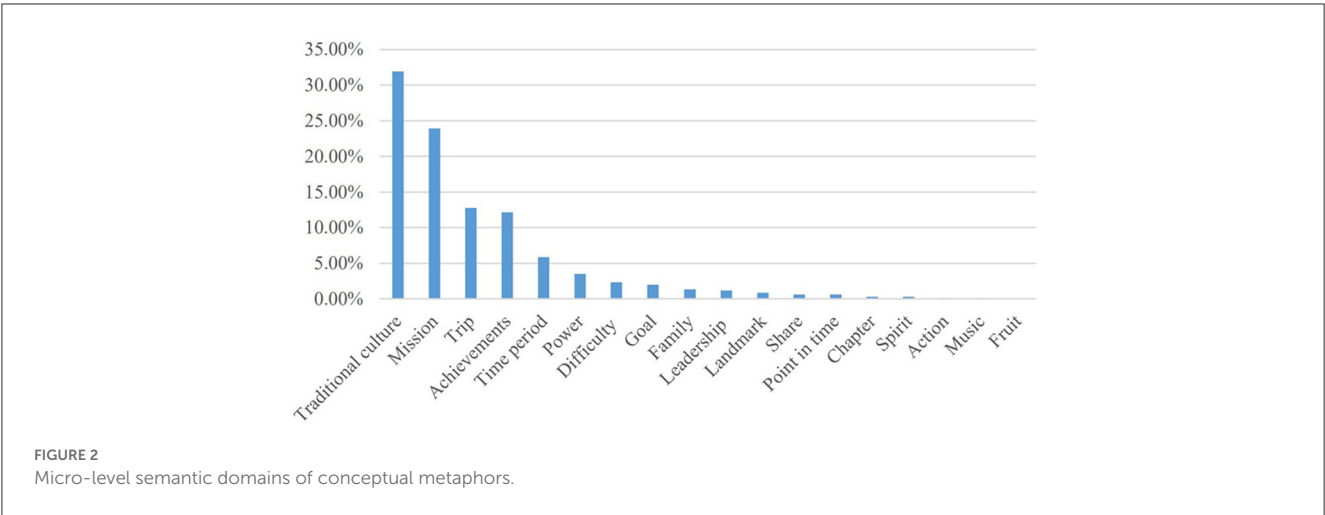
TABLE 2 Main conceptual domains and the number of metaphors.

Domains	Sub-domains (835)	Words	Frequency (%)
Traditional culture	Traditional culture (520)	Shenzhou (295); Tiangong (108); Tianhe (52); Tianzhou (48); Tianwen (7); Wentian (3); Mengtian (3); Chang'e (3); culture (1)	62.28
Strivers	Mission (153)	Mission (144); exploration (9)	18.32
	Goal (2)	Spirit (1); proactive (1)	0.24
	Spirit (1)	Dream (1)	0.12
Significance	Meaning (57)	Success/successful/successfully (22); complete (21); remarkable (2); historic (2); improve/improvement (4); revolutionary (1); strategic (1); advanced (1); promote (2); cutting-edge (1)	6.83
	Achievement (26)	Accomplish/accomplishment (17); achieve/achievement (5); feat (1); contribute (2); tribute (1);	3.11
	Action (3)	Stride (2); seize (1)	0.36
Journey	Trip (53)	Long March (27); journey (13); travel (4); trip (4); voyage (1); level (1); foundation (2); closed the gap (1)	6.35
	Occupants (2)	Occupants (2)	0.24
	Landmark (1)	Milestone (1)	0.12
Family	Family (10)	Home (5); backup (5)	1.20
Leadership	Lead (3)	Leading (1); guidelines (1); forerunners (1)	0.36
	Hero(3)	Hero (3)	0.36
Time	Point in time(1)	Age (1)	0.12

metaphor expresses that the Chinese aerospace industry is at a new stage.

Next, the conceptual metaphor domains can be divided into three categories, and domains in each category and their word frequency are listed as follows:

1. Chinese aerospace industry is going upward (162): Shenzhou XIII is mission (153) > Shenzhou XIII is action (3) = Shenzhou XIII is hero (3) > Shenzhou XIII is goal (2) > Shenzhou XIII is spirit (1).
2. China has a good wish for the space industry (583): Shenzhou XIII is traditional culture (520) > Shenzhou XIII is trip (53) > Shenzhou XIII is family (10).
3. Shenzhou XIII is of great significance (90): Shenzhou XIII is meaning (57) > Shenzhou XIII is achievement (26) >

Shenzhou XIII is lead (3) > Shenzhou XIII is occupants (2) > Shenzhou XIII is time (1) = Shenzhou XIII is landmark (1).

To sum up, the conceptual metaphors in the news series of *China Daily* by the case of Shenzhou XIII and Chang'e-5 reflect that Chinese aerospace is going upward, Chang'e-5 is of great significance and China has a good wish in future for the space industry.

Discussion

This study mainly explores the scope of aerospace news from 2008 to 2022. Compared to the 28 news editorials discussed by Li (2016) from 1986 to 2016, it has an advantage of the corpus and the

classification of metaphorical concepts. China's image constructed by this study is closer to the development level of modern China's aerospace industry, which presents significant differences in the constructed image of China by Li's (2016) study. Based on the metaphorical analysis above, it can be seen that *China Daily* takes an important role in constructing the image of the Chinese aerospace industry from several aspects:

(1) Chinese aerospace industry is a dream-building action with lofty goals. In the case of the space probe by the series of *China Daily*, the "Traditional Culture (Chang'e, Yutu/Jade Rabbit, Shenzhou, Tiangong, Tianwen, and Queqiao)" metaphor expresses that Chinese people's yearning for the moon and the spirit of exploration for the outer space. For example:

[1] China has seen breakthroughs in scientific explorations like the **Tianwen-1** (Mars mission), **Chang'e-5** (lunar probe), and **Fendouzhe** (deep-sea manned submersible).
[2] Then the two space labs—**Wentian or "Quest for Heavens"**, and "**Mengtian" or "Dreaming of Heavens"**—will be lifted to complete the **Tiangong** station.

Culture deeply influences people's values, and our values always form a coherent system with the metaphorical concepts

FIGURE 3
Macro-level semantic domains of conceptual metaphors.
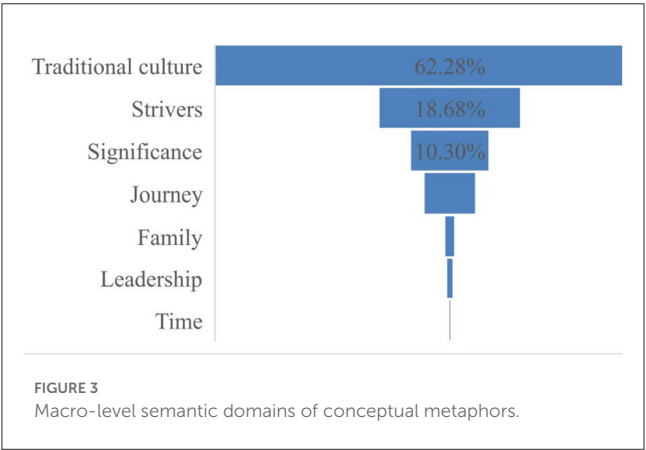
we live by, thus, metaphorical expressions embed people's culture (Lakoff and Johnson, 1980; Deignan, 2003). Chinese culture is rooted in the heart of Chinese people, there is no doubt that Chinese culture deeply influences metaphors in *China Daily* news reports. Even in the field of technology, it embodies the confidence of traditional Chinese culture.

(2) Chinese aerospace industry is an enterprising action that represents the prosperity and progress of China. In the case of the space probe by the series of *China Daily*, the "Goal (start, goal, dream, and wake-up call)" and "Spirit (spirit)" metaphors show that China is optimistic and confident about the future of the aerospace industry. For example:

[3] the successful return of the Chang'e-5 probe is a vivid demonstration of the lunar exploration **spirit** of "pursuing dreams, daring to explore, collaborating in tackling difficulties, and win–win cooperation", which shares a great similarity with the Olympic motto of "faster, higher, and stronger".
[4] The Chang'e-5 mission will be yet another historic **moment** for China's lunar program.

(3) Chinese aerospace industry is an exploratory action that is constantly forging ahead and pursuing. In the case of space probes by the series of *China Daily*, the "Mission (mission, exploration, attempt, prototype, and endeavor)" metaphor is widely used, which makes up 23.91% and 18.32%, respectively. It constructs the image of Chinese people advancing bravely and being modest. In addition, the "Trip (step, phase, stage, course, and on its way/pave the way)" metaphor highlights that the Chinese aerospace industry is at the developing stage and China still needs to strive and explore continuously. For example:

[5] Pei Zhaoyu, a spokesman for the mission, said if the mission is successful, it will be a milestone in the nation's lunar exploration **endeavors** and will show the world China's scientific, technological, and engineering capabilities.

FIGURE 4
Micro-level semantic domains of conceptual metaphors.
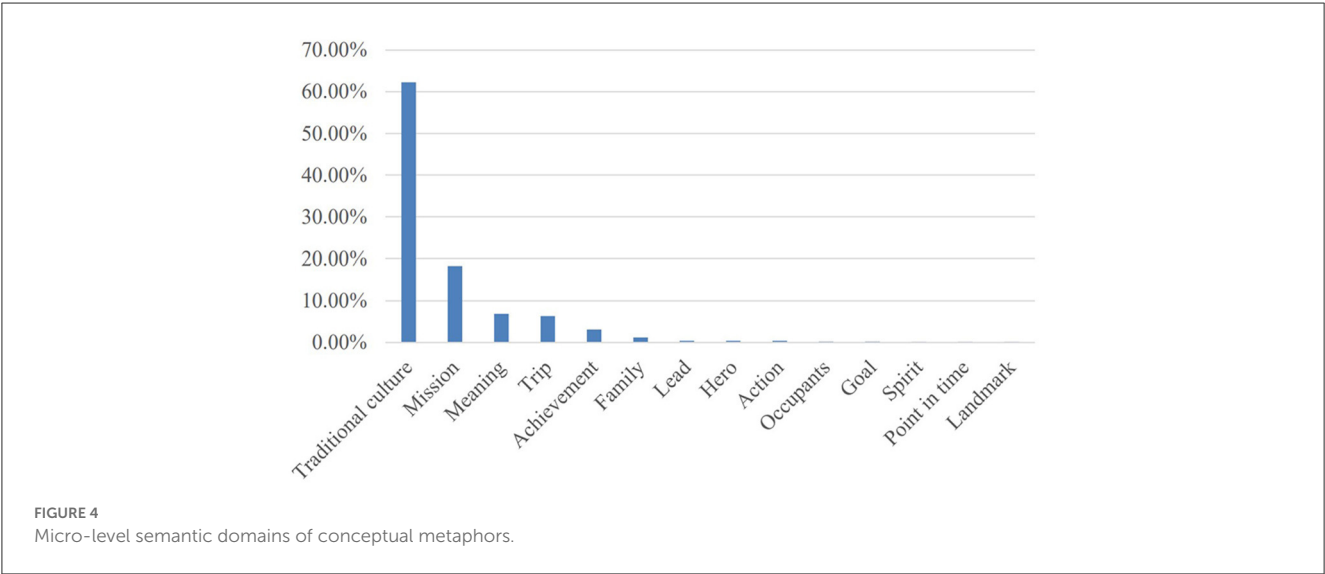
[6] A next-generation engine, that will **pave the way** for lunar exploration, was successfully tested on Sunday.

The conceptual metaphors reflect the proactive spirit of China's aerospace industry, which is consistent with the speech by Xi (2021) "We should continue to leverage the advantages of the new national system, increase efforts in independent innovation, make further efforts to promote the innovative development of China's aerospace science, space technology, and space applications, actively engage in international cooperation, and make new and greater contributions to enhancing human welfare."

(4) Chinese aerospace industry is a leading action that opens a new chapter and leads a new journey. The series of reports of a space probe in *China Daily* widely used the "Significance (success/successful/successfully, achieve/achievement, historic, breakthrough/breakthroughs, strategic, lift, and power)" metaphor, which speaks highly of two missions. The "Difficulty (challenge/challenging, complicated, and overcame)" metaphor highlights the challenges of Chang'e-5. "Leadership (heads and lead)," "Chapter (chapter)," and "Music (trilogy and rehearsal)" metaphors emphasize the significance of Chang'e-5, which promotes the development of the Chinese aerospace industry and brings China's aerospace industry to the forefront of the world. For example:

[7] Chang'e-5 will achieve several **breakthroughs,** including automatic sampling, ascending from the moon without a launch site, and completing an unmanned docking 400,000 km above the lunar surface.

[8] Adopting a complicated technological approach, the Chang'e-5 mission **overcame** many technological challenges, including China's first spacecraft liftoff from an extraterrestrial body and the first unmanned rendezvous and docking in lunar orbit.

It is the spirit of Chinese astronauts and scientists to be "particularly capable of enduring hardships, fighting, tackling challenges, and dedicating themselves", which is reflected in the news reports of Chang'e-5. These spirits greatly promote the development of China's aerospace, and become a great force for the rise of China's aerospace industry.

(5) Chinese aerospace industry is a brave action that dares to be the first to live in space. The "Journey (journey, travel, trip, and occupants)" metaphor used in the news reports of Shenzhou XIII shows that China dares to forge ahead, breaks the Convention, and advances the development of the world's aerospace industry one step. For example:

[9] ......and will become the first **occupants** of the core module after their spacecraft docks with the module, which is **traveling** in a low-Earth orbit hundreds of kilometers above the ground.

(6) Chinese aerospace industry is a great activity to create a community with a shared future for mankind. The "Share (share and willingness)" metaphor in the news reports of Chang'e-5 emphasizes that China is willing to share scientific and technological achievements with other countries and promote the world aerospace industry, which fully reflects

the idea of a community with a shared future for mankind. For example:

[10] The Chang'e-5 was the first space expedition from any country to bring back lunar samples in decades, and China has put in place measures to ensure these can be **shared** with the international research community.

In the technological field, China is willing to share the fruit with other countries and promotes common progress. Just as Tang and Zhang (2011) believe that "the news dissemination of major aerospace practice activities can explain China's intention to adhere to independent innovation and maintain a harmonious world of lasting prosperity. It showcases the continuous progress of China's technological field, constructs the image of China actively participating in international exchanges, which gradually changes the impression of China constructed by Western media as politically closed, culturally mysterious, and socially chaotic, and further attracts more countries to accept China's concept of 'common development' and deepen cooperation".

Conclusion

In conclusion, using conceptual metaphors, this article investigates metaphor words in 460 series reports of *China Daily* in the case of space probes, all of which are working together to construct the six types of China's image in the aerospace industry. It found that the conceptual metaphors used in the case of the space probe by the series of *China Daily* construct the image of China in the aerospace industry characterized by the following features: the Chinese aerospace industry is a dream-building action with lofty goals, an enterprising action that represents the prosperity and progress of China, an exploratory action that is constantly forging ahead and pursuing, a leading action that opens a new chapter and leads a new journey, a braving action that dares to be the first to live in the space, and an achieving action to create a community with a shared future for mankind.

According to Lakoff and Johnson (2005, p. 27), "The essence of metaphor is understanding and experiencing one kind of thing in terms of another." In this process, the metaphorical target is constructed by our understanding and experience, which can reflect people's thoughts, emotions, and cognition about the source. That is to say, "We talk about arguments that way because we conceive of them that way—and we act according to the way we conceive of things (1980)." Although the news reports are about the development of the aerospace industry, they reflect the value orientation and ideology of China. Through examining the conceptual metaphors used in the aerospace news reports, this article investigates China's image constructed by Chinese journalists in the aerospace field, which is a powerful counterattack to the Western construction of China's national image. However, in terms of methodology, the current study mainly adopts the methods of manual reading, identification, and recognition when selecting metaphorical words, so subjectivity and omissions are inevitable. Thus, in future research, the corpus tools can be used to examine the metaphor words and enhance the objectivity of the research.

Data availability statement

Ethics statement

Author contributions

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Conflict of interest

Publisher's note

Supplementary material

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Conceptions of geography and history as school disciplines: an approach from lexical availability

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This paper aims to examine students' conceptions of Geography and History as school disciplines at different educational stages. The sample, composed by a total of 73 participants from Primary School ($n=26$), Secondary School ($n=29$) and Higher Education ($n=18$), completed a lexical availability test in Spanish and English or in Spanish and French. The results show that lexical availability increases as the educational stage increases, although the differences are not significant between all of them. The available lexical items on Geography and History, most of which are not shared between the different stages, are very generalist, showing a rigid and formal view of the disciplines. After the analysis carried out, we consider that lexical availability may constitute a valid tool for accessing students' conceptions.

1. Introduction

The initial development of lexical availability is framed in the work for the elaboration of the *Français Fondammental* (Gougenheim et al., 1956), a basic vocabulary intended to facilitate the acquisition of French by foreigners, when the lexical selection criterion of frequency was joined to that of available vocabulary, defined by López-Morales (1995–1996, p. 245) as "the set of words that speakers have in their mental lexicon and whose use is conditioned by the specific subject of the communication." Thus, from associative tests carried out around certain prompts, a related vocabulary emerges: "the potential lexicon that belongs to the active stock of the subjects" (Ávila and Sánchez, 2011, p. 47) and which is used when the need arises. Since that early work, studies have diversified both theoretically and methodologically. On the theoretical level, the approaches have been gaining in depth and applicability to varied fields such as dialectology, linguistics, psycholinguistics, ethnolinguistics and the teaching of both native and foreign languages. With regard to methodological developments, the work carried out in the Spanish-speaking world, initially promoted by López-Morales (1995-1996), has contributed not only to the establishment of common guidelines in terms of the samples, the prompts surveyed or the development of the tests, but also to an improvement in the statistical treatment of the data and to the development of mathematical formulae to adequately explain the relationship between knowledge and lexical production.

If, as we explained above, the applications of lexical availability are diverse, in the field of education, its contributions have shown the influence of certain variables on the lexical availability, the differences in this between students and teachers or its usefulness for assessment and teaching (Zambrano et al., 2019). Likewise, as Santos and Juárez (2022) point out, the

methodological bases of availability have been used to study students' perception of reality (Ávila et al., 2020) as well as their conceptions of education (Santos and Juárez, 2022) or reading and literary education (Juárez, 2019; Trigo and Santos, 2023).

Students' ideas or conceptions are a particularly relevant issue for didactics because, as García (2002) points out, they directly affect the consideration of school knowledge, both in its design and construction process. In this way, this study strengthens the line of lexical availability that explores the conceptions of students (high school and university) regarding topics of specific disciplines, such as Geography, History, Education, Reading, Mathematics, Algebra, etc. (*cf.* Ferreira et al., 2014; Pacheco et al., 2016; Martínez-Lara, 2021). More specifically, knowledge of conceptions about scientific content or about certain school disciplines, in our case the Social Sciences (Geography and History), is a fundamental aspect that can be investigated from the initial stages of the schooling process to the end of higher education (Feixas, 2010). In this respect, the didactic research carried out has been decisive in understanding students' and teachers' conceptions of the disciplines with which they will work and learn, given that these can be determining factors both in their learning and in classroom practice. Let us not forget that when we talk about conceptions we are talking about implicit social, cultural, environmental, and academic elements that interrelate and materialize in the different actions of individuals (Machuca, 2012).

Geography and History are core subjects of exceptional formative power present from the initial educational cycles. Research has resulted in an abundance of scientific literature in which conceptions of this subject do not focus exclusively on how it is understood by students or future teachers. Thus, in the field of students, transversal and longitudinal research has been carried out on disciplinary conceptions and the change or evolution of these conceptions (Fuentes, 2004; Vera and Cubillos, 2010; Fraile-Delgado, 2020), as these conceptions are mainly mediated by video games, social networks, and cinema. Similarly, and in the field of teacher training, research has been carried out on conceptions referring to disciplinary epistemology, *about* and *of* History (Suárez, 2012; Montaña, 2016; Gómez et al., 2018; Martínez-Hita and Miralles, 2021); also on content specific to each subject –controversial topics, heritage, gender, etc.– (Cuenca and Estepa, 2007; López-Zurita and Felices, 2023) or educational assessment, resources and procedures and textbooks (López-Sánchez et al., 2018). We cannot forget that, in this context of initial training, knowing the conceptions allows, in the first instance, to visualize, intervene and modify them, letting the trainee teacher change the vision of the discipline and his or her work in the classroom (Ibagón-Martín, 2020).

Access to conceptions has traditionally been carried out following qualitative approaches, through questionnaires with open-ended questions that seek to get respondents to make explicit their ideas about the disciplines. However, in this paper we propose an approach to these conceptions through lexical availability, understood as the tool or technique that allows us to obtain the available lexicon (Hernández and Tomé, 2017), with the aim of examining the conceptions that students from different educational stages have about Social Sciences –Geography and History– as a school discipline, trying to categorize their available lexicon in this regard and analysing the evolution through the different educational stages.

In this paper we present the preliminary results of a study carried out with students following a bilingual education in French or English, in which Geography and History are partially taught in these languages. More specifically, we have analysed the lexical availability not only about both disciplines, but also about some prompts that are related to the thematic areas that structure them, although, at this point, we will focus on the results from Spanish and only about the *Geography and History* prompts.

2. Methods

The research design used in this piece of research is cross-sectional, descriptive, and non-correlational. The methodology of analysis is mixed, presenting both quantitative and qualitative results. The sampling carried out was not probabilistic, as the students were chosen intentionally, since, for the purposes of the research, data were collected from students who were taking Social Studies subjects in a foreign language, in the context of the bilingual programmes implemented in the region of Extremadura.

2.1. Sample

The sample of the present research was composed by 73 students ($n = 73$), who are taking a subject related to Social Sciences: *Social Sciences*, in the 6th year of Primary Education ($n = 26$), belonging to a bilingual section Spanish-French (group 1); *Geography and History* in the 3rd year of Compulsory Secondary Education ($n = 29$), belonging to a bilingual section Spanish-English (group 2), and *Didactics of Social Sciences*, in the 2nd year of the University Primary Education Degree ($n = 18$), also belonging to a bilingual training Spanish-English (group 3). As a whole, the sample shows a balance between the genders, although the percentage of male participants is somewhat higher (55.3%). The mean ages were 11.5 years old in group 1, 14.5 in group 2 and 21.6 in group 3. Since the sample is not representative of the universe explored, the results just serve as a first approximation, but they cannot be generalized.

2.2. Instrument

The data obtained in the present study come from two instruments: a sociological questionnaire with questions relating to gender, age, academic year, mother tongue, languages in which they take their subjects and activities carried out in those languages, and a lexical availability test. This is an associative test in which, starting from a stimulus, students have to come up with the lexical item that comes to their mind, associated with that stimulus. The test, as set out in the *Pan-Hispanic Lexical Availability Project*, is based on the open list system, and allows 2 min to complete the lexicon for each prompt (López-González, 2014). The students were introduced six prompts: *Geography*, *Physical environment*, *Population*, *History*, *Prehistory* and *Middle Ages*, which they completed firstly in Spanish and later in English/French, although, in this paper, it is only dealt with the Spanish results of prompts 1 (*Geography*) and 4 (*History*).

2.3. Procedure and data analysis

The tests were administered in the second and third trimester of the 2022–23 academic year, in a single session. After collecting informed consent for participation in the study, which was signed by parents in the case of minors, participants completed the sociological questionnaire and then the availability test. In this, the prompts were presented orally and in writing and they were given 2 min to complete each of them, first in Spanish and then in a foreign language. They were instructed not to worry about spelling correction to avoid this affecting lexical productivity.

Once the lexicon was retrieved, it was edited according to the guidelines established by Samper (1998) for Spanish. It was also decided to admit all the words evoked by informants, for better understanding of the relationships between words, in accordance with the criteria retained by Trigo and Santos (2023). The data were processed with the *Dispogen II* package (Echeverría et al., 2005) for the specific calculations of availability; with *IBM SPSS Statistics* v. 23, for the statistical analysis taking into consideration the variables analysed, and with *Atlas.ti* for the qualitative analysis and the generation of word clouds based on frequency.

3. Results

A total of 2009 words were updated by the participants, of which 1,056 belonged to prompt 1 for *Geography* and 953 to prompt 4 for *History*. The total number of tokens was 736, with more words in the first prompt (400) than in the second one (336). Table 1 shows the data specified according to the stage of education the students are at.

As it can be seen, the average production in both prompts increases from one educational stage to the next, although the differences are more marked in the transition from Primary to Secondary, between which there are three academic years, than between the latter and Higher Education, between which there are 4 years of difference. Likewise, although the trend is identical between the two prompts, it is in *Geography* where the values are higher, both in tokens and in the average number of answers per respondent. In order to determine whether these differences by educational stage are statistically significant, the assumptions that must be met by the data series were verified, and accepted in the case of *Geography*, the one-factor ANOVA test was carried out, while in *History*, as the randomization assumption was not met, the non-parametric Kruskal-Wallis test was performed. The results show that, in the *Geography* prompt, there are differences in the

total word production taking into account the educational stage in which they are ($F = 3.235$; $p = 0.045$). The post-hoc analyses, using the Scheffé test, do not reveal the existence of differences between groups, probably because the p value is at the limit of significance. T-tests for group comparisons using Student's T test do reveal the existence of differences between students in Primary and Secondary Education ($t = -2.013$; $p = 0.049$) and those in Primary and Higher Education ($t = -2.290$; $p = 0.027$). On the other hand, in the centre of *History* there are also differences between groups ($H = 14.667$; $p = 0.001$), specifically between Primary and Secondary Education ($Z = -3.061$; $p = 0.002$) and Primary and Higher Education ($Z = -3.435$; $p = 0.001$), but not between the productive vocabulary, measured through lexical availability, of Secondary and Higher Education students ($Z = -0.791$; $p = 0.429$).

In terms of lexical density, the result of dividing the total number of tokens by the number of types, it is also higher in Geography than in History, with the sole exception of the data for Primary School, where the density in History is slightly higher than in Geography. In this prompt, the data are more homogeneous as, overall and in each of the groups, the cohesion index is higher.

For the qualitative analysis, it has been taken into consideration the 10 most available words in the three groups, which are listed in Table 2.

Focusing on the *Geography* prompt, it is found that, among these most available words, only two words are present at all stages: country and mountain. Primary and Secondary students also share three words (Spain, continent, and city), the same as Secondary and Higher Education students (lake, map, and river), but students at the two most distant stages have no words in common other than those listed as shared by all.

In the History prompt, on the other hand, only two words common to the three educational stages have been found: king and war, which, although they appear in the last positions in Primary, are in the first two positions in the upper stages. In this prompt, in addition to these two words, the different stages share only one word: neolithic (Primary-Higher Education), prehistory (Primary-Secondary Education) and palaeolithic (Secondary-Higher Education).

In relation to frequency, Figures 1, 2 present word clouds in which the larger ones indicate their more frequent character.

In Geography, the predominant lexicon is that derived from physical geography of a descriptive nature, an aspect confirmed by the predominance of terms such as mountain, continent, atmosphere, ocean, hydrography, vegetation. Terms related to political geography (borders, limits, administrative units) such as country, Spain, Autonomous Community, province, capital city also stand out.

TABLE 1 Number of tokens and types by educational stages.

	N	Geography				History			
		Tokens	Types	Mean	Cohesion index	Tokens	Types	Mean	Cohesion index
Primary	26	314	143	12.07	0.08	261	112	10.03	0.08
Secondary	29	448	202	15.44	0.07	415	250	14.31	0.05
Higher education	18	294	124	16.33	0.13	277	164	15.38	0.09
Total	73	1,056	336	14.46	0.04	953	400	13.05	0.03

TABLE 2 Most available words by educational stage.

Geography			History		
Primary E.	Secondary E.	Higher E.	Primary E.	Secondary E.	Higher E.
Earth	Country	Mountain	Middle ages	War	King
Planet	Map	Relief	The discovery of America	King	War
City	Continent	Map	Ancient history	Napoleon	Conquest
Spain	Mountain	River	Modern age	French revolution	Queen
Continent	River	Climate	Prehistory	Prehistory	Castle
Mountain	City	Fauna	Metal ages	Past	Evolution
City	Spain	Country	Contemporary age	Ancient	Discovery
Sun	Sea	Lake	War	Palaeolithic	Neolithic
Solar system	World	Flora	Neolithic	Rome	Palaeolithic
Rome	Lake	Hydrography	King	Time	Stage

FIGURE 1
Geography lexicon according to frequency.
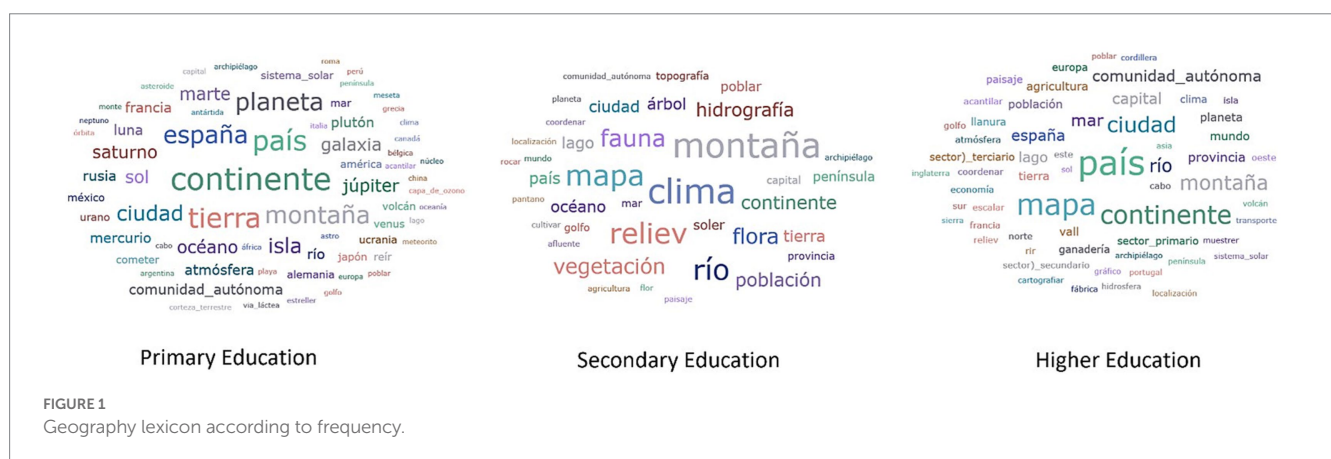
In History, the terms oscillate in three areas: those related to the classical temporal organization of the different stages of history, names of important historical figures and historical events. The division of historical periods –Prehistory, Ancient, Middle Ages, Modern and Contemporary– seems to be related to the citation of certain characters, such as Napoleon, Hitler, Franco or Columbus, as well as the exclusively human phenomenon of war. No reference to women is found. Historical events include the French Revolution, the Industrial Revolution and, especially, the Discovery of America.

4. Discussion and conclusions

From the analysis of the above data, it can be seen that the available lexis is somewhat higher in *Geography* than in *History*, and that both increase as the educational stage of study increases. Although there are no previous studies that have been interested in lexis related to school disciplines, in general, with reference to the lexis of the prompts surveyed by the traditional studies of lexical availability, the increase in lexis as the level of education rises is a constant in both mother tongue and foreign languages (Carcedo, 2000; Galloso and Prado, 2012; Herranz-Llácer and Marcos-Calvo, 2022). It is also logical to think that, as the block of contents on subjects related to the social sciences are addressed, the lexis studied will be greater, since the contents are diversified and studied in greater depth. However,

although the differences between the Primary and Secondary stages are significant, it is striking that the lexis available increases from one stage to the next by only three or four words (Escudero et al., 2022).

Another interesting issue is the lack of shared lexicon among students at different stages. Given that the lexis available seems to be permeable to external factors (Galloso and Prado, 2012), it is normal that the lexis updated by the respondents responds to the content being worked on at the time, as shown by the fact, for example, in History, of including events or historical figures already cited which coincide with the basic knowledge of the teaching programme for that year. But, to a certain extent, it seems that with each new year of study, pupils make a clean sweep of what they have previously internalized and do not evoke in their available lexicon certain words that could be considered key.

