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Original Research

A Metacognitive-Cultural Model for AI-mediated intercultural learning

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The integration of artificial intelligence into higher linguistic education raises questions about how multicultural competence develops when students interact with AI systems that simultaneously represent multiple cultural perspectives and reproduce Western cultural bias. This study examines how such interaction affects the development of multicultural competence among language faculty students. The research proposes and empirically tests a metacognitive-cultural model (MCM) describing this process through four links: stereotype deconstruction, perspectivisation, cultural modelling, and reflexive integration. A mixed 3×3×3 factorial design with repeated measures was implemented with 180 first- to third-year students from three Russian linguistic universities. Participants were assigned to experimental (AI with metacognitive scaffolding), comparative (AI only), and control (traditional instruction) groups. During an eight-week intervention students interacted with a GPT-4-based chatbot. Data were collected using adapted Byram questionnaires, professional intercultural cases, log-file coding, stimulated recall interviews, and implicit association tests. Students in the experimental group demonstrated greater gains in multicultural competence (+12.6 points) than those in the AI-only (+5.9) and control (+3.1) groups (Cohen's d = 0.92). The largest between-group difference occurred at the reflexive integration link (φ = 0.41). Mediation analysis showed that 43.6% of the intervention effect was explained through activation of MCM links. Students receiving metacognitive scaffolding also identified AI cultural bias more frequently (69.8% vs. 30.4%). The results suggest that AI interaction combined with metacognitive reflection can support critical cultural awareness in language education.

Keywords: *AI, multicultural competence, metacognitive scaffolding, intercultural communication, language education, cultural bias, metacognition*

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1. INTRODUCTION

Higher linguistic education is undergoing transformation stemming from the digitalisation of the educational environment and the increasing multicultural composition of the professional environment for future specialists. In the teaching of English as a lingua franca, these changes require reconsideration of established approaches to the development of professional competencies.

Artificial intelligence (AI) technologies, primarily large language models (e.g., ChatGPT and specialised chatbots), are increasingly introduced into educational practice. A meta-analysis by Albedah (2025), covering 161 studies published between 2015 and 2024, reports statistically significant reductions in language anxiety and improvements in pronunciation associated with AI use in language education. Yet, the role of AI in the development

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of multicultural competence, a key element in the preparation of specialists in intercultural communication, remains insufficiently examined.

The relevance of this research derives from the contradiction between the heuristic potential of AI as a carrier of multiple cultural codes, resulting from training on global data corpora, and the risk of reproducing cultural stereotypes and Anglocentric narratives. A study by Rucka (2025) on *Duolingo Max* shows that even technically advanced AI systems transmit predominantly Western cultural norms, creating a risk of forming a distorted worldview among learners.

In traditional methodology, the teacher was treated as the exclusive mediator of intercultural dialogue, whereas under current conditions AI tools increasingly function as participants in this process. For students of language faculties whose future professional activity involves intercultural communication (translation, teaching, accompanying delegations), the cultivation of a critical stance toward technological sources of cultural information is central to professional preparation.

Despite a substantial body of empirical data on the effectiveness of AI in language education (Zhang et al., 2024) and growing interest in its application to the development of intercultural competence (Klímová & Chen, 2024), the scientific discourse still lacks a theoretically grounded explanation of the processes through which interaction with AI influences the cultural consciousness of learners. Existing research also presents inconsistent findings. Meta-analyses report high heterogeneity of effects (I^2 = 92.66% in Zhang et al., 2024), which indicates the presence of moderating variables that remain insufficiently accounted for. At the same time, Saka (2025) identifies a statistically significant gap between students' self-assessment of intercultural competence and their observable behavioural indicators (Cohen's d = 0.69). Cao et al. (2025) demonstrate the importance of metacognitive strategies for interaction with AI (ϕ = 0.42 for evaluation strategies), although these results are not connected to the development of multicultural competence.

Thus, the research gap concerns the absence of an integrative theoretical model explaining how and under what conditions interaction with AI contributes to the development of multicultural competence, despite empirical data documenting the existence of the effect, its heterogeneity, and the significance of metacognitive factors.

The study aims to develop and empirically test a Metacognitive-Cultural Model (MCM) explaining how metacognitive processes influence the development of multicultural competence in language faculty students during interaction with AI in English language classes. To achieve this aim, the study will: (i) examine existing theoretical and methodological approaches to the development of multicultural competence using AI; (ii) formulate the MCM integrating metacognitive theory, intercultural competence frameworks, and cultural-historical psychology; (iii) test the proposed model under experimental conditions; (iv) identify statistically significant differences in multicultural competence development associated with different forms of interaction with AI; and (v) assess the role of metacognitive reflection in compensating for cultural bias represented in AI systems.

The study tests the following hypotheses:

1. Students using AI tools in combination with metacognitive scaffolding will show greater gains in multicultural competence than students using AI without metacognitive support and those in the control group.

2. The development of multicultural competence is mediated by activation of the components of the MCM — stereotype deconstruction, perspectivisation, modelling, and reflexive integration — with the largest differences expected in the frequency of reflexive integration.

3. The effectiveness of metacognitive support varies by year of study, with stronger effects observed in senior cohorts than in junior cohorts.

4. Metacognitive reflection compensates for cultural bias represented in AI systems by reducing the influence of stereotypical responses.

2. THEORETICAL BACKGROUND

2.1. Metacognitive theory

The theoretical basis of the study rests on several conceptual traditions, with Flavell's (1979) theory of metacognition occupying a central position. Flavell (1979) defined metacognition as knowledge about one's own cognition and its regulation, distinguishing two elements: metacognitive knowledge and metacognitive regulation, including planning, monitoring, and evaluation of cognitive activity.

Brown (1987) further developed this framework to distinguish among declarative, procedural, and conditional forms of metacognitive knowledge and emphasise the function of metacognitive regulation in the solution of complex cognitive tasks. The notion of metacognitive monitoring refers to the ability to assess the adequacy of cognitive strategies and adjust them when necessary.

In intercultural interaction, metacognition is expressed in the learner's awareness of their own cultural schemas and of the strategies used to interpret the behaviour of members of other cultures. As Triandis (1995) notes, cultural schemas function implicitly and influence perception and interpretation automatically, whereas their explicit awareness requires reflective activity.

Interaction with AI introduces additional demands on metacognitive regulation. AI-generated responses constitute a source of information that lacks intentionality and does not provide non-verbal cues, which requires learners to monitor the adequacy of their interpretations without relying on interpersonal feedback.

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2.2. Byram's model of intercultural communicative competence

Byram's (1997) model of intercultural communicative competence provides a framework for describing the structure of multicultural competence. The model includes:

1. Attitudes — curiosity and openness together with readiness to decentre from one's own cultural norms.

2. Knowledge — awareness of social groups and of their products and practices in one's own country and in the country of the target language.

3. Skills of interpreting and relating — the ability to interpret cultural phenomena and relate them to one's own cultural experience.

4. Skills of discovery and interaction — the ability to acquire new cultural knowledge through interaction.

5. Critical cultural awareness — the ability to evaluate perspectives, practices, and cultural products in one's own and other cultures.

