What matters in AI-supported learning: A study of human-AI interactions in language learning using cluster analysis and epistemic network analysis

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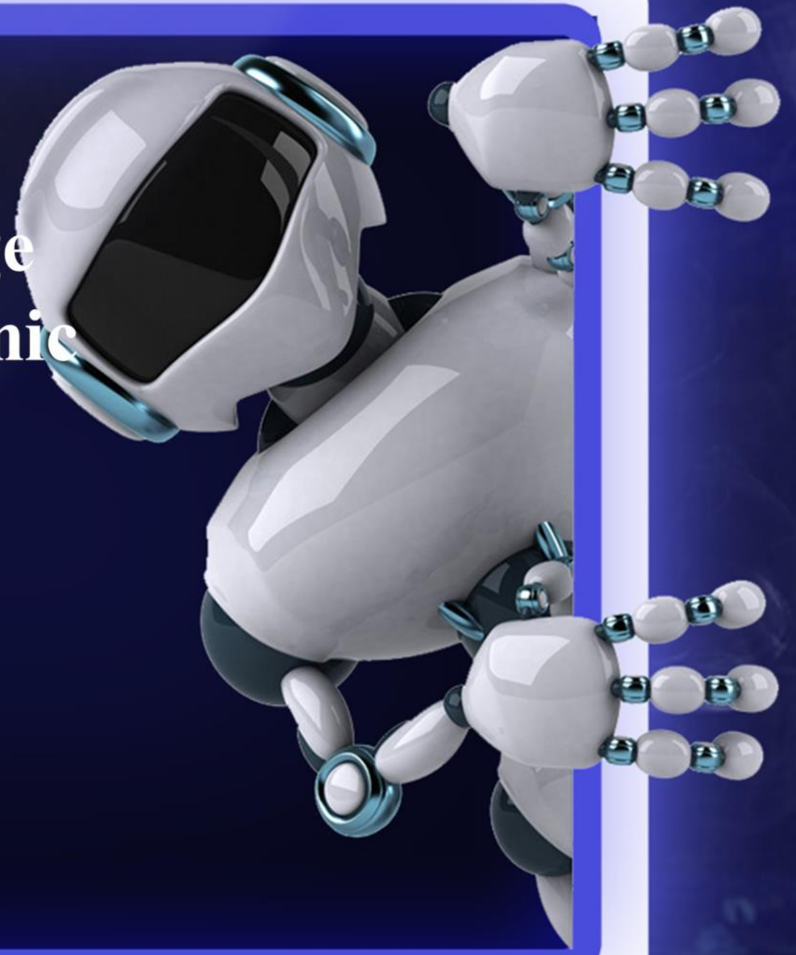

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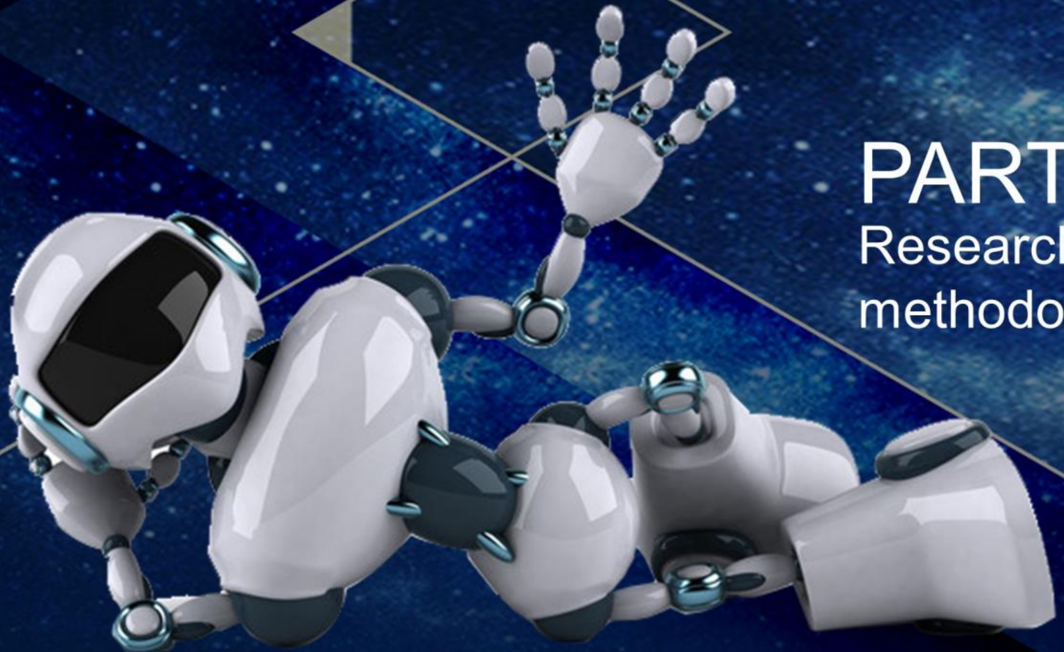