As far as the students' conceptions of the disciplines are concerned, it must be pointed out that the differences are minimal with respect to other studies focusing exclusively on the conceptual sphere. The use of an extraordinarily generalist lexicon suggests that pupils have a rigid and excessively formal view of the disciplines from the most elementary stages of education. Thus, in the case of Geography, the use of terms such as continent, Spain or country place us before a merely descriptive Geography, typical of basic educational cycles, far removed from the current problems set out in the SDGs (García, 2002). However, the similarity of the lexicon collected in the university context suggests a continuity in the

FIGURE 2
History lexicon according to frequency.
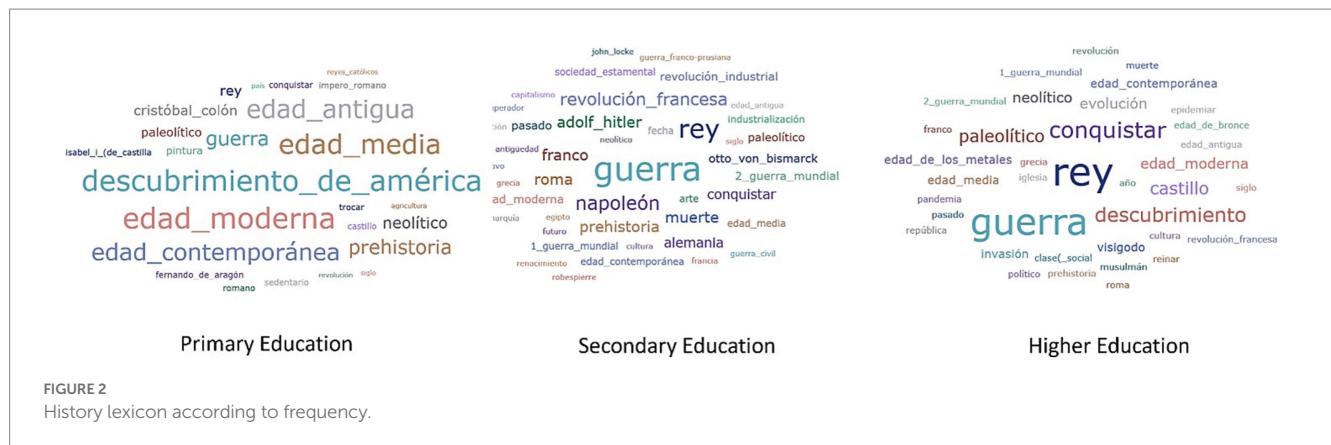
conceptual field that has not been substantially modified in the intermediate cycle (Secondary), despite registering a significant and improved increase in vocabulary.

Similar results can be found in the field of History. The words collected convey a linear vision of history in which the synchronic ordering of the stages of the past occupies a relevant place, at least in the initial cycles (Ancient, Medieval, Modern, Contemporary). In the same way, terms such as war, king, conquest, the mention of certain characters linked to specific events such as the First and Second World Wars and, especially, the Discovery of America (1492) occupy a relevant place. This allows us to affirm that factual, descriptive (López-Zurita and Felices, 2023), teleological and possibly uncritical elements underlie the reductionist views of the discipline that are not only maintained in the different educational cycles (Gómez et al., 2018; Ibagón-Martín, 2020), but that probably resist possible attempts at modification developed didactically in university contexts (Montaña, 2016).

Since this work is a preliminary presentation of results, it will be necessary in future work to go into them in greater depth, introducing, in addition, a comparison between the lexis available in Spanish and in the foreign language in which the students study these disciplines when they participate in bilingual teaching programmes. Also, it will be necessary to continue exploring this line with a broader population to verify whether the results of this research mark a trend in the autonomous community of Extremadura.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Bioethics and Biosecurity Committee of the University of Extremadura (No. 30/2023). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants themselves or their legal guardians/next of kin.

Author contributions

JM, GM, and ML contributed to conception and design of the study. ML organized the database. GM performed the statistical analysis. JM wrote the first draft of the manuscript. JM, GM, and ML wrote sections of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The influence of cognitive ability in Chinese reading comprehension: can working memory updating change Chinese primary school students' reading comprehension performance?

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With the development of educational cognitive neuroscience, language instruction is no longer perceived as mechanical teaching and learning. Individual cognitive proficiency has been found to play a crucial role in language acquisition, particularly in the realm of reading comprehension. The primary objective of this study was to investigate two key aspects: firstly, to assess the predictive effects of the central executive (CE) on the Chinese reading comprehension scores of Chinese primary school students, and secondly, to explore the influence of CE training on the Chinese reading comprehension performance of Chinese primary school students. Chinese primary school students were recruited as participants. Experiment 1 used a Chinese N-back task, a Chinese Stroop task, and a number-pinyin conversion task to investigate the predictive effect of the CE components on Chinese reading comprehension. Experiment 2, based on the results of Experiment 1, used the Chinese character N-back training to explore the influence of updating training on Chinese reading comprehension. The findings from Experiment 1 underscored that CE had a predictive effect on Chinese reading comprehension scores. And updating had a prominent role in it. Experiment 2 revealed that the experimental group exhibited an enhancement in their updating performance following N-back training. Although the reading comprehension performance of the two groups after training did not produce significant differences in total scores, the experimental group showed maintained and higher microscopic reading comprehension scores than the control group in the more difficult post-test. In summary, this study yields two primary conclusions: (1) CE was able to

predict Chinese reading comprehension scores. Updating has an important role in prediction. (2) Updating training enhances students' updating performance and positively influences students' Chinese microscopic reading comprehension performance.

1. Introduction

Working memory (WM) is an essential human cognitive ability. The central executive (CE) is the core component of WM, a control system with limited attentional resources, and coordinates other components of WM (Baddeley and Hitch, 1974). Researchers have separated CE and found that there are three independent and moderately related components of CE: updating, inhibition, and shifting (Miyake et al., 2000). CE plays an important role in individual reading comprehension (Skehan, 1998, 2002; Giofrè et al., 2018; Shin, 2020; Zaccoletti et al., 2023).

Lower levels of CE are more likely to result in reading comprehension problems (Abu-Rabia, 2003; Nicolielo-Carrilho et al., 2018; Brunfaut et al., 2021; Linares and Pelegrina, 2023). However, most previous studies have focused on the role of CE in reading comprehension of phonetic characters, as represented by English. Little attention has been paid to the role of CE in reading comprehension of ideographic characters, represented by Chinese. However, there are significant differences between reading comprehension of ideographic and phonetic characters in both the acquisition and use processes. Further exploration of the role of WM in the reading comprehension of ideographic characters would be beneficial in refining the model of the role of WM in the process of reading comprehension. In addition, the CE developmental critical period occurs mainly during the individual school-age period (Welsh et al., 1991). The results of previous studies based on the critical period of CE have also confirmed the positive transfer effect of CE (Loosli et al., 2012; Ang et al., 2015; Artuso et al., 2019). Students in grades 4–5 are in the middle-high learning transition period. During this period, reading comprehension requires further acquisition of the ability to analyze articles, grasp their main ideas, and infer their meaning. At this time, reading comprehension activities rely heavily on WM.

Currently, with the development of educational neuroscience, research has found that general cognitive factors represented by WM are closely related to individual language learning (Wen, 2012; Van der Steen et al., 2017; Lukasik et al., 2018; Siu et al., 2018; Mavrou, 2020; Shin, 2020; Deldar et al., 2021; Vasylets and Marín, 2021; Fresneda, 2022; Kim, 2023).

Some studies have explored the role of WM on reading comprehension in children with learning disabilities and found a positive correlation between WM level and reading comprehension (Nicolielo-Carrilho et al., 2018). Studies based on normal participants have also confirmed the correlation between WM and reading comprehension (Peng et al., 2018; Shin et al., 2019; Hijikata and Koizumi, 2021; Huang et al., 2022;

Orsolini et al., 2023). Loosli et al. (2012) conducted WM training with normal children and found that the training improved their English reading comprehension. Artuso et al. (2019) conducted WM updating training with Italian primary school students and found that the participants' reading comprehension scores were significantly improved after the training. Several studies have examined the effects of WM training on the reading comprehension abilities of Chinese children with learning disabilities and similarly found positive effects of the training (Luo et al., 2013; Yang et al., 2017; Siu et al., 2018).

The purpose of the present study was to examine the predictive effects of CE of WM on Chinese reading comprehension scores of Chinese primary school students and how CE component training can influence reading comprehension performances. To solve this problem, we designed two experiments. Experiment 1 used Gao (2019) revised Chinese N-back task, Chinese Stroop task, and number-pinyin conversion task to examine the predictive effects of CE updating, inhibition, and shifting on primary school students' Chinese reading comprehension scores. Experiment 2 was based on the results of Experiment 1 using Gao et al. (2023) revised Chinese character N-back training task for primary school students to investigate the influence of training on Chinese reading comprehension performance of Chinese primary school students.

Based on the limited extant research, we proposed two hypotheses. First, updating, inhibition, and shifting all predict Chinese reading comprehension scores of Chinese primary school students. Among them, updating reflects the continuous stability during the continuous processing of WM, and therefore plays a prominent role. Second, training on updating will have a positive influence on the Chinese reading comprehension performance of Chinese primary school students.

2. Experiment 1: the predictive effect of CE on Chinese reading comprehension scores of Chinese primary school students

2.1. Materials and methods

2.1.1. Participants

We recruited 20 participants in the top 25% (high reading comprehension level group) and 20 participants in the bottom 25% (low reading comprehension level group) of grades 4–5 within

a Chinese primary school based on their score ranking in the reading comprehension section of the previous semester's Chinese final exam. A total of 40 participants (24 boys and 16 girls) were recruited. The participants' age was 10.73 years (SD = 0.64). The total score for the reading comprehension section was 100. The difference in scores between the high level group (M = 70.10, SD = 10.07) and the low level group (M = 34.21, SD = 13.53) was significant [$t_{(38)}$ = 9.57, p < 0.001, Cohen's d = 3.01, r = 0.83]. All participants were from the same neighborhood school, had similar language use experiences and similar living environments, were right-handed, and had no similar experimental experiences. None of the students participating in the experiment had psychiatric, neurological, or developmental disorders, according to previous assessments by the medical and mental health departments of the school. The participants voluntarily took part in the experiment and signed written informed consent forms. Written consent was obtained from the students' parents and the school before the experiment. The experiment was conducted for the period from November 15 to 20, 2021.

2.1.2. Experimental design

A between-participants design was used for the experiment. Both high and low reading comprehension score groups were required to complete an updating task, an inhibition task, and a shifting task and record the accuracy. The experiment was completed in a double-blind experimental setting with a 1-day interval between tasks.

2.1.3. Stimulus materials

To match the Chinese reading comprehension process, the updating task used the Chinese N-back task, which is more appropriate for the Chinese reading comprehension characteristics (Gao, 2019). The inhibition task used a Chinese character-color task adapted from the classic Stroop task (Spinks et al., 2000). The shifting task was adapted from Rogers and Monsell (1995) number-alphabet conversion task to a number-pinyin conversion task. Because some participants (fourth grade) had not fully acquired vowel and consonant discrimination, the alphabetic material was partially replaced with Chinese pinyin material.

2.1.4. Procedures

(1) Chinese character updating N-back task

Harvey et al. (2004) found that the 1-back task is a pure updating task, so the whole Chinese character N-back task contains only two levels, 0-back and 1-back. The 0-back task requires judgments on Chinese characters "书" or "车." The 1-back task requires judging whether the current presented Chinese character is consistent with the last presented Chinese character and responded with a key press. The 0-back and 1-back tasks each contain one block of five practice trials with feedback. At the end of the practice session, the participant can choose to practice again or go to the formal task. There was no feedback on the formal task. The 0-back formal task consisted of one block of 20 trials for the character "书" and 12 trials for the character "车." The 1-back formal task consisted of three blocks of 96 trials. Each block had 20 trials of consistent judgments and 12 trials of inconsistent judgments. The accuracy of the participants was recorded.

(2) Chinese inhibition Stroop task

According to Wen and Li (2007), a Chinese Stroop word-color task was used. Chinese characters of different colors were presented in the experiment, and participants were asked to judge whether the color of the character's meaning was consistent with the color of the character presented and responded with a keypress. There were three types of judgments: First, the color of the character matches the presented color. For example, the character "红(red)" is presented in red color. Second, the color of the meaning and the color of the presented character do not match. For example, "绿(green)" is presented in red. Third, the meaning of the character has no color meaning. For example, "师(teacher)" is presented in green color. The task starts with a block of five practice trials containing feedback. At the end of the practice session, the participant could choose to practice again or go to the formal task. There is no feedback on the formal task. Each block had 16 trials in which the color of the character was consistent with the presented color, 13 trials in which it was inconsistent, and three trials in which there was no color meaning. There were three blocks of 96 trials.

(3) Shifting number-pinyin conversion task

In the number-pinyin conversion task, a number, a pinyin, or a combination of a number and a pinyin is presented in blue or red. For example, "8b" in blue. Participants were required to make judgments based on the color and content of the material and responded with a key press. There are three types of judgments: First, when a blue number-pinyin combination is presented, the participant has to judge whether the number in the combination is odd or even. Second, when a red number-pinyin combination is presented, the participant needs to judge whether the pinyin in the number-pinyin combination is any of the single rhymes "a, o, e, i, u, ü." Third, when a number or a pinyin is presented in red or blue alone, the participant has to ignore the presentation color and judge the number or pinyin directly. The task started with a block of five practice trials with feedback. At the end of the practice session, the participant could choose to practice again or go to the formal task. There was no feedback on the formal task. Each conversion block contained eight trials of the blue combination and eight trials of the red combination. The non-conversion task contained eight trials of independent numerical judgments and eight trials of independent pinyin judgments. Total three blocks, 96 trials.

2.2. Results

The accuracy of the participants' three tasks was selected as the indicator, and the measurement scores of all participants were within 3 SDs, no data could be deleted. The accuracy rates of the participants with high and low Chinese reading comprehension scores in each task were shown in Table 1. The score of the high-level Chinese reading comprehension group was higher than the low-level group on all three tasks (ps < 0.05).

Participant type was targeted, and updating, inhibition, and shifting task accuracy were the independent variables for constructing the model. A logistic regression analysis was conducted by the forward selection method (Wald). The results of the analysis revealed the predictive effect of the CE components on primary school students' Chinese reading comprehension scores (Table 2). The logistic regression model was significant (χ^2 = 10.54, p = 0.001, -2 $log\ likelihood$ = 44.81). The $Hosmer\ and\ Lemeshow$ test

TABLE 1 Central executive (CE) tasks accuracy rates of two groups in Chinese reading comprehension ($M \pm SD$).

Group	High scores group	Low scores group	t	Cohen's d	r
Updating	0.71 ± 0.19	0.53 ± 0.14	3.42**	1.08	0.48
Inhibition	0.79 ± 0.17	0.68 ± 0.17	2.18*	0.65	0.31
Shifting	0.46 ± 0.19	0.32 ± 0.12	2.75**	0.88	0.40

$N = 40$.
*$p < 0.05$; **$p < 0.01$.

was good ($\chi^2 = 4.84$, $p = 0.77$). The correct prediction rate of the model for the high Chinese reading comprehension score group was 61.9%. The correct prediction rate of the model for the low-score group was 73.7%. The correct prediction rate of the model for all participants was 67.5%. Among the variables included in the model, updating had a significant effect on Chinese reading comprehension scores ($\beta = 6.64$, $OR = 763.31$, $p = 0.007$). in the inhibition task and shifting task did not play a role in the model ($ps > 0.05$).

The experimental results suggest that CE has an important role in Chinese reading comprehension learning for Chinese primary school students. The findings are consistent with the results of the current study exploring the correlation between reading comprehension and WM (Artuso et al., 2019). The present study further refined the role of the CE components on Chinese reading comprehension and verified that updating plays an important role in Chinese reading comprehension (Hypothesis 1).

3. Experiment 2: the influence of updating training on Chinese reading comprehension score of Chinese primary school students

3.1. Materials and methods

3.1.1. Participants

Seventy-three students in two natural classes of fourth grade within a Chinese primary school were re-recruited. The age was 10.06 years ($SD = 0.60$). The two classes were randomly divided into experimental and control groups, with 35 students in the experimental group (18 boys and 17 girls) and 38 students in the control group (18 boys and 20 girls). All participants were from the same community school, had similar language use experience and living environment, were right-handed, and had no similar experimental experience. None of the students participating in the experiment had psychiatric, neurological, or developmental disorders, according to previous assessments by the medical and mental health departments of the school. The participants voluntarily took part in the experiment and signed written informed consent forms. Written consent was obtained from the students' parents and the school before the experiment. The experiment was conducted for the period November 22, 2021 to January 5, 2022.

3.1.2. Experimental design

A between-participants design was used for the experiment. The independent variable was whether or not to receive updating

TABLE 2 Results of the first iteration of logistic regression of CE on scores in Chinese reading comprehension.

Factor	β	SE	Wald	p	OR
Updating accuracy	6.64	2.45	7.37	0.007	763.31**

**$p < 0.01$.

training. The dependent variable was the Chinese reading comprehension scale score. All participants received normal school instructional activities from the same Chinese teacher. The experimental group received 14 updating training sessions over 4 weeks. The control group did not receive any specific training. Reading comprehension scales were conducted for both groups before and after training. Participants' reading comprehension scales were reviewed and updating training was conducted in the double-blind experimental setting.

3.1.3. Stimulus materials

(1) Updating training procedure

Brain imaging studies have confirmed that the N-back task better activates brain areas related to WM and executive functions (Richards et al., 2009). The Chinese character N-back training task and Chinese character stimulus materials from the Gao et al. (2023) experiment were used in this experiment.

(2) Chinese reading comprehension test

The Chinese reading comprehension test was selected from *The Big Rooster* (pre-test) and *A Favorite Picture* (post-test) of the Primary scholar's Chinese Reading Ability Scales (Wen, 2005). Both were paper-pencil tests. The mean difficulty of the scales on the pre-test was 0.60 and on the post-test was 0.69. The discrimination of the pre-test was 0.30 and the post-test was 0.31. The scale contained three parts: micro reading comprehension, macro reading comprehension, and divergent reading comprehension. The scale internal consistency coefficient (Cronbach's α) was $r = 0.81$.

3.1.4. Procedures

(1) Chinese updating N-back training procedure

The experimental group training procedure was presented on the computer. There were four difficulties of the training task: 1-back task, 2-back task, 3-back task, and 4-back task. Each difficulty contained 15 + n trials. As shown in **Figure 1**, the response time per trial was 3000 ms, and the participant was required to judge whether the current presented character was consistent with the previous nth presented character and responded with a key press. A total of 10 trials were inconsistent and five trials were consistent. All trials were randomly presented. Each participant was trained for 15 min each time, three to five times per week, for a total
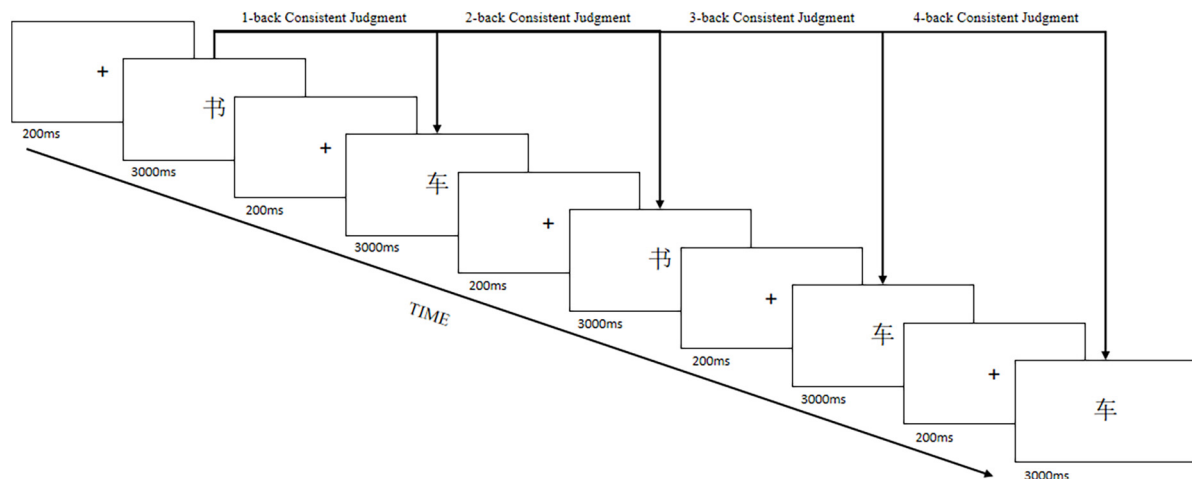
FIGURE 1
N-back training task.

of 14 training sessions. The training was conducted in the school computer room. The participants were given a sticker as a reward at the end of each training session.

Each participant started with a 1-back task difficulty. In each difficulty, if the accuracy rate was higher than 80%, the participant entered the next difficulty; if the accuracy rate was lower than 80%, the participant stayed at that difficulty and retrained. There was only one chance to retrain, and if the retraining was not passed, the difficulty was dropped by one. The program ended automatically after 15 min of training for each participant.

(2) Reading comprehension scale

During the entire experimental period, the two groups of participants were administered both the pre-test and the post-test of the Primary scholar's Chinese Reading Ability Scales. The pre-test was administered 1 week before the start of the training. The post-test was administered 1 week after the end of the training. The Primary scholar's Chinese Reading Ability Scales comprised 100 points and lasted 30 min. Both groups underwent the scales simultaneously.

3.2. Results

3.2.1. Updating training

The mean accuracy of the 14-day training for the experimental group is shown in Figure 2. To verify the effectiveness of the training, the mean accuracy of the first 3 days of training was compared to the last 3 days of training in a paired samples t-test. The mean accuracy rate on the last 3 days was significantly higher than that on the first 3 days [$t_{(34)} = -11.07$, $p < 0.001$, Cohen's $d = 2.18$, $r = 0.74$].

3.2.2. Chinese reading comprehension scales

The pre-test and post-test reading comprehension scores of the experimental and control groups are shown in Table 3. A 2 (participant type: experimental group vs. control group) × 2 (time: pre-test vs. post-test) repeated measures ANOVA of the total reading comprehension scale scores of the two groups revealed

that the training failed to promote the total reading comprehension scores of the experimental group. The main effect of time on Chinese reading comprehension scale scores was significant [$F_{(1,71)} = 6.78$, $p = 0.01$, $\eta_p^2 = 0.09$]. The main effect of participant type was not significant [$F_{(1,71)} = 0.34$, $p = 0.56$, $\eta_p^2 = 0.01$]. The interaction effect of participant type and time was not significant [$F_{(1,71)} = 0.20$, $p = 0.65$, $\eta_p^2 = 0.003$].

A total of 2 (participant type: experimental group vs. control group) × 2 (time: pre-test vs. post-test) repeated measures ANOVAs were conducted for micro reading comprehension scores, macro reading comprehension scores, and divergent reading comprehension scores. The results of the analysis revealed changes in reading comprehension patterns after training in the experimental group. The repeated measures ANOVA for microscopic reading comprehension revealed a significant main effect of time [$F_{(1,71)} = 7.50$, $p = 0.01$, $\eta_p^2 = 0.10$]. A significant main effect of participant type [$F_{(1,71)} = 4.02$, $p = 0.049$, $\eta_p^2 = 0.05$]. A significant interaction effect of participant type and time [$F_{(1,71)} = 4.47$, $p = 0.04$, $\eta_p^2 = 0.06$]. Simple effects analysis showed no significant difference between the pre-test scores of the two groups of participants [$F_{(1,71)} = 0.01$, $p = 0.94$, $\eta_p^2 = 0.00$]. The experimental group scored higher than the control group in the post-test [$F_{(1,71)} = 9.06$, $p = 0.004$, $\eta_p^2 = 0.11$]. There was no change in the experimental group's scores between the two tests [$F_{(1,71)} = 0.19$, $p = 0.67$, $\eta_p^2 = 0.67$]. The control group scored lower on the post-test than on the pre-test [$F_{(1,71)} = 12.27$, $p = 0.001$, $\eta_p^2 = 0.15$]. Because the post-test was more difficult than the pre-test, the decrease in the control group's scores suggests a maintenance effect of training on the experimental group's microscopic reading comprehension. The repeated measures ANOVA for macro reading comprehension scores revealed a significant time main effect [$F_{(1,71)} = 5.31$, $p = 0.02$, $\eta_p^2 = 0.07$]. The participant type main effect was not significant [$F_{(1,71)} = 0.13$, $p = 0.72$, $\eta_p^2 = 0.002$]. The interaction effect of participant type and time was not significant [$F_{(1,71)} = 0.29$, $p = 0.59$, $\eta_p^2 = 0.004$]. The repeated measures ANOVA for the discrete reading comprehension scores indicated that the main effect of time was not significant [$F_{(1,71)} = 0.000$,
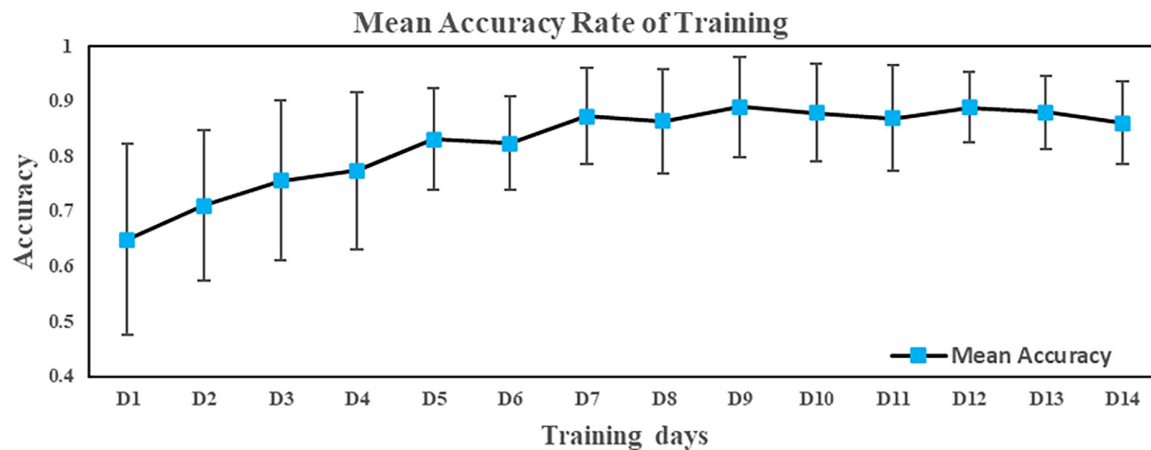
FIGURE 2
The mean accuracy rate of training in the experimental group.

TABLE 3 Pre-test and post-test reading comprehension scores of the experimental and control group.

Group	Pre-test				Post-test			
	Micro reading	Macro reading	Divergent reading	Total score	Micro reading	Macro reading	Divergent reading	Total score
Experimental group	13.25 ± 5.72	18.91 ± 8.22	16.99 ± 9.12	45.80 ± 16.84	12.71 ± 5.05	21.20 ± 11.72	15.69 ± 5.66	49.60 ± 17.50
Control group	13.16 ± 5.73	17.59 ± 6.63	16.79 ± 10.01	42.86 ± 16.61	8.95 ± 5.59	21.26 ± 9.97	18.05 ± 9.72	48.26 ± 18.60

$p = 0.96$, $\eta_p^2 = 0.000$]. The main effect of participant type was not significant [$F_{(1,71)} = 0.35$, $p = 0.56$, $\eta_p^2 = 0.005$]. The interaction effect of participant type and time was not significant [$F_{(1,71)} = 1.84$, $p = 0.18$, $\eta_p^2 = 0.03$].

The above results indicate that updating training significantly improved the participants' updating performance. However, the increase in updating performance could not change the total Chinese reading comprehension performance. Further analysis revealed that the increase in updating performance could change the participants' reading comprehension patterns. This was reflected in the maintenance effect on microscopic reading comprehension when the difficulty of the reading task was increased (Hypothesis 2).

4. Discussion

Our study was divided into two experiments to explore the influence of CE on Chinese primary school students' reading comprehension performance. Experiment 1 used the Chinese N-back task, the Chinese Stroop task, and the number-pinyin conversion task to verify the predictive effect of CE components on primary school students' Chinese reading comprehension scores. Experiment 2 used Chinese character N-back training on Chinese primary school students based on the results of Experiment 1 to examine whether the enhancement of particular CE could promote the reading comprehension performance of the participants. We found that CE was a great predictor of Chinese reading comprehension for Chinese primary school students. Among them, updating had a prominent role in the prediction (Hypothesis

1). Further updating training of the participants revealed that the training did not improve the participants' total scores on the reading comprehension scale but was able to maintain their microscopic reading comprehension scores on the more difficult post-test (Hypothesis 2).

The first result suggests that CE has a predictive effect on Chinese reading comprehension in Chinese primary school students. The findings of the present study align with previous research on the relationship between WM, especially CE, and reading comprehension (Huang et al., 2022; Linares and Pelegrina, 2023; Zaccoletti et al., 2023). Among these factors, updating plays a prominent role. This implies that CE, as a fundamental cognitive ability, plays a crucial role in how individuals process Chinese reading comprehension information. Our results are consistent with previous studies that have demonstrated a predictive effect of WM on English reading comprehension (Loosli et al., 2012). We provide ideographic evidence for a positive relationship between WM and reading comprehension from a Chinese reading comprehension perspective. The second result indicates that updating training enhances individual updating performance and demonstrates a maintenance effect on microscopic reading comprehension performance in more difficult tasks. This is consistent with findings from current research on the effects of WM training on reading comprehension (Artuso et al., 2019; Chang et al., 2019). We filled the gap of the lack of recruiting school-age children as participants and using ideographic characters as the content of the study, and the results suggest that updating training also affects the reading comprehension patterns of children. The experimental results also suggest that there may be an upper limit to the role of WM on reading comprehension.

Reading comprehension is one of the more complex and integrated processes in language acquisition. The reliance on WM is particularly prominent in reading comprehension. Individuals need to use the processing and storage functions of WM to process current information and to make connections between current information and general knowledge in long-term memory, and between current and prior information about the article, ultimately forming an overall mental representation of the article. At the same time, individuals also need to reveal the meaning of the reading material through activities such as expectation and reasoning. Therefore, during reading comprehension individuals need not only to have sufficient WM capacity, but also to maintain the continuous stability and flexibility of their WM operations (Muijselaar and de Jong, 2015). Those with high and low WM capacities have low WM capacity occupancy and low WM load when processing elementary, simple reading material, and there is no significant difference in reading comprehension between the two WM capacities. When processing advanced, complex reading material WM capacity was occupied heavily and WM load surged. The advantage of high WM capacity individuals was reflected in higher reading comprehension performance than low capacity individuals. At this time, high-capacity readers not only had sufficient WM capacity and higher processing storage space, but also could better focus their attention on reading. This facilitates high-capacity individuals to grasp the core information of the text and to process the reading material in detail. In contrast, low-capacity individuals exhibit poor attentional focus ability and tend to be attracted to irrelevant information. They can only use quick skimming and guessing to complete reading (Cowan, 1999; Peng et al., 2013).

However, at the primary school reading comprehension learning stage, reading comprehension content is at a relatively simple and elementary level. The difficulty of the reading material follows the same order of difficulty of learning: character–word–sentence–paragraph–chapter. Compared to the advanced and complex reading comprehension process, which requires complex processing of the information in the reading material and relies on the WM capacity, this elementary and simple reading comprehension process requires a continuous and stable regulation of the information in the WM. This ensures the coherence and integrity of the reading comprehension process. This means that there is a higher level of dependence on the continuous conditioning of WM content that is responsible for updating. This idea is supported by neuroimaging, where researchers found that the joint activity of the fusiform middle gyrus and precuneus gyrus in individuals after WM training suggests that WM reinforces Chinese language learning (Opitz et al., 2014). The continuous and stable modulation of updating provides a new perspective on the role of an individual's general cognitive ability on reading comprehension: when individuals deal with complex language issues, higher levels of updating can make it easier for those with low WM capacity to use block strategies. That is, integrating words, phrases, and sentences into a block (WM unit) for processing and storage in WM. Thus, the limitation of WM capacity can be overcome. Then, updating training to enhance individual updating level during the critical period of CE can not only lay the foundation for the formation of block strategies in future higher stage reading comprehension activities, but also enhance the stability and flexibility of continuous regulation of WM. In turn, it can reduce the loss rate and error rate of information processing and storage in the current primary reading comprehension stages, and improve the individual's microscopic reading ability. This would also release some of the WM capacity for alleviating the competition for resources in character-word-sentence comprehension, continuous processing of textual material, reasoning about the meaning of the text, and forming coherent and complete representations of the text in reading comprehension (Peng et al., 2013; Doyle et al., 2018).