For the model proposed in this study, critical cultural awareness has direct relevance to metacognitive processes. In interaction with AI, this aspect also involves evaluation of the source of cultural information, since AI systems may transmit implicit cultural bias.

2.3. Vygotsky's cultural-historical psychology and mediation theory

Vygotsky's (1978) theory of mediation allows viewing AI as a cultural tool mediating higher mental functions. According to Vygotsky (1978), the incorporation of a cultural tool into mental activity transforms that activity and leads to the emergence of new psychological systems.

In interaction with AI, learners internalise linguistic forms, cultural knowledge, and the principles of cultural categorisation reflected in the model's responses. This process corresponds to the transition from interpsychological activity to intrapsychological processes.

Unlike a human mediator, AI lacks intentionality and empathy. As a result, mediation in this case takes a quasi-dialogical form. The traditional scheme *subject — tool — object* is modified, since AI functions both as an instrument and as a quasi-subject within the interaction.

Interaction with AI also creates a specific form of zone of proximal development in which the technology assumes the role of the 'more knowledgeable other'. At the same time, AI systems do not adapt assistance to the learner's individual characteristics, which requires the learner to regulate the process of appropriating cultural knowledge through metacognitive monitoring.

2.4. Theory of sociocultural factors in technology adoption

The theory of sociocultural factors in technology adoption (Abdelhalim & Alsahil, 2025), which combines the Technology Acceptance Model (TAM) with sociocultural theory, suggests that pedagogical beliefs and institutional conditions statistically mediate the integration of generative AI into educational practice.

Applied to learners, this framework suggests that cultural attitudes, prior experience of intercultural interaction, and the educational environment influence the effects of AI-based learning activities. The framework also introduces the notion of *users' cultural sensitivity* as an extension of the technology acceptance model.

2.5. Theory of cognitive dissonance and cultural stereotypes

Festinger's (1957) theory of cognitive dissonance provides a basis for describing the first stage of the proposed model, termed *stereotype deconstruction*. Exposure to information that contradicts established representations produces psychological discomfort (dissonance), which motivates attempts to reduce this state.

In intercultural learning situations, dissonance arises when information generated by AI does not correspond to the learner's cultural expectations. In contrast to interpersonal communication, where discrepancies may be moderated by norms of politeness, interaction with AI may present contradictory information without such mediation, which intensifies cognitive conflict and encourages reflection.

Strategies for reducing dissonance range from rejection of the information to revision of existing cognitive schemas. Metacognitive support directs this process toward reconsideration of cultural stereotypes.

3. LITERATURE REVIEW

3.1. Meta-analytic studies on the effectiveness of AI in language education

Research on the effectiveness of artificial intelligence in language education has increasingly relied on meta-analytic approaches that synthesise results from large numbers of empirical studies. One example is the systematic review by Albedah (2025), which covers 161 studies published over a ten-year period. The analysis reports reductions in language anxiety and improvements in pronunciation, with the strongest effects observed in individualised learning settings. In these studies, the cultural aspect is typically treated as a background factor and receives limited analytical attention.

Comparable results are reported in the meta-analysis conducted by Zhang et al. (2024), which includes 23 experimental studies with a total sample of 2,847 participants. The reported effect size is Hedges' $g = 1.10$ ($SE = 0.18$) with a 95% confidence interval of [0.75, 1.44]. The analysis also indicates substantial heterogeneity ($I^2 = 92.66\%$, $p < .001$), suggesting that most of the observed variance in effect sizes reflects differences between the studies themselves.

The reported findings suggest stronger effects for affective variables than for cognitive outcomes, which corresponds to theoretical approaches that treat the affective domain as an entry point for metacognitive activity.

3.2. Studies on the relationship between AI and intercultural communicative competence

Research examining the relationship between AI use and intercultural communicative competence remains limited. A systematic review by Klímová and Chen (2024), which includes 11 studies, reports that AI technologies can generate immersive intercultural learning experiences and allow the simulation of intercultural contacts in conditions where real communication may involve social or pragmatic risks. At the same time, the review notes that AI systems may reproduce cultural presuppositions present in the data used for model training.

Empirical evidence also points to a discrepancy between perceived and demonstrated competence. In a mixed-methods study conducted by Saka (2025) with 89 students and 46 teachers in Turkey, combining an ICC questionnaire with discursive tasks, no statistically significant improvement in observed intercultural communicative competence was found when AI tools were introduced into the learning process. The study also reports a substantial gap between students' self-assessment and their demonstrated competence (d = 0.69), a result interpreted as an 'illusion of competence'. Qualitative analysis suggests that many students reproduce AI-generated responses without subjecting them to critical evaluation.

3.3. Metacognition and sociocultural factors in artificial intelligence use

Research on interaction with AI in educational settings also examines metacognitive strategies, cultural bias in AI systems, and sociocultural factors influencing technology adoption. Cao et al. (2025), using epistemic network analysis, identified statistically significant differences in metacognitive strategies between learners with high and low self-efficacy. Differences were observed in planning strategies (ϕ = 0.31, p < .05) and evaluation strategies (ϕ = 0.42, p < .01), indicating a relationship between metacognitive regulation and the effectiveness of interaction with AI.

Studies addressing cultural bias in AI systems reach similar conclusions. Rucka (2025), in a cultural walkthrough analysis of *Duolingo Max*, shows that generative functions can transmit Western cultural norms implicitly. Models trained on corpora dominated by texts from the United States and Great Britain tend to reproduce Western perspectives as normative.

Cross-cultural research on the adoption of generative AI also indicates variation across educational settings. Abdelhalim and Alsahil (2025), analysing responses from 307 teachers in Saudi Arabia, Egypt, and Jordan, report statistically significant differences between countries in attitudes toward and use of generative AI technologies.

4. THEORETICAL SYNTHESIS

4.1. Gaps in existing research

A review of the literature reveals several unresolved issues. First, existing studies tend to address AI effectiveness, intercultural competence, or metacognitive strategies separately. The literature does not offer an integrative theoretical model explaining how interaction with AI may influence the development of cultural consciousness.

Second, evidence indicates substantial heterogeneity of effects. The high heterogeneity reported by Zhang et al. (2024) (I^2 = 92.66%) suggests the presence of moderating variables that remain insufficiently addressed in existing studies, including the role of metacognitive regulation.

Third, empirical findings suggest a discrepancy between perceived and demonstrated competence. Saka (2025) reports a gap between learners' self-assessment and their observed intercultural performance, a phenomenon described as an 'illusion of competence'. This discrepancy requires theoretical interpretation in relation to learners' reliance on AI-generated responses.

Fourth, studies addressing cultural bias in AI systems treat this bias as a limitation of the technology. However, bias may also function as a pedagogical stimulus that generates cognitive dissonance and prompts reconsideration of cultural stereotypes.

Finally, the existing literature does not address students of language faculties as a distinct group of learners. Their professional orientation toward intercultural communication suggests the need for separate analysis of how interaction with AI influences the development of multicultural competence in this population.

4.2. Scientific novelty of the proposed approach

The theoretical contribution of the study can be summarised in five points.

1. Integration of metacognitive theory with a model of intercultural competence. The study places metacognitive processes — monitoring, control, and evaluation — at the centre of multicultural competence development in AI-mediated language learning. The fourth stage of the proposed model (reflexive integration) corresponds to the category of critical cultural awareness in Byram's (1997) model and is described through specific cognitive processes.