AI agents

- Definition: entities that are capable of performing tasks related to intelligent beings through reasoning, learning, and expressing themselves, to a certain extent (Berendt et al., 2020; Wang et al., 2022).

- Characteristics:
  - Appearances (Randall, 2019): e.g., anthropomorphic (with human-like appearances), cartoon-like (with exaggerated cartoon features), and mechanomorphic (with machine-like features).

  - Visibility: embodied and disembodied (Lee & Jeon, 2022)
    - Embodied AI agents: physical robots and virtual agents (e.g., Randall, 2019; van den Berghe et al., 2019)

    - Disembodied agents: invisible and delivered through smart devices such as Google Assistants and Amazon's Alexa (e.g., Dizon, 2020; Moussalli & Cardoso, 2020)

AI agents

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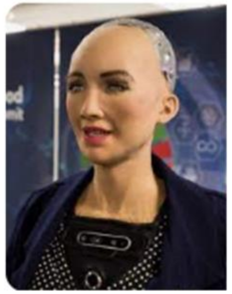

3. DragonBot (Cartoon-like)

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4. Scribbler (Mechanomorphic)

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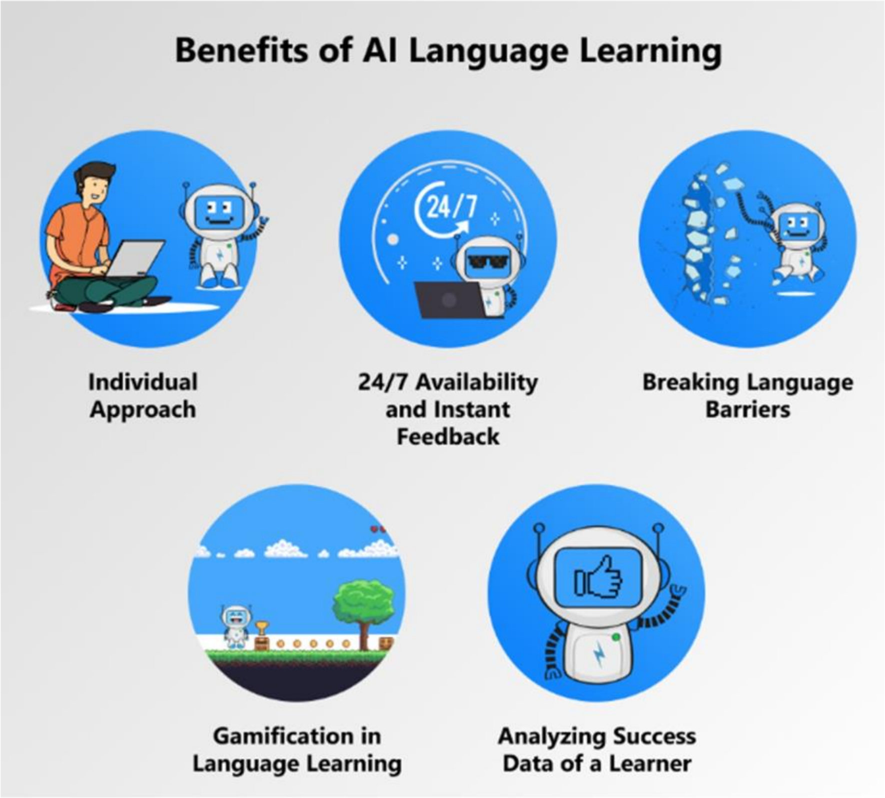
AI agents’ benefits