5. Limitations and prospects

Participants from the same group (same school, instructional teacher, and community) were selected to balance the participants' reading comprehension performance, language experience, and other factors. Firstly, the similarity of this group of participants in terms of instructional processes, reading strategies, and experiences may be responsible for their developing similar patterns of reading comprehension. These limitations may also be the main reason why the results of current research on the relationship between WM and reading comprehension remain controversial. Secondly, the balance of participant levels allowed us to analyze only the differences in participants' reading comprehension scale scores, but failed to provide in-depth statistical test results. Thirdly, these considerations in the experimental design resulted in a small participant size for this experiment. It can only provide preliminary evidence for in-depth research in this field. Future studies with large samples across regions should be conducted so as to balance the effects of participants' educational environments, reading strategies, learning motivation, and attitudes. Ultimately, this will provide persuasive evidence for the numerous debates among studies in this field.

In the updating training studies, it was found that the increased performance of WM positively transferred not only language acquisition processes such as reading and writing, but also individual fluid intelligence (Chein and Morrison, 2010; Zhao et al., 2013; Chen et al., 2018). This transfer effect suggests that WM, especially CE, may have a more fundamental role for the cognitive abilities and learning activities of individuals. It also suggests that individuals with a better level of WM before educational activities are an important prerequisite for successful learning activities. Then, in the future, further clarification of the mechanisms of WM in language learning with the help of brain imaging technology will provide an important basis for building a model of the role of WM in language learning and specifying the minimum level of WM required for successful language acquisition. It will also provide a new solution to the problem of balancing the learning time and learning efficiency of school-age children under the current education policy.

6. Conclusion

The present study assessed the predictive effect of the CE components of WM on the Chinese reading comprehension performance of Chinese primary school students by using the Chinese N-back task, the Chinese Stroop task, and the number-pinyin conversion task. The effect of updating training on Chinese

reading comprehension of Chinese primary school students was further examined through Chinese character N-back training. We provide the first evidence of the predictive effect of CE on Chinese reading comprehension scores of Chinese primary school students. Of these, updating is the most important component. The second evidence we provide suggests that updating training, while not changing the total Chinese reading comprehension scores of Chinese primary school students in the scale, can have a maintaining effect on their Chinese reading microscopic reading comprehension scores. Combined with the currently limited literature on the effects of CE of WM on Chinese reading comprehension, these findings suggest that future research on the effects of CE of WM on reading comprehension should focus more on which specific aspects of reading comprehension are influenced by CE, rather than simply assessing the relationship between them. WM, especially CE, is an important cognitive ability that influences language learning, and such future work will provide us with a comprehensive understanding of the relationship between them.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Ethics Committee of the College of Psychology of Xinjiang Normal University. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

Author contributions

JG: Conceptualization, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Validation, Writing – original draft, Writing – review and editing. ZY: Data curation, Investigation, Project administration, Visualization, Writing – review and editing. FL: Data curation, Investigation, Project administration, Writing – review and editing. BY: Investigation, Project administration, Writing – review and editing. SW: Conceptualization, Supervision, Validation, Writing – review and editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Dimensions of reading: a study of the beliefs of language and literature preservice teachers

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This study aims to analyze the beliefs that future Language and Literature teachers hold regarding reading. This work is part of a broader research endeavor focused on the reading habits and practices of teachers in training and their role as prospective mediators since the way in which they perceive reading significantly impacts the mediation processes they undertake in their teaching practices to cultivate readers. To achieve these objectives, a multiple case study is conducted, involving interviews with 1st-year students ($n = 15$), 3rd-year students ($n = 15$), and 5th-year students ($n = 15$) enrolled in Language Pedagogy programs across three universities affiliated with the Chilean Council of Rectors. For data analysis, a content analysis approach is employed, supported by NVivo 12. The findings reveal that beliefs about reading primarily fall into two dimensions: academic and personal, with the former exhibiting clearer definition and characterization. This can be attributed to the influence of the disciplines integrated into their education, namely literature and linguistics. In conclusion, it is imperative to address the social dimension of reading during the initial teacher education program, as this aspect is not emphasized by preservice teachers, despite its pivotal role in shaping their identity as reading mediators within the context of their teaching practice.

KEYWORDS

reading, reading habit, teacher education, literature, beliefs

1. Introduction

Reading is a complex construct that exhibits various conceptualizations depending on the disciplinary fields from which it is approached as a subject of study (Maina and Papalini, 2021) and also on the reading modes adopted, according to each reader's experiences (Cuesta, 2006; Munita, 2016). According to Lluch and Zayas (2015), reading is currently conceived as an activity that demands the cultivation of skills in accessing and selecting information based on reading objectives, in addition to the ability to interpret texts. Alternatively, it can be regarded as the capacity to reflect upon what is read, contingent upon the social context within which one interacts. The foregoing is complemented by the assertions of Elche et al. (2019), who state that reading serves as the foundation through which learning is acquired. Thus, reading would be a tool for literacy and, consequently, it would contribute to the acquisition of knowledge (Trigos-Carrillo, 2019). On the other hand, it is considered an interactive process, mainly due to the dynamic nature of reading, where the reader would have an active role, as it is required going beyond mere decoding of the presented written content and implementing comprehension skills (Asselin, 2000). The foregoing is part of an academic dimension of reading, from which such activity, guided by specific objectives, would enable the reader to perform in various learning situations. Meanwhile, at a personal level, according to Lluch and Zayas (2015), reading is

oriented towards satisfying an individual's specific interests and maintaining personal relationships with others. It is within this context that reading for pleasure is situated. It refers to reading as a social practice (Margallo, 2012) and which, by definition, should be free and autonomous, as it takes place in leisure time and, simultaneously, it enhances various cognitive abilities that will contribute to one's professional development (Sánchez-Chévez, 2012).

Given that our field of study falls within the realm of initial teacher education, it is deemed necessary to refer to studies associated with the beliefs held by both in-service and preservice educators regarding reading and its connection to this construct. This is understood in light of the fact that beliefs consist of cognitive propositions that are not necessarily structured and are derived from a personal dimension (Cambra et al., 2000). Thus, as pointed out by Jiménez et al. (2014), at the level of beliefs, individuals tend to pragmatically use theory to interpret situations and plan their behaviors. This, to some extent, explains why teachers' beliefs about reading are pertinent, as these shape their practice as mediators of reading.

Building upon this notion, an investigative panorama is presented, enabling an understanding of the beliefs held by future Language and Literature teachers regarding this construct. However, it is important to note that this review is constrained, given that studies in this vein with future secondary Language and Literature teachers are scarce. Hence, reference will be made to research related to in-service and preservice teachers in primary and early childhood education to augment the theoretical framework.

In regard to service teachers, it is relevant to mention the insights put forth by Errázuriz et al. (2020), who indicate that diverse evidence has emerged concerning the impact of teachers' beliefs and reading habits on their teaching practices which are related to fostering reading habits in the classroom. This phenomenon can be explained by the fact that research on teacher perceptions is grounded in the notion that a teacher's instructional performance is conditioned by the representations they hold about the object of teaching and learning (Pozo et al., 2006; Jiménez et al., 2014). In this vein, the study conducted by Munita (2016) stands out, as it examines the relationship that female primary school teachers establish between their reading profiles, belief systems regarding literary reading, and their approach to literature in the school setting. In this work, the author underscores the significance of teachers' beliefs in their instructional practices, since their conception of reading and literature determines their teaching practice, the formative objectives they pursue, and their role as mediators within the classroom context. While individual differences may exist, all concur that the primary goal is to cultivate engaged readers. Taking this point into consideration, it becomes imperative to have well-prepared teachers to mediate and facilitate the reading process, who are actively engaged in the construction of reading pathways and capable of guiding diverse disciplinary readings. This necessary endeavor extends beyond the conventional or general pedagogical scope, as it is often the case with primary education teachers (Errázuriz et al., 2022). To this end, it is essential that teachers serve as role models for reading and take on the task of teaching how to read literary works. However, it has been noted that in-service teachers are not always ideal reading models due to a deficiency in the frequency of personal reading engagements (Díaz-Díaz et al., 2022).

In the realm of initial teacher education, studies concerning the relationship that preservice teachers maintain with reading reveal its

inadequacy. This is affirmed by international research wherein a significant percentage of future educators exhibit reading profiles indicative of weak reading habits, as well as a limited interest in autonomous reading (Díaz-Díaz et al., 2022) alongside minimally developed beliefs about reading (Shaw and Mahlios, 2011). In the study conducted by Larrañaga and Yubero (2019), 861 students enrolled in the Bachelor's program for Early Childhood and Primary Education were surveyed to investigate their reading behavior and engagement as it is expected they develop competencies that enable them to train readers. In this study, 40.4% of the participants reported being occasional readers, which undoubtedly raises concerns and invites reflection. If their role is to nurture regular readers, they would lack a habit strong enough to impart to their potential students, and they also lack a clear understanding of what reading signifies for them. A similar situation was reported by Granado and Puig (2015), who indicated that 43.2% of prospective teachers identify themselves as weak readers and lack a clear self-perception as readers. Lastly, in the study by Vera Valencia (2017), 32.3% of future educators stated that they never or rarely read for pleasure, underscoring that reading is not part of their daily activities.

Meanwhile, the study by Muñoz et al. (2018) presents a similar landscape, as they conclude that future teachers in primary and early childhood education from five Chilean universities do not exhibit reading habits, nor do they demonstrate engagement with reading either academically or personally. Regarding Language and Literature teachers, Asfura and Real (2019) who investigated the reading aspect of teachers in this group upon their graduation, portrayed a reading profile that distinguishes between reading practices in the academic realm and personal space, based on three dimensions: the familial and social environment for reading, the place of reading in their daily lives, and literary reading. Based on the above, the authors argue that preservice teachers exhibit a developing reading habit, alongside, these teachers lack a significant relationship with literature. Similarly, the study by Merino et al. (2020) underscores the notion that these prospective educators lack a robust reading foundation upon entering higher education and that their affinity for reading increases as they progress in their pedagogy studies, thereby reaffirming the idea that this group of future teachers is also characterized by being low readers, and their relationship with reading is weak.

Regarding the beliefs of preservice teachers, about reading, it is pertinent to mention the study by González Ramírez et al. (2020), where it was reported that a group of prospective primary and early childhood education teachers primarily recognize three facets of reading: functional, cognitive, and social. The results demonstrate that future teachers define reading based on its functional facet (71%), followed by the cognitive facet (25%), and lastly, the social facet (4%). These results align with the findings by Álvarez-Álvarez and Diego-Mantecón (2019) and Míguez-Álvarez et al. (2023), where it is evident that future primary school teachers tend to approach reading and literature from an instrumental perspective, as they seldom engage in regular reading practices or derive personal enjoyment from it. This reflects that prospective teachers have not integrated reading as a regular practice but rather approach it as tools to accomplish specific tasks in their academic work. Their perspective does not extend towards their teaching practice; instead, their concept of reading is shaped by their experiences as students.

The results presented above are not promising and tend to be general in nature; thus, we believe that qualitative studies are

needed to delve into the beliefs that future Language and Literature teachers hold about reading. As seen, teachers' belief systems directly impact classroom performance, and since this group will serve as future mediators and will need to foster reading habits in secondary education, it is pertinent to understand how they conceptualize reading based on their beliefs. This is relevant because it offers insight into an essential aspect of their connection with reading.

2. Methods

This work, framed in educational research, is a qualitative investigation which applies an interpretative approach (Creswell, 2013). A multiple case study design was employed, following the guidelines outlined by Dörnyei (2007). This means that the study was extended to several cases, as the focus was not on isolated cases but rather on the collective as representative of a phenomenon (Dörnyei, 2007; Stake, 2007). It is important to note that this work is part of a larger, multi-stage research endeavor. It is organized into three phases: (1) the first one was contextualization, where we gained a deeper understanding of the Initial Teacher Education programs of the collaborating universities; (2) the second phase entailed inquiry with future teachers from three training programs, conducting interviews that were subsequently analyzed for the purposes of this study; finally, (3) the interpretation stage which involved analyzing the results obtained from the previous stages. Therefore, the primary aim of this study is to analyze the beliefs that prospective Language and Literature teachers hold about reading. The choice to begin with an examination of their beliefs about reading stems from the conviction that understanding their perspectives enables us to grasp their relationship with reading, besides it aids in the characterization of reader profiles.

2.1. Participants

The study includes a total of 45 students enrolled in first year (15), third year (15), and fifth year (15) of Pedagogy in Language programs from 3 universities belonging to the Chilean Council of University Rectors (CRUCH), as shown in Table 1. Their ages range between 18 and 25 years on average. The sample was collected through intentional, non-probabilistic convenience sampling (Sáez, 2017). Each participant agreed to take part voluntarily, following the relevant bioethical norms for conducting this research.

TABLE 1 Description of the participants.

Level	Gender/No. Participants	Semesters completed
1st year	Female: 11 Male: 4	1
3rd year	Female: 9 Male: 6	5
5th year	Female: 10 Male: 5	8

2.2. Data collection instruments

For data collection, semi-structured interviews (Kvale, 2011) were conducted with each participant. This technique was chosen as, according to Lluch and Zayas (2015), interviews provide access to information about participants' reading and teaching habits, experiences, and practices. To achieve this, an interview protocol was designed after a thorough documentary and theoretical review. This instrument encompassed the data associated with the research and a script comprising 19 questions, which were grouped under the following themes: (1) reading habits, frequencies, and preferred genres; (2) practices of literary reading; and (3) conceptions about reading mediation both, in the school and initial training context. The first theme was addressed because it was of interest to know what and how much they read, both in their personal spaces and within academic settings, considering their self-perception as readers too, as it would allow to initially profile their reading habits. The second theme complements the previous one, as it allows us to delve into literary reading practices to explore their relationship with reading, as well as investigate where they typically engage in reading, seeking to identify which environments associated with their reading habits they frequently visit. Lastly, the third theme addresses two aspects: (a) their conceptions and beliefs about the mediation of literary reading in the school context, considering questions about reader training and the role of the literature teacher and (b) inquiry about their own initial training in pedagogy programs in this field, with the purpose of investigating how they perceive their training as reading mediators and whether the concept of mediation is effectively integrated into Initial Teacher Education programs.

2.3. Procedure

Between the months of June and November 2022, after adhering to ethical procedures and obtaining the relevant informed consents, participants were contacted via email to invite them to take part in the project and conduct semi-structured interviews. These interviews could be conducted via Zoom or in-person, depending on each participant's availability. For the purposes of this study, a total of 45 interviews were transcribed and prepared for analysis. Each interview was assigned a code, and a pseudonym was used for each student. It's important to note that the transcriptions are verbatim and faithfully represent the statements made by each participant.

2.4. Data analysis

In this study, a content analysis was employed following the guidelines outlined by Miles et al. (2014), who propose a two-cycle analysis. In the first coding cycle, an inventory of emerging codes was generated from the data gathered through interviews with prospective teachers. These codes were subsequently organized and systematized into dimensions and analytic categories during a second cycle, in order to construct a codebook. To achieve this, the researcher cross-validated the generated codes and categories as part of the analysis. The level of agreement between coders reached 98% for the total reviewed codes. Data analysis was facilitated through the use of NVivo 12 software.

3. Results

To present the findings, a preliminary exploration of reading beliefs will be provided. This initial examination highlights the assessment preservice teachers make of this construct. Subsequently, the focus will shift to the dimensions primarily elicited during the interviews when participants were queried about their perceptions of reading. This analysis encompasses both the academic dimension and the personal dimension, underscoring that this construct is linked to both matters of knowledge and to enjoyment and leisure activities primarily.

3.1. Evaluation of reading

Across all analyzed interviews, a positive evaluation towards reading was consistently observed. Participants converge on the notion that reading is an enjoyable activity. Moreover, they underscore the significance of reading for personal development. According to the perceptions of the prospective teachers, reading brings about changes and broadens perspectives. We highlight two representative statements that encapsulate these notions; the first from a first-year student and the second from a fifth-year student, indicating a shared sentiment within the participant group.

EU1_N1_02_Kira: I really like it because I feel that, this is how… getting to know different perspectives.

EU2_N5_04_Rodolfo: "But I stick with this idea that reading truly changes people, perhaps it broadens our perspective, tells us that there are things we were not seeing before."

The metaphor of "broadening one's perspective" alludes to the concept of gaining access to knowledge, a circumstance that would be facilitated by reading, as it enables an acquaintance with various perspectives and viewpoints, ultimately fostering a deeper learning experience. Nevertheless, this notion is limited as it refers to an instrumental approach to reading and literature, pointed out by Míguez-Álvarez et al. (2023). Most of the identified evaluations are primarily associated with the potential that reading offers for learning; therefore, it can be inferred that preservice teachers reading activity mainly occurs in academic environments. This highlights a weak connection with reading as a social practice linked to enjoyment in personal contexts (Álvarez-Álvarez and Diego-Mantecón, 2019; Díaz-Díaz et al., 2022).

3.2. Academic dimension

The academic dimension pertains to a perspective of reading centered on accessing knowledge and fostering learning. Prospective teachers draw upon their own experiences as students to articulate the significance of reading for them. It is noteworthy that the findings are consistent across the three groups, encompassing students in their 1st, 3rd, and 5th years of study. Among 5th-year students, references to disciplinary knowledge in relation to reading are more prevalent than among 1st-year students.

Within this dimension, two primary notions of reading are situated, conceptualized based on insights gleaned from the prospective teachers. Key associated concepts were considered in their analysis. The outcomes are presented in Table 2.

Below are some excerpts from the interviews where references can be found that have contributed to the formulation of the conceptualization presented regarding learning:

EU1_N5_04_Fabiola: "To me, reading is an epistemic skill… Yes, for me, reading is first and foremost a skill or a competency that comprises many sub-skills contributing to learning, whether personal or for academic-disciplinary work.

EU1_N1_02_Kira: "For me, that's it, learning, whatever one reads, to me, it's learning."

Regarding knowledge, the following statements are considered:

EU1_N1_02_Kira: "Above all, as I mentioned, it's a contribution of culture… to people."

EU2_N1_05_Carlos: "I really like it because I feel that, this is how… getting to know different perspectives."

These notions are regarded as limited and inadequately developed in conceptual terms by the prospective teachers, which aligns with the findings of Shaw and Mahlios (2011). This emphasizes the necessity to expand the theoretical frameworks accessible to them, enabling the progression towards more extensively elaborated conceptualizations within disciplinary terms. As stated in previous sections, reading is a complex construct that presents different definitions (Maina and Papalini, 2021). Therefore, it is necessary for prospective teachers to have knowledge about this and be capable of reflecting on this idea so that the representations they construct are grounded in a conceptual framework, not solely based on their reading and literary experience.

3.3. Personal dimension of reading

The personal dimension of reading has been approached through the beliefs of the prospective teachers, wherein they affirm that reading is a leisure activity, a source of enjoyment, and relaxation.

TABLE 2 Academic dimension of reading.

Academic dimension		
Categories	Conceptualization	Topics
Learning	Reading is understood as a tool for learning, as well as an epistemic ability that allows the subject to acquire knowledge and also build meaning from reading texts. This refers to a functional perspective.	Tool Ability Competence Interpretation
Knowledge	The underlying belief in this category refers to reading as a source of knowledge, which allows access to culture and different worldviews. Similarly, it is considered from a functional perspective	World view Access to knowledge Culture

TABLE 3 Personal dimension of reading.

Personal dimension		
Categories	Conceptualization	Topics
Leisure activity	Reading is understood as a form of escape from reality, that is, a pastime that contributes to their recreation in their personal space, outside of the academic environment.	Escape or evasion entertainment disconnection Hobbie
Enjoyment	Reading is conceived as an instance in which fruition and aesthetic appreciation is experienced, mainly from literary reading.	Aesthetic enjoyment like

Table 3 presents the categories derived from their perspectives, the conceptualization of each, and the topics associated with them.

To comprehend the presented ideas, examples from the category labeled as "leisure activity" are provided, wherein reading becomes a moment of evasion or escape from reality:

> EU1_N1_03_Josefa: just like some people have dedicated their entire lives to ballet, I've been reading my whole life… It's been my hobby.

> EU3_N3_05_Claudio: as a moment of disconnection where I can be with the book, and I know no one else is going to bother me and I know that what's happening outside does not interest me at that moment.

Regarding enjoyment, the following example is relevant:

> EU2_N5_02: with more literary reading, with juvenile classics, Narnia, Harry Potter to a certain extent… it's a pleasure, for example, to imagine that story in one's head and read it and think, "Oh! I'm enjoying this."

In this way, it is possible to observe how the prospective teachers position reading as a pleasurable activity, one they enjoy and that allows them to escape from reality. However, it is noteworthy that the notion of disconnection or escape with which they associate reading is noticeable. This concept echoes the traditional notion of engaging in the act of reading a book. In this scenario, the reader sets aside their usual tasks to immerse themselves where the focus is on enjoyment through literary reading. This is evident in the discussed interventions, which explicitly refer to the book as a literary artifact.

4. Conclusion

In this preliminary study, it is possible to observe that the reading beliefs elicited from future Language and Literature teachers lack substantial conceptual elaboration, which can be attributed to their weak connection with reading (Larrañaga and Yubero, 2019). Nevertheless, a positive evaluation of reading was evident, emphasizing its significance in gaining access to cultural literacy. This is primarily due to the fact that reading continues to hold social prestige on a collective level, regardless of whether it is actively pursued as a regular practice (Díaz-Díaz et al., 2022).

Equally relevant to mention is that fifth-year students employ more abstract concepts to refer to reading compared to first-year students, who tend to use more generic concepts not directly associated with their field of study. This indicates that the education received while pursuing a pedagogy program has an impact on their beliefs regarding reading, although these beliefs still remain limited. Therefore, it is essential to explore potential approaches that empower future teachers to contemplate reading and their own personal reading habits. This should be supported by a reference framework that allows them to access various conceptualizations of reading from different spheres of knowledge, enabling them to construct definitions beyond their own experience. In this regard, it is considered relevant to emphasize the study of the social dimension of reading while they undergo initial teacher training programs. This is a key element for the development of their role as reading mediators in their teaching endeavors, as they will need to read with others and for others.

Furthermore, it is noteworthy that despite finding enjoyment in the activity, a utilitarian perspective of this construct prevails among them. Upon analyzing the interviews, no mentions were found that could account for the social dimension of reading, understood as a practice that enables them to become part of the reading community (Margallo, 2012). Instead, reading seems to occur in their individual space. Moreover, encounters with books are often sporadic. While they express enjoyment of reading and, consequently, the aesthetic experience that literary works provides them with, their reading activity is predominantly confined to academic settings due to the demands of their studies. Therefore, it could be stated that, during their pursuit of a degree in Language and Literature Pedagogy, their reading serves primarily as a means of acquiring educational knowledge for their future teaching practices.

Lastly, it is important to acknowledge the limitations of this study, which are primarily related to the data collection instrument. As it was an interview, participants primarily drew upon their spontaneous experiences and memories to respond. This may, to some extent, affect how they articulate their thoughts and beliefs about reading. Similarly, it is crucial to continue prioritizing the reading processes of future educators, aiming to enhance their relationship with reading and ultimately solidify their reading habits by the conclusion of their educational journey.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving humans were approved by Bioethics and Biosafety Committee of Pontifical Catholic University of Valparaíso (code: BIOPUCV-H486-2022). The studies were conducted in accordance with the local legislation and institutional requirements.

The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

CG: Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing. EP: Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Multimodality in language education: implications of a multimodal affective perspective in foreign language teaching

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Foreign language learners often encounter various emotional challenges within academic environments, which can hinder their progress in developing literacy skills. Effective language instruction should encompass teaching approaches that acknowledge the emotional requirements of students. To address this need, we propose a multimodal affective methodology designed to evaluate emotions in foreign language education scenarios. This methodology also holds the potential to elucidate the pedagogic contributions of various emotional variables to academic outcomes. Our study focuses on German as a foreign language (GFL) learning and utilizes it as an example to investigate ways to improve writing proficiency. The study explores the effects of integrating multimodal corrective feedback (MCF) into academic writing exercises. We delve into suitable modalities for analyzing emotions in academic writing practices. Furthermore, we investigate how the choice of corrective feedback mode intricately influences the nature of feedback itself and subsequently influences students' emotional responses. Through a comprehensive exploration of the interplay between distinct modes of delivering feedback and their impacts on learners' engagement, this investigation strives to decode the intricate dynamics of emotions that underlie language acquisition. With these insights, the study discusses how teachers can enhance their teaching strategies by combining changes in learners' emotional states and providing emotional support.

KEYWORDS

academic writing, language teaching, emotion, multimodal, GFL

1. Introduction

Emotions play a critical role in daily tasks by influencing cognitive capacity and providing the necessary energy for behavioral action (Ekman, 1992; Liu, 2022). In this turn, there exists a direct link between emotions and language learning. Negative emotions are often a source of challenges for foreign language learners in academic writing curriculums. Despite the substantial amount of research conducted on the factors affecting writing processes and products, the role of emotion has been given scant attention in writing studies. This study aims to evaluate and determine the appropriateness of various modalities for analyzing emotions within the German as a Foreign Language (GFL) learning context. We thus introduce a multimodal method to accurately assess emotions in academic writing classes.

Considering students' emotions in their academic literacy development can provide insight into the conditions under which emotions are associated with academic functioning.

In recent years, researchers in positive psychology have recognized the effectiveness of positive reinforcement in promoting efficient learning among students (Dewaele et al., 2019; Li, 2020). Similarly, negative emotions are often observed to cause disruptions in students, but they can also stimulate activation in long-term memory associated with learning. Most research on emotions and academic competence has focused on negative emotions such as anger (Gan et al., 2022), anxiety (Thompson and Lee, 2013), and boredom (Shen, 2022) with minimal attention paid to other positive emotions. Influenced by positive psychology scholars, who realized that emotion is one of the most effective ways to enhance student's learning efficiency (Li, 2020; Ergün and Dewaele, 2021; Yang et al., 2021). Researchers advocate a shift in the focus from repairing negative affection to fostering positive subjective experiences that promote hope, courage, and happiness (Dewaele et al., 2019; Han and Wang, 2021).

Emotions are complex and expressed through various modalities, including facial expressions, gestures, and oral expressions (Liu P. et al., 2022). Scholars agree that emotions consist of multiple components and are thus complex to study (Gao and Cui, 2022; Liu et al., 2023; Wen et al., 2023). Several studies claim that a single modality is insufficient for providing a comprehensive understanding of emotions due to their complexity (Goncalves et al., 2017; Liu W. et al., 2022). To address this issue, this study focuses on emotions and their interplay in a multimodal affective perspective.

This paper delves into the potential of a multimodal affective approach to enrich language education, particularly its pertinence within the context of German as a foreign language (GFL) of academic Writing curriculum. In the realm of written production assessment, educators encounter a spectrum of choices in delivering corrective feedback to students. Normally, educators deliver corrective feedback through the written modality. Instead, the paradigm shift toward digital and distance learning has accentuated the necessity for enhanced pedagogical training beyond the written modality (Trigo et al., 2019; Ibáñez et al., 2022). The incorporation of technology has expanded the scope through which educators can provide multimodal corrective feedback (MCF) to their students. Rather than confining themselves to conventional textual output, educators now possess the capacity to provide MCF through video channels. Nevertheless, instructors must exercise awareness of how modalities might impact both the nature of their feedback and the emotional responses of students. By harnessing an array of nonverbal cues encompassing gestures, eye contact, and facial expressions, this modality becomes a potent tool to captivate learners' sensory engagement. This work posits an imperative shift, acknowledging the multimodal nature of emotions and their constructive role in foreign language learning.

2. Literature review

The expression and identification of emotions by individuals are recognized to be multifaceted. The implementation of a multimodal affective perspective offers the potential to augment our knowledge of the interplay between academic functioning and emotions, as it enables chances for new research directions. We conduct a review of current emotional studies within academic contexts.

2.1. Multimodal emotion and multiliteracies

Learning is emotional and cognitive, as affective states cause or are accompanied by changes in how individuals process information (Dylman and Bjarta, 2019). The learning environment is multimodal, wherein students engage with instructors (Forceville, 2005; Liu, 2022). Teachers express their emotions through various modalities (Unsworth, 2001; Kress and Van Leeuwen, 2020). The concept of multimodality originates from systemic functional linguistics, a theory developed by Michael Halliday and his colleagues (Halliday and Matthiessen, 2013). Multimodality involves various aspects of interaction and environments, including speech and nonverbal elements such as visual, aural, embodied, and spatial cues (Jewitt, 2013). Generally, multimodality involves the use of two or more modalities.

Different from the disparate perspective, researchers have recently advocated emotion as highly integrated, multilevel, and complex systems (Rothermund and Koole, 2018; Scherer and Moors, 2019). Recent studies have revealed that multimodal data can enhance accuracy and provide better insight into emotions and academic literacy development process (Soleymani et al., 2012; Lee and Anderson, 2017), while single-method assessments are often problematic in monitoring dynamic students' emotional states (Chrysafiadi and Virvou, 2013).

Some scholars focused on modality-specified features, such as language resources (Kövecses, 2003), facial expressions (Ekman and Friesen, 1978), vocal features (Scherer, 2003), psychological reactions (Fan et al., 2016; Dzedzickis et al., 2020; Yang, 2021) or body language (Behoora and Tucker, 2015). To enhance the reliability of obtained results, a multimodal affective perspective is needed, as most studies of emotion analysis have been modality-specific. With the rapid development of machine learning and affective computing (Scherer and Moors, 2019; Liu et al., 2023), automated emotion evaluation is a potential trend. Those studies offer helpful lessons on assessing multimodal emotions, as the experimental results indicate that multimodal systems attain better effects on performance than unimodal counterparts (Goncalves et al., 2017).

Although emotion analysis has been extensively investigated, existing studies have not focused on designing a multimodal affective framework. There is an urgent need for an ecologically valid instrument for measuring emotions in academic writing practice. To this end, we provide a multimodal affective framework to analyze the complex multimodal meaning of emotions.

2.2. Emotions and foreign language learning

Emotions and language learning are interconnected (Dewaele and MacIntyre, 2014; Liu, 2022). Scientists have noted that emotions serve as a crucial component of individuals, influencing their learning behavior, cognitive capacity, and interpersonal relationships (Ekman, 1992). In response to this recognition, educational theorists and practitioners have begun to emphasize the significant value of integrating positive emotional engagements into curricula. This emphasis stems from the understanding that doing so can substantially enhance students' engagement in the learning process and foster more

positive attitudes toward their educational experiences (Vicente-Yagüe Jara, 2018).

Moreover, the growing body of research has delved into the effects of affectivity on various dimensions of well-being, emotional intelligence, and academic accomplishments (Sansúan, 2020; López Martínez et al., 2023). For instance, Sansúan (2020) examined the consequences of emotional engagement within the context of poetry education among adolescents, shedding light on the profound impact that emotions can have on the learning process. Collectively, these investigations support the idea that emotions should not be viewed as mere byproducts of the educational process. Instead, they should be regarded as integral and influential factors that have the potential to significantly shape the educational experiences of both children and adolescents.

To reveal the interplay between emotions and the language learning process, researchers have explored various emotional states in the foreign language classroom. Negative emotions such as anxiety (Thompson and Lee, 2013), anger (Gan et al., 2022), and boredom (Shen, 2022) or positive emotions like enjoyment (Pavelescu and Petric, 2018; Yang, 2021) are important for successful learning (Burić et al., 2016). While negative emotions narrow the mindset, positive emotions stimulate innovative ideas. Some researchers constructively move positive psychology forward by putting negative and positive realms together (Ryff, 2022). Literature has examined that emotion impacts learning in the foreign language classroom (Han and Wang, 2021; Wang and Ye, 2021). Learning is emotional and cognitive, as affective states cause or are accompanied by changes in how individuals process information (Dylman and Bjarta, 2019), student with high language anxiety can positively contribute to seeking assistance for taking actions in learning engagement (Ryff, 2022).

As we delve into the analysis of emotions in foreign language learning, specifically focusing on the implementation of corrective feedback (CF). Existing literature underscores the profound impact of CF in foreign language learning contexts (Langum and Sullivan, 2017; Han and Hyland, 2019; Yu et al., 2020). CF facilitates students in the rectification of misspellings, the avoidance of grammatical errors, and the refinement of language accuracy. However, the emotional dimensions associated with corrections remain relatively unexplored.

While written corrective feedback (WCF) is mostly employed to revise students' errors due to their convenience and validity, there is a dearth of research that delves into the emotional factors within the context of the multimodal approach (Scherer and Moors, 2019). With this research gap in mind, we aim to provide a multimodal affective perspective on the emotional processes and components of multimodal emotional expressions, which intends to bring new perspectives to the attention of emotion in academic settings, especially investigating the underlying mechanisms in foreign language writing lectures. This study analyzes the inherent multimodality embedded within the construct of teacher corrective feedback, which holds the potential to catalyze fostering positive emotional experiences, such as a sense of enjoyment.