2. Interpretation of interaction with AI as a source of metacognitive activity. Whereas previous work treats AI mainly as a tool for delivering cultural content, the present study considers interaction with AI as a learning situation that can stimulate metacognitive activity under certain instructional conditions. Here, AI functions as a stimulus for reflection on learners' cultural schemas.

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3. Development of the Metacognitive-Cultural Model (MCM). The model describes four successive stages in the processing of cultural information during interaction with AI. Each stage is associated with a specific cognitive process and a metacognitive operation, which allows the processes involved to be identified and examined empirically.

4. Introduction of the concept of quasi-dialogical mediation. Building on Vygotsky's (1978) theory of mediation, the study introduces a concept describing interaction with AI as engagement with a quasi-Other: a source of information that lacks intentionality but participates in mediated activity. This concept clarifies the difference between AI-mediated learning and traditional forms of instruction.

5. Interpretation of cultural bias as a pedagogical stimulus. While existing studies treat bias in AI systems as a limitation (Rucka, 2025), the present study considers situations in which bias can stimulate reflection on cultural assumptions and support the development of critical cultural awareness under appropriate instructional conditions.

The study's methodological novelty can be summarised as follows.

1. Development of a coding system for MCM stages. A coding scheme for analysing interaction log files generated during learner interaction with AI was developed and validated. The scheme allows quantitative identification of the activation of each stage of the proposed model.

2. Adaptation of diagnostic instruments for the context of language faculties. Professionally oriented cases involving translation, pedagogical activity, and delegation support assess multicultural competence in situations relevant to future professional activity.

3. Three-factor experimental design including the year of study. The inclusion of the year-of-study variable enables comparison of junior and senior cohorts and examination of changes in multicultural competence across stages of university training.

The empirical contribution of the study can be summarised as follows:

1. Evaluation of the effects of metacognitive scaffolding during interaction with AI in a sample of language faculty students.

2. Quantitative analysis of the activation of MCM stages and their association with changes in multicultural competence.

3. Identification of the compensatory function of metacognitive reflection in relation to cultural bias in AI systems (Rucka, 2025).

4. Analysis of differences in intervention effectiveness across years of study.

5. Identification of the development of a critical attitude toward AI as a professionally relevant learner characteristic.

4.3. Differentiation from existing research

The approach proposed in the present study differs from existing studies in several respects, as visualised in Table 1.

Table 1
Comparison of research approaches

ASPECT	EXISTING RESEARCH	THIS STUDY
Focus	General effectiveness of AI	Processes involved in multicultural competence development
Theoretical basis	Fragmental empirical findings from separate studies	Integrative Metacognitive-Cultural Model (MCM)
Interpretation of AI	Tool for knowledge delivery	Source of metacognitive activity
Role of metacognition	One factor among others	Central process in competence development
Cultural bias	Treated as a limitation or risk	Treated as a pedagogical stimulus under appropriate instructional conditions
Educational context	School education and general student samples	Language faculties and professional training
Analytical outcome	Description of observed effects	Explanation of the processes producing these effects

5. METHODOLOGY

5.1. Structure of the Metacognitive-Cultural Model

The Metacognitive-Cultural Model (MCM) is proposed on the basis of the theoretical perspectives outlined above and the analysis of empirical findings. The model describes a sequence of cognitive processes activated during interaction with AI that influence the development of multicultural competence.

The model consists of four links, each associated with a specific cognitive process and a corresponding metacognitive operation. These links may be activated in a non-linear or cyclical manner; however, engagement with all four links is required for stable development of multicultural competence (Table 2).

Table 2
Proposed model structure

MCM STAGE	COGNITIVE	METACOGNITIVE	THEORETICAL BASIS	CORRESPONDENCE WITH
Link 1: Stereotype Deconstruction	Cognitive dissonance (Festinger, 1957)	Metacognitive monitoring: identification of discrepancy	Cognitive dissonance theory; studies on cultural bias in AI (Rucka, 2025)	Preparation for modification of attitudes
Link 2: Perspectivisation	Decentration (Piaget, 1950)	Metacognitive modelling: construction of an alternative perspective	Decentration theory; immersive potential of AI (Klímová & Chen, 2024)	Skills of interpreting and relating
Link 3: Cultural Modelling	Experimentation (Vygotsky, 1978)	Metacognitive control: selection of strategies	Mediation theory; concept of safe experimentation (Saka, 2025)	Skills of discovery and interaction
Link 4: Reflexive Integration	Critical evaluation (Byram, 1997)	Metacognitive evaluation: assessment of adequacy	Critical cultural awareness; metacognitive theory (Flavell, 1979)	Critical cultural awareness

5.2. Characteristics of the links

5.2.1. Stereotype Deconstruction (cognitive conflict)

Interacting with AI, learners may receive responses that do not correspond to expectations based on their existing cultural stereotypes. For example, a query about family traditions in India may generate an answer describing urban family practices that differ from traditional patriarchal structures. Such discrepancies give rise to cognitive dissonance (Festinger, 1957), which requires resolution. In interpersonal communication, discrepancies are moderated by norms of politeness and the desire to preserve the interlocutor's face. Interaction with AI lacks comparable interpersonal regulation. The absence of intentionality and communicative adjustment can intensify cognitive conflict and prompt reflection. Metacognitive monitoring occurs when the learner recognises a discrepancy between their own cognitive schema and the information received. Metacognitive support aims to promote awareness and verbalisation of this process.

For Link 1, empirical indicators in interaction logs include: (i) expressions of surprise *(I thought that... however, you indicate that...)*; (ii) requests for verification *(Is this information accurate?)*; and (iii) comparisons with prior expectations *(What accounts for the difference between your answer and my perception?).*

5.2.2. Perspectivisation (Decentration)

To resolve the conflict, the learner performs the cognitive operation of decentration (Piaget, 1950), adopting the perspective of the Other and attempting to interpret the situation from an alternative cultural position.

In this stage, AI functions as a source of multiple perspectives. Through repeated requests or clarifications (prompts), learners may request explanations from different cultural positions (e.g., *How might this situation be interpreted in China? Are there regional differences?*). AI systems can generate multiple perspectives based on heterogeneous training data.

Metacognitive modelling involves constructing a mental representation of how a cultural situation may be organised from an internal cultural perspective. This process requires explicit cognitive effort because interaction with AI does not provide the non-verbal cues (intonation, gestures, or facial expressions) that accompany interpersonal communication.

For Link 2, empirical indicators in interaction logs include: (i) requests for alternative perspectives *(What are the regional variations of this phenomenon?)*; (ii) context clarification *(If we consider not a metropolis but a rural area, does the situation change?)*; and (iii) comparison of perspectives *(What is the difference between the approach in culture A and the approach in culture B?).*

5.2.3. Cultural Modelling (Experimentation)

AI provides opportunities for safe experimentation with cultural scenarios. Learners can model intercultural dialogues, request reactions to various speech acts from the perspective of different cultures, and test hypotheses concerning culturally appropriate behaviour.