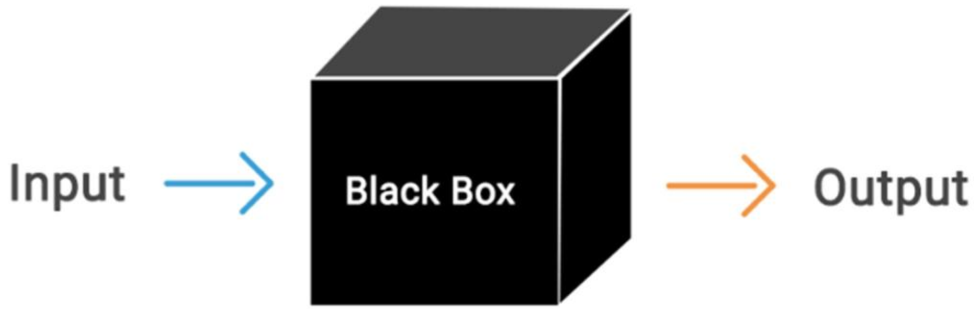
- Reading, speaking, vocabulary, listening, writing, etc.

- Increasing learners’ overall L2 competence (e.g., Chen et al., 2020; Lee & Jeon, 2022)。



Research gaps

- Short intervention-novelty effect: e.g., using language robots for only ten to fifteen minutes over two days (Engwall & Lopes, 2020) or using only an hour of Google Assistant (Chen et al., 2020)
- Solely relied on attitudinal data from surveys or interview (e.g., Chen et al., 2020; Lee & Jeon, 2022), potential respondents' biases.
- Lack of knowledge of human-AI interaction: most studies (e.g., Dizon, 2020; Tai & Chen, 2020) aimed at examining the effectiveness of AI agents in improving students' L2 competence.
  - Few insights can be gained to improve the design and implementation of AI agents in language learning as well as the pedagogy of AI-supported language learning.



- Lack of knowledge regarding whether there are differences in human-AI interactions among distinct types of students.

Research questions

- (RQ1) How many distinct types of learners can be identified with respect to the AI usage?

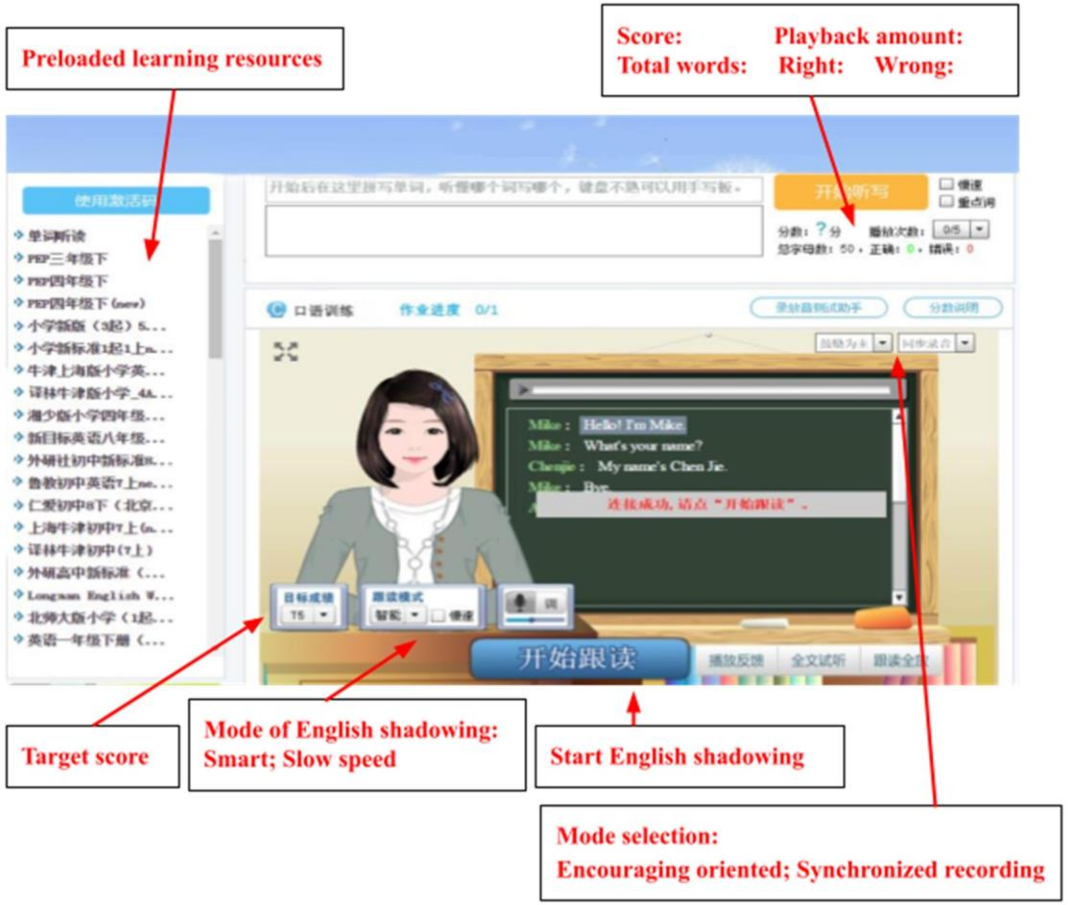
- (RQ2) How do distinct types of learners interact with AI for language learning and what are their differences in human-AI interactions, if any?