3. A bibliometric analysis of emotion in academic contexts

In our pursuit of the intricate involvement of emotions in the development of academic literacy, we conducted a thorough bibliometric analysis of existing research to identify prevalent clusters and potential connections. To collect relevant data, we employed the Web of Science search engines, utilizing the keywords "Emot*, academic Lit*." These keywords were selected to explore how emotions and academic literacy concepts have been integrated into existing emotio   n research literature.

Our search yielded 676 results in total, with the documents published between 1995 and 2023. Figure 1 visualizes the results and their interconnections, which offers a comprehensive view of the landscape of emotion research within the realm of academic literacy. It has brought to light the recurring themes of "approach," "measure," and "process" as commonly referenced concepts when evaluating emotions within academic contexts. Notably, self-reported questionnaires emerge as the predominant method employed for this purpose (Scherer and Moors, 2019). While substantial progress has been made in understanding the impact of emotions on foreign language learning, there remains a gap in research about using a multimodal perspective for analyzing emotions. The proposed multimodal affective approach has the potential to analyze diverse educational settings using a unified and applicable paradigm for assessing emotional factors. Given the relative shortage of attention in previous research, this method could offer a more comprehensive understanding of the issue.

Given the profound impact of emotions on students' learning activities, it becomes imperative to cultivate positive emotions within the learning process. Emotions serve a functional purpose by equipping individuals with the capacity to respond effectively to challenging educational situations. Emotions are not limited to verbal expressions or self-reporting. They manifest through various modalities, including nonverbal cues. It is essential to note that nonverbal behaviors, encompassing diverse modes such as gestures, posture, gaze, and movements, constitute an integral facet of teachers' CF and should not be overlooked when assessing the pedagogical effectiveness of their feedback.

Table 1 enumerates various modalities in the multimodal affective approach. Multimodality encompasses various facets such as facial expressions, body movements, vocal intonations, and the utilization of technological tools, all of which accompany teachers' corrective feedback. This paradigm can analyze different modalities of emotions by using the equally applicable paradigm so that the findings can be simultaneously compared. The integration of multiple data streams holds the potential to enhance the precision of emotion recognition, as evidenced in recent studies (Liu et al., 2023; Wen et al., 2023). These methods offer a relatively straightforward means of data collection, often involving video frame analysis. Within this visual record of the teacher's multimodal corrective feedback, both verbal and nonverbal semiotic elements, including gestures, gazes, and postures, have been meticulously captured (Table 2).

4. Methodology

4.1. Research design

This research aims to deepen the understanding of the perceived distinctions between various modalities that evoke emotions and to provide valuable insights for educators and practitioners regarding the potential implications of modality selection. These insights will, in

FIGURE 1
Bibliometric analysis with keywords "Emot*, academic Lit*" in VOS Viewer.
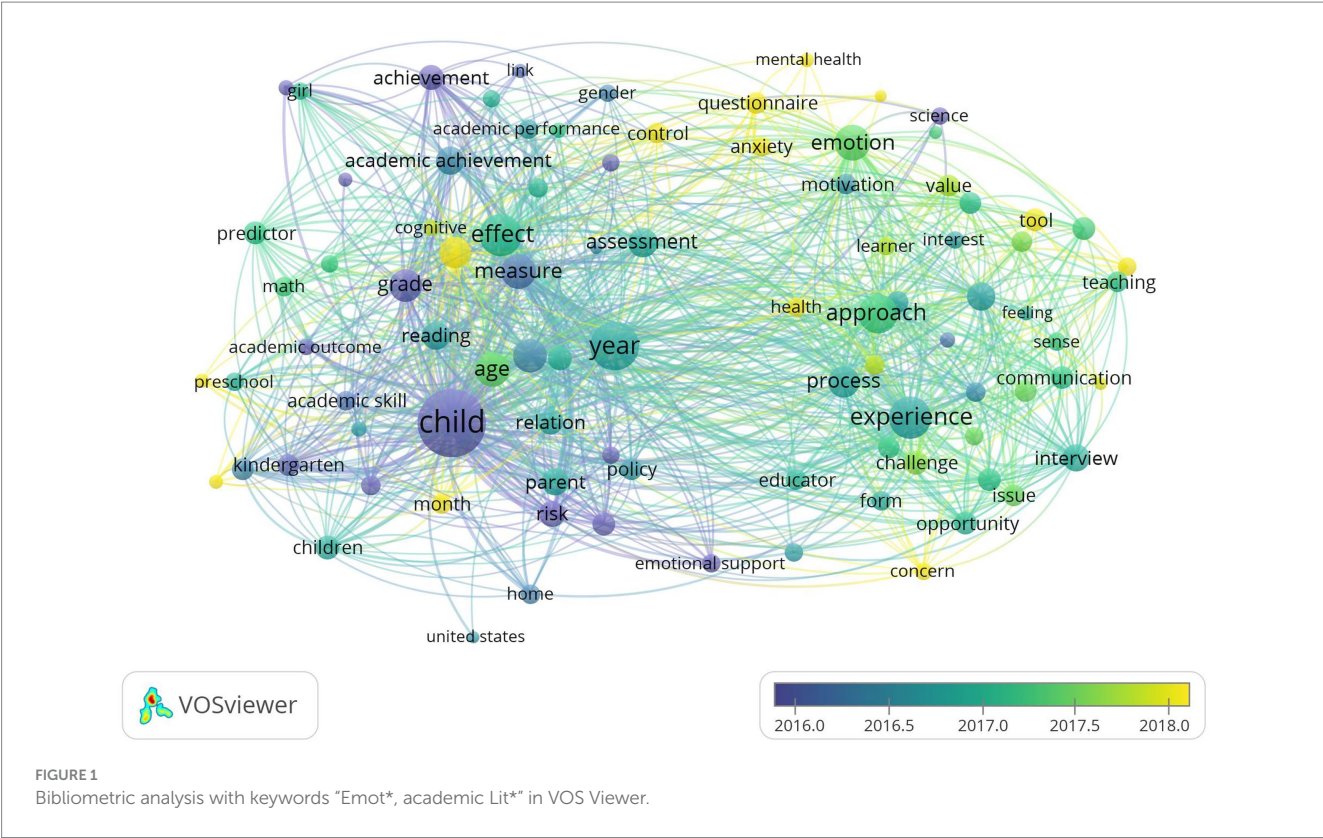
TABLE 1 Modalities in the multimodal affective approach.

Modality	Sensors or tools	Description	Strength	Weakness
Auditory modality	Speech recognition tools	The use of tone, intonation and rhythm	Covey emotions and highlight key point; capable for assessing spontaneous emotion	Lack of theoretical framework in emotion detection
Visual modality	Image recognition	Visual aids, such as diagrams and images	Simplify complex concepts; engage learners with visual information	Limiting usability and accessibility; Variability of human emotional expressions
Gestural modality	Facial Action Coding System (FACS)	Assessing facial motion and gestures	center of emotion detection; reinforce verbal explanations; Easily detectable in and out of classroom	Variability of human emotional expressions, limited success rate for sole use, lacks detailed temporal information
Kinesthetic modality	Visual gesture recognition system	Assessing body movement	Indicator of emotions; indicator to interactive experiences; reinforce emotional connections; less obtrusive methods	Lack of capability to detect fine body movements with emotions; require more resources and time
Text modality	NLP Tools and questioner	Written content	Easily gathered data; provide detailed explanations and directly connected to emotional expressions; suitable for various contexts	Not real-time; data need post-processed; might lead to cognitive overload

turn, aid in the development of more effective setups for foreign language teaching. The specific focus of this study is on the context of German as a Foreign Language (GFL) academic writing classes. It is motivated by the observation that, compared to English learning, German learning often requires a higher degree of emotional support from teachers. This heightened need for emotional support can be attributed to factors such as the grammatical complexity of the German language, structural differences from learners' native languages, and the presence of cultural barriers.

Conducting a multimodal affective analysis of CF in foreign language education can potentially yield deeper insights into how different modes exert their influence on student emotions. Particularly, the emotion triggered in response to teachers' MCF holds the promise of enhancing students' learning experiences, leading to improved comprehension. The multimodal affective approach enables effective comparisons between different modalities of emotional expression. Researchers can assess the relative impact of verbal and nonverbal elements in delivering CF,

TABLE 2 Distribution of students' emotional reactions to MCF/WCF according to the questionnaire.

Questions	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Section 1: Multimodal corrective feedback and intellectual engagement					
(1) I believe that teacher's multimodal corrective feedback is beneficial to improve my English.	0	1 (3.33%)	3 (10%)	3 (10%)	23 (76.67%)
(2) Multimodal corrective feedback plays a significant role in helping me recognize and correct my mistakes in writing.	1 (3.33%)	0	5 (16.67%)	18 (60%)	7 (23.33%)
(3) The use of multimodal corrective feedback attracts my attention in the revision process.	2 (6.67%)	0	1 (3.33%)	6 (20%)	21 (70%)
Section 2: Multimodal corrective feedback and emotional response					
(4) The teacher's use of multimodal corrective feedback made me feel more confident about my learning progress.	0	2 (6.67%)	4 (13.33%)	11 (36.67%)	13 (43.33%)
(5) I find the multimodal corrective feedback enjoyable.	0	1 (3.33%)	3 (10%)	4 (13.33%)	22 (73.33&)
(6) I find Teacher's written corrective feedback enjoyable.	4 (13.33%)	3 (10%)	14 (46.67%)	7 (23.33%)	2 (6.67%)
Section 3: Preference of different feedback modes					
(7) The combination of visual cues and spoken feedback assisted me in identifying and rectifying errors better.	1 (3.33%)	0	3 (10%)	7 (23.33%)	19 (63.33%)
(8) I believe that teacher's multimodal corrective feedback should be an integral part of teaching.	1 (3.33%)	1 (3.33%)	2 (6.67%)	1 (3.33%)	25 (83.33%)
(9) I prefer receiving multimodal corrective feedback from the teacher over written corrective feedback.	0	1 (3.33%)	2 (6.67%)	4 (13.33%)	23 (76.67%)

shedding light on which aspects are more influential in evoking specific emotional responses. This comparative analysis can guide instructional practices.

Nevertheless, a challenge persists in terms of developing an approach that can examine both textual and video feedback within a consistent and equally relevant framework. This need for uniformity in analysis methods is crucial to facilitate meaningful comparisons of students' emotional responses. By adopting a multimodal affective perspective in the study of emotions within the CF process, we can better address the pedagogical demands of foreign language teaching and gain a more nuanced understanding of the interplay between emotion and academic literacy development. This paper aims to answer the following questions:

1. How do different modalities of corrective feedback (e.g., WCF, MCF) influence the intellectual engagement and emotional responses of GFL learners?
2. What pedagogical implications can be derived from the study's findings to optimize the use of MCF in GFL academic writing classes?

4.2. Participants

To shed light on emotions' real impacts on GFL, we conduct an empirical study within the context of a Chinese university, involving a cohort of 30 students who were actively enrolled in an academic German academic writing class. Participants were selected to ensure a balanced representation of gender and language proficiency levels. They were assured that their participation was entirely voluntary and that they possessed the autonomy to withdraw their consent or

discontinue their involvement at any point during the research process without any repercussions.

4.3. Procedure

The empirical phase of this study spanned 8 weeks within the context of a Chinese university. This empirical inquiry was structured into two distinct phases, each lasting 4 weeks. In the initial phase, a cohort of 30 students underwent language learning sessions during which they were exclusively exposed to written corrective feedback (WCF) provided by their instructors. Subsequently, in the second phase, the same group of participants experienced a transition to a multimodal corrective feedback (MCF) format, delivered through videos.

Throughout both phases, we closely observed and documented the emotional experiences of the learners during their interactions with corrective feedback. To facilitate this analysis, we applied our multimodal affective approach, which allows for a comprehensive exploration of emotional responses within the context of foreign language learning.

4.4. Instruments

To collect data, two research instruments were deployed: a 10-item questionnaire and an in-depth interview. The questionnaire operation employed a 5-point Likert Scale encompassing categories of strongly agree, agree, neutral, disagree, and strongly disagree. Additionally, the questionnaire encompassed open-ended components that let students articulate their perceptions concerning both teacher-provided multimodal and written corrective feedback. During these interviews,

participants engaged in discussions related to their emotional states concerning the teacher's corrective feedback. This approach offers insights into the intricate interplay of multiple modes within teachers' CF, considering both their application in the classroom and the emotional atmosphere that arises as a result.

4.5. Data analysis

This study used quantitative and qualitative methods to analyze the data gathered from student responses and interviews. The integration of both quantitative and qualitative analyses provided a comprehensive view of the data.

1. Quantitative analysis: To assess students' preferences regarding corrective feedback modalities, we used descriptive statistics. Specifically, we calculated the percentage of students who strongly agreed or agreed with the statements related to MCF and WCF. These percentages provided a clear quantification of student preferences.
2. Qualitative analysis: In addition to quantitative analysis, we conducted a qualitative analysis of the interview data. We employed thematic analysis to identify recurring themes and patterns in the participants' responses.

5. Results

The results yielded by this investigation shed light on the concept that the choice of corrective feedback modality during feedback delivery could influence students' emotional states. The methods employed in this study have indicated the promise of the multimodal affective framework as an effective analytical instrument. By understanding the mediating function of emotion in academic literacy development, GFL teachers can adopt a practical approach to handling students' emotional difficulties. This research provides a template that can be applied to a variety of scenarios.

The first goal of this study was to examine students' preferences regarding teacher-provided corrective feedback. The findings revealed that a majority of students perceive MCF as pivotal to enhancing their English language skills, as evidenced by their responses. Among the participants, 23 students (77%) strongly agreed and 3 students (10%) agreed.

The impact of the teacher's MCF was multifaceted. It was found that such feedback could effectively engage learners' attention. As illuminated by participants during the interviews, when addressing complex aspects like conditional sentence formulation, learners faced difficulties. Nonetheless, the teacher's MCF combined with hand gestures, gaze, and body language assisted her in overcoming this challenge. This observation confirms the significance of employing multimodal strategies in pedagogical interactions. The amalgamation of various modes of communication not only captured learners' attention but also provided a comprehensive and holistic learning experience.

It is noteworthy that participants also acknowledge the role of teacher-provided MCF as a positive factor contributing to enjoyment, with 22 students (73%) strongly agreed and 4 students (13%) agreed.

For comparison, students' perception of WCF was mainly marked a neutral experience by 14 out of 30 participants (47%). As a showcase, one participant aptly articulated this experience stating "Having studied foreign language studies for so many years, I find myself emotionally detached. I have become used to encountering errors and consequently correcting them." The teacher's MCF in this study can be regarded as feedback imbued with positive emotions due to three factors:

1. The teacher's skillful use of semiotic resources effectively managed the challenge of learners committing errors in the class, with 13 participants strongly agreed and 7 students (23%) agreed. For instance, when a learner made a mistake, the teacher's sustained eye contact accompanied by a smile served to motivate them to approach this challenge with enthusiasm.
2. The teacher's MCF effectively heightened learners' attention. For example, when the teacher altered his intonation while pointing out an error, this action redirected the learner's focus toward the correct form.
3. The teacher's nuanced multimodal approach facilitated a heightened intellectual engagement with the learners' focus on the correct form. By using specific gestures to point out errors, the teacher guided the learners' understanding of the correct forms.

Overall, over 90% of students (4 agreed and 23 strongly agreed) emphasized the significant role of the teacher's multimodal approach in delivering CF, attributing a sense of enjoyment and heightened attention to these interactions. Similarly, nearly all interviewed students were in agreement that the teacher's use of multimodal feedback served as an enjoyable method of increasing their awareness of errors and their appropriate forms.

Nonverbal resources, such as eye gaze and gestures, have proven to be more potent than mere written commands in providing corrective feedback. They foster a sense of involvement and bridge the gap between teachers and students. The findings underscore the significance of teachers employing affective resources to convey emotions and assess stances that can potentially influence students' emotional states. The teacher's multimodal feedback assists in offering a more accurate interpretation of the intended purpose. Through understanding a wide range of verbal and nonverbal affective factors, students can enhance their ability to grasp information more effectively. For instance, when explaining a complex grammatical structure in the subordinate clause of the German language, the teacher might use their arms to visually represent the relationships between different elements of the sentence. They might use specific arm movements to depict subjects, objects, verbs, and other grammatical components. These gestures can help create a visual representation of the sentence's structure, making it more comprehensible to the learners.

The teacher's multimodal correction is effective due to the interplay between verbal and nonverbal cues. At times, these nonverbal cues align with verbal signals, conveying the same meanings. Additionally, there are situations where the teacher's nonverbal cues create a clearer structure for learners to comprehend the corrective message. For example, the teacher's posture helps learners understand the corrective intention of the written forms.

6. Discussion

The above empirical study shows that the expression and identification of emotions by individuals are recognized to be multifaceted. The implementation of a multimodal affective perspective offers the potential to augment our knowledge of the interplay between academic functioning and emotions, as it enables chances for new research directions. We discuss our emotional study results' implications and the potential future work.

6.1. The pedagogy approach of the multimodal affective approach in academic writing

The findings of this study confirm the significance of multimodal corrective feedback in academic writing. Through the nuanced selection of modes and the integration of various cues, educators can possess the means to enhance learners' engagement, comprehension, and enjoyment (Liu, 2022). For example, non-verbal cues like eye gaze or gestures may be more useful than written text when conveying instructions to students. MCF offers more support for foreign language acquisition. The MCF not only accommodates diverse comments for students' written production but also presents content that resonates with learners on a personal level in a multimodal manner. Through attentive consideration of instructors' visual and verbal cues, learners exhibit a heightened ability to discern corrective cues. The findings underscore the effectiveness and interest of the teachers' CF with an amalgamation of hand gestures, gaze, silence, and shifts in intonation.

Our research reinforces the notion put forth by Sansuán (2020) regarding the intricate relationship between emotions and literacy education. Our study extends this perspective by illustrating that multimodal teaching methods can serve as a means for instructors to regulate students' attitudes. The incorporation of the multimodal affective approach in the realm of academic writing manifests a multifaceted paradigm for educational instruction. By encompassing both verbal and non-verbal elements, educators can foster an enriched learning environment that is more attuned to students' cognitive and emotional nuances (Unsworth and Mills, 2020). This holistic approach recognizes that education is not merely about the transmission of knowledge but also about nurturing the emotional well-being of learners. While prior research has explored multimodality in language learning (Jewitt, 2013), the focus on the affective dimension in this study prompts further investigations into how emotions can be intentionally harnessed to improve language education.

Our finding aligns with the work of Han and Hyland (2019), who emphasized the importance of academic emotions in written corrective feedback situations. Their contention that positive emotions, such as enjoyment and engagement, are pivotal for effective learning resonates with our findings. Our study further demonstrates that multimodal approaches contribute to creating a positive emotional ambiance that broadens learners' attention and engagement. Moreover, our results indicate that when students become emotionally engaged through diverse modalities, they are inclined to display heightened levels of engagement.

Taking into account the above verbal and nonverbal affective dimensions of corrective feedback, this study demonstrates the potential of a teacher's multimodal corrective feedback to foster enjoyment in a GFL writing course. The findings confirm the inherent multimodality of corrective feedback and emotion. These dimensions encompassed students' heightened attention, intensified focus on the corrected structures, and an improved understanding of the teacher's corrective discourse. From a pedagogical standpoint, the outcomes of this case study highlight the importance of increasing teachers' awareness regarding the multimodal nature of their corrective feedback and its role in creating a positive emotional ambiance. They counteract the presumed link of learners' negative emotional reactions to corrective feedback and instead cultivate a more positive atmosphere that broadens learners' attention and engagement.

The analysis illustrates discrepancies delivered across two modalities of CF, even when originating from the same instructor. This result can guide instructors into the potential influence of technology selection on feedback modalities. It can empower educators to align technological tools with pedagogical objectives, thereby optimizing their instructional strategies. Educators may utilize multimodal teaching methods to match students' needs, which could aid in the enhancement of their emotion regulation. During the instructional process, teachers may integrate non-verbal resources such as images, body language, and other materials to communicate their attitudes more clearly, which may be more accessible and comprehensible for students learning foreign languages. The implications of this study extend beyond the realm of German academic writing and foreign language teaching. They resonate with the broader field of education, emphasizing the importance of recognizing and harnessing the affective dimension of learning.

6.2. Multimodal affective approach in assessing students' emotions

Our proposed multimodal affective approach can also assist in assessing students' emotional responses. The realization that different modes of feedback can elicit disparate emotional reactions highlights the intricate relationship between pedagogical methods and students' affective states. By emphasizing students' enjoyment and building their confidence, teachers may extend their multimodal expression of attitude by utilizing different choices of writing feedback, as writing suggestions could be expressed with diverse types. The study suggests teachers could align the mode of expression with their specific pedagogical intents.

This study's focus primarily lies in exploring students' emotions through self-report measures, taking into account the interplay of multimodal elements in eliciting these emotions. However, as we delve deeper into the domain of MCF and its implications for foreign language learning, a more comprehensive approach could involve a meticulous multimodal analysis of students' emotional reactions (Liu, 2022).

Such a comprehensive investigation could encompass various modalities, including verbal and non-verbal cues, that contribute to the holistic emotional experience within the context of foreign language learning. By embracing this approach, we could gain a better understanding of the nuanced ways in which different modes of communication interact with one another and jointly influence students' affective engagement.

6.3. Future work

It is important to acknowledge certain limitations inherent in the application of the multimodal affective approach that deserves future work. To begin with, the successful implementation of this approach relies on educators' proficiency in navigating diverse modalities of teaching, which may necessitate additional training and workload for them. Our study offers valuable insights for educators to select the appropriate modalities and stimulate students' positive emotions in the context of GFL and can be extendable to other language learning contexts in future work. Future research could also focus on designing effective training programs that equip educators with the skills to navigate diverse modalities efficiently.

The current study focuses on delving into the emotional dimensions of corrective feedback. It is worth extensively delving into the broader contextual factors that might influence students' emotional responses, which we leave as a future work. Emotion within academic literacy development should be understood as an interface between individual and their environment, which is mediated by social contexts (Mulligan and Scherer, 2012). For instance, delving into individual differences such as cultural backgrounds, learning preferences, and personality traits might unveil additional layers of complexity in the emotional interplay. This extended perspective could also involve the exploration of potential mediators that might either enhance or mitigate the impact of certain multimodal cues on emotional states.

Furthermore, students' emotions can be assessed through heterogeneous sources to obtain a comprehensive understanding of emotion and academic literacy development. Emerging technologies, such as wearable devices for real-time emotion tracking and advanced neuroimaging techniques, could shed further light on the neural and physiological underpinnings of emotional responses during educational interactions. For example, emotional triggers can cause a student's heart rate to change, their facial expression to alter, and their muscles to tense. The integration of deep-learning-based fusion methods for analyzing multimodal data from heterogeneous sources (Huang et al., 2020), presents a promising trajectory. Models like Word2Vec (Mikolov et al., 2013), GloVe (Sakketou and Ampazis, 2020), Transformer network (Huang et al., 2020) and BERT (Su et al., 2019) could be leveraged to enhance the understanding of different modalities in teaching.

Lastly, the implementation of a multimodal affective method, adept at detecting, analyzing, and interpreting expressions across various modes corresponding to diverse emotional states, can enrich pedagogical practices. Through a better understanding of emotional knowledge, educators may optimize their teaching methods by employing various modalities to alleviate student learning stress and enhance their learning interests (Wang and Ye, 2021). To address these issues, future investigations can enhance the application of the multimodal affective approach in language education and contribute to the creation of a more supportive and emotionally responsive learning environment.

7. Conclusion

This investigation advances the proposition that emotion constitutes a complex, multi-faceted construct, advocating for the adoption of a multi-dimensional approach to dissecting and comprehending emotion. The present study introduces a multimodal affective approach for dissecting emotion, offering a versatile tool applicable across diverse scenarios, such as within the realm of teacher-student interactions, particularly evident in the context of the provision of corrective feedback.

This finding highlights the significance of incorporating multimodal emotion in the GFL writing curriculum and underscores the need for multimodal teaching strategies. Through an in-depth analysis, we have uncovered the potential of integrating diverse modalities of expression in the educational process. The study's findings underscore the importance of considering not only verbal but also non-verbal elements when designing teaching strategies. Multimodal approaches provide educators with versatile tools to create an enriched learning environment that caters to student's cognitive and emotional nuances. From incorporating gestures to utilizing images and body language, educators can effectively enhance their ability to convey complex concepts and emotions.

Furthermore, this research introduces a multimodal affective perspective that has broader applicability in education. It offers new insights into the intricate relationship between academic literacy development and emotions, encouraging foreign language teachers to regulate students' emotions through a multimodal approach. Despite the numerous benefits of multimodality, it is important to acknowledge that its successful implementation may require additional training for educators. Future work should focus on designing effective training programs that equip teachers with the skills needed to navigate diverse modalities efficiently.

In a rapidly evolving educational landscape, the study of multimodality in language education opens up exciting avenues for research and pedagogical innovation. As technology advances and our understanding of emotional engagement deepens, multimodal approaches are poised to play a pivotal role in creating supportive and emotionally responsive learning environments.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

XG: Writing – original draft, Writing – review & editing.

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The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Student writing in the engineering curriculum: discursive rhetorical model of the laboratory report genre in Spanish

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Introduction: The laboratory report is a widely used genre in the academic training process in civil computer engineering. Students produce this genre in the university classroom for diverse academic and professional purposes. Despite its relevance, empirical rhetorical-discursive descriptions of the value of student writing are still scarce in Spanish. Thus, we describe the rhetorical-discursive organization of the laboratory report genre in this subdiscipline.

Methods: To fulfil this purpose, we followed a methodological design based on Swalesian Genre Analysis and used a corpus of ninety-eight texts. The sample was collected in a self-compiled form through consultation with teachers and students in the university classroom. The application of this method allowed us to determine the macro-moves, moves, and rhetorical steps of the genre, its communicative functions, and textual features.

Results: The resulting rhetorical model consisted of four macro-moves, twelve moves and seventeen steps. This model shows the highly dynamic and mesogeneric nature of this genre, the new functions of multimodal artefacts, and the genre's presence across the curriculum. To know about the teachers' and students' views on the process of training professional writers in engineering, the rhetorical model was complemented with an ethnographic phase (in the terms proposed by Swales: corroboration process with a couple of members of the community) before and after collecting the textual corpus.

Discussion: Finally, the implications for genre theory, Spanish language theory and pedagogy of the Spanish language and genre pedagogy are discussed.

KEYWORDS

student genre, macro-genre, mesogenre, lab report genre, curriculum, civil engineering computer science

1 Introduction

Research on university students as writers in the disciplines is still a vast area of exploration. Despite the advances at an international and national level (Calle-Arango and Avila-Reyes, 2020), new descriptions and reflections must be incorporated that connect the discursive production with the broader educational and professional practices. Thus, the production of laboratory reports stands out within the academic genres used in undergraduate education. The laboratory report (in Spanish, Informe de Laboratorio, and from now on called ILAB) is a hybrid academic training genre characteristic of curricular and scientific writing. This type of genre can be identified in different computer engineering courses, ranging from the initial cycle to the

professional or terminal cycle. The methodology of working in a laboratory is common in scientific education and professional training; however, its mediation through texts has been scarcely explored. ILAB is a commonly used genre in the teaching and learning processes in the area of engineering and sciences as a suitable medium to report findings of empirical studies (Parkinson, 2017). Moreover, Lerner (2007) traces interest in the teaching of this genre dating from at least 1890. This interest continues and the laboratory's teaching and learning processes are an object of study in the scientific education of multiple disciplines, mostly due to the impact that both the traditional method and more recent inquiry-based (Resendes, 2015) and virtual simulation approaches (Rodríguez-Llerena and Llovera-González, 2014) have on learning.

Furthermore, recently this genre has been identified and described in other disciplinary areas such as psycholinguistics and computational linguistics (Dreyfus et al., 2016) and biology in first and second year at university (Humphrey and Hao, 2013; Dreyfus et al., 2016), in the context of undergraduate academic training at an Australian university. In this vein, Martin and Rose (2008) identify similar genres in the science field in the secondary classroom, and they classify them within the genre family of "procedural recounts" of great relevance for scientist-researchers. This family includes technical notes, research articles, and experiment reports. This genre also aligns with what are called the school science genres (Veel, 1997) in which students complete the experiments in a laboratory and then present the results. In this sense, we can conclude that the Laboratory Report is an academic training genre in civil engineering (GEFIC) with an applied orientation or implementation genre (Author). In Latin America, studies on academic genres and genres "report" in general stand out (Merodo and Natale, 2012; Navarro and Chiodi, 2013; González and Burdiles, 2018; Meza and Da Cunha, 2019; Londoño-Vásquez and Ramírez Botero, 2020).

Our research problem seeks to answer the question *How are communicative purposes organized in a training genre highly relevant to civil engineering education?* The objective is to describe the rhetorical-discursive organization of the laboratory report genre in this subdiscipline due to their theoretical and applied impact on the training of advanced writers. This article structure is as follows: we begin with a theoretical conceptualization and a literature review of the report as a genre and the technical report as a macro-genre. Then we develop the research methodology, followed by the results, which include the rhetorical-discursive model developed. Finally, we provide a discussion and conclusions on genre description in the Spanish language and the training of writers in the 21st century's multimodal society.

2 State of the art

2.1 The report as an academic training genre

Academic writing is a key activity for secondary and higher education students. Although the specialized literature on academic training genres is still incipient, it is possible to trace approaches to academic writing of students at different education levels; thus, some studies have explored argumentative textual sequences (Hael, 2012; López, 2012; Fernández et al., 2017), explanatory (Albano de Vázquez et al., 2001) and descriptive ones (Oyanedel, 2005). The

report genre has received greater attention from specialists in the Latin American settings, who have described some thematic and figures of speech construction mechanisms (Oyanedel, 2006), lexical patterns associated with disciplinary identities (Muñoz, 2006; López-Bonilla, 2013), and students' difficulties for information processing to be able to generate texts with an intention, texts that are autonomous, and texts that construct and reconstruct disciplinary knowledge (Tapia Ladino et al., 2003; Vázquez and Miras, 2004; Tapia Ladino and Burdiles, 2009; Navarro, 2014; Trigo Ibáñez and Núñez-Sabaris, 2018).

The academic report genre has been defined as an interaction fulfilling a particular social purpose within the various discursive practices used by students in undergraduate programs, which makes it possible to estimate a level of development in a specific disciplinary area (Núñez and Espejo, 2005). In an academic report, both a university student as the utterer and an academic as the receiver, who assesses the application of textual-discursive applications (Harvey and Muñoz, 2006; Núñez et al., 2006). The report genre has several names depending on the academic communities, and it is recognized as a relevant textual artifact in undergraduate education (Harvey and Muñoz, 2006).

Harvey's (2005) analysis distinguishes between four types of reports: bibliographical, diagnostic, case, and research report. On the other hand, Tapia Ladino and Burdiles (2009) analyzed a corpus of 208 reports produced in twenty-eight programs (3° and 4° year) of four majors representing different areas: health, sciences, education, and economy. They found six types of reports: case, research-article-like, questionnaire, monograph, observation, and teaching intervention proposal. The case report exhibited the highest internal variability, while on the other extreme is the teaching intervention proposal. This characterization and distribution of the texts that are actually produced by students leads the researchers to reflect on this genre's functionality:

Distinguishing between texts that favor the learning processes within the classroom from those that are addressed to the lecturer as a member of the discipline or the profession can shed light on the demands our students are subject to Tapia Ladino and Burdiles (2009, p. 43).

Moreover, recent studies in the Anglo-Saxon context have looked into this genre and its linguistic and textual configuration. Gardner (2012) develops a register analysis and compares the structural organization of student-written reports belonging to two generic families: the research report and the methodology report. A linguistic and discursive description of the laboratory report has been proposed by Parkinson (2017), who points out that these types of discourses have been studied by the scientific education and the teaching of scientific writing as learning and assessment instruments, but not from a linguistic and discursive point of view.

Even though the report has been the most frequently studied academic-student training genre, studies have recently emerged that are focused other writing practices of the academic discourse, such as the academic-teaching genre essay-type test (Farlora, 2015), which is defined as a projection of general school genres (Parodi, 2008) and "as part of an academic-evaluative macro-genre whose purpose is to assess the degree of belonging to a disciplinary community" (Farlora, 2015, p. 263). A set of research proposals in the literature analyze strategies to introduce university students to the knowledge and use of expert genres such as the conference presentation (Padilla and

Carlino, 2010), the review (Alzari et al., 2014), and case study (Merodo and Natale, 2012; Ávila, 2016).