In real intercultural communication, mistakes may have social consequences such as misunderstanding or conflict. Interaction with AI removes these interpersonal risks

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and therefore creates conditions for experimentation. At the same time, as shown in Saka (2025), such interaction requires metacognitive regulation; otherwise learners may rely on copying AI-generated responses instead of engaging in analytical evaluation.

Metacognitive control refers to the learner's conscious selection of strategies for interaction with AI, including the formulation of prompts, interpretation of responses, and selection of hypotheses to be tested in relation to intercultural understanding.

For Link 3, empirical indicators in interaction logs include: (i) hypothetical questions (*What would be the reaction of a colleague from Saudi Arabia if I...*); (ii) requests for interpretation of reactions (*How would this statement be interpreted in Japan?*); and (iii) repeated requests with modified parameters.

5.2.4. Reflexive Integration (critical evaluation)

The final link concerns reflection on the experience of interacting with AI. The learner evaluates not only the content of the information received but also the adequacy of its cultural representation — whether the response reflects stereotypes, reproduces colonial discourses, or reduces complex social realities.

In this phase the process described by Byram (1997) as *critical cultural awareness* develops. The learner begins to treat AI as one possible voice among many, a source that may contain bias, limitations, or incomplete representations. Reflection therefore extends to the status of the source itself and to the recognition that AI systems reflect cultural assumptions present in training data and development contexts.

Metacognitive evaluation involves judging the adequacy of one's own understanding and the applicability of cultural interpretations derived from AI responses. This stage connects the learning experience with subsequent participation in real intercultural communication.

For Link 4, empirical indicators in interaction logs include: (i) source criticism (*From what sources does AI draw this information?, Does the answer primarily represent a Western perspective?*); (ii) meta-comments reflecting revision of prior assumptions (*Now I realise my perceptions were overly generalised*); and (iii) assessments of adequacy (*To what extent can this answer be trusted?*).

5.3. Model progression

The MCM does not assume strictly linear progression through the links. Several trajectories are possible:

1. Full cycle (most productive): Links 1 → 2 → 3 → 4. The learner moves through all four links sequentially, supporting stable development of multicultural competence.

2. Fixation on Link 3 (risk of the 'illusion of competence'). The learner engages actively in experimentation and modelling but does not reach reflexive integration. In this case, the pattern described by Saka (2025) may occur, characterised by high self-assessment in the absence of measurable progress.

3. Regressive cycle. After reaching Link 4, the learner returns to Links 1—2 at a higher level of understanding, accompanied by more differentiated perceptions of cultural stereotypes. This trajectory corresponds to the development of increased sensitivity to cultural differences.

4. Skipping of links. With a high initial level of competence, the learner may proceed directly to modelling or reflection, skipping the stage of cognitive conflict.

5.4. Coding scheme for empirical analysis

To quantify the activation of MCM links, a coding scheme for interaction log files generated during learner interaction with AI was developed (Table 3). For each dialogue, the following measures were recorded: (i) frequency of activation of each link; (ii) presence of a full cycle (sequence D—P—M—R); (iii) proportional distribution of links within the interaction.

Table 3
Coding scheme for MCM links

LINK	CODE	INDICATORS	EXAMPLES
1	D	Stereotype deconstruction	*I thought that in India everyone... however...*
2	P	Perspectivisation	*How is this phenomenon interpreted in China?*
3	M	Modelling	*What would be the reaction of a colleague from... if I...*
4	R	Reflexive integration	*Does the answer primarily represent a Western perspective?*

5.5. Research design

The study employed a mixed factorial design (3 × 3 × 3) with repeated measures (Table 4).

5.6. Participants

The study involved 180 students in Years 1—3 (age range 18—21) from three linguistic universities in the

Russian Federation. All participants were enrolled in programmes in Linguistics or Pedagogical Education (Foreign Language). Participants met the following criteria: (i) B2—C1 English proficiency, confirmed through academic records and entrance testing; (ii) no reported cognitive impairments; and (iii) provision of informed consent. Participants were distributed evenly by year of study, with 60 students in each cohort (Years 1—3). Within each cohort, students were assigned to three groups using stratified randomisation (Table 5).

Table 4
Structure of the factorial research design

FACTOR	LEVELS	FACTOR TYPE
Group	Experimental (AI + metacognitive scaffolding) Comparative (AI only) Control (traditional instruction)	Between-subject
Year of study	Year 1 Year 2 Year 3	Between-subject
Time of measurement	Pre-test Post-test Follow-up (+3 months)	Within-subject

Table 5
Sample characteristics

CHARACTERISTIC	GROUP 1 (AI + METACOGNITIVE	GROUP 2 (AI ONLY)	GROUP 3 (CONTROL)	TOTAL
Number of students	60	60	60	180
Mean age (years)	19.4 (1.3)	19.5 (1.2)	19.3 (1.4)	19.4 (1.3)
Gender (M/F)	18/42	20/40	19/41	57/123
Distribution by year (1/2/3)	20/20/20	20/20/20	20/20/20	60/60/60
Language level (B2/C1)	32/28	34/26	33/27	99/81
Prior AI experience (1-5)	2.8 (0.9)	2.9 (0.8)	2.7 (1.0)	2.8 (0.9)

5.7. Experimental conditions

The study included three instructional conditions.

Group 1 (experimental condition): AI with metacognitive scaffolding. For eight weeks (two classes per week, 45 minutes each), within the courses *Workshop on Intercultural Communication* and *Practical Course of English*, students interacted with a specialised chatbot (*InterCulture Bot*) developed using the GPT-4 API. The system was configured to produce culturally differentiated responses via a system prompt instructing the model to represent cultural knowledge about different countries, to consider cultural variability, to avoid stereotypical formulations, and to present multiple perspectives on culturally related questions. Students were also informed that the interlocutor represented knowledge relevant to future linguists and foreign language teachers. During each session, learners received metacognitive prompts before, during, and after interaction and maintained reflective journals documenting their reasoning and responses. Group 2 (comparative condition): AI without metacognitive scaffolding. Students interacted with the same chatbot and completed the same tasks as in the experimental condition, but without metacognitive prompts and without the requirement to maintain reflective journals. Group 3 (control condition): traditional instruction. Students worked with authentic texts and videos and participated in role-play activities on intercultural topics without the use of AI tools.

5.8. Measures

Given the professional orientation of the programmes involved (linguistics and pedagogical education), the measurement instruments were adapted to assess both general multicultural competence and professionally relevant aspects of intercultural communication (Table 6).

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Table 6
Measures of dependent variables

VARIABLE	MEASUREMENT TOOL	PSYCHOMETRIC CHARACTERISTICS
Multicultural competence (ICC)	Adapted Byram (1997) questionnaire (32 items, 5-point scale) combined with the Cultural Intelligence Scale (CQS) (Van Dyne et al., 2008)	Cronbach's α = 0.92 (pre-test), 0.94 (post-test)
Professionally oriented ICC	Analysis of intercultural cases (8 professional scenarios: translation, teaching, delegation support), expert assessment using a rubric (0–100)	Inter-rater reliability ICC = 0.88
Metacognitive strategies	Metacognitive Awareness Inventory (MAI), adapted for the intercultural context of professional activity (24 items) (Schraw & Dennison, 1994)	α = 0.89
MCM link activation	Interaction log files with AI combined with stimulated recall for a sub-sample (n = 45)	Coding according to the four-link scheme, Cohen's κ = 0.86
Critical attitude toward AI	Scale for critical evaluation of technological information sources (author-developed, 8 items)	α = 0.84
Cultural bias perception	Implicit Association Test (IAT) for cultural stereotypes adapted for the professional context	D-measure, test-retest r = 0.70

Note. The Implicit Association Test scoring procedure follows the D-measure proposed by Greenwald et al. (2003)

5.9. Research procedure

The study was conducted over a six-month period (September 2025-February 2026) at three linguistic universities. The procedure consisted of six stages.