Therefore, more information is needed about *what* students write during the different stages in their academic training and various academic literacy levels (Marinkovich and Córdova, 2014; Marinkovich and Poblete, 2014). Moreover, more studies based on broad text corpora representing a particular area.

Finally, in the present study, the Laboratory Report is defined as follows (Author):

Undergraduate discursive genre whose communicative purpose is to present observed phenomena and interpret them in controlled conditions. Its predominant discursive organization is descriptive. Semiotically, it is configured preferably by the verbal, graphic, and mathematical modes. The relationship between participants is undergraduate student-writer-expert reader. The context of circulation is scientific. Its implied learning outcome is to analyze and apply procedures characteristic of the scientific method.

This characterization allows us to address the textual analysis considering a wide range of variables for genre identification; the learning outcome is particularly relevant, given the formative nature of this discursive genre.

2.2 Characterization of the technical report macro-genre in civil computer engineering

The laboratory report is an academic training and epistemic genre of a mesogeneric nature which belongs to the Technical Report family or macro-genre. In fact, the curricular stage called *capstone plan* or terminal professional cycle articulates a great variety of genres (Devitt, 1991; Bazerman, 2004) that undergraduate students have to use according to their role in the community of practice. In this vein, the findings available from a previous study (Author) configure a map or genre system made up of thirty-three generic instances grouped in seven macro-genres or families. Figure 1 presents the macro-genres found:

This wide diversity is supported by the available literature on engineering writing in other higher education systems such as the British one. Nesi and Gardner's (2006) early studies and Gardner (2008) have pointed out written production in engineering is relatively demanding in terms of genre variation. Through corpus-based research and ethnographic methods carried out in disciplinary departments, the authors conclude that undergraduate engineering students produce writing tasks belonging to the thirteen genre families, which range from essays to design specifications (including exercises, explanations, research reports, reviews, proposals, among others).

The latter reflects the multidisciplinary nature of engineering "that draws on disciplines from mathematics to management" (Gardner, 2016, p. 5). In addition, research on engineering vocabulary has demonstrated that significant differences exist between the vocabulary used by groups depending on cohort and academic cycle, and even between undergraduate and graduate students (Durrant, 2016). Durrant (2014) asserts that the vocabulary used in fourth year of engineering compared with that of third year is closest to business-related vocabulary. This can be explained by the steady increase in the importance given to project management in engineering undergraduate professional cycles as well as master programs. Moreover, the available research on the report genre in an undergraduate context confirms a much greater frequency of report writing in the last years of engineering studies (Gardner and Holmes, 2009; Nesi and Gardner, 2012; Parkinson, 2013).

Based on the analysis of the HÉLICE-2017 Corpus (Sologuren, 2020), the technical report macro-genre in computer civil engineering has been defined as follows:

The genres belonging to this category share the macro-purpose of stating the state of a procedure, experimental work, state of
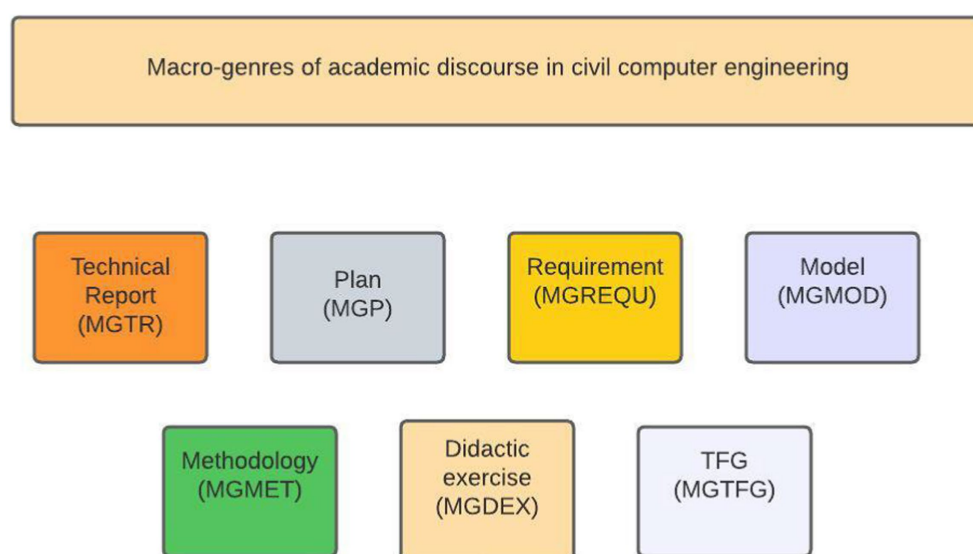

FIGURE 1
Macro-genres of academic discourse in civil computer engineering (MGEFIC).

development, or a project status. The predominant sociosemiotic process of this macro-genre is to present.

Thus, the technical report is a macro-genre exhibiting a high genre variation, and it fulfils sociodiscursive roles within a community of practice and formative contexts:

> These types of genres have as their central purpose to give an account of the state of progress of experimental work. It requires students to provide information from one or more sources, analyze such information and provide recommendations about the process developed based on the analysis (Author).

In fact, within this macro-genre, training genres converge which share writing practices aimed at (1) familiarizing students with the disciplinary concepts and methods—that is, these training genres are more of a *Pedagogical Text* (Gotti, 2014), (2) other practices focused on research writing, and (3) practices for a greater level of professionalization that prepares students for the workplace.

In this continuum represented in Figure 2, we can observe the emergence of networks of training genres or hybrid-type epistemic genres. A genre network in the terms proposed by Swales (2004) seeks to capture some notion of the current general framework or the global view more dynamically than does Bazerman's construct of genre system. Genre networks refer to broader intertextual relations between genres in a specific discipline and in a specific learning community. Ultimately, they capture genre relations, which are always dynamic and constantly evolving.

Figure 2 illustrates a genre network which is heavily academic or research-oriented. It comprises four genres approaching a completely academic pole: *Lab Report (ILAB), Algorithm Report (IAL), Research Report (INV), and Field Report (ITERR)*. However, these exhibit hybrid features characteristic of a textual space (Bhatia, 2010) that is highly dynamic due to the convergence of different disciplines, specific writing practices, and academic and professional cultures: "Expert professional writers who constantly operate within and across generic boundaries, creating new but essentially related and/or hybrid (both mixed and embedded) forms to express their 'private intentions' within socially accepted communicative practices and shared generic norms" (Bhatia, 2015, p. 23).

At the other end of the continuum there is a numerous network of non-academic, professional-oriented genres that have been updated to pedagogically-oriented versions to develop a several types of skills expected in the workplace. These seven genres are the following: *Project Report (IPRO,* see Sologuren and Venegas, 2021), *Software*

Report (ISOFT), *Assessment Report (IEVAL), Diagnostic Report (IDIAG), Consulting Report (ICON), Market Research Report (IEM), Business Analysis Report (IAN),* and *Financial Status Report (EF)*. They align not only with the applied engineering curriculum, but also with management education, finance, economy, and project management. In fact, the educational ends of these courses are in line with the following feature of the science-based engineer who graduates, recognized by Washington's agreement:

WA11: Demonstrate knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work as a member and leader in a team, to manage projects and in multi-disciplinary environments (International Engineering Alliance, 2014, p. 15).

In each of these textual spaces or constellations (Swales, 1990) which circulate at a specific time and educational cycle (terminal), the different members of the technical report macro-genre establish various types of embedding, mixing, and connection relations, whose understanding and practice allows the appropriation of the generic resources, in Bhatia's terms (2015: 24): "Appropriation of generic resources is also common in various forms of hybrids, such as mixing, embedding and bending of genres." Thus, an undergraduate engineer as a legitimate peripheral participant (Lave and Wenger, 2001) of a community of practice will have to become aware that genres do not operate in an isolated manner and that their acquisition during the learning trajectory is vital to be able to move toward positions of greater time and effort commitment within the communities of practice, and thus, to positions that build one's professional identity (Noceti and Benedetti, 2010).

Moreover, at the center of the MGITEC continuum there are three heavily-curricular genres, that is, they target "goal driven classroom activities, devoted to the accomplishment of significant educational ends" (Christie, 2002, p. 22). These are genres whose possible expert versions in the academic and professional communities are less clear; these are generic resources characteristic of institutional contexts, and they adhere to classroom discourse (Cotos and Chung, 2019) from a wide perspective.

In this manner, the case report (ICAS), the professional internship report (IPP), and the reflective report (IRREFLEX) become useful preparation for the workplace, but their focus is the application of key disciplinary concepts, work methods, and the reflection arising from real cases or professional situations. ICAS, on the other hand, can be even more hybrid: if it is part of a business analysis, it can be integrated into the genre of business analysis report (IAN), whose
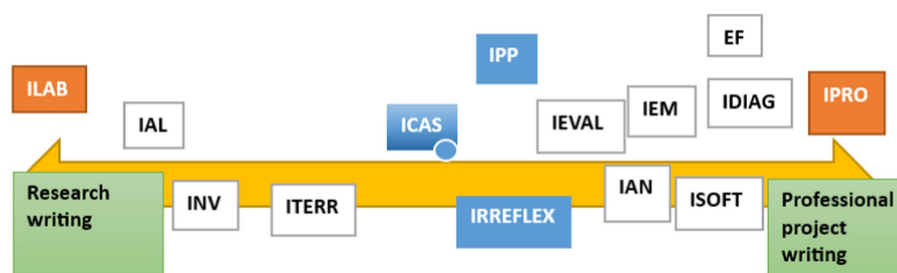

FIGURE 2
Genre continuum in the Technical Report macro-genre (MGITEC) in Civil Computer Engineering.

target is a professional audience and whose aim is to persuade the reader to make a financial decision (Yeung, 2007).

Based on these results, there are three generic subcolonies or subfamilies: (1) *research*, (2) *curricular*, and (3) *professional* each represented by the most prototypical, relevant, and frequent genre in the students' corpus. These genres, which act as nuclei in each of their networks, have been categorized within the technical report macro-genre as mesolevel type, as they share rhetorical and discursive characteristics with the members of their constellations as well as similar communicative purposes. These mesogenres allow the development of a research design, implementation, and appreciation (ILAB), the understanding of professional internships (ICAS), and the organization of an action plan (IPRO). All of this makes it possible to understand the production context of these academic training genres and their contextual relevance for the teaching of academic writing in a specific disciplinary area.

This article centers on the Laboratory Report mesogenre (ILAB). The following sections delve into this mesogenre within MGITEC by describing its rhetorical organization and its main discursive characteristics through the development of a rhetorical-functional model.

3 Methodology and corpus

This study focuses on academic writing within an engineering community of practice, an area which has not been sufficiently researched. The present research is qualitative and descriptive, based on genre's empirical analysis. The methodological proposal is based on previous studies of the same research team on other genres in the Technical Report family (Author).

The subcorpus used to develop the ILAB genre's rhetorical-functional model is made up of 112 written texts with an average word count of 2,483, and a total of 301,078 words. All the texts come from the multigenre corpus HÉLICE-2017. This ecological collection was built thanks to the contributions of 103 civil computer engineering students in their terminal undergraduate cycle, belonging to three Chilean universities of national and international prestige: Pontificia Universidad Católica de Valparaíso, Universidad Técnica Federico Santa María, and Universidad de Chile. The courses that promote the production of this genre are presented in the following section. This allows a curricular contextualization for the findings.

The texts making up the corpus are current (2015–2019), complete texts, writing tasks with a high or acceptable grade (higher than or equal to 5,5 on a scale of 7,0 as the highest grade), and part of a course plan within the terminal or professional cycle study plan. All of these characteristics make us consider them as validated by a community of experts. It should be noted that each of the voluntary participants contributing with their texts signed the corresponding informed consent that ensures the ethical treatment of the data.

For this study, we used a deductive-inductive model analysis to identify the moves and rhetorical steps making up the rhetorical-discursive organization of the identified genre (Biber et al., 2007). Move analysis was carried out through manual labeling (Upton and Connor, 2001; Wu et al., 2006; Ding, 2007; Bianchi, 2008). By applying

TABLE 1 Methodological phases for genre analysis (Manrique-Losada et al., 2019).

(i) Determine the rhetorical purpose of each genre.
(ii) Determine the function of each textual segment in its context.
(iii) Group the semantic-functional themes (steps).
(iv) Piloting the analysis in order to refine the code scheme.
(v) Develop a move and step protocol.
(vi) Code the complete set of remaining texts making up the subcorpus.
(vii) Carry out an inter-analyst validation.
(viii) Check the resulting code protocol.

the analytical steps, we achieved a description of the corpus-based discourse structure (Kanoksilapatham, 2007, 2011, 2015). Table 1 synthesizes the main methodological aspects for the genre analysis which were considered within a rhetorical discourse analysis (Manrique-Losada et al., 2019):

Textual analysis also implies a quantitative description of the corpus' rhetorical moves and steps. A move is conceptualized as a rhetorical unit carrying out a communicative purpose in a specific discursive genre, while a rhetorical step refers to a smaller rhetorical unit that allows the move to achieve its purpose (Swales, 1990, 2004). Rhetorical organization, on the other hand, is defined as "a genre's functional structure by systematizing its rhetorical-discursive units and subunits" (Burdiles, 2015, p. 190).

A macromove is understood as a larger rhetorical unit than the move, and it enables rhetorical-functional analyses in longer, unstudied texts through is unitarian shape, as in the case of the macro-genre Final Degree Report (MGTFG) (Venegas, 2010) and the thesis genre (Parodi, 2008).

This is also observed in the Technical Report macro-genre (MGITEC) which is part of our HÉLICE-2017 student corpus. It is a functional-discursive unit that exhibits a communicative macropurpose and that structurally aligns with the larger sections of a macro-genre or a specific genre (introduction, theoretical framework, results, conclusion, etc.). In this vein, for the concept of rhetorical move and for the complete genre analysis, a key notion is the communicative purpose that the members of a discursive community will aim to fulfil (Meza and Moyano, 2023).

For the segmentation and assignment of communicative purposes, some of the criteria considered are the researcher's previous knowledge, the institution's material, the existing descriptions of some genres in other languages, the empirical information coming from the observation of several microcorpora, and expert judgments. The *QSR Nvivo pro 12 software* was used for coding, which allowed the characterization and validation of the rhetorical units by the principal investigator and two annotators trained for this purpose. Table 2 details the methodological steps during data analysis:

We apply a bottom-up model that is complemented by the following specific methodological steps making up the analysis plan of this rhetorical-discursive organization (Burdiles, 2011, 2015; Manrique-Losada et al., 2019). After applying all the phases, we obtain a preliminary model of the rhetorical organization within the MGITEC family (Table 3):

For data processing, we used text editing tools (Word) and spreadsheets (Excel) for data systematization and occurrences identification.

TABLE 2 Methodological steps for data analysis.

1. Review of the existing literature to look into descriptions of some of the genres found in other languages.
2. Configuration of each genre's preliminary rhetorical-functional models with a microcorpus (33%).
3. Validation of the rhetorical-functional models with 3 engineering disciplinary experts and 2 experts on genre analysis.
4. Adjustments to the preliminary rhetorical-functional models, after the validation process.
5. Analysis of the full corpus (remaining 67%) based on the validated models.
6. Establishment of move occurrences in the corpus by distinguishing between obligatory (100-80%), very frequent conventional (79-60%), frequent usual (59%-40%), infrequent (39-20%), exceptional (19-1%) in the corpus.
7. Identification of the distinctive textual characteristics.

TABLE 3 Analysis plan for the rhetorical-discursive characterization.

1. Random selection of four samples belonging to one of the most frequent genres in the subcorpus of the technical report macrogenre MGITEC: Laboratory Report (ILAB), making sure each sample belongs to a different university, within the three universities considered in this study, so as to be balanced.
2. Incremental construction of the preliminary model based on the manual analysis of the structure and superstructure in order to identify common rhetorical organization units.
3. Definition of the rhetorical moves as genre functional sections (Swales, 1990, 2004). At this stage, we consider the concept of macromove (Parodi, 2008) defined above, which considers a particular communicative purpose.
4. Identification of the purposes of a high hierarchy level or macropurpose compared with a set of smaller communicative purposes that enable the achievement of this general purpose, which are carried out through specific rhetorical moves and detailed rhetorical steps. We used as initial guides for analysis the proposals of Swales (1990, 2004); Yang and Allison (2003); Lorés (2004); Kanoksilapatham (2007), and Parkinson (2017); all of them are proposals for the analysis of scientific research articles, except the last study which focuses on the laboratory report.
5. Application of the rhetorical discursive mesomodel to the whole subcorpus considered.
6. Validation of the moves and steps protocol through the quantitative description of their degree of occurrence. The occurrence percentage of moves are described in the general methodology section.
7. Corroboration of the rhetorical-discursive model with an expert discipline informant: in order to check and validate the rhetorical-discursive analysis, we interviewed a lecturer in the area of civil computer engineering and an expert in genre analysis.

4 Results

The following sections present the resulting rhetorical-discursive model for the ILAB mesogenre. We also analyze and exemplify the ILAB's rhetorical organization and provide a discussion of the findings, which focuses on the relations established by the different genres making up the MGITEC genre.

Writing a laboratory report not only enables the assessment laboratory work in engineering and science, but it also becomes a

TABLE 4 Civil computer engineering courses requiring ILAB.

Algorithm design and analysis	Computer networks
Computer systems workshop	Computational statistics
Scientific computing	Operations research
Introduction to data mining	Computational intelligence
Computational intelligence and robotics laboratory	Information and communication technologies
Information and communication technologies laboratory	

TABLE 5 Multimodal artifacts (Boudon and Parodi, 2014, p. 180).

Formula	Graph
Artifact built preferably from three modalities: mathematical, verbal, and typographical. The formula makes it possible to establish relations between mathematical properties or assign values in a numerical equation (180).	Artifacts that preferably combine these four modalities: verbal, graphic, mathematical, and typographical. In it, a visual summary of statistical information is represented as a picture (180).

suitable choice to communicate the findings of empirical studies (Parkinson, 2017) and situate students in their own scientific activity (Dreyfus et al., 2016).

The number of courses that require the writing of this genre in this formative cycle continues being considerable; therefore, this activity is not exclusive of the first years of the major, but it remains throughout the study plan. Table 4 shows the courses that promote this genre's update, which belong mostly to semester seven through ten:

Gardner (2012), based on data from the *BAWE* corpus, points out that the laboratory report gives greater importance to the methodology and results sections, and that, although it is a canonical *Introduction-Methods-Results-Discussion (IMRD)* structure, it is different from published academic texts. In this sense, it is important to analyze the training genres on their own merit, taking into account the social context of knowledge evaluation and demonstration.

For the disciplinary community studied, the laboratory report can account for two types of experiences: one of simulation, which implies using computer tools for system design and analysis (Markvart and Castañer, 2003; Silvestre et al., 2008); and a practical one, which involves manipulating instruments and concrete artifacts such as circuits, parts, and components of different devices. In both cases, this laboratory activity is crucial for the development of knowledge, skills, and empirical thinking modalities in engineering and sciences (Parkinson, 2017). What follows presents and exemplifies the resulting rhetorical-discursive mesomodel for *ILAB*.

The rhetorical organization of *ILAB* is made up of four macromoves, twelve moves, and seventeen steps. Each of these rhetorical units and microunits are specified in Table 5 (presented later), which details the rhetorical discursive mesomodel, as well as Table 6, which describes the identified steps, many of which are recursive or cyclical as we shall see in subsequent paragraphs.

TABLE 6 Global rhetorical organization of ILAB's MM1.

Macromove 1's rhetorical organization (MM1): Introduce the reader to the laboratory experience		
Move/Step	Communicative function	Example from the HÉLICE-2017 corpus
Move 1I: Establish the topic of the experiment/simulation		
Step 1.1: Indicating the importance	Stating the importance of the topic	a. From biology to astronomy, these systems have significantly contributed to the respective studies, leading to unprecedented advances (421-1).[1] b. Technology has acquired an across- disciplines role, fostering the quality of learning and the development of skills in society, increasing economic productivity, among others (419-3).
Step 1.2: Presenting the known information	Provide general background information	c. Image processing applications extend to multiple areas (ICI_438-2). d. that allows faster search and insertion operations in very large datasets (DCC_75-3).
Step 1.3: Outlining the structure	Present the report's organization	e. For this, we will explain the structure of an R-tree, how the insertion and search processes work, and how overflows are handled with the different algorithms (DCC_75-3). f. The most relevant results of the training, validation, and testing process will be presented, along with the subsequent analyses and conclusions (420-5).
Move 2I: Advance a hypothesis		
Move 3I: Introduce the experiment		
Step 3.1: Establishing the purpose	Indicate the aim of the experiment	g. The aim of this Laboratory Activity is to implement and analyze simple algorithms of movement detection and object tracking (438-2). h. This report's aim is to present in detail task 1's resolution process, which consists in creating and comparing two algorithms (or heuristics) used in an R-tree construction (DCC_75-3).

[1]The first number identifies the document in the student corpus, and the second number corresponds to the page from where the textual evidence is extracted.

Now we will outline the resulting functional organization of this Mesogenre[1] which exhibits an *I-M-R-C* rhetorical sequence: *Introduction-Methods-Results and Conclusion*, combining a sequential display of rhetorical moves with iterations *from* and *to* methodology's rhetorical macromove 2 (MM2), given the centrality of this section in the analyzed texts. In this manner, we can assert that this MM2 constitutes the nuclear macromove (Figure 3):

In fact, the methodology's rhetorical macromove (MM2), "*Presenting background and methodological procedures*" are highly dynamic, due to the recursiveness of its rhetorical steps and its functional flexibility. This cyclic property was considered in the reformulation of Swales' *CARS* model (2004), and it means a move or step can occur again in other text sections or macromoves, as they are conceptualized in this research.

This dynamic nature is relevant for laboratory reports, as this section or macromove in the scientific discourse works as an epicenter: "It is an explicit bridge between the review of relevant literature and the newly-obtained results" (Cotos et al., 2017, p. 92). This epicentric character accounts for the emphasis the discipline gives to methodology, which aligns with what professors and students express in Chapter 7 in relation to the writing of the MET microgenre.

Another element that is worth pointing out relates to the use of multimodal artifacts to achieve the communicative purposes of this academic training genre. In fact, as demonstrated by Castro-Alonso and Fiorella (2019), visual–spatial processing is very important not only for the area of health sciences (such as medicine, anatomy, surgery, dentistry), but also for the natural sciences (such as biology, chemistry, physic, geology, meteorology), which are present in the curricula and the problems of applied engineering. Moreover, the role played by multimodal artifacts has been highlighted in economics discourse (Parodi and Julio, 2017).

The multimodal artifacts found in the ILAB subcorpus are the formula and the graph. For the academic discourse of economics, Boudon and Parodi (2014) define these artifacts as follows:

Thus, based on these starting-point definitions, new research cycles on the student writing corpus collected for this project should look into the function of these rhetorical devices in different text display patterns, for example, in the problem-solution types (Hoey, 1983), which are frequent in the engineering academic discourse. Based on the analysis of the 112 texts making up the subcorpus, Table 7 shows the frequency of rhetorical moves and steps:

As we can see, six of the twelve moves are obligatory (80% or more) and the remaining six moves are very frequent conventional (between 60 and 79%) or frequent usual (40% and more). Regarding steps, ten out seventeen are obligatory, four are frequent conventional, one frequent usual, and two infrequent. Tables 6, 8 show the communicative functions determined for the moves and steps of each ILAB genre's macromove, based on the HÉLICE-2017 corpus analysis. It is therefore a model of communicative purposes. Moreover, each rhetorical step example shows the lexicogrammatical clues that allow the manual corpus annotations.

Move 3I, which is obligatory, oscillates between stating the objective from the point of view of a researcher writer or from the

1 Obligatory rhetorical moves are highlighted in pink.

TABLE 7 Moves and steps of the ILAB Mesogenre.

IMRC moves and steps	Frequency
Move 1I: establish the topic of the experiment/simulation	**96**
Step 1.1: Establishing the importance	66
Step 1.2: Presenting the known information	100
Step 1.3: Outlining the structure	85
Move 2I: Advance a hypothesis	**61**
Move 3I: Introduce the experiment	**100**
Step 3.1: Establishing the purpose	72
Move 1M: Restate the topic of the experiment/simulation	**73**
Step 1.1: Presenting the known information	100
Move 2M: Describe the inquiry problem	**100**
Step 2.1: Establishing the relation with the specialized literature	84
Step 2.2: Presenting the background to address the procedure	100
Move 3M: Specify experimental procedures	**93**
Step 3.1: Listing the materials	67
Step 3.2: Detail of procedures	100
Step 3.3: Visualization of procedure through a diagram or formula	76
Move 4M: Detail statistical and data analysis procedures	**69**
Move 1R: Announce results	**100**
Step 1.1: Justification of the methodology	36
Step 1.2: Focusing results	100
Step 1.3: Display/visualization of results through figures, tables, and graphs	100
Step 1.4: Calculation of results and/or development of equations	87
Move 2R: Comment and discuss results	**74**
Step 2.1: Explanation of results	100
Move 1C: Synthetize the inquiry problem in the laboratory experience	**77**
Move 2C: Evaluate the laboratory experience	**73**
Move 3C: Present the implications of results and findings	**80**
Step 3.1: Establishing limitations	55
Step 3.2: Indicating suggestion for improvement	43

point of view of the student's learning activity (examples *a* and *b*). This illustrates the social formative (training) purpose of this genre and the organization texts adopt to situate the experimental work of the civil computer engineering student (Tables 9, 10).

5 Discussions and conclusion

The rhetorical-discursive model presented shows a hybrid form of the laboratory report genre in civil computer engineering education. In fact, the analysis of its rhetorical organization evidences both its curricular writing and its research writing nature. An example of the latter is the display of macromove 3: "*Report results of the laboratory experience.*" In this vein, it is a genre of the Technical Report family which is very close to the academic forms of communication, as it can be seen in the rhetorical organization of macromove 2: "*Present background and methodological procedures.*" Thus, MM2's rhetorical steps aim at the development of research and interpretation tools: description, justification, definition, visualization, and explanation; in contrast, MM3's steps aim at the development of application, synthesis, and integration in academic contexts. It implies, therefore, the design, implementation, and appreciation of simulated or physical experiences that make it possible to contrast hypotheses about relevant scientific phenomena.

The laboratory report genre thus becomes an implementation genre fulfilling a role of polar nucleus within the Technical Report family or macro-genre. This is because it consists of a composition task that combines elements that are typical of research writing with others typical of curricular writing, and in so doing, it develops diverse higher-order cognitive skills in engineering students. This mixture and polarity within the continuum makes it a relevant discursive practice in engineering education, which can be developed in depth and also assessed in engineering classrooms. In this way, students will be able to apply strategies to adapt writing to a more investigative or applied context and transfer their rhetorical knowledge in the production of new specialized genres. Table 11 shows this hybrid nature and educational potential:

ILAB is then situated in the research writing pole, and in this sense, it aligns more prototypically with the curricular activities of the engineering classroom. Figure 4 shows the location of ILAB within the macrogeneric family as a mesogenre oriented toward developing experimental research:

In fact, this mesogenre defines and projects to a great extent the discursive performance of students in this cycle as advanced writers: "I would like to call it 'discursive performance', which extends the scope of analysis from genres as discursive product to professional practice that all discursive acts tend to accomplish" (Bhatia, 2016b, pp. 21–22). Thus, from an area of the discipline's nucleus, the circulation context is clearly scientific, but at the same time it is an evaluation academic genre (Jarpa, 2016) that establishes different discursive trajectories with other genres in the university classroom. For example, with the "scientific research article" that reports the results of an experimental inquiry or with "methodological accounts" that propose experimental designs to address various problems around study.

In the same manner, these discursive trajectories (Sabaj, 2017) are displayed during the writing process in different stages and parts of a genre (Breeze, 2016) as it can be seen in the corroboration interview carried out with the program's lecturers:

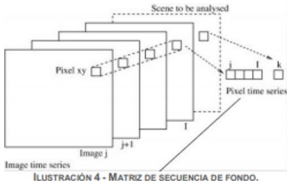TABLE 8 Global rhetorical organization of ILAB's MM2.

Macromove 2's rhetorical organization (MM2): Presenting background and methodological procedures		
Move/Step	Communicative function	Example from the HÉLICE-2017 corpus
Move 1M: Restate the topic of the experiment/simulation		
Step 1.1: Presenting known information	Provide information available in the specialized literature	i. The frame difference motion detection algorithm is one of the simplest detection methods (438-3). j. An artificial neural network is defined as a "linear mapping system, whose structure is based on principles observed in human and animal nervous systems." (419-5).
Move 2M: Describe the inquiry problem		
Step 2.1: Establishing the relation with the specialized literature	Link the experience with the specialized bibliography	k. The concept of linear separability of sets can be seen in Illustration 2 (420). l. Gradient descent algorithm [2] The present method used in neural network training defines a function that is given by the system error, which depends on the synaptic weights that make it up (421).
Step 2.2: Presenting the background information to address the procedure	Present preparatory information needed to carry out the experiment	m. Now, it should be noted that the weights variations in each training adjustment is represented by the learning rate α, which, if it is too small, it will imply the algorithm's low convergence speed. In contrast, if it is large, oscillatory effects will appear in the convergence (420-10). n. The general structure of the convolutional network for the present experience is the following (421).
Move 3M: Specify experimental procedures		
Step 3.1: Listing the materials	Listing the necessary materials	ñ. Cisco Catalyst 3,650: • Switching capacity: 88 Gbps • Stack bandwidth: 160 Gbps • Total number of MAC addresses: 32000 • Total number of IPv4 routes: 24000 • DRAM: 4 Gb • Flash: 2 Gb • Total switched virtual interfaces (SVIs): 1000 • Total routed ports per 3,650 stack: 208 • Number of access points per switch/stack: 25 • Number of wireless clients per switch/stack: 1000 (206-3) o. HP 3800-24G-2SFP+: • Processor: HP ProVision ASIC/ARM @ 350 MHz • Flash: 4 GB • SDRAM: 2 GB • Packet buffer size: 18 MB dynamic • Latency 1,000 Mb: <2.8 microseconds (64 Bytes packs) • Latency 10 Gb/s: <1.9 microsegundos (64 Bytes packs) • Performance: over 65.4 million packs per second (64 Bytes packs) • Switching capacity: 88 Gb/s • IPv4 Routing table size: 10000 • MAC address table size: 65500 (207-4).
Step 3.2: Detailing the procedure	Present the procedures needed for the experiment.	p. In this algorithm, a background model is developed by calculating the mean and standard deviation of an image set for the same pixel, so the algorithm learns to recognize the scene's background (438-7). q. When the optimization process of a neural network's costs function deviates from the established criteria, it must be penalized so as to correct the algorithm, in the weight update (420-9).

(Continued)

"We do have the concept of *writing reports* when we have to submit something. That is very present, even from the beginning with basic sciences courses. In all the physics laboratories, for example, the student has to write a *pre-report* and a *post-report* after [the laboratory] experience." (P06_ICI_10-6)

"…and they iterate that *report from the beginning of the semester, and they have three iterations.* Then in the first one they do a smaller version, in the second one they improve that text and explore a *new part of the document,* and in the third one they improve all the previous work and submit a final part as result." (P05_ICI_12-7)

TABLE 8 (Continued)

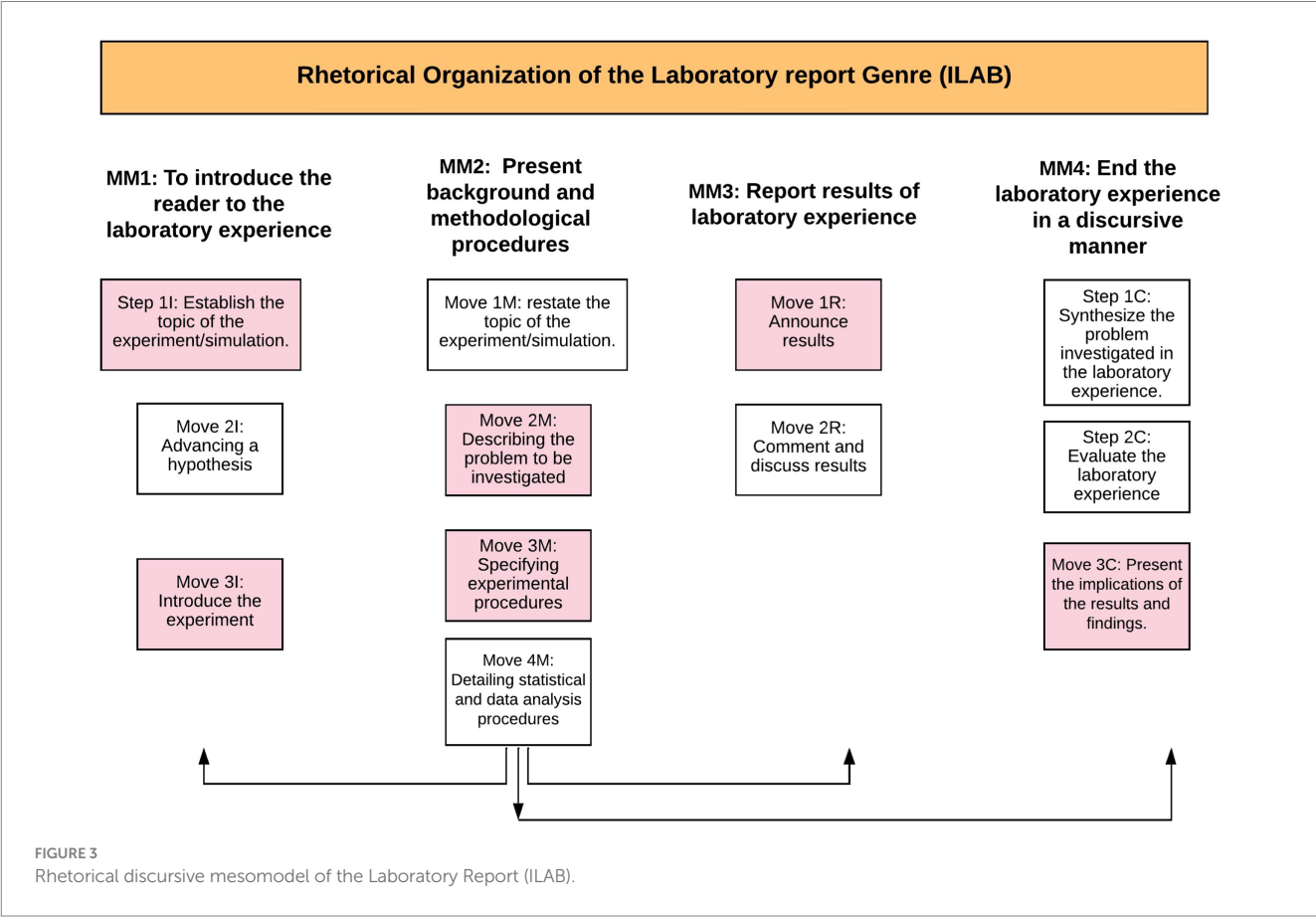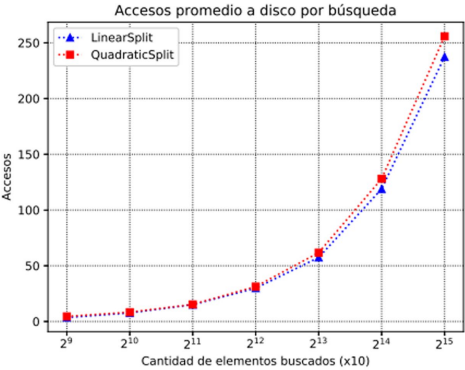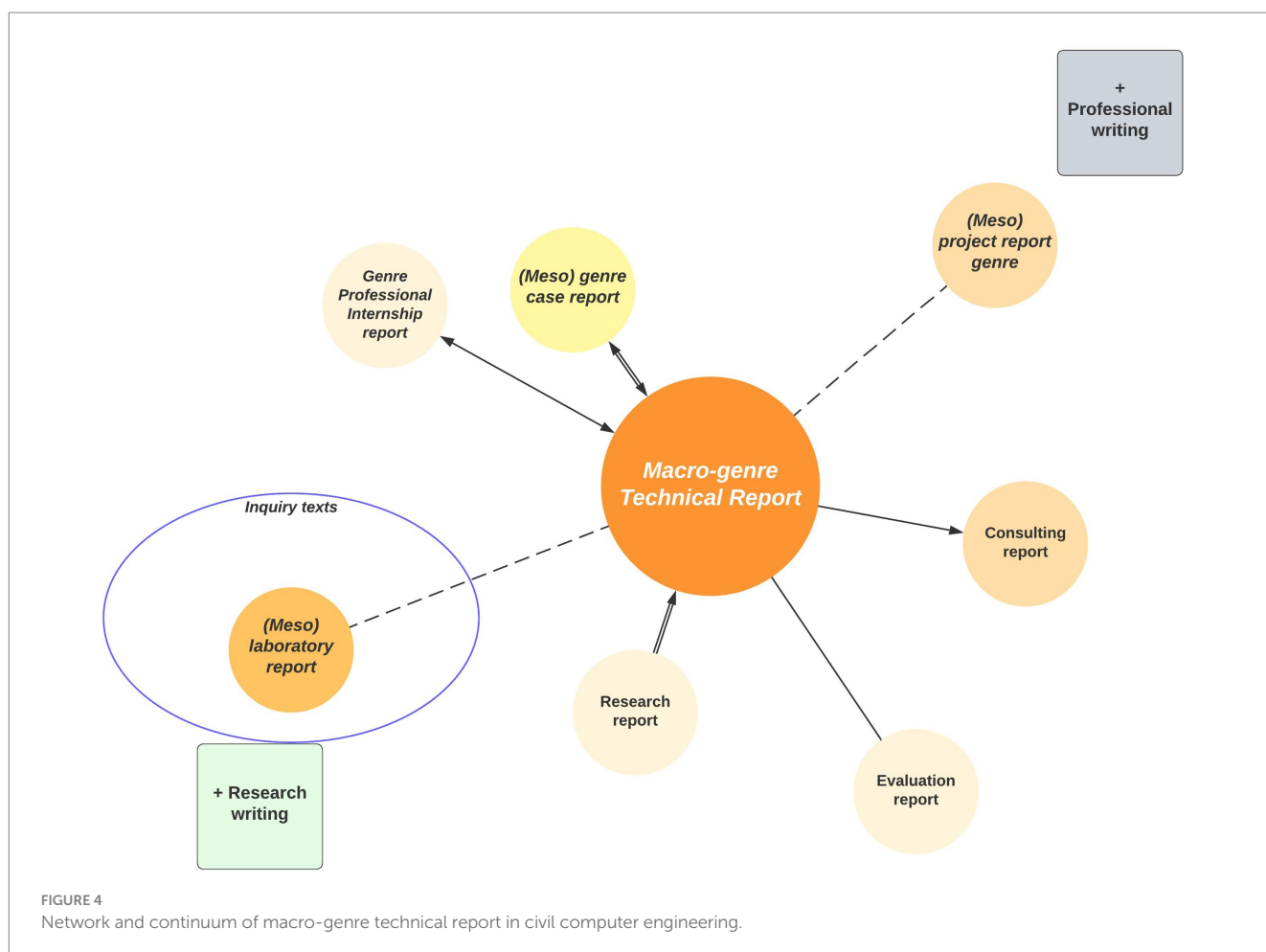| Macromove 2's rhetorical organization (MM2): Presenting background and methodological procedures		
Move/Step	Communicative function	Example from the HÉLICE-2017 corpus
Step 3.3: Visualizing the procedure through diagram or formula	Graphically Project methods and procedures implied in the experiment or simulation	r. En síntesis, y en términos matemáticos, el algoritmo backpropagation queda expresado a través de las ecuaciones *Ecuación 3 y 4*: $$w_{ji}(t+1) = w_{ji}(t) + |\alpha \delta_{pj} y_{pj} + \beta \Delta w_{ji}(t)|$$ ECUACIÓN 3 - ALGORITMO DE ENTRENAMIENTO BACKPROPAGATION. $$\delta_{pj} = \begin{cases} (d_{pj} - y_{pj}) f'_j(h_j) & \text{si } j \text{ es una neurona de salida} \\ \left(\sum_k \delta_{pk} w_{kj}\right) f'_j(h_j) & \text{si } j \text{ es una neurona oculta} \end{cases}$$ ECUACIÓN 4 - DEFINICIÓN DE FUNCIÓN AUXILIAR PARA ALGORITMO DE ENTRENAMIENTO BACKPROPAGATION. (420-9). s. ILUSTRACIÓN 4 - MATRIZ DE SECUENCIA DE FONDO. (438-7).
Move 4M: Detailing statistical and data analysis procedures		

FIGURE 3

Rhetorical discursive mesomodel of the Laboratory Report (ILAB).

TABLE 9 Global rhetorical organization of ILAB's MM3.

Macromove 3's rhetorical organization (MM3): Report results of the laboratory experience		
Move/Step	Communicative function	Example from the HÉLICE-2017 corpus
Move 1R: Announce results		
Step 1.1: Justifying the methodology	Explain methodological decisions	t. The inclusion of the bias gradient per layer, weight gradient per layer, evolution accuracy, and costs evolution graphs will allow the analysis of the effects of the variations carried out (421-8). u. The detection of object dynamics in the frames through the present algorithm presents greater robustness facing external noise, although the difference criterion is used with an associated threshold (438-7).
Step 1.2: Focusing results	Highlight obtained results	v. As it can be observed in Results 7, the average Matrix of the sequence of background images is able to establish a robust frame of reference (438-10). w. As part of the obtained results, Figure 1 shows that as the number of inserted elements increases, the difference in insertion times (ms) applying LinearSplit and QuadraticSplit, also increases (75-15).
Step 1.3: Display/visualization of results through figures, tables, and graphs	Represent experiment findings	x. Figura 5: Gráfico comparativo de cantidad de elementos vs numero de accesos a disco por búsqueda en R-Trees de distintos tamaños utilizando LinearSplit y QuadraticSplit (75-14) y. (420-14).
Step 1.4: Calculating results and/or presenting equations	Calculate to obtain quantitative data	z. the optimal number of units is established in the hidden layer, which makes it possible to obtain the maximum average percentage of classifications, 50. This is supported by Función 4 (420-16). aa. $$x(t) = x(t-1) + 0.5(x(t-1) - x(t-2))$$ $$y(t) = y(t-1) + 0.5(y(t-1) - y(t-2))$$ FUNCIÓN 4 - ESTIMACIÓN DE MOVIMIENTO (438-13).
Move 2R: Comment and discuss results		
Step 2.1: Explaining results	Provide a coherent explanation of the obtained results	bb. This is because the neural network's optimization process deviates from the established criteria, so the weight updates are penalized and the number of epochs increases (420-17). cc. Based on the experiences carried out, we are able to determine that a convolutional neural network classifies with a greater accuracy and lower associated costs than one with a multilayer perceptron, both in the training and classification periods (421-15).

FIGURE 4
Network and continuum of macro-genre technical report in civil computer engineering.

Therefore, each genre becomes a phase in the genre chain (Swales, 2004) which will enable the fulfillment of the communicative macropurposes with a specific chronological order. It is a genre with considerable internal variability in terms of themes, argumentation and analysis procedures, as well as ways to address the issue; moreover, it shows various possible rhetorical move and step combinations that can be updated, since it is a genre with only six obligatory moves out of twelve, which are also distinctively cyclic (as can be seen in Figure 3). The latter makes it more flexible and adaptable for formative and academic needs, and it also makes the genre suitable for combination with other types of reports in the technical report family. In addition, the various multimodal resources such as graphs, formulas, and tables play a key role in this genre, to the extent that many times they become rhetorical steps or tactical cognitive strategies of the student-writer. Es decir, queda en evidencia que las funciones comunicativas de las unidades retóricas se pueden expresar no solamente vía recursos lingüísticos, sino que también a través de otros modos de construcción del significado como el tipográfico, matemático y visual. Los recursos multimodales son por tanto parte esencial del género.

However, the corpus analysis shows the tendency to emphasize the methodology and results sections of the practical experience or simulation. In fact, the rhetorical moves of the discussion and conclusion sections have a lower frequency than the central moves involving the presentation of results. The analyzed texts tend not to signal the closing generic stage. In this sense, we observe a tendency toward fragmentation in laboratory report writing, where the emphasis is put on the presentation of the experiment or virtual simulation results. This weakness in the creation of the discussion section is expressed by the professors as one of their students' writing difficulties. Nevertheless, this concern does not lead to an action or concrete initiative to address this issue in the professors' discourses. Thus, the development of critical thinking skills becomes an interesting future direction to inform the curricular innovation processes in undergraduate engineering.

Our research objective was to describe the rhetorical organization of this training genre in a key engineering subdiscipline. This research significantly contributed to the study of the rhetorical-discursive sphere in the Spanish language, and consequently, to the description of a discursive genre typical of an engineering disciplinary area. In so doing, the study contributes to complete the genre mapping of disciplinary discourses. Moreover, in terms of projections, the next step will be to relate the discursive rhetorical units with the preferred lexicogrammatical resources, contributing to the development of local grammars. Another important aspect is to promote the transfer of this new rhetorical knowledge to pedagogical devices and teach hybrid genres that combine curricular and reflective writing with the kind of writing expected in academic and professional settings, as it occurs in the laboratory report.

TABLE 10 Global rhetorical organization of ILAB's MM4.

Rhetorical organization of macromove 4 (MM4): End the laboratory experience in a discursive manner		
Move/step	Communicative function	Example from the HÉLICE-2017 corpus
Move 1C: Synthesizing the inquiry problem in the laboratory experience		
Move 2C: Evaluate the laboratory experience		
Move 3C: Present the implications of results and findings		
Step 3.1: Establishing limitations	Identify the study's limitations	dd. Even when these uniformity conditions are not always met, the delivered estimations are adequate, taking into consideration the simplicity of the implemented methods (438-15). ee. However, it has some disadvantages that ranked them below dynamic routes. • They are not easy to implement in a large network. • Handling the static configurations can become tedious when the network begins to grow. • If a link fails, static routing cannot redirect traffic (206-19).
Step 3.2: Indicating suggestions for improvement	Identify improvements that can be applied	ff. Other points to take into account when choosing RIP over a static routing is route search speed and the handling of redundancy (broken links and redirection (206-19)]. gg. it is important that each of the components of the robotic system is in good condition, since with them the processes of data acquisition, processing, and decision-making will be carried out (434-10).

TABLE 11 Rhetorical step that states the writing purposes of laboratory reports.

ILAB
Step 3.1: Establishing the purpose
g. The objective of this Laboratory Activity is implementing and analyzing simple algorithms of movement detection and object tracking (438-2).

Finally, another projection of this research will be to systematically relate the teaching-learning methodologies of the civil computer engineering classroom, in which the production of texts (e.g., training genres produced and used as well as the associated writing tasks to produce those genres) is relevant for the achievement of relevant disciplinary learning outcomes. The in-depth study of this pedagogical-curricular triad is needed to understand the role of this genre in text comprehension and production processes, the cognitive demands it mobilizes, the writing purposes in academic and professional settings, and the degree of connection it has with tasks considered as of highest relevance in the professional career.

In this sense, these variables should be added to the study of texts in Spanish. Writing in the 21st century, as Montolío (2019) asserts, implies knowledge transfer, and the linguistic work—particularly of applied linguistics—has the challenge of linking its expert work to the challenges of current society. As discursive genre analysts, we should respond to the challenges implied in the formulation and resolution of problems linked to the comprehension and production of texts in relevant areas for current communities.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the author, without undue reservation.

Ethics statement

The studies involving humans were approved by Comité ético-científico CEC Universidad de Los Andes, Chile (Scientific and Ethical Committee CEC Universidad de Los Andes, Chile). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

ES: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Visualization, Writing – original draft, Writing – review & editing.

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The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The influence of transmedia and extra-academic narratives on the formation of the historical culture of high school students

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This paper concerns with the importance of traditional and extra-academic sources of knowledge in the configuration of historical culture of Spanish adolescents. To conduct the research, a descriptive phenomenological approach has been designed by analyzing the responses of forty-eight students to a semi-structured interview in which they had to choose 5 characters of contemporary history and indicate the origin of the information. The results show the high coincidence about who are historical significant characters: males and politicians, coincident with other studies conducted in Spain and other countries of the near sociocultural context. The degree of coincidence can be considered as a homogeneous image of the historical culture of the participants. In that sense, there is a high rate of coincidence in the source where this vision of history is mainly generated: the history classroom. The information obtained leads us to confirm the need to reflect on the important stereotypes generated after many decades of formal history teaching with contents far from a necessary critical review. For this reason, it is necessary to reorient the teaching of history to provide a better critical reasoning about how the past is used to understand current societies (ontological perspective) along with how we know about the past (epistemological perspective).

1 Introduction

For at least three decades, the omnipresence of new technologies and the influence of mass media have brought about significant changes in the societies of traditionally Western cultural countries (Abylkassymova et al., 2019).

One of the areas in which the influence of the mass media can be clearly seen is education: the ease with which every student has access to an enormous amount of information means that, in many cases, informal learning, which is not always adequate, competes with the teachings offered in the formal educational environment (Martín-Barbero, 2001; Souto-Otero, 2021) and becomes mediatized. Recent studies, such as that of Scolari et al. (2020), have shown that the channels of knowledge in the 21st century are not exclusively educational centers and teachers, but that others have gained great relevance, as in the case of transmedia narratives, a recently coined term that alludes to the possibilities of informal learning through different channels where anyone can create and upload their own explanatory materials (YouTube, Google, Wikipedia, TikTok, among others).

In this line, the subject of history serves as a perfect example to measure these issues. This discipline is not only present in all secondary education courses, but also plays an important role in various non-academic channels, such as cinema, radio, television, comics, websites, social networks, etc. This high presence in informal media contrasts with the low motivation that the subject usually shows at the academic level (Fuentes Moreno, 2003; Prats Cuevas, 2017). As a result, in recent decades and in many Western countries, there has been a broad debate about what history should be taught and how it should be taught.

In terms of the characteristics of the approach to historical knowledge, informal and non-academic contexts are becoming increasingly important, leading to a "decentering and spreading of knowledge" (Martín-Barbero, 2001). Decentralization means that much of the knowledge displayed by today's students is produced outside the traditional academic environment. Various studies have shown the presence of historical content in high consumption products such as films, series, video games, novels, comics, etc (Barton, 2008; de Groot, 2018). Their viewing or mass consumption plays a key role in the formation of people's historical culture, which is complemented by the influence of the immediate environment (family members, ascription groups) as well as tourism (visits to museums, interpretation centers, etc.).

All these elements are undoubtedly key to the conceptions that students bring to the subject of history in the academic environment, to which we must add the idea of a participatory historical culture (Grever and Adriaansen, 2019), which fits perfectly with the notion of collaboration and interaction that today's societies demand and that digital resources make possible. The great success of platforms such as Google, Wikipedia, TikTok, YouTube, etc., which allow users not only to consume content but also to create it themselves, is framed in this context; this is what we call transmedia. Transmedia literacy refers to the abilities, skills, competencies, and both social and cultural skills needed to perform adequately in today's digital media (González Martínez et al., 2018). Within this, transmedia narratives (*narrative storytelling*) have been defined by researchers such as Jenkins (2008), p. 31 as a new aesthetic that has emerged in response to the convergence of media, which depends on the active participation of knowledge communities and is developed through multiple media platforms, with each new text making a specific and valuable contribution to the whole.

Scolari (2019), for his part, defines transmedia narratives as a type of storytelling in which the story unfolds through multiple media and communication platforms, and in which part of the consumers take an active role in this expansion process. The same researcher has launched an extensive project on literacy and transmedia narratives, in which the uses and skills of adolescents in digital media are studied in formal and informal contexts, in a way that has begun to develop the connections of the digital world with the educational field (Scolari et al., 2020). Along the same lines, there are other studies that work with *transmedia narratives* related to citizenship education (Jover Olmeda et al., 2015), linguistics (Freire, 2020), working with media in the classroom (Scolari, 2018), or literature (Jenkins et al., 2013). All these studies, and others, such as those analyzed in the article of Meyerhofer-Parra and González-Martínez (2023) about the use of transmedia storytelling, are just an example of the pedagogical possibilities offered by the new transmedia concepts in the field of education, which should

be taken into account in the formal field for the formation of competent and responsible citizens of the 21st century.

All these challenges, together with the demands of today's students for a more active role, seem to justify the gap between school history and young people, since history has usually been presented as an educational subject in which only the transmissive and unidirectional model ("knower-teacher/learner-student") has a place. However, engagement with these more dynamic or motivating resources does not necessarily imply more critical or different learning in terms of construction of meaning if it is not accompanied by a challenge to the narratives created in the school environment. And indeed, preliminary studies seem to point in the direction that the new digital resources do not contradict or challenge such narratives (Luyt, 2011).

In bearing in mind all these aspects, it is worth asking whether it is possible that transmedia narratives and informal channels controlled by non-educators have gained such importance among today's youth that they have become the most useful and valid source of information in their historical cultural formation. That situation drives us to rise our research question: Which are the influence of formal and informal education in the construction of historical knowledge? By supplementing this question, some several auxilliar research questions emerge, such as Who are the relevant characters of history to students? Where do the students obtain information about those characters? Therefore, the main objective of this research is to analyze the influence of formal and informal education in the construction of historical knowledge. This objective is concretized into two specific objects: (1) To identify the most cited historical characters and events of world Contemporary History; (2) To describe the sources from which they have extracted the information for the construction of this historical knowledge in students in the last stages of pre-university education. To carry out the research, a case study has been conducted in a public secondary school in the city of Murcia (Spain) with forty-eight students from the 4th secondary school (ESO) and the 2nd high school (baccalaureate), the results of which are presented in this article.

2 Materials and methods

2.1 Participants

The fieldwork was carried out in a public secondary school in the northern part of the city of Murcia (Spain), which is more than thirty years old and located in a neighborhood with a medium socioeconomic and cultural level. About 10% of the students are immigrants, mainly from North Africa, Latin America, and Eastern Europe. The more than 600 students are divided into compulsory secondary education (ESO) with multilingual options in English and French, Baccalaureate (including the research program) and Training and Development Studies (T&D).

It was decided to have a purposive sample of these students, selected on the basis of the objectives set in this research; therefore, students belonging to 4th ESO and 2nd year of Baccalaureate of any educational modality were selected. Students in the 4th grade receive the subject "History of the Contemporary World," which includes content related to universal and Spanish history since

the 18th century. In the 2nd year of the Baccalaureate, they take "History of Spain," a subject that ranges from prehistory to the democratic transition and the Constitution of 1978.

Participation was voluntary and a total of 48 complete responses were obtained, of which 25 are in the 2nd year of Baccalaureate and 23 are in the 4th year of ESO. Almost all of them (46) belong to bilingual (English) or multilingual (English and French) groups.

2.2 Instruments

The information was collected through direct and personal interviews with the students selected for this study. This technique is of great importance in the field of educational research because it makes it possible to give meaning to the data obtained, to categorize them (both the data and the interviewees) and to facilitate the nuances of the answers given (Gibbs, 2018). The interviews were organized in a semi-structured manner, with a first question in which the participant had to select 5 figures from contemporary history that he/she considered relevant. The next step was to clarify the origin of the information that had led him/her to select each of the characters. To do this, the respondent had to select the sources of information from 5 possible categories and rate them between 1 and 10 (1 being "not at all" and 10 being "totally"), as shown in the example in **Table 1**.

As can be seen, the first category ("History classes at my school or high school") corresponds to formal or academic sources of information, while the remaining categories are related to informal or extra-academic contexts. Finally, interviewers were asked to explain their answers.

2.3 Procedure

Considering the proposed objectives, a qualitative and quantitative research methodology is established, a mixed approach that combines the strengths of each in both data collection and analysis (Sammons and Davies, 2017; Rodríguez and Rubia, 2021). This methodology has a broad consensus in the scientific community because "the amalgamation (not just the sum) of quantitative and qualitative data in the same design or research method, is something new, with great potential for more complete studies" (Ramirez-Montoya and Lugo-Ocando, 2020, p. 18).

Other authors, such as Schuster et al. (2013), defend this model in educational research for its validity in exploring aspects such as the search for conclusions about the teaching-learning

process, about educational reality (whose protagonists are mainly teachers and students), the evaluation of the impact of a particular methodology, or the contribution that this type of research can make to understanding the socio-cultural characteristics of the educational environment.

Lastly, the research is framed within a phenomenological approach of a descriptive type, with which a description has been made of the answers obtained by the participating students in relation to the origin of their knowledge and their experiences have been identified. This approach allows describing the study phenomenon by reflecting the reality lived by people in their context and individuality and using some instruments such as the survey or the interview (Fuster Guillen, 2019).

Responses were collected on an Excel spreadsheet, and after the five categories were rated, a brief conversation was held with the student to clarify the responses. For example, if they gave a rating above "1" to the category "History classes at my school or high school," they were asked about the course in which they received this information or the content topic to which they related it. In any case, it was an open interview in which the student was free to express, qualify and/or expand the data collected in the questionnaire; at the same time, it allowed the researcher to relate the responses to the previously established categories and even ask new questions to clarify the data (Valles, 2003; Vargas, 2012). The answers were transcribed on the spot by the researcher.

Therefore, the entire data collection can be framed within what Jansen (2010) calls "pre-structured or deductive surveys," in which the categories have been previously defined and, therefore, the diversity expected to be found, with the goal of the research being to observe which of the predefined categories were found in the study population.

3 Results

The participants in the study selected a total of 86 personalities out of the 240 possible options, which represents a high level of saturation in the identification of characters. That is, with only 35.8% of the exclusive cases that could be selected by the students, the total number of answers given by the students (240) was covered. Among them are the 9 personalities with the highest number of choices, representing 52.34% of the total (123 out of 235), as shown in **Table 2**.

It seems evident that political and scientific issues have prevailed in the choice of these personalities.

The relative index of each personality in relation to each of the sources of information has been analyzed (**Table 3**). The percentage

TABLE 1 Example of information source categories and their rating.

Person 1. The information I have was obtained from:	1	2	3	4	5	6	7	8	9	10
The history classes at my school or high school.									x	
My personal and social environment (family, friends, etc.).				x						
Historical fiction (novels, series, movies, comics, etc.).	x									
Technological media (internet, social networks).					x					
Museums, exhibitions, tourist visits, etc.	x									

Own elaboration.

TABLE 2 Most selected personalities.

	Personality	Amount
1	Adolf Hitler	27
2	Napoleon	24
3	Albert Einstein	15
4	Francisco Franco	12
5	Marie Curie	11
6	Nelson Mandela	10
7	Charles Darwin	8
8	Christopher Columbus	8
9	Karl Marx	8
	Total	123

Own elaboration.

value of each personality was obtained by taking into account the maximum score that could be obtained by each of them in each of the information sources, taking into account that the maximum value for each one was 10. Consequently, the maximum value for a person chosen, for example, on 5 occasions would be 50 in each source. Therefore, if he or she obtained 25 points, he or she would get an index of 50%. Following this criterion, Table 3 shows the average value of the percentages obtained by the personality in each of the origins. Thus, we can see that the highest value is in "school," the lowest is in "visits," and the remaining values are quite similar. This indicates that the origin "school" is the most valued, globally, for all the characters selected by the respondents.

This tendency is maintained if we analyze these selected individuals a greater number of times. In Table 4 (the overall position in the origin is indicated in brackets if it is below the first nine), we can see how the origin "school" clearly dominates for these personalities as the main origin to obtain information about them, which is also confirmed by the clarifications collected in the interviews: "I studied him in the 4th ESO" (reg. 203), "in the subject of Ferdinand VII" (reg. 215), "in works on characters in the subject of Physics and Chemistry," "in the English book on historical characters" (reg. 201), or "in Baccalaureate in subjects such as the French Revolution" (reg. 205), are some of the answers obtained for the characters selected on a greater number of occasions.

The exceptions are Hitler and Franco. In the case of the German leader, we can see that his presence is easily traceable in all the areas analyzed. Perhaps the "fiction" source stands out a bit, but in short, his presence is recurrent in all areas. Franco's presence, on the other hand, stands out for its moderate score in almost all areas, except perhaps in "Environment." He is a figure who, despite his continuous frequency, does not seem to have a very prominent profile. It is only in the family environment that access to the figure shows a prominent element, which is also clarified in the interviews:

"My grandfather talked to me about him, he used to talk to me a lot" (reg. 418), "in family conversations where politics are discussed, Francoism is talked about quite a lot, comparing it with the present" (reg. 211), "my grandparents and great-grandparents told me that they were affected in the post-war period" (reg. 208).

Moreover, the decision to consider only "school" as a source of knowledge was reinforced by the students' responses in the interviews. They were asked to be as specific as possible about the origin of the information they provided. Well, none of the respondents, when identifying the provenances of "fiction," "environment" or "new technologies," referred to any website, blog, broadcast, document, person or collective that could be considered a reliable and rigorous source of information, as can be seen in these examples of responses: "I have seen documentaries from *La 2* [a Spanish TV channel]" (reg. 421, reg. 419, reg. 221), "A video game that recreates the Battle of Waterloo" (reg. 225), "I had seen something about him in recommended Instagram and YouTube posts" (reg. 414), "In the series The Simpsons" (reg. 210).

Similarly, those who identified the source as "visits" were not able to name almost any museum, monument, or specific place, nor did they identify any of them as a possible primary source of knowledge. Some examples: "On a trip to Germany they explained to me many things about his life" (reg. 212), "In Paris I made visits in which this figure was named" (reg. 414), or "I visited some museums in which there were paintings about him" (reg. 409). However, we can see a consistency in the fact that personalities that are not usually included in school curricula, such as Steve Jobs, Paco Gento, or drug traffickers such as "Chapo Guzmán," etc., are rated very highly by students in the areas of "fiction or social networks" (values above 80% on average) and very low in "school" (percentages below 30%). In the same way, figures such as Malala Yousafzai, Xi Jinping, Ursula von der Leyen do not score high in the area of "school" (usually below 10%) and high in "new technologies" (above 90%), as some answers in the interviews show: "YouTube videos after the Nobel Prize" (reg. 421), "videos from the *VisualPolitik* channel" (reg. 203), "on Twitter and Instagram channels" (reg. 205, reg. 219, reg. 407), "on the Narcos series" (reg. 403, reg. 415, reg. 418).

Another rating that increases the importance of the "school" source in relation to the others is the number of times it was selected as the main source of the characters' knowledge, as shown in Table 5. Both 4th ESO and 2nd Baccalaureate students chose "school" more often as the main source of knowledge (125 times), of which only 12.8% (16 times) were rated with the same score as another source of knowledge (in these cases, one point was added to each of the sources). The source "new technologies" received less than half as many points as "school"; "personal environment" and "fiction" tied with 1/3 of the votes as the most valued, and "visits" was hardly valued as the main source (6 times).

Finally, another element that reinforces the idea of how a historical culture is generated is the fact that the school reinforces

TABLE 3 Relative index (RI) of personalities in relation to sources of information, in percentage.

RI Personalities at school	RI Personalities at environment	RI Personalities in fiction	RI Personalities at technologies	RI Personalities at visits
56.68%	40.83%	36.37%	47.18%	17.63%

Own elaboration.

TABLE 4 Origin of information about the most voted personalities.

	Personality	School	Environment	Fiction	New technologies	Visits
1	Adolf Hitler	164	142	184	164	48
2	Napoleon	191	64	95	71	71
3	Albert Einstein	102	46	52	74	19
4	Francisco Franco	57	88	45	55	29
5	Marie Curie	81	22	14 (16th)	40	11
6	Nelson Mandela	71	49	26	40	14
7	Charles Darwin	65	18 (12th)	24 (12th)	53	29
8	Christopher Columbus	61	30	26	26	16
9	Karl Marx	65	32	31	33	8 (17th)

Own elaboration.

TABLE 5 Total rating of choices as the most valued source of knowledge and number of times it shares being the most valued source.

Source/level	ESO	Baccalaureate	Total
School	57 (8)	65 (8)	125 (16)
Personal Environment	22 (11)	23 (8)	45 (19)
Fiction	23 (7)	22 (6)	45 (13)
New technologies	23 (7)	30 (10)	53 (17)
Visits	5 (2)	1 (1)	6 (3)

Own elaboration.

its image of historical relevance through the presence of the same content replicated in other areas of access to information. For this purpose, we have taken into account the relative index to the value of each area (school, environment.), quantifying the percentage obtained by each selected personality out of the total given to the source of information (**Table 6**). As can be seen, it is common to find the same names in the most prominent positions.