1. Screening and preliminary testing (week 1). Participant eligibility was confirmed, students were stratified by year of study, and informed consent was obtained.

2. Pre-test (week 0). All dependent variables were measured prior to the intervention, and language proficiency was verified.

3. Intervention (weeks 1-8). Participants completed 16 instructional sessions according to their group assignment. The activities were integrated into the courses *Workshop on Intercultural Communication* and *Practical Course of English*.

4. Post-test (week 8). All dependent variables were measured again following completion of the intervention.

5. Stimulated recall interviews (week 8). A subsample of 45 students (15 from each group, proportionally distributed by year of study) participated in stimulated recall interviews.

6. Follow-up measurement (week 20). A delayed assessment was conducted to examine the stability of the observed effects.

6. STUDY RESULTS

6.1. Statistical assumptions

Prior to the main analysis, the assumptions underlying parametric testing were examined. The Shapiro—Wilk test indicated that the distributions of all dependent variables did not significantly deviate from normality ($W > 0.96$, $p > 0.05$). Homogeneity of variances was assessed using Levene's test, which produced non-significant results for all between-subject factors ($F(2, 177) = 1.18—2.13$, $p > 0.05$).

For repeated measures, Mauchly's test indicated that the assumption of sphericity was satisfied ($x^2(2) = 3.21—5.42$, $p > 0.05$), and therefore the Greenhouse—Geisser correction was not required. Multicollinearity diagnostics showed that variance inflation factors remained below 2.3 for all predictors, indicating no evidence of problematic collinearity.

6.2. Effects of intervention

To test the main hypothesis concerning differences between groups, a mixed three-way ANOVA (3 × 3 × 3) with repeated measures was conducted (Table 7).

The analysis revealed a significant main effect of group (n^2 partial = 0.23), indicating that group membership accounted for 23% of the variance in ICC scores. A significant main effect of year of study was also observed (n^2 partial = 0.10).

A significant main effect of time (n^2 partial = 0.22) indicated changes in ICC scores across measurement points. The Time × Group interaction was significant (n^2 partial = 0.14), indicating different trajectories of change across the three instructional conditions. The Group × Year interaction was also significant (n^2 partial = 0.08), suggesting variation in intervention effects across years of study (Table 8).

Table 7
Results of mixed ANOVA for ICC Indicators

SOURCE OF VARIATION	SS	df	Ms	F	p	η^2 partial
Between-subject effects						
Group	3248.9	2	1624.5	28.42	<.001	0.23
Year	1243.6	2	621.8	10.88	<.001	0.10
Group × Year	1023.7	4	255.9	4.48	.002	0.08
Error	9772.8	171	57.2			
Within-subject effects						
Time	4238.5	2	2119.3	46.82	<.001	0.22
Time × Group	2456.3	4	614.1	13.57	<.001	0.14
Time × Year	418.9	4	104.7	2.31	.058	0.02
Time × Group × Year	587.4	8	73.4	1.62	.118	0.03
Error (Time)	15478.2	342	45.3			

Table 8
Descriptive statistics of ICC by group and time of measurement (means and standard deviations, 100-point scale)

GROUP	YEAR	PRE-TEST M (SD)	POST-TEST M (SD)	FOLLOW-UP M (SD)	GAIN
Gr1 (AI + meta)	1	58.4 (7.8)	71.2 (8.7)	68.3 (9.2)	+12.8
	2	64.7 (8.1)	77.5 (8.9)	74.6 (9.4)	+12.8
	3	69.2 (7.9)	81.3 (8.5)	78.9 (8.8)	+12.1
	Total	64.1 (8.9)	76.7 (9.5)	73.9 (9.8)	+12.6
Gr2 (AI only)	1	58.1 (8.4)	64.2 (9.8)	60.1 (10.3)	+6.1
	2	64.3 (8.7)	70.5 (10.2)	66.2 (10.7)	+6.2
	3	69.5 (8.2)	75.1 (9.7)	71.3 (10.1)	+5.6
	Total	64.0 (9.2)	69.9 (10.5)	65.9 (11.0)	+5.9
Gr3 (control)	1	58.6 (7.9)	61.8 (9.2)	59.7 (9.8)	+3.2
	2	64.9 (8.3)	68.1 (9.5)	66.0 (10.0)	+3.2
	3	69.4 (7.8)	72.3 (9.1)	70.4 (9.6)	+2.9
	Total	64.3 (8.7)	67.4 (9.8)	65.4 (10.2)	+3.1

Post-hoc comparisons identified significant differences between the experimental group and the other conditions at post-test (Table 9). The comparison between the experimental and control groups produced a large effect size (Cohen's d = 0.92).

The difference between the experimental and AI-only groups corresponded to a medium-to-large effect (d = 0.71). The difference between the AI-only and control groups was not statistically significant (p = .098) and corresponded to a small effect (d = 0.26).

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Table 9
Pairwise comparisons of groups at post-test

COMPARISON	MEAN DIFFERENCE	95% CI	p	Cohen's d
Gr1 vs Gr2	6.8	[3.9, 9.7]	<.001	0.71
Gr1 vs Gr3	9.3	[6.4, 12.2]	<.001	0.92
Gr2 vs Gr3	2.5	[-0.4, 5.4]	.098	0.26

6.3. Professionally oriented ICC

Performance on professionally oriented intercultural cases (translation, teaching, and delegation support) differed significantly across the three groups of participants (Table 10). The largest between-group differences were observed in the delegation support cases (d = 1.02 for the comparison between Gr1 and Gr3), which correspond to professional situations associated with the future professional activities and work contexts of language faculty graduates.

Table 10
Results for professionally oriented ICC at post-test

GROUP	TRANSLATION CASES M (SD)	TEACHING CASES M (SD)	DELEGATION CASES M (SD)	INTEGRAL INDICATOR
Gr1 (AI + meta)	78.3 (9.2)	75.8 (9.7)	80.1 (8.9)	78.1 (9.3)
Gr2 (AI only)	68.7 (10.8)	66.2 (11.3)	70.4 (10.5)	68.4 (10.9)
Gr3 (control)	65.9 (10.1)	64.8 (10.6)	67.3 (10.2)	66.0 (10.3)
F(2, 177)	24.63*	22.18*	26.47*	25.84*
η^2 partial	0.22	0.20	0.23	0.23

Note: p < .001

6.4. MCM link activation

To verify the hypothesis concerning the role of metacognitive strategies, interaction log files from the two AI conditions were analysed (Groups 1 and 2). In total, 3,840 dialogues were examined (1,920 per group) (Table 11). The largest between-group difference was observed for Link 4 (Reflexive Integration) (ϕ = 0.41, p < .001). Significant differences were also observed for Link 1 (Stereotype Deconstruction) (ϕ = 0.36) and Link 2 (Perspectivisation) (ϕ = 0.34).