4 Discussion

In order to answer the first of our auxiliary research questions, the selection of figures obtained in the answers obtained places this research in line with others such as those of Ibagón Martín et al. (2021) and Rivero et al. (2022) in the Spanish case, and those of Mieres et al. (2022) and Ordóñez and Cerri (2023), in the Latin American case. All of them point out that, despite the great availability of sources of access to historical information and the freedom of choice of historical figures offered, there is a high coincidence in the answers. The characters with the highest number of choices by the respondents of the four studies, which are more comparable due to the participants and the subject matter treated (in the study of Ordóñez and Cerri, 2023, only the history of Mexico is asked about), show quite significant coincidences, as can be seen in **Table 7**.

Table 7 shows how this study is consistent with that of Rivero et al. (2022) in 6 of the 9 personalities with the highest number of choices by the participants (Hitler, Napoleon, Franco, Columbus, Einstein, and Marie Curie). Of these 6, the 2 referring to the history of Spain appear in the study by Ibagón Martín et al. (2021), whose

survey asked for characters from the history of their own country and not from universal history as in the other two. In the study by Mieres et al. (2022), the responses referring to relevant figures in contemporary world history coincide with Hitler, Marx, Darwin, and Marie Curie. These results, shown in **Table 7**, allow us to verify the correspondences between the four studies in terms of the affiliation of the personalities, with a clear predominance of those of a political-military nature [something that can also be observed in the study on Mexico by Ordóñez and Cerri (2023)], followed by those linked to the scientific field (Einstein, Newton, Darwin and Marie Curie), although it is true that this last bias does not appear in the study by Ibagón Martín et al. (2021), probably due to the fact that exclusively national data were requested. These results link directly to the uniformizing and stereotyped vision of traditional academic teaching. This vision is generated in classrooms, to a large extent, through textbooks (Grever and van der Vlies, 2017). Studies such as those of Valls (2019) in Spain; Lucy et al. (2020) in USA; Kropman et al. (2020) in Netherlands; or Johnson-Khokar (2021) in Pakistan, reveal school texts focused on a homogeneous collective memory based on a narrative of great characters, mainly male, belonging to the contemporary age and referents of glorious and exemplary events, leaving many other relevant contents in oblivion, giving rise to a narrative that shows a "univocal, uncritical and unidirectional historical identity" (Ibagón Martín et al., 2021, p. 308). Other studies, such as that of Lanoix (2018) have shown the influence of teachers and the contents of educational curricula on such constructions of identities, in this case of a national identity clearly visible in the results of his research in Quebec (Canada), where most teachers, to a greater or lesser extent, transmit to their students the traditional identity values of the history of this territory (Lanoix, 2018). This study reinforces the importance of teachers in the connection between relevance and historical culture; that is, in the ability to interpret the past, understand the present and project the future. Not in vain, as has been shown in different research, teachers are the main element of change in what refers to teaching (Molina Puche and Ortuño Molina, 2018, p. 45).

It is also possible to make an appreciation of the global traits in which most of the selected personalities can be framed and which present an important consonance with the research of Arnoso et al. (2018). There, they show some of the elements that influence the historical significance that has been configured for

TABLE 6 Figures with the highest relative index in school, environment, fiction, technologies, and visits, in percent.

School		Environment		Fiction		Technology		Visits	
Figure	%	Figure	%	Figure	%	Figure	%	Figure	%
Napoleon	13.0	Hitler	14.7	Hitler	19.9	Hitler	15.1	Napoleon	16.3
Hitler	11.2	Franco	9.1	Napoleon	10.3	Einstein	6.8	Hitler	11.0
Al Capone	6.7	Napoleon	6.6	Einstein	5.6	Napoleon	6.6	Darwin	6.7
Marie Curie	5.5	Mandela	5.1	Franco	4.9	Franco	5.1	Franco	6.7
Mandela	4.8	Einstein	4.8	Hawking	3.6	Darwin	4.9	Einstein	4.3
Darwin	4.4	Karl Marx	3.3	Karl Marx	3.3	Marie Curie	3.7	Columbus	3.7
Karl Marx	4.4	Columbus	3.1	Columbus	2.8	Mandela	3.7	Mandela	3.2
Columbus	4.2	Hawking	2.7	Mandela	2.8	Karl Marx	3.0	Isabella II	2.5
Franco	3.9	Marie Curie	2.3	Pablo Escobar	2.8	Columbus	2.4	Marie Curie	2.5
Isabella II	2.7	Juan Carlos I	2.0	Washington	2.7	Hawking	2.4	Anna Frank	2.3
Mother Teresa	1.8	Darwin	1.9	Darwin	2.6	Tesla	2.3	Juan Carlos I	2.3
J. F. Kennedy	1.4	Isabella II	1.9	Elizabeth II	1.9	Churchill	2.2	Tesla	2.0

Own elaboration.

TABLE 7 Comparison between the most selected personalities of this study and those of Ibagón Martín et al. (2021), Mieres et al. (2022) and Rivero et al. (2022).

Own data		Rivero et al. (2022)	Ibagón Martín et al. (2021)	Mieres et al. (2022)
1	Adolf Hitler	Adolf Hitler	Francisco Franco	Adolf Hitler
2	Napoleon	Christopher Columbus	Christopher Columbus	Lenin
3	Albert Einstein	Francisco Franco	The Catholic Monarchs	Gavrilo Princip
4	Francisco Franco	Napoleon	Carlos I	Karl Marx
5	Marie Curie	Isaac Newton	Carlos V	Bakunin
6	Nelson Mandela	Albert Einstein	Isabella the Catholic	Charles Darwin
7	Charles Darwin	Stalin	Felipe II	Edison
8	Christopher Columbus	Marie Curie	Juan Carlos I	Marie Curie
9	Karl Marx	B. Mussolini	Charles III of Spain	Nikola Tesla

Our own, based on data published in the above studies.

decades in formal educational contexts and that provide valuable information about the reason for the choices that have been collected in this study. Associated with the "biased views" and "violence and traumatic historical pasts" (Arnoso et al., 2018, p. 3–4) that make us consider European and North American history as the most important next to that of our own country, especially when it comes to violent and traumatic events that impact the lives of many people such as wars or revolutions, we have several examples among the most recurrent in our research such as Hitler, Franco or Napoleon. These same examples, and the vast majority of those we see in Table 7, reveal to us the clear dominance of male characters, a clearly androcentric view of the discourse and the exclusion of the voice of women (Lucy et al., 2020). Likewise, the impact of the traumatic is also in a constant in the identification of what is relevant in history, because "people tend to emphasize the role of violence, wars, and military leaders (...). The centrality of wars and conflicts is linked to the emotional impact they generate" (Arnoso et al., 2018, p. 4). This would explain the presence of figures such as

Hitler both in the "school" provenance and in "fiction" and "new technologies." Similar case to Franco, except that in this case he has been more silenced in educational channels and appears highlighted in the family environment ("environment") as can be seen in Table 6.

With respect to the second auxiliar question, and going in depth with some of the ideas already aforementioned, our study allows us to recognize that the vision generated by the formal spheres seems to be reinforced by non-academic channels, forming a current toward the same characters, which explains their recurrent selection. It is only from this recurrence that we can speak of the historical culture of individuals, that is, the shared way of interpreting and transmitting the past. In this way, young people see that the contents studied in class are reproduced in the media of consumption more suited to their profile (transmedia and digital resources), so that there is no conceptual change or challenge to the historical narratives consumed, whether in the academic or extra-academic field. And everything seems to indicate that the teaching of or access to history is determined by traditional narratives,

regardless of the resources used (Carretero, 2020). And although this situation seems to favor the fact that adolescents see this subject as a non-interactive knowledge that they should only memorize, or that their most common opinions about the subject are that they find it "easy, boring and not very useful (...) it only requires a good memory" or "it is very uninteresting" (Prats Cuevas, 2017, p. 18), the truth is that the analyzed responses seem to show the high effectiveness of the message offered, since students tend to be consistent in their answers.

Finally, regarding the influence of media and technological channels, there are some interesting studies, such as that of Abylkassymova et al. (2019), which, although contextualized for the case of Russian youth, their conclusions fit perfectly with the Spanish reality.

5 Conclusion

This study has provided examples of what were considered relevant historical personalities for the students in the last stages of pre-university education who participated in this study. The degree of coincidence can be considered as a more or less homogeneous image of the historical culture of the participants, with some identifiable characteristics, let us say, in politics and contemporaneity as keys, and a high rate of coincidence also in the focus where this vision of history is mainly generated. The information obtained leads us to confirm the need to reflect on the important stereotypes generated after many decades of formal history teaching with contents far from a necessary critical review. For this reason, it is necessary to reorient the teaching of history in order to provide a better vision and understanding of historical culture.

If we admit that the subject of history has an important potential for the formation of students' identities and, consequently, for the development of responsible citizenship, we must direct our efforts toward teaching a more critical and reflective history that analyzes their social environment and makes them more sensitive to the multicultural social reality in which they live and with better skills to cope in a globalized society, all without losing their own identity (Molina Puche and Ortuño Molina, 2018). And in this context, what happens in our classrooms has a particular relevance, because despite the undeniable difficulties that the teaching of history finds itself in, it is still this formal context that has the greatest impact on adolescents when it comes to shaping their historical culture. These contributions do not detract from the value of the content taught, but rather seek to emphasize their social and civic competence.

Furthermore, and in parallel, the 21st century has already begun to develop the idea of how the use of new technologies has evolved and what Spanish adolescents and young people know how to do with them, many of whom are integrated in the so-called "millennials" generation (Álvarez Monzoncillo and De Haro Rodríguez, 2017). All this from a social and educational perspective since it is necessary to address the educational implications of a phenomenon as present in postmodern society as digital media.

It is indisputable that we live in a society that has validated other channels of knowledge that are more in line, at least in their forms and procedures, with the interests and skills of the younger population groups; but they do not yet seem to have the weight of what happens in the classroom. The contribution of informal sources, among which are some elements defined in transmedia narratives, is a reality but does not reach the importance of academic teaching.

The results of this research reaffirm the importance of didactics, the importance of continuing to improve and reflect on what and how one teaches, because therein lie the keys to interpreting the past, understanding the present and projecting the future (Rüsen, 2018), which is the basis for the formation of citizens capable of responding to the demands of 21st century society.

Likewise, the results of the informal sources of knowledge, especially "Fiction" and "New Technologies," must be evaluated in order to rethink these didactics and to make it more consistent and binding with the needs and demands of young people, since a coherent combination of these sources, integrating them with meaning in the classroom, could mean a more than interesting advance in the formation of citizens who act responsibly in a society in which they are protagonists of the present and the future.

Regarding the limitations of this research, we are aware that, to analyze the influence of extracurricular narratives on the historical formation of students, it is necessary on the one hand not only to identify the sources of the knowledge about historical characters or events, but to verify the content of the narratives about them. Therefore, it would be advisable to analyze whether both academic narratives and extracurricular ones help to consolidate a certain type of image of the past or if, on the contrary, they present complementary, divergent, or antagonistic visions. An adequate comparison of these narratives, as well as the students' own narrative about these characters or events, would help to deepen how the social representation of what they consider relevant in the history of humanity is generated, as well as the relative influence of the different elements that help create the historical culture of the interviewees. At the same time, it would be convenient to replicate this study in more educational centers, which would allow to have a larger sample that would facilitate a more robust idea of both the social representation and the weight of the different sources that make up the historical culture of the participants.

However, this research opens the door to concrete implications that could improve students' critical capacity about the past. We have shown that the importance of learning history continues to rely on the school environment (formal education). It allows us to be aware of which contents are the most selected and which are the most meaningful for students. The vision given of such historical icons and their values in the educational field is crucial to help to change certain social representations that remain based on a biased perspective of history. The action that can be taken on the values that these contents usually possess is a task that we can do from schools from two areas: developing educational resources deepening against stereotypes and acting on the initial training of teachers to help them to teach a more critical and multivocal vision of that icons (the importance of cultural context, the unvoiced people who influenced on that icons, etc.). With this we would be helping young people who continue to access history through schools to have a more complex and multivocal vision of the past, and therefore, a greater capacity for reflection on the present and the future we want.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by the Ethics Committee of University of Murcia. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin. Written informed consent was obtained from the minor(s)' legal guardian/next of kin for the publication of any potentially identifiable images or data included in this article.

Author contributions

PM-M: Investigation, Resources, Software, Writing – original draft. JO-M: Conceptualization, Formal analysis, Methodology, Supervision, Validation, Writing – review & editing. SM-P: Conceptualization, Data curation, Formal analysis, Funding acquisition, Supervision, Validation, Writing – review & editing.

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The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Reading for gain or reading for fun: empirical evidence from China on the adoption mechanism of integrated children's books

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Introduction: With the increasing number of children's publications that integrate new media technologies in the global publishing community, understanding the adoption and use of these publications from a child's perspective is of great significance for both children's education practitioners and the publishing industry.

Methods: This article integrates a dual-effect path based on the utilitarian-motivation system (UMS) and hedonic-motivation system (HMS) on information technology adoption via a questionnaire, systematically demonstrating the psychological mechanism of children's reading with respect to integrated books.

Results: This study finds that children's willingness to use integrated children's books is related to UMS and HMS except for facilitating conditions. In addition, this study also reveals the structural differences existing in the adoption psychology of children from various age groups and home education backgrounds.

Discussion: This study provides a systematic explanation for understanding the adoption psychology of integrated children's books. Based on these findings, it is suggested that publishers should balance the concepts of education orientation and child orientation when producing children's books, conduct technical innovation of children's books according to individual children, and constantly innovate the service mode to avoid the risk of children's bad reading.

KEYWORDS

children reading, integrated publishing, HMSAM, UTAUT, HMS, UMS

1 Introduction

Children's books are an important medium for children and are of great significance to children's early-stage knowledge acquisition and reading habits cultivation. With the maturity and popularity of digital media technology, children's book products with increasingly new technological elements based on paper book content continue to bring forth the new through the old and have become a requisite part of the children's publishing market, bringing an ever-expanding market scale.

There are already numerous cases of new media technology applied to children's book design around the world. In 2012, a Bologna-based sponsor, in collaboration with the Children's Technology Review of the United States, launched the 'BolognaRagazzi Digital Award' with the aim of producing interactive media products that combine educational and innovative elements from online children's publications. Since 2018, in the entries, there has been a significant increase in the number of paper books that incorporate technologies such as AR and VR. In 2021, the award was renamed the BolognaRagazzi Cross-Media Award, with a focus on further development and transformation between children's books and children's content in other mediums (Bologna Children's Book Fair, 2021). Thus, it can be seen that the publishing business is not limited to a certain kind of single type of children's books, such as printing or digital children's books, and the key focus of the publishing industry has extended to the type of children's books that integrate multiple media or technologies. This new type of book is different from traditional paper-printed books and is a manifestation of the integrated development of the publishing business. We refer to this new type of book as integrated books.

Existing integrated children's books mainly reflect two product design concepts: one is to optimize the content presentation, through the implementation of audio and video content, to convey useful messages multimodally and to enhance the readability and expandability of children's books (Li and Ruiwei, 2017; Children's Literature, 2018; Zhou and Fang, 2023); the other is to improve the user experience of children's books, to add human–computer interaction such as tap, click, and scanning, to enhance the interactivity and interest of the reading process, and to enhance the charm of products (Huwei et al., 2014; Hu and Jincheng, 2015; Juanjuan, 2017).

Academia generally understands the impact of integrated children's books on children's reading matter and education from the perspective of educators or designers. The infiltration of new technologies has made multisensory experiences an important medium for children to absorb knowledge from books. Kljun et al. described and discussed the design space of digitally augmented comic books based on AR technology; Cheng et al. found that students perceive less cognitive load, stronger motivation, and a more positive attitude toward the experience when reading AR books (Cheng, 2017). While grasping children's attention, multisensory experiences simultaneously enhance their understanding and imagination of book content (Deng and Cong, 2023). Martin et al. explored the learning quality of interactive cooperation among students through different media based on the combinative use of digital reading and textual reading (Kljun et al., 2019).

Past experience in the publishing market shows that the application of new technologies does not always yield positive usage effects and market returns. Especially in the market of children's books and textbooks, publications adopting new technologies may encounter market resistance due to a variety of factors, such as innovation cost, product pricing, market structure, and educational ideas. Therefore, without a systematic recognition of children's reading psychology, publishers frequently hesitate to make innovative decisions. Consequently, although a number of publishing houses have tentatively launched new integrated children's books relying on more advanced new technologies, the mainstream product type in the market is still relatively homogeneous. At the same time, considering that children's books are purchased by parents for the most part, for the publishing purpose of inculcating knowledge and cultivating

individuality, children's book publishers often ignore the subjectivity of child readers in the process of product design, resulting in the increasingly high proportion of educational attributes in the design process of children's book products (Duan and Li, 2023). In this regard, the publishing industry has called for the return of the children-oriented concept when publishing children's books (Zhigang and Fei, 2022). However, there is still a lack of discussion on how to balance the implementation of education-oriented and child-oriented ideas in the children's book design process.

This article aims to understand the use of integrated children's books from the perspective of children. As a form of children's media that applies new media technology, this new media is not only a brand-new educational technology resource but also a novel multimedia technology product. From the perspective of adopting new technologies, the motives of people choosing a new technology product are generally the following: firstly, out of utility considerations, people hope that the new technology can help them better achieve a certain objective. Secondly, for the sake of good feelings, people hope that the new technology can bring unconventional experiences. By utilizing empirical evidence from China, this article explains the psychological mechanism of children's adoption of comprehensive children's books, hoping to provide practical and feasible suggestions on innovative product decisions for children's book publishers. The research issue of this article is: why do children read integrated children's books? Are there group differences in children's reading motivation of integrated children's books?

The purpose of this article is to explore the psychological mechanisms of children's adoption of integrated children's books through empirical evidence from the perspective of technology adoption and, then, to provide practical suggestions for children's book publishers to make decisions on product innovation.

2 Literature review and research hypothesis

2.1 Utilitarian motivation and hedonic motivation: dual mechanisms for the adoption of integrated children's books

The rapid development of digital media technology has triggered the digital transformation of the publishing business, with more and more integrated publications subsequently emerging. In 2017, a product called *Tara's Locket*, developed by the Big Motive Digital Product Innovation Studio in Ireland, which combines VR technology with graphic content, was nominated for the *BolognaRagazzi Digital Award*. In 2017, the Quantum Story Company launched a series of children's books called *'Operation YOU'*, which combines traditional printing techniques, augmented reality (AR), and virtual reality (VR). Moreover, through a free smartphone app, printed text can fly off the paper and be presented in a highly interactive and visual form for readers. In addition, tailored VR glasses can also be used to allow readers to see vivid and wonderful virtual images. In a word, the emergence of integrated publication has sparked interest for all concerned in explaining its adoption motivations in both publishing circles and academia.

In terms of the explanation of adoption motivation, most technology adoption studies focus on pragmatic motives, which reflect users' practical purposes for the determination of new

technology adoption. For example, Vasiuk et al. (2022) argue that 'learning knowledge' and 'mastering professional skills' are the main motives for students to study (Vasiuk et al., 2022). Lin et al. (2023) hold that the utilitarian benefits (i.e., being helpful, effective, functional, necessary, and practical) that AI-based social robots bring to children's English learning are of great significance for the adoption rate of AI-based social robots (Lin et al., 2023). Al-Abdullatif and Alsubaie (2022) argue that behavioral intentions and facilitating conditions are significant determinants of teachers' actual use of the IRA digital platform. Chin et al. (2020) assume that the most influential factors in the consumptive use of enterprise social network are content value and performance expectancy. Fagan (2019) reckons that performance expectancy has a prominent and direct effect on the intention to use iPads for m-learning.

Correspondingly, there is another intrinsic emotional motivation toward the product itself. For example, Hamari and Koivisto (2015) found that hedonic motivations have a positive direct association with continued use. Aboelmaged (2018) believe that hedonic motivations have a positive profound influence on using ESN for knowledge sharing (Aboelmaged, 2018). Fagan (2019) found that the total effect of hedonic motivation on intention was significant, while the effect of hedonic motivation on intention was fully mediated by performance expectancy. Song et al. (2015) argue that utilitarian and hedonic expectations had a positive impact on users' intentions to adopt 3G mobile technology. Oluwajana et al. (2019) believe that the acceptance of a gamified learning environment could serve as a new educational tool to expedite the improvement of pedagogical and instructional technology.

It can be seen that academia has outlined two main interpretation paths for studying the motivation of information technology adoption, namely, whether users primarily use technology out of utilitarian or hedonic purposes. Based on traditional paper-based children's books, integrated children's books construct a complex type of information system by introducing new presentation forms and interaction techniques. Technology is an essential component of information systems, providing the base and support for information systems. Conversely, information systems are also an important stage for technological applications. Therefore, this article takes technology adoption motivation as the theoretical basis for the adoption of integrated children's books. Indeed, theoretical models of relevant information system adoption research can be used to explain two psychological mechanisms of integrated children's book adoption: utilitarian motivation and hedonic motivation. They are constructed as two classic technology adoption models: the **Unified Theory of Acceptance and Use of Technology (UTAUT)** and the **Hedonic-Motivation System Adoption Model (HMSAM)**. These are the theoretical starting points for constructing a systematic interpretation model for this study.

The UTAUT is mainly used to explain the influential mechanism of utilitarian motivation on technology adoption, and it is composed of eight theoretical models, including the Theory of Reasoned Action, Technology Acceptance Model, and Motivation Model. These models contain four core exogenous latent variables and four exogenous moderating variables, which are used to explain users' usage intentions and usage behaviors (Venkatesh et al., 2003). The UTAUT and its topology model have been used to explain information system adoption behaviors in a variety of contexts, such as mobile health, mobile wallet, and mobile payment (Dwivedi et al., 2020), where the exogenous variables of performance expectancy, effort expectancy,

community influences, and facilitating conditions and the endogenous variables of usage intention and usage behavior are the six most frequently used core variables.

The HMSAM is primarily used to explain the mechanisms by which hedonic motivation influences technology adoption. In light of the recent boom of social networks and video games, Lowry argues that attention should not only be focused on the role of **utilitarian-motivation systems (UMS),** which are a specific outcome of information system use, but also on how **hedonic-motivation systems (HMS)** play a role in the usage process itself. Therefore, Lowry constructed the HMSAM to emphasize the explanation of HMS mechanisms. In addition to performance expectations (perceived usefulness), the HMSAM places more emphasis on the influence of effort expectations (perceived ease of use), curiosity, and joy on users' usage intentions. The HMSAM has been used in relevant information system adoption research, such as online education (Francke and Alexander, 2018; Rosmansyah et al., 2019), radio programs (Lim and Park, 2016), mobile health (Lim and Park, 2016), VR travel (Kim and Hall, 2019), and online shopping (Xiaozhou, 2020), and its validity has been preliminarily verified.

This article argues that children's willingness to read integrated children's books may be collectively determined by utilitarian motivation and hedonic motivation. Therefore, this study integrates the two underlying models, the UTAUT and HMSAM, in order to validate the psychological mechanisms of children's adoption of integrated children's books.

2.2 The effect of hedonic motivation on reading intentions for integrated children's books

Curiosity and joy are two key variables in the HMSAM that explain users' adoption intentions. In studies on information system adoption, users' curiosity was found to enhance their usage intention (Qin et al., 2009). According to educational psychology, curiosity is a kind of aspiration of children for intrinsic development, and curious young children are more creative and more willing to attempt and discover (Liu, 2004). Therefore, this article defines 'curiosity' as the extent to which children are curious about integrated children's books and hypothesizes:

> H1a: Children's curiosity about integrated children's books has a significant positive effect on their intention to read.

Joy refers to, in addition to the expected utility, the degree of pleasure and satisfaction for users brought by the process of using an information system (Hong and Tam, 2006). User studies from certain mobile social media have found that enjoyment has a significant impact on users' usage intentions and usage behaviors (Kim and Forsythe, 2008). Educational psychology believes that game-based learning is conducive to stimulating students' learning pleasure, guiding them to gain new knowledge and improve their academic performance (Lijuan, 2007). Research on children's educational apps has found that most apps would optimize their character settings, interface design, storylines, and voice-overs to increase the interest of the reading content to meet the demand of "teaching for fun" (Zheng and Zhuang, 2017). Therefore, this article defines 'joy' as the fun of

integrated children's books that can be perceived by children and assumes that:

> H2a: Children's joy perception of integrated children's books has a significant positive effect on their intention to read.

2.3 Influence of utilitarian motivation on reading intentions of integrated children's books

Utilitarian motivation in the UTAUT model consists of four key variables: performance expectancy, effort expectancy, social influence, and facilitating conditions. **Performance expectancy (PE)** refers to the assistance extent for users' work that is brought by new technology, and this variable is also referred to as perceived usefulness in certain models such as TAM. In the context of home education, parents' performance expectancy - i.e., the help provided for children's learning - can also have an impact on children's behavioral intentions to learn. For example, it has been found that primary school students' home motivations for learning English are mainly instrumental, and few parents believe that learning English will not benefit their children (Yutong, 2021) In the reading context, empirical studies on online reading (Liu and Liu, 2015) and audiobooks (Zhipeng and Zhang, 2020) have shown that the performance expectation is an important variable influencing readers' usage intentions. Research on children's digital reading has also found that parents' perceived usefulness of digital publications had a significant effect on children's digital reading intentions (Han, 2019). Therefore, this article defines 'performance expectation' as whether children think that integrated children's books can help them gain knowledge and competence and hypothesizes:

> H3a: Children's performance expectations for integrated children's books have a significant positive effect on their intention to read.

Effort expectancy (EE) is the difficulty of using a system. In TAM, MPCU, IDT, and other models, effort expectancy is also called perceived ease of use. Some studies have suggested that tablet-based electronic picture books are more nearly three-dimensional and interesting in shaping characters, and the audiovisual effects can provide children with more intuitive image shaping, and child readers are therefore more likely to apply reality to the story characters (Wei and Juan, 2017). The results of relevant empirical studies show that the higher the perceived ease of use of an online reading environment (Venkatesh et al., 2003) and e-reading devices by children (Rosmansyah et al., 2019), the stronger their reading intentions. Therefore, this article defines 'effort expectancy' as children's difficulty in using integrated children's books and hypothesizes:

> H4a: Children's effort expectancy of integrated children's books has a significant positive effect on children's reading intentions.

Social impact (SI) is derived from the subjective norms and social factors of the Theory of Planned Behavior, which refers to the degree to which individuals are influenced by surrounding groups. Some researchers have pointed out that social impact does not have a

significant effect on the usage willingness of information system users in the case of voluntary use (Wu, 2016). However, in the study of home education, some researchers have pointed out that parents sometimes tend to compare with higher achievers, thus struggling to create ideal living and learning conditions for their children (Wu, 2009). With the emergence of education marketization, the comparison mentality of parents has become increasingly complicated, leading to irrational education expenditure and even poverty caused by 'education' (Jiuyu, 2019). Moreover, kids also have a certain degree of comparison, which is caused by the adult-oriented social environment in which teachers and parents are involved (Jiaqi, 2017). Therefore, this article defines the macro sense of 'community influence' as children's subjective perception of the community influence of reading integrated children's books and hypothesizes:

> H5a: Children's perceptions of community influence of integrated children's books have a significant positive effect on reading intentions.

Facilitating conditions (FCs) refer to the individuals' possession of knowledge and resources that are available for using a new technology or system. The effect of facilitating conditions on users' usage willingness has been preliminarily verified in previous research on information system usage behaviors (Si-Hang, 2018). In the educational context, some studies have found that facilitating conditions can explain users' adoption intentions and usage behaviors of new educational technologies when they use electronic educational devices (Qin et al., 2018) and online educational resources (Geng, 2016; Chao and Mei, 2022). This article defines 'facilitating conditions' as technological or resource support that children can access when reading integrated children's books and hypothesizes:

> H6a: Facilitating conditions have a significant positive effect on children's behavioral intention to use integrated children's books.

In addition, it has been found that in the UTAUT model, facilitating conditions not only indirectly affect users' usage behaviors by influencing users' usage intention but also directly affect users' usage behaviors. Therefore, this article hypothesizes:

> H7: Facilitating conditions have a significant positive effect on children's reading behavior of integrated children's books.

2.4 The mediation role of reading intentions of integrated children's books

Behavioral intention of usage (BIOU) is the intensity of a user's willingness to continue to use an information system (Venkatesh and Davis, 2000). **Behavior of usage (BOU)** is the behavior of users who continue to use technology and recommend it to their friends and relatives after the initial trial of the technology (Fishbein and Ajzen, 1977). In studies on online education (Li, 2016) and the usage behavior of open educational resources in universities (Kim and Forsythe, 2008), scholars have found that usage intention has a strong influence on usage behavior. Therefore, this article assumes that children's reading intentions of integrated children's books have a
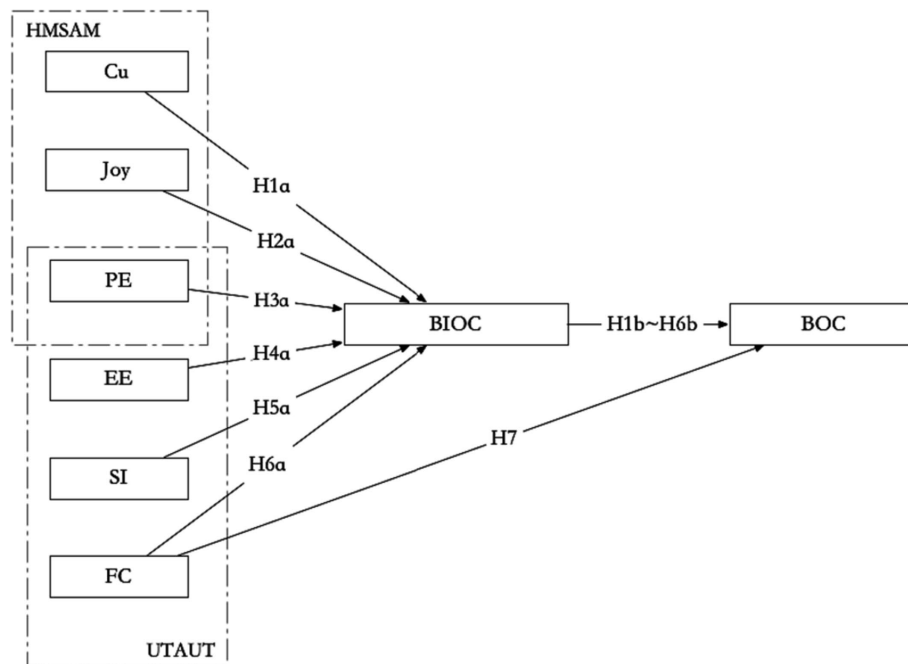
FIGURE 1
Theoretical hypothesis model for the adoption of integrated children's books.

direct influence on their reading behavior. Therefore, this article hypothesizes:

> H1b to H6b: Children's behavioral intention to use integrated children's books has a significant positive effect on their behavior in using children's books.

In summary, this article constructs an integrated theoretical model of integrated children's books adoption behavior based on the HMSAM and UTAUT, as shown in Figure 1.

3 Methodology

3.1 Measurements

The scales required for this study were altered based on the conceptual interpretations in the UTAUT and HMSAM, with reference to well-established measurement tools in the relevant literature. A total of eight concepts were included in the model for measurement, and the literature sources and the scale items in the formal survey are shown in Table 1. The items were measured using a five-point Likert scale, with numbers 1 to 5 indicating 'not at all', 'not quite', 'maybe' 'comparatively conform', and 'completely conform'. In the questionnaire, the items appear in random order.

3.2 Data collection

In July 2022, we distributed the questionnaire through Questionnaire.com. The respondents were informed of the purpose and process of the survey to confirm that they were voluntarily participating in the questionnaire survey with full informed consent. Certainly, they had the right to withdraw from the survey at any time during the process. The questionnaire screened the object of the study through two questions, the first being whether there were children under 12 years of age in the household and the second being whether they had seen or come into contact with integrated children's books.[1] A pre-survey was conducted prior to the formal survey in order to validate and correct the scale ($n = 190$). Taking into account the potential ethical risk existing in juvenile research, the questionnaires were completed by the parents on behalf of their children. The research process was examined by the School of Journalism and Communication, Henan University (approval number: 2023–0001).

The formal survey was based on the data of the age distribution of the regional population in the *China Statistical Yearbook 2021* (National Bureau of Statistics of China, 2021), and the sampling frame was delineated using regional stratified sampling. The regional distribution is shown in Table 2. A total of 513 questionnaires were collected in the formal survey, and 334 valid questionnaires were screened. The average time to complete a valid questionnaire was 5 min and 56 s. The average annual household income of the

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1 In order to avoid confusing respondents because of the concept of 'integrated children's books', the questionnaire referred to integrated children's books as a 'new-type of children's books' and illustrated four common types of products currently on the market, which are 'children's books that can be used with reading pens', 'reading machines which are equipped with children's books', 'children's books that can be scanned to listen to audio and watch videos', and 'children's early learning machines and learning machines that can read children's books'.