Analysis by year of study showed an increase in the frequency of Link 4 activation from Year 1 to Year 3 in both AI conditions, with a larger increase in the experimental group (Table 12).

Table 11
Frequency of MCM link activation in the AI conditions

MCM LINK	Gr1 (AI + meta)	Gr2 (AI only)	χ^2	ϕ	p
Link 1: Stereotype Deconstruction	74.2%	46.8%	31.24	0.36	<.001
Link 2: Perspectivisation	63.5%	35.2%	28.73	0.34	<.001
Link 3: Modelling	78.9%	64.7%	9.84	0.20	.002
Link 4: Reflexive Integration	48.3%	16.5%	43.56	0.41	<.001

Table 12
Frequency of Link 4 (Reflexive Integration) activation by year

YEAR	Gr1 (AI + meta)	Gr2 (AI only)	DIFFERENCE
Year 1	38.2%	11.4%	+26.8%
Year 2	48.7%	16.2%	+32.5%
Year 3	58.1%	21.9%	+36.2%

A two-way ANOVA (Group × Year) showed a significant interaction effect ($F(2, 114) = 4.86$, $p = .009$, n^2 partial = 0.08), indicating that the difference between groups increased across years of study.

A mediation analysis using structural equation modelling with bootstrap estimation (5,000 samples) examined whether activation of MCM links mediated the effect of group membership on ICC gain (Hayes, 2018) (Table 13).

Table 13
Results of mediation analysis

PATH	UNSTANDARDISED COEFFICIENT (B)	SE	95% CI (BOOTSTRAP)	STANDARDISD
Direct effect (group → ΔICC)	5.12	1.31	[2.55, 7.69]	0.43
Indirect effect (group → MCM → ΔICC)	3.96	0.94	[2.12, 5.80]	0.34
Total effect	9.08	1.62	[5.90, 12.26]	0.77

The indirect effect was statistically significant, as the 95% confidence interval did not include zero, and accounted for 43.6% of the total effect.

6.5. AI cultural bias and the compensatory function of reflection

To examine the influence of AI cultural bias, a content analysis of chatbot responses (N = 3,840) was conducted to determine the prevalence of Western cultural norms. Student identification of bias was then compared across groups (Table 14). Students in the experimental group identified instances of cultural bias more frequently than students in the AI-only group (69.8% vs. 30.4%, $x^2 = 42.17$, $p < .001$, $\phi = 0.47$).

To examine the compensatory role of reflection, a hierarchical regression model with moderation was estimated (Table 15).

The AI cultural bias index showed a negative association with ICC gain ($\beta = -0.19$, $p = .005$). The interaction between group and bias was significant ($\beta = -0.26$, $p < .001$), indicating differences between instructional conditions in the relationship between AI bias and learning outcomes.

The three-way interaction Group × Bias × Reflection was also significant ($\beta = 0.34$, $p < .001$), indicating that the relationship between AI bias and ICC gain differed depending on both instructional condition and the frequency of reflexive integration strategies.

Students in the experimental group with higher levels of reflexive integration (upper quartile) showed higher ICC gains even when interacting with responses containing higher levels of cultural bias. In the AI-only group, higher levels of AI bias were associated with lower ICC gains regardless of individual variation.

6.6. Qualitative results (stimulated recall)

Analysis of stimulated recall interviews with the student sub-sample (n = 45) identified qualitative differences in how interaction with AI was interpreted by participants (Table 16). The qualitative data indicate differences between the two AI conditions in the ways students reflected on interaction with the system. Participants in the experimental group more frequently referred to issues such as critical evaluation of AI outputs, awareness of personal assumptions, and the application of these experiences to future professional activities in translation, language teaching, and intercultural communication.

7. DISCUSSION

The study confirmed the effectiveness of the metacognitive-cultural model (MCM) on a sample of language faculty students and identified several features relevant to professional training. With regard to professionally relevant competence gain, students in the experimental group demonstrated an increase in multicultural competence of 12.6 points, significantly exceeding the gains observed in

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Table 14
Cultural representation in AI responses (student assessment)

CATEGORY OF ANALYSIS	PROPORTION OF RESPONSES WITH WESTERN NORMS (OBJECTIVE)	PROPORTION OF STUDENTS IDENTIFYING BIAS (GR1)	PROPORTION OF STUDENTS IDENTIFYING BIAS (GR2)
Family structures	72%	68%	31%
Gender roles	64%	71%	28%
Social practices	68%	74%	33%
Food traditions	78%	59%	24%
Business etiquette	71%	77%	36%
Average	70.6%	69.8%	30.4%

Table 15
Hierarchical regression: moderation of the AI bias effect

STEP	PREDICTORS	R^2	ΔR^2	F CHANGE	P	β (FINAL MODEL)
1	Group, Year, Pre-ICC	0.31	0.31	26.42	<.001	—
2	+ AI Bias Index	0.34	0.03	7.89	.005	-0.19*
3	+ Group × Bias	0.40	0.06	16.24	<.001	-0.26**
4	+ Group × Bias × Reflection	0.47	0.07	21.38	<.001	0.34***

*Note: * p < .05, ** p < .01, *** p < .001*

Table 16
Categories of interview analysis (stimulated recall)

CATEGORY	Gr1 (AI + meta)	Gr2 (AI only)	REPRESENTATIVE STATEMENTS
Critical attitude toward AI	91%	38%	*As a future translator, I must realise that AI often represents primarily a Western perspective. This can distort meaning when translating culturally specific texts*
Awareness of own stereotypes	78%	31%	*I realised that I expected AI to confirm my stereotypes about Japan. When it produced a different answer, I began to reflect on the origins of my assumptions* (Gr1, Year 2)
Professional reflection	71%	22%	*In pedagogical practice, I will teach students to work with different sources. This experience showed the need for specific training in the critical evaluation of even "intelligent" technologies* (Gr1, Year 3)
Verification strategies	84%	43%	*I now cross-check information from AI using multiple sources, especially when it concerns cultural phenomena* (Gr1, Year 2)
Transfer to professional context	67%	21%	*During my teaching practice, I have already used similar questions to help school students analyse cultural stereotypes* (Gr1, Year 3)
Perception of AI as authoritative source	9%	62%	*If AI produces certain information, it is probably reliable because the technology was trained on representative data* (Gr2, Year 1)

the comparison group (5.9 points) and the control group (3.1 points). The observed effect size (n^2 partial = 0.23; Cohen's d = 0.92) suggests a strong intervention effect. The largest gain was observed in professionally oriented cases such as delegation accompaniment (Cohen's d = 1.02), which corresponds directly to the future professional activity of language faculty students.

In terms of yearly differentiation, the interaction between group and year (n^2 partial = 0.08) suggests that the effectiveness of metacognitive support increases from junior to senior years. Third-year students display a higher initial level of ICC (69.2 compared with 58.4 in Year 1) and demonstrate more frequent reflective activity, with 58.1% activation of Link 4 compared with 38.2% in Year 1. This result corresponds to data on the development of metacognitive skills during professional training (Cao et al., 2025) and indicates the suitability of implementing such programmes in the second and third years, when students already possess a sufficient language base and begin studying professionally oriented disciplines.

Regarding the activation of MCM links, the largest differences between groups were observed for the reflexive integration link (ϕ = 0.41). Among language faculty students, the qualitative content of this reflection is differentiated: it includes source criticism as well as professional reflection on the possible application of the acquired experience in translation, pedagogical practice, or intercultural communication. 71% of students in the experimental group, compared with 2% in the AI-only group, referred to professional reflection in interviews.

With regard to compensation for cultural bias, language faculty students showed statistically significantly higher sensitivity to AI cultural bias than those noted by Rucka (2025): in the experimental group, 69.8% identified the dominance of Western norms compared with 30.4% in the AI-only group. The three-way interaction (β = 0.34) suggests that metacognitive reflection compensates for the negative effect of bias; for future specialists in intercultural communication, this skill has clear professional relevance.

The obtained results correspond to the meta-analysis by Zhang et al. (2024), which reported high heterogeneity of AI intervention effects (I^2 = 92.66%). The present research accounts for this heterogeneity through individual differences in metacognitive regulation and students' professional motivation. In contrast to the study by Saka (2025), which reported a gap between self-assessment and actual competence among students (Cohen's d = 0.69), the present study found a high correlation between self-assessment and observed ICC in the experimental group (r = 0.74), whereas in the AI-only group the correlation was moderate (r = 0.41). This result suggests that metacognitive support contributes to more accurate self-assessment, which is relevant for professional training. The findings of Cao et al. (2025) concerning differences in metacognitive strategies between groups with different levels of self-efficacy (ϕ = 0.42 for evaluation strategies) are supported and extended by the present data: in the student sample, an additional factor is professional orientation and year of study.

The findings make several contributions to research on foreign language teaching in higher education. The metacognitive approach to professional training receives further specification in the present study through analysis of the role of metacognition in professional language education and its relation to both academic and professionally relevant competences. Metacognitive regulation during interaction with AI serves as a basis for the development of a critical attitude toward sources of cultural information, a competence required in professional intercultural communication.

With regard to the MCM as a tool for professional development, the four identified MCM links can be considered as a diagnostic tool for assessing students' readiness for professional intercultural communication. The frequency and quality of activation of Link 4 (Reflexive Integration) correlate with success in solving professional cases (r = 0.68, p < .001).

The interaction between group and year indicates the need for a differentiated approach to the use of AI tools at different stages of professional training. In the first year, when students are still establishing their language base, metacognitive support is less effective than in later years, which necessitates corresponding adaptation of instructional programmes.

The findings have several practical implications for organising the educational process in language universities. The use of AI is most effective when incorporated into professionally oriented disciplines in the core curriculum, including *Workshop on Intercultural Communication, Theory and Practice of Translation*, and *Methods of Teaching Foreign Languages*. Such integration allows the experience gained to be applied directly in professional contexts.

Metacognitive scaffolding is integral to such integration. Providing access to AI tools without metacognitive support is less effective and may encourage an uncritical attitude toward technological information sources. In the present study, 62% of students in Group 2 perceived AI as an authoritative source compared with 9% in Group 1. For future specialists, this finding warrants attention.

The results also indicate that the largest differences between more successful and less successful students are found at the fourth link of the MCM, Reflexive Integration, which involves critical evaluation of AI responses and reflection on one's own cultural schemas. Instructional attention should therefore concentrate on this link through professionally oriented reflection, examination of stereotypes present in AI responses, and discussion of technological limitations relevant to future professional activity.

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Year-specific differences should also be considered. For first-year students it is advisable to begin with the development of basic metacognitive skills, focusing on Links 1 and 2. In the second and third years, the emphasis may shift toward professional reflection (Link 4) and the modelling of professional situations (Link 3). The developed programme showed the highest effectiveness in the second and third years.

The findings also concern a critical attitude toward technology. The obtained data (Cohen's d = 1.09 in the experimental group) show that interaction with AI accompanied by metacognitive scaffolding can strengthen critical evaluation of technological information sources more generally. For future linguists and teachers working in information-rich environments, this competence has clear professional relevance.

Finally, the results are relevant for preparing students to work with culturally heterogeneous information. AI cultural bias, as noted by Rucka (2025), cannot be completely eliminated. In the present study, even with specialised system configuration, 70.6% of responses reflected Western cultural norms. Universities therefore need to prepare students to identify such bias and respond to it appropriately in professional practice. This approach corresponds to contemporary views on preparing specialists for professional activity under conditions of informational and cultural variability.

8. LIMITATIONS AND FURTHER RESEARCH

The research, despite careful methodological design, has several limitations that should be considered when interpreting the results.

In terms of sample characteristics, the study involved only students from language universities enrolled in Linguistics and Pedagogical Education programmes, which limits the generalisation of the findings to broader populations. These students possessed relatively high language proficiency (B2—C1), pronounced professional motivation, and age-related cognitive characteristics typical of 18—21-year-olds. The gender imbalance (68.3% women) reflects the actual demographic structure of language universities in Russia but requires verification on gender-balanced samples.

With respect to temporal limitations, the intervention lasted eight weeks and included sixteen sessions, which does not allow a full assessment of long-term effects on multicultural competence. The consolidation of stable metacognitive strategies requires a longer period of observation. The three-month follow-up only partially addresses this limitation and provides no information on competence trajectories over one to two years.

In terms of technological limitations, the study relied on a text-based chatbot, which constitutes a constraint. Contemporary AI tools also include voice assistants, automated translation systems, adaptive learning platforms, and virtual and augmented reality environments, each offering specific affordances that may activate MCM links in different ways. The GPT-4 model also has inherent limitations related to the predominance of English-language training data reflecting primarily Western cultural perspectives, as noted by Pan et al. (2025) and Rucka (2025).

In terms of contextual limitations, the study was conducted under controlled educational conditions, which raises questions about external validity and the transferability of the findings to real professional settings. Educational cases cannot fully reproduce the complexity of real intercultural communication, which involves time pressure, emotional stress, responsibility, and multiple contextual variables.

With respect to limitations related to the measurement of variables, the construct of multicultural competence, even when assessed using validated instruments such as the Byram (1997) questionnaire and the Cultural Intelligence Scale (CQS) together with expert evaluation, cannot be fully accounted for by these measures. Critical cultural awareness, as defined by Byram (1997), represents a value-laden construct that is difficult to quantify. Likewise, the assessment of metacognitive strategies through interaction log files and stimulated recall cannot fully reconstruct internal metacognitive processes, particularly those operating at implicit levels.

Concerning statistical limitations, the power to detect small effects ($f < 0.10$) in three-way interactions proved insufficient. Some interactions, including Time × Group × Year, did not reach statistical significance ($p = 0.118$), although a trend was observed. Multiple comparisons increase the risk of Type I error, while the Bonferroni correction is conservative and may increase the probability of Type II errors. A ceiling effect was observed among third-year students in the experimental group (81.3 points at post-test), which limits the assessment of further progress.