TABLE 1 Scale design and literature sources.

Concept	Question	Scale source
Curiosity	Cu1 My children are always very curious when they see 'new-type children's books'.	Agarwal and Karahanna (2000) and Lowry et al. (2012)
	Cu2 'New-type children's books' will stimulate my child's imagination.	
	Cu3 'New-type children's books' have always aroused my child's curiosity.	
Joy	J1 My children can discover fun in 'new-type children's books'.	Agarwal and Karahanna (2000) and Lowry et al. (2012)
	J2 My kids are happy when they read 'new-type children's books'.	
	J3 My children are very happy when they read 'new-type children's books'.	
Performance expectancy PE	PE1 Children think that they can learn knowledge quickly with 'new-type children's books'.	Davis (1989) and Venkatesh et al. (2003)
	PE2 Children think that 'new-type children's books' will help them learn more.	
	PE3 Children think that reading 'new-type children's books' is very efficient.	
	PE4 Children think that 'new-type children's books' make reading relaxing.	
Effort expectancy EE	EE1 Children find that 'new-type children's books' are easy to use.	Davis (1989) and Venkatesh et al. (2003)
	EE2 Reading 'new-type children's books' is easy for children.	
	EE3 Children find it is easy and simple to read new-type children's books.	
Social impact SI	SI1 My child also wants to have one when they see other children reading 'new-type children's books'.	Moore and Benbasat (1991) and Venkatesh et al. (2003)
	SI2 Children believe that many children are reading 'new-type children's books' nowadays.	
	SI3 Children feel that reading 'new-type children's books' improves other children's abilities or knowledge.	
Facilitating conditions FCs	FC1 My child has the necessary equipment to read 'new-type children's books', such as reading pens, electronic reading machines, mobile phones, and tablets.	Thompson et al. (1991) and Venkatesh et al. (2003)
	FC2 My child has sufficient knowledge or skills to read 'new-type children's books'.	
	FC3 My child has access to ample network resources if necessary, such as mobile traffic and wireless Wi-Fi.	
	FC4 'New-type children's books' have simple instructions that children can understand at a glance.	
	FC5 When the going gets tough, there is always someone who can teach a child how to use 'new-type children's books'.	
Behavioral Intention of Usage BIOC	BIOC1 My children really enjoy reading 'new-type children's books.'	Bhattacherjeen (2001)
	BIOC2 My children always want to read 'new-type children's books'.	
	BIOC3 My children invite a small group of friends to read 'new-type children's books'.	
Behavior of usage BOC	BOC1 My child regularly reads 'new-type children's books'.	Venkatesh et al. (2003), Kankanhalli et al. (2005) and He and Wei (2009)
	BOC2 My child frequently reads 'new-type children's books'.	
	BOC3 My child spends a lot of time on 'new-type children's books'.	

respondents was 162,000 yuan (SD = 20.807), the average age of the parents was 36.1 years (SD = 5.825), the education level of the parents was mainly 'undergraduate/diploma' ($n = 168$), and there were more female parents who completed the survey ($n = 240$). The average age of the children was 7.8 years (SD = 3.500), with the proportion of girls (48.2 per cent) being slightly lower than that of boys. The sample was essentially in line with the population distribution characteristics of Chinese adolescents.

3.3 Data analysis

In this article, SPSS26 was used for the pre-processing of the questionnaire, descriptive statistics of variables, and reliability and validity tests. The process plug-in was used for the mediating effect test. Simultaneously, the AMOS software was employed to construct a structural equation model and to subsequently perform analysis and group comparisons.

4 Data analysis and research findings

4.1 Reliability test of the scales

The internal consistency reliability (Cronbach's alpha) and combined reliability (CR) were calculated for the scales, as shown in Table 3. The internal consistency (alpha) reliability of the conceptual scales was entirely greater than 0.7 in the pre-survey and the formal survey, and the combined reliability (CR) was entirely greater than 0.8, indicating that the reliability of the scale is generally good. The structural validity of the scales was calculated by the method of confirmatory factor analysis, extracting a common factor stably from each scale. The factor loading and KMO of each question item were greater than 0.6, and the AVE was greater than 0.7, indicating that the structural validity of the scales was generally good.

The AVE square root and correlation coefficient of the scales were calculated to test discrimination among the scales, as shown in Table 4. The correlation coefficient among the scales was entirely less

TABLE 2 Regional distribution of respondents.

Region	Population (0−14)	Sample	Region	Population (0−14)	Sample	Region	Population (0−14)	Sample
Beijing	2,591,507	3	Anhui	11,742,682	15	Chongqing	5,098,363	7
Tianjin	1,868,056	2	Fujian	8,025,225	11	Sichuan	13,471,112	18
Hebei	15,088,968	20	Jiangxi	9,922,364	13	Guizhou	9,242,038	12
Shanxi	5,709,895	8	Shandong	19,062,638	25	Yunnan	9,237,474	12
Inner Mongolia	3,377,673	4	Henan	22,988,954	31	Tibet	894,865	1
Liaoning	4,737,939	6	Hubei	9,420,477	12	Shaanxi	6,852,205	9
Jilin	2,818,723	4	Hunan	12,969,522	17	Gansu	4,853,543	6
Heilongjiang	3,286,466	4	Guangdong	23,749,882	31	Oinghai	1,232,956	2
Shanghai	2,436,296	3	Guangxi	11,842,501	17	Ningxia	1,468,004	2
Zhejiang	12,891,948	17						

TABLE 3 Reliability test results of each scale.

	Pre-survey (n = 334)			
	α	CR	KMO	AVE
Cu	0.813	0.890	0.815	0.854
Joy	0.881	0.928	0.884	0.900
PE	0.878	0.917	0.845	0.856
EE	0.808	0.887	0.868	0.850
SI	0.700	0.833	0.879	0.789
FC	0.703	0.808	0.808	0.676
BIOC	0.839	0.905	0.676	0.872
BIC	0.867	0.919	0.693	0.889

than the AVE square root, indicating that the scales had good discrimination.

4.2 Structural equation modeling analysis

It was necessary to construct a structural equation model based on the theoretical model. The initial model contained a total of eight latent variables and eight effect paths among the latent variables, as shown in Figure 2. The results of the initial analysis showed that the effect paths of curiosity, joy, performance expectation, effort expectation, and social influence on children's reading intentions were significant in the structural model, the effect path of facilitating conditions on children's reading intentions was not significant ($\gamma = 0.024$, $p = 0.708$), and the effect path of facilitating conditions on children's reading behaviors was also not significant ($\gamma = 0.073$, $p = 0.299$). Therefore, the initial model needed to be corrected.

After deleting the insignificant structural model path, the modified structural equation model was obtained, as shown in Figure 3[2]. After testing, each fit index of the modified model

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2 All the structural model path coefficients in the text are standardized estimated values.

conformed to the determination conditions: since the chi-square value was greatly affected by the number of parameters and the number of samples (Qiu and Lin, 2009), the relative fit index (GFI = 0.910, AGFI = 0.880, PGFI = 0.684), the substitutability index (CFI = 0.970, RMSEA = 0.049), and the residual analysis of the test model (RMR = 0.033, SRMR = 0.039) were used to test the fitting of the model. Except for AGFI, which was slightly lower than the standard criterion, all the fit indices were within the scope of judgment (Qiu and Lin, 2009), indicating that the model had good explanatory power.

The revised structural equation model showed that the effect paths of curiosity, joy, performance expectations, effort expectations, and community influence on children's reading intentions were generally significant, and the effect path of children's reading intentions on children's reading behaviors was also generally significant. Therefore, hypotheses H1a ~ H5a and H1b ~ H5b were preliminarily supported, while H6a, H6b, and H7 were not valid.

4.3 Mediation effect test

Based on the structural equation model, a further mediation effect test was performed. The latent variables in the structural model were firstly packaged with the factor methods (Yan and Wen, 2011), and then, we used the bootstrap method to perform 5,000 instances of repeated sampling and to analyze the mediation effects of the structural model through the controls of child gender, child age, parental educational level, and annual household income.

As shown in Table 5, the test results showed that the mediation effect of effort expectation (EE) on the behavior of children's reading (BOC) through the behavioral intention of children's reading (BIOC) was not significant due to the fact that the first half of the pathway was not significant ($\beta = 0.077$, $p = 0.175$), suggesting that the pathway was not sound in the structural equation model (further explanation will be provided below through group comparisons). The mediation effect of the other four paths were all significant (none of the confidence intervals contained 0), and hypotheses H1, H2, H3, H4b, and H5 were supported. The results of the mediation effects test also showed that the control variables of child age ($\beta = -0.023*$) and parental educational level ($\beta = -0.077*$) also had a significant effect on children's reading behavior.

TABLE 4 Pearson correlation coefficient and AVE mean value for the scales.

	Cu	Joy	PE	EE	SI	FC	BIOC	BIC
Cu	0.924							
Joy	0.822**	0.949						
PE	0.726**	0.662**	0.925					
EE	0.637**	0.569**	0.827**	0.922				
SI	0.676**	0.615**	0.705**	0.683**	0.888			
FC	0.570**	0.515**	0.584**	0.567**	0.683**	0.822		
BIOC	0.602**	0.539**	0.683**	0.633**	0.736**	0.616**	0.934	
BIC	0.482**	0.428**	0.511**	0.498**	0.639**	0.688**	0.615**	0.943

** denotes $p < 0.01$, and values on the diagonal line are the AVE mean value of the scale.

FIGURE 2
Initial structural equation model.
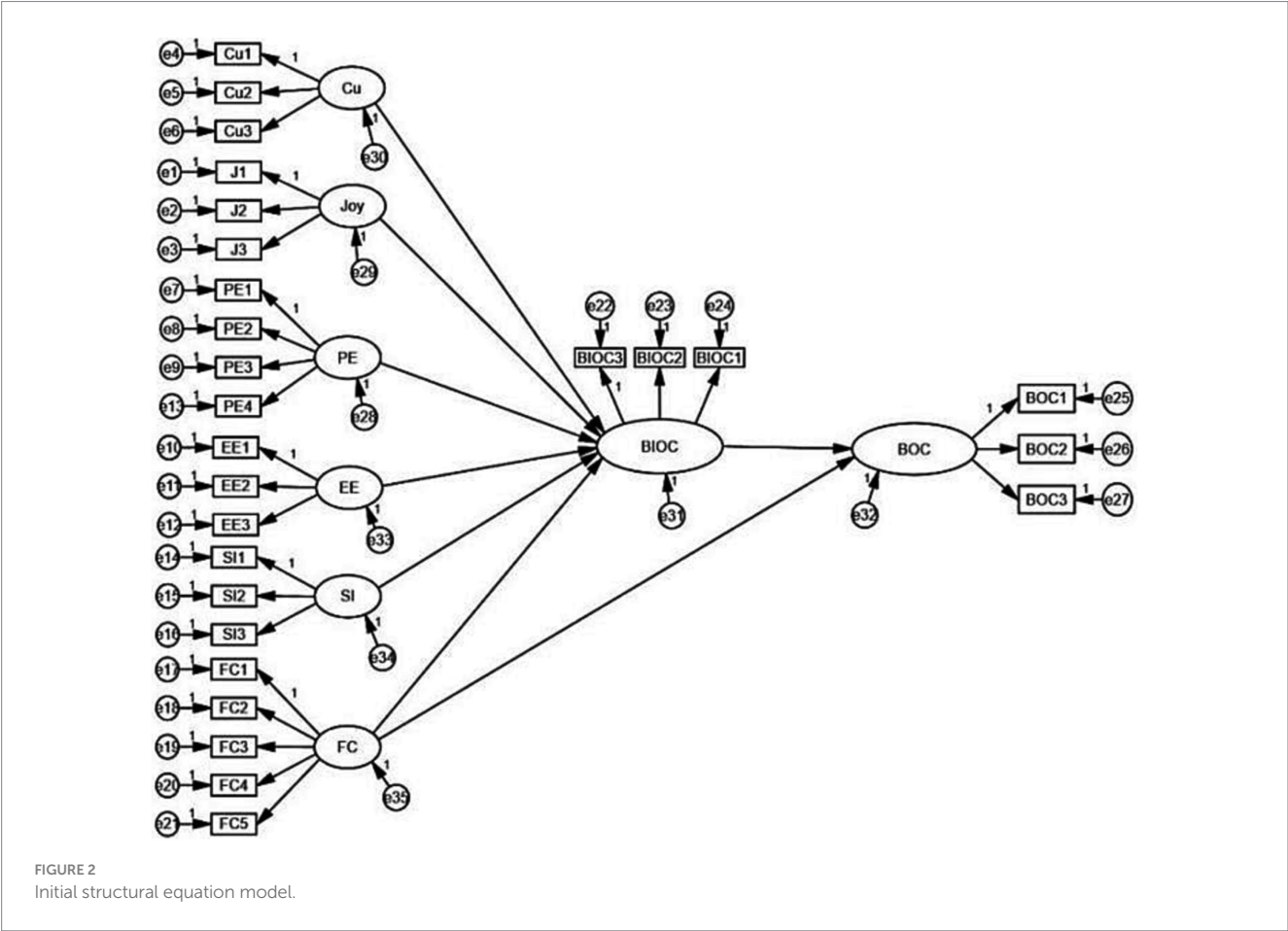
4.4 Group comparison

Since the results of the mediation effect test slightly differed from the structural equation model after the inclusion of the control variables, the group comparison of the structural equation model was conducted based on the differences of children's age and parents' educational level. The children were divided into three groups according to their age distribution: old age (10–12 years old), middle age (7–9 years old), and young age (0–6 years old); the parents were divided into three groups according to their educational level: high level (master's degree and above), middle level (university or diploma), and low level (senior high school and below). The results of the group comparison are shown in Table 6.

From the path coefficient of the structural model for each child age subgroup, there was detected a certain influence of joy, curiosity, performance expectancy, and effort expectation on the adoption mechanism of integrated children's books. As children grow older, the effects of curiosity and effort expectation on children's reading intentions gradually decline, while the effects of joy and performance expectancy on children's reading intentions become increasingly strong.

In terms of family educational background, the effect path of hedonic motivation on children's reading intentions was potentially
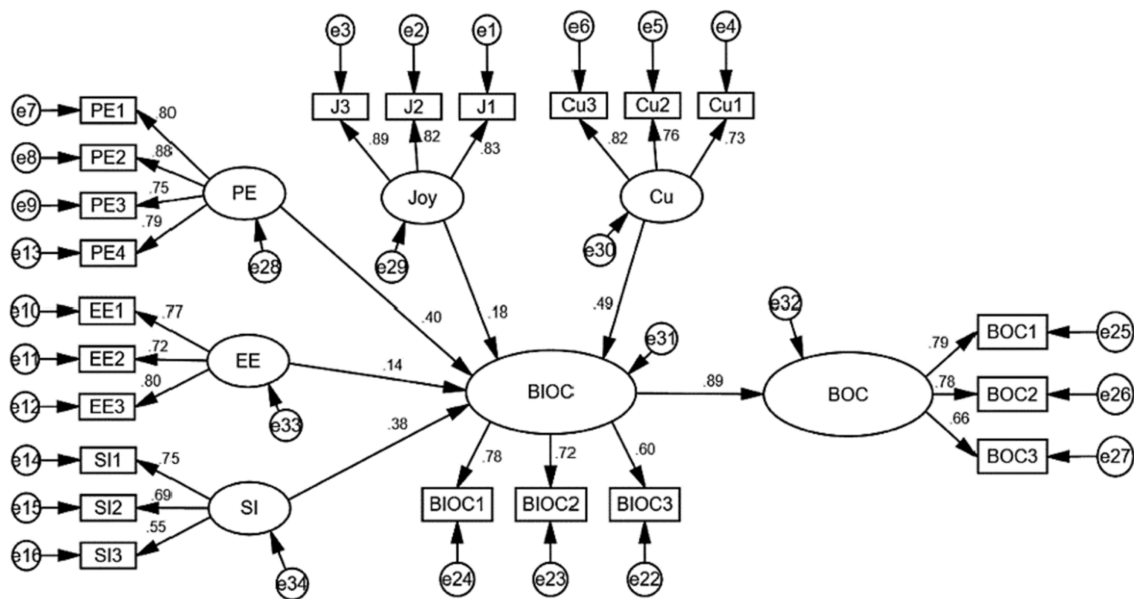
FIGURE 3
Modified structural equation model 2.

TABLE 5 Summary of the results of the mediation effects test (*n* = 334).

trails	c	a	b	a*b	a*b Boot CI
Cu=>BIOC=>BOC	0.218**	0.294**	0.671**	0.197	0.103~0.301
Joy=>BIOC=>BOC	0.059	0.145*	0.671**	0.097	0.010~0.186
PE=>BIOC=>BOC	0.258**	0.180**	0.671**	0.121	0.026~0.223
EE=>BIOC=>BOC	0.110*	0.063	0.671**	0.042	−0.027~0.112
SI=>BIOC=>BOC	0.207**	0.247**	0.671**	0.166	0.084~0.254

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

constrained by the level of parental education. In the low-level group (parents' educational level at senior high school level and below), joy was found to be an important factor driving children's reading intentions, which was not significant in any of the medium-level or high-level groups. In contrast, the role of curiosity in children's reading of integrated children's books was found to become more prominent as the parents' educational level enhanced.

5 Results

Based on the UTAUT and HMSAM, this article has constructed and validated an adoption model for integrated children's books, as shown in Figure 4.

The model tests and verifies the assumption from previous texts that integrated children's book reading is influenced by both hedonic motivation and utilitarian motivation. The two existing technological concepts of integrated children's books also indicate that designers hope new technology could not only help children understand and grasp knowledge but also raise their interest in reading. It is conducive to achieving the goal of 'teaching for fun'. In addition, the data analysis reveals that the factors influencing the adoption of integrated children's books may differ among children of different ages and home educational environments, which provides empirical evidence for

technological innovation and the publishing marketing of children's book products.

In the aspect of hedonic motivation, the data tests the positive impact of curiosity and joy on children's reading intentions and reading behaviors in general. For children, the new technique elements of integrated children's books make the reading experience more attractive and interesting, which contributes to the cultivation of their reading habits. The results of the data analysis also show that the impact of joy and curiosity on children's reading intentions is varied across different age groups and home educational environments. For younger children, the emergence of new technology may make them itch to try it out of curiosity, but they are not yet ready to appreciate the joy of reading. As children get older, they lose their curiosity about integrated books, and only those who enjoy reading integrated books will continue to use them. Curiosity is less important for children whose parents have lower levels of education, and only those who can perceive the pleasure of reading will have a higher intention to read.

In the aspect of utilitarian motivation, the data tests the effects of performance expectations, effort expectations, and community influence on children's reading intentions in general. As children grow older, the influence of reading performance expectations on children's reading intentions becomes more prominent, while the influence of effort expectations on their reading intentions diminishes. For children of any age, community influence is a critical factor in their

TABLE 6 Summary of standardized path coefficient for each subgroup in the structural model.

trails	Age of the child			Parents' level of education		
	young (n = 115)	Medium (n = 105)	old (n = 114)	Low (n = 75)	Medium (n = 168)	High (n = 91)
Joy=>BIOC	0.131	0.025	0.293**	0.607***	0.088	0.042
Cu=>BIOC	0.644***	0.624***	0.253*	−0.013	0.515***	0.814***
PE=>BIOC	0.191*	0.445***	0.528***	0.386**	0.439***	0.231*
EE=>BIOC	0.316**	−0.007	0.064	−0.008	0.305***	0.192*
SI=>BIOC	0.318**	0.288**	0.422**	0.185	0.321***	0.230*
BIOC=>BOC	0.896***	0.95***	0.822***	0.945***	0.864***	0.885***

* indicates $p < 0.05$, ** indicates $p < 0.01$, *** indicates $p < 0.001$.

FIGURE 4
Validated convergent children's books adoption model.
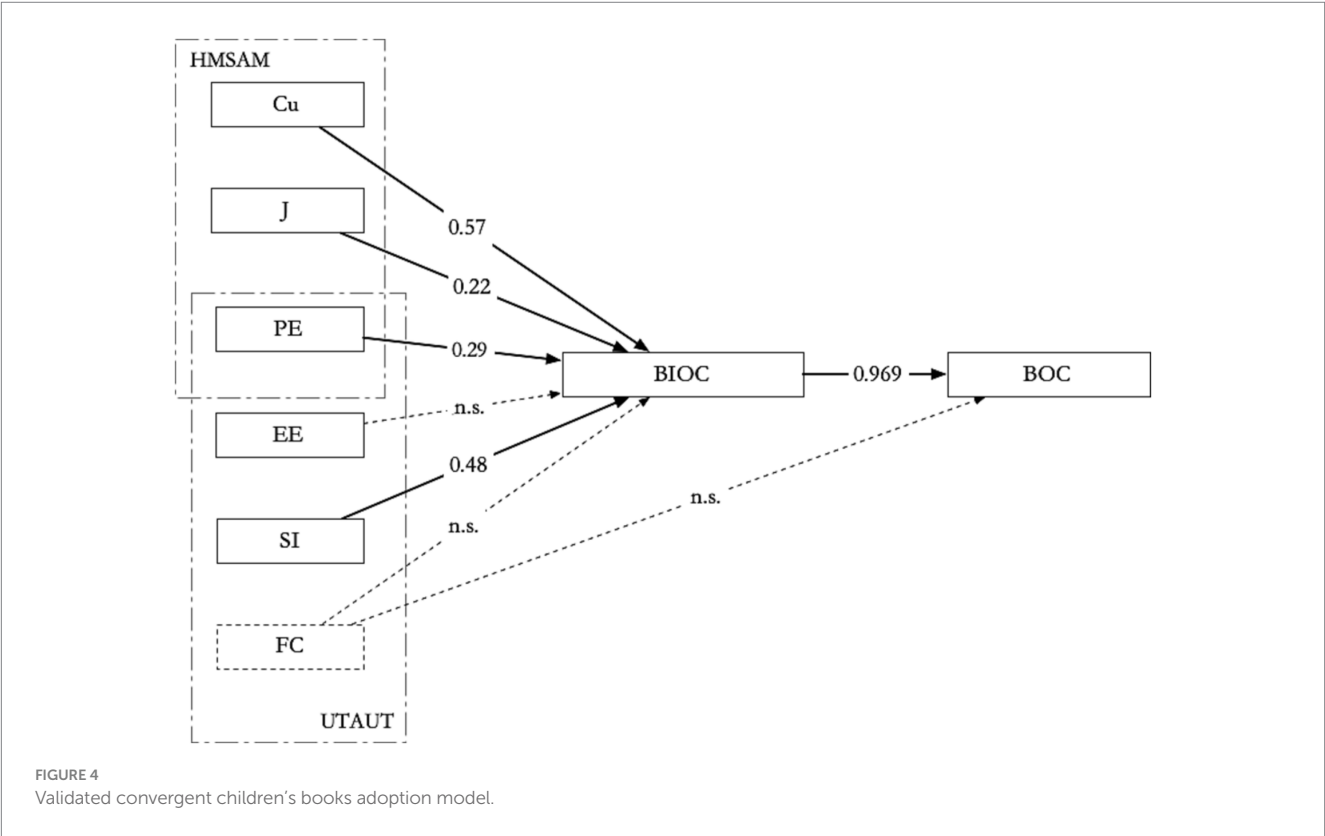
choice of integrated children's books. This suggests that there is also a group effect on children's reading and that herd mentality and mind of rivalry will reinforce children's reading intentions, which is a reflection of children's early socialization. The effect of facilitating conditions on reading intentions was not supported by the data. In the original UTAUT model, the researcher also found that facilitating conditions could not affect users' usage intentions as a separate explanatory variable, but they work together with other variables such as age and use experience. Only elderly users who are not familiar with technology need a service guide for an information system (Zheng and Zhuang, 2017). This article argues that because China has made great achievements in information infrastructure construction, the Internet and electronic equipment have already entered thousands of households; at the same time, the technical solutions of the integrated children's book products sold in the market today are relatively simple, and children often do not need to rely on product usage instructions or support services when they use such products.

6 Discussion

Based on the empirical evidence provided by empirical studies for technological innovation and the publishing marketing of children's book products, this article argues that children's book publishers can optimize the publishing progression of integrated children's book products in the following three dimensions.

6.1 Balance between the concepts of education orientation and child orientation

Driven by the reading concept of 'Reading is always beneficial', parents naturally hope that their children can acquire a certain amount of knowledge from children's books, and publishers also attach great importance to the educational attributes in integrated children's books when designing and selling them. However, from the

perspective of children's psychological development law, children's early psychological characteristics are curiosity of the perceptual world, and utilitarian goals such as the acquisition of knowledge and the perceived utility require a certain amount of accumulation of social experience. This means that it is difficult for children to internalize their parents' utilitarian reading motivations at an early age. The empirical evidence from this study also suggests that, at an early age, children are insensitive to the educational functions of integrated children's books and lack cognitive awareness of the delight of reading because their willingness to read integrated children's books is mainly driven by curiosity. This finding reminds children's book publishers that they should pay extra attention to 'child orientation', i.e., whether the product is appealing to children when designing integrated children's books for younger children.

However, this article argues that the design of integrated children's books must not ignore educational factors completely. According to Piaget's explanation of the stages of children's psychological development, children aged 2 to 7 are in a critical period of early socialization (Piaget, 1982). The empirical evidence provided in this article also suggests that children's perception of the utility of reading will be gradually strengthened as they enter the school-age stage. If children's books do not help children develop good reading habits, it is feared that school-age children will find it difficult to develop an interest in reading. Publishers should pay attention to the balance between the concepts of child orientation and education orientation when pursuing integrated children's book products with long life cycles: not only should integrated children's books conform to children's nature of strong curiosity and love of fun at a very young stage, but they should also allow children to capture the joy of reading progressively and help them develop good reading habits so that they can also gain knowledge through reading when they are of school age.

6.2 Technology-enabled children's book publishing needs to be child specific

In the discussion of children's reading, there is no lack of discussion on the issue of level reading, but studies have mainly been concerned with 'how to read', such as the analysis of children's reading catalogues launched by European and American booksellers or the children's book scoring table that elucidates the reading levels of Chinese children (Hongwei, 2010). The report called *Opinions on Promoting Reading for All issued by the Central Propaganda Department in 2020* stated that 'carrying out activities compatible with the physical and mental development of preschoolers and conducive to the cultivation of reading interests and reading habits' is an important task in the course of nationwide reading that should target all young people. Within the social background of a highly digitized media environment, publishers should also attach importance to the reading psychology of children of different ages when launching integrated children's book products and pay more attention to the issue of 'how to read'.

Based on the empirical evidence provided in the previous section, publishers can adopt targeted technology empowerment strategies according to the reading psychology of children of different ages when designing integrated children's book products. For younger children aged 0–6, publishers should pay extra attention to the design of sound, animation, and other content elements to attract their perennial attention and usage as they are still in the early stage of socialization. For middle and older children aged 7 and above, due to the maturity of their minds, the low threshold of interaction and relatively simple content design may be a bit childish. Publishers can contribute to enriching the usage experience of their products with more advanced content presentation technologies, such as VR and AR, and utilize interaction techniques that require a higher degree of operational precision to attract middle-aged children and older children to use their products. Meanwhile, publishers also need to gradually strengthen the knowledge attributes of their content step by step to meet the knowledge needs of middle-aged children and older children.

6.3 Optimizing product service patterns to avoid the risk of children's bad reading

Proponents of the parent–child reading model believe that parental companionship and guidance are key to influencing children's reading efficiency. However, in the real world, not all parents possess the concept of parent–child reading, nor do they have the ability or time to accompany their kids in reading. Moreover, according to the empirical evidence provided in this article, curiosity, playfulness, and community imitation may become new motives to promote children's reading after adding new technology elements to integrated children's books. Especially in subgroups where parents have low education levels, product enjoyment has a greater impact on children's willingness to use them. Therefore, it is difficult to ensure that such integrated children's book products can be used appropriately. The recent incident of pornographic content on the 'Little Genius Tablet' is also an alarm bell for the design and regulation of children's educational products. Publishers must therefore consider how to regulate the use of their products to avoid the risk of children's bad reading.

This article argues that children's book publishers can avoid the occurrence of similar risky events through product and service innovation. First, they can provide parents and children with value-added educational services such as reading guidance. Currently, there are some children's accompanied reading apps in the market based on the common needs of parents and children that can design reading topics according to the ideas of children and parents. During their children's reading process, parents will also receive reading instructions or content interpretation reminders. When designing integrated children's book products, publishers can also expand the content appropriately based on the needs of parent–child reading so that children's books can play an educational function and become a bond that maintains parent–child relationships as well.

The second is to strengthen the control of children's reading processes to help them cultivate healthy reading habits. As some parents lack the time or ability to read with their children, children's book publishers need to help parents supervise the process of their children's reading through technical services. In recent years, there have been a number of mobile phone and tablet apps that have gone online with a teen mode to help parents correct their children's media usage behavior. Integrated children's book publishers can use existing cases for reference and incorporate parental control functions into their product design to provide technical safeguards for the reasonable use of such products.

7 Conclusion

Based on the UTAUT and HMSAM, this article studies the effects of curiosity, joy, performance expectancy, effort expectancy, social impact, and facilitating conditions on children's adoption of integrated children's books by constructing a structural equation model, and it concludes that children's reading of integrated children's books is simultaneously influenced by hedonic and utilitarian motivations.

At the level of hedonic motivation, both curiosity and joy have a positive impact on children's reading intentions and behaviors, the effect of reading delight on reading intentions becomes more pronounced as children get older, and curiosity about integrated children's books becomes less and less important. Moreover, a child's home educational environment may be an important factor influencing their hedonic reading motivation: the parents' level of education determines, to some extent, whether the child reads integrated children's books out of joy or curiosity.

At the level of utilitarian motivation, performance expectancy, effort expectancy, and social impact all have an impact on children's reading intentions. As for the two influencing factors of performance expectancy and effort expectancy, as children grow older, knowledge and technological thresholds are no longer the main constraints on children's reading intentions, and parents' perceptions of reading performance are transmitted to children more and more intensely, which is an important source of reading motivation. Nevertheless, in terms of social impact, it has always been a significant factor influencing children of any age group to choose integrated children's books.

Based on the above verification, this article argues that children's book publishers need to optimize the publishing path of integrated children's products in three dimensions in the future. Firstly, publishers need to balance the concepts of 'education oriented' and 'children oriented' and integrate the two creative factors of 'catering to nature' and 'cultivating habits.' Secondly, publishers need to develop targeted technological empowerment strategies based on the different cognitive psychology of children in different age groups in order to satisfy the requirement of 'Level Reading.' Finally, publishers need to continuously innovate and optimize the service patterns of their children's book products by introducing models such as parents accompanying studying and adult supervision to help children avoid the risk of poor reading. To be brief, the children's book publishing industry needs to fully integrate various motivations and factors so that children can both gain knowledge and joy during reading.

8 Limitation

It must be acknowledged that this study has the following limitations:

Above all, due to the vast territory and large population of China, conducting rigorous probability sampling will add significant research costs. Therefore, this study adopted regional stratified sampling in an attempt to control for potential sampling bias. However, this may still affect the external validity of the study; thus, future research is required to reveal more evidence to validate the findings of this study.

Secondly, the respondents of this study were children aged 0–12 from 31 regions in China. Considering the ethical issues in research, the online questionnaire survey was conducted by child guardians, who answered the questions on the children's behalf. Although we screened a considerable proportion of unqualified questionnaires by the answer–question time standard, there is potential for measurement bias in these answers. Henceforward, direct measurement methods such as offline observation and behavioral experiments can be used to avoid potential measurement bias and improve the reliability of research conclusions.

In addition, this study is mainly based on existing literature, theories, and the current situation of the Chinese digital publishing industry, using a top-down quantitative research path to inquire into the influence of utilitarian motivation and hedonic motivation on children's adoption of integrated children's books. However, there may be some other potential new influence factors that have not been fully contemplated. In the future, the understanding of this research problem can be expanded by observing children's use of integrated children's books and conducting qualitative analysis of interview data.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by Ethics Committee of School of Journalism and Communication, Henan University. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study. Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

JC: Formal analysis, Supervision, Writing – original draft. JG: Data curation, Writing – review & editing. JY: Conceptualization, Resources, Writing – review & editing. LW: Conceptualization, Resources, Writing – review & editing. YB: Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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