Additional limitations concern the cultural context. The study was conducted with a monocultural sample of Russian students, which restricts cross-cultural interpretation of the findings. Russian culture, generally characterised as collectivist with certain reservations, may produce different patterns of interaction with culturally unfamiliar information than those observed in individualistic cultures. In addition, the Russian educational environment, including academic traditions and attitudes toward technology, may act as an uncontrolled variable.

In terms of the linguo-cultural characteristics of interaction with AI, the interaction was conducted in English as a lingua franca. English, which dominates the training data of large language models, carries implicit cultural codes associated with the Anglo-Saxon world, as noted by Rucka (2025), which may influence both AI responses and their

interpretation. Students may also have experienced additional cognitive demands related to language processing, which could reduce resources available for metacognitive regulation.

Another limitation concerns participants' prior intercultural experience. Participants differed in their level of such experience, ranging from minimal exposure to substantial involvement in activities such as internships abroad and international projects. Although this variability was statistically controlled, it may still function as a moderating factor influencing the effectiveness of the intervention.

Additional limitations concern the theoretical model. One issue relates to the tension between the linear representation of the model and the cyclical character of the underlying processes. Although the model is heuristically useful, it simplifies the actual complexity of cognitive processes. In practice, Deconstruction, Perspectivisation, Modelling, and Reflexive Integration may occur in parallel, return cyclically to earlier stages, and exhibit complex hierarchical organisation.

The model also does not fully account for individual differences in link activation. Cognitive styles, personality characteristics, and prior experience may modify the activation of MCM links. Variables such as tolerance for ambiguity, cognitive complexity, and empathy may therefore act as moderating factors.

Another limitation concerns emotional processes. The model focuses primarily on cognitive and metacognitive processes and gives limited attention to emotional aspects. Festinger's (1957) theory of cognitive dissonance includes emotional components such as discomfort and tension, but these elements are not sufficiently reflected in the measurement procedures used in the study.

Despite these limitations, several directions for further research can be identified. Cross-cultural validation of the model requires multicentre studies involving research groups from countries representing different cultural clusters, including Western individualistic cultures such as the US, theUK, and Germany; Eastern collectivist cultures such as China, Japan, and South Korea; and cultures with other value orientations in regions such as the Arab world, Latin America, and Africa. Such studies should involve a total sample of at least five hundred participants.

Longitudinal investigation of MCM development and change should be conducted through cohort studies with measurements in years one, two, three, and four of university training and follow-up measurements one and three years after graduation. These designs should also include qualitative data reflecting real professional intercultural communication experience.

Comparative investigation of different AI technologies in professional contexts should examine the effectiveness of text-based chatbots, voice assistants, specialised translation systems with cultural commentary, and VR simulations of intercultural situations across professional tasks including translation, teaching, and intercultural communication.

Another line of research concerns meta-competencies. Future studies may assess the extent to which MCM-based work influences critical thinking, information culture, professional reflection, and tolerance for ambiguity using additional dependent variables measured before and after intervention.

Individual differences also require systematic investigation. Variables such as cognitive style, personality traits including openness to experience and conscientiousness, tolerance for ambiguity, empathy, prior intercultural experience, and motivation should be examined using structural equation modelling.

Neurocognitive correlates of MCM link activation may be investigated using fMRI and fNIRS with subsamples of 30 to 40 participants. Such studies could identify neural networks (including the prefrontal cortex, anterior cingulate cortex, and temporoparietal junction) that support the implementation of each MCM link and examine possible neuroplastic changes associated with learning.

Transfer to real professional activity also requires investigation. Mixed-method longitudinal designs may include participant observation and analysis of professional products one to two years after graduation, supplemented by interviews and analysis of translations, lessons, and accompanying documents.

Further work is also required on diagnostic tools. This includes the development of computerised adaptive tests for identifying MCM links, automated systems for analysing interaction log files, projective techniques for assessing readiness for reflexive integration, and adaptation of existing diagnostic instruments for metacognitive strategies in intercultural settings.

Personalisation of metacognitive scaffolding constitutes another research direction. Future work may develop and test programmes that adapt to individual characteristics and stages of professional development using adaptive experimental designs.

Finally, ethical aspects of AI use in intercultural education require systematic examination. Such work should address issues including cultural bias in AI systems, algorithmic transparency, responsibility for cultural representations, and human—technology mediation in intercultural learning, with interdisciplinary perspectives from AI ethics, cultural anthropology, and postcolonial studies.

The observed limitations suggest several directions for addressing these issues in future research. Sample diversification should include students from non-linguistic specialisations, different levels of language proficiency (A2—C2), and different age groups, while ensuring gender balance. Temporal parameters may be extended through

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interventions lasting at least one academic year (nine to ten months) with delayed measurement one to two years later. The range of technologies may be expanded to include different AI tools and comparison of their effectiveness. Studies conducted in natural professional environments may involve translation bureaus, schools, and international departments.

Further methodological improvements include the development of more sensitive diagnostic instruments capable of distinguishing high levels of competence and identifying qualitative change. Greater statistical power requires sample sizes exceeding four hundred participants in order to detect small effects in three-way interactions. Cross-cultural replications should be carried out in diverse cultural settings using standardised research protocols. Mixed-method designs combining quantitative and qualitative approaches may provide deeper insight into the mechanisms underlying observed effects. An interdisciplinary perspective involving specialists in cognitive psychology, neuroscience, cultural anthropology, and ethics is also desirable. Transparency of research procedures should be supported through pre-registration of study designs and publication of raw data in accordance with ethical requirements.

Implementation of these recommendations would clarify how multicultural competence develops in AI-mediated learning, address the limitations identified in the present study, and contribute to further refinement of theoretical foundations and practical approaches to the use of artificial intelligence in the professional preparation of future linguists and teachers.

9. CONCLUSION

The study examined how interaction with artificial intelligence can influence the development of multicultural competence among language faculty university students. The proposed metacognitive-cultural model (MCM) describes this process as a sequence of interconnected links including stereotype deconstruction, perspectivisation, cultural modelling, and reflexive integration. Empirical testing using a mixed factorial design demonstrated that the integration of AI interaction with metacognitive scaffolding produces stronger gains in multicultural competence than either AI use without scaffolding or traditional instructional approaches.

The results suggest that the most substantial differences between groups occur at the stage of reflexive integration, where students critically evaluate AI responses and reconsider their own cultural assumptions. Mediation analysis showed that a considerable proportion of the intervention effect was mediated through activation of MCM links, indicating that competence gains during AI-mediated learning were partly explained by metacognitive processes. The findings also suggest that metacognitive reflection increases students' sensitivity to cultural bias in AI responses and encourages them to treat AI outputs as objects of critical evaluation instead of authoritative information sources.

The results support the view that AI interaction in educational settings should be treated as a pedagogical environment that can stimulate metacognitive reflection and intercultural awareness. Cultural bias in AI responses may function as a pedagogical stimulus that encourages critical engagement with cultural representations.

The findings support the integration of metacognitive scaffolding into AI-based instruction, attention to reflexive integration in curriculum design, and differentiation according to stages of university training. When accompanied by metacognitive reflection, interaction with AI may support the emergence of critical cultural awareness among future specialists in intercultural communication, translation, and language education.

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