How do we do?

- Participants and research setting: An English as a Foreign Language (EFL) class involving 16 sixth-grade students in a primary school; A semester
  - their English proficiency was normally at very basic levels due to limited exposure to authentic L2 environments and exam-oriented education

- AI coach: The AI coach was a virtual AI agent installed on mobile devices and was embodied as a female teacher. It was specifically created for EFL learning, supporting unlimited English practice and providing personalized feedback on students' speaking.

- Cope with the lack of native English-speaking teachers and to assist the students in learning English anywhere and anytime



Data sources

- Two sources:
  - (a) Students’ usage data of the AI system
    - Four components: average frequencies of English shadowing, listening practice, and vocabulary learning (100 points), as well as average scores of English shadowing.
  - (b) Reflection essays

Cluster analysis

Summary of the four-cluster solution

Clusters		Frequency of ES		Frequency of LP		Frequency of VL		Scores of ES	
	N (%)	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
C1	4 (25%)	51.75	1.26	22.50	3.11	16.00	7.44	92.30	1.023
C2	2 (12.50%)	51.50	6.37	27.50	6.36	6.00	0.00	83.05	1.48
C3	7 (43.80%)	50.571	3.46	31.86	2.27	10.43	6.13	90.53	1.30
C4	3 (18.80%)	55.67	4.04	24.67	5.13	57.00	9.54	88.73	3.02
Comparisons		[$C1_{sum}$ = 90.25; $C2_{sum}$ = 85.00; $C3_{sum}$ = 92.86;$C4_{sum}$ = 137.33]* C4 > C3 > C1 > C2						C1 > C3 > C4 > C2	

Note. ES = English shadowing; LP = Listening practice; VL = Vocabulary learning.
*Comparisons were calculated based on summed values of the three engagement variables.

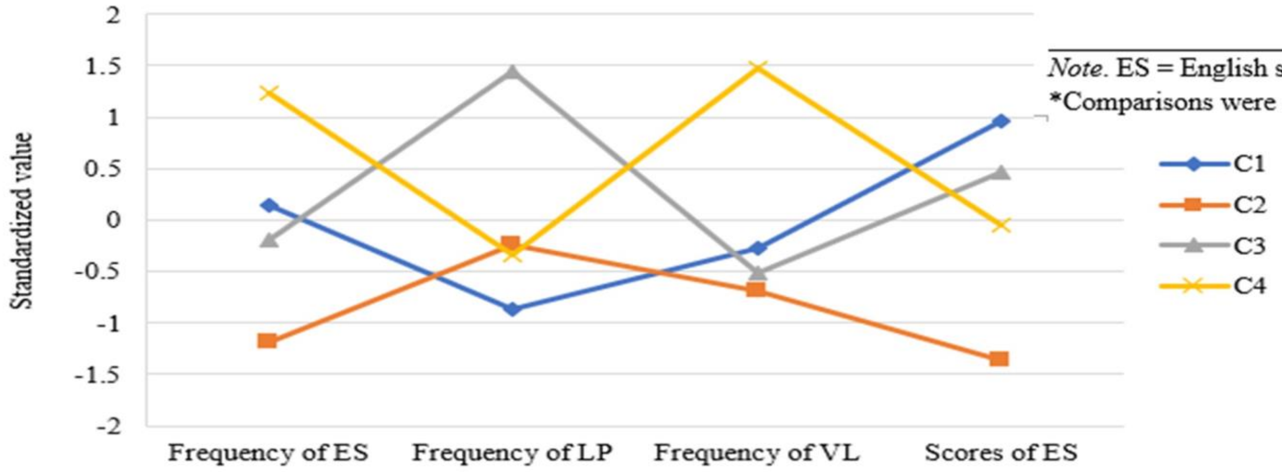


Figure 2. Distribution of the four clusters across the four variables.
Note. C1 (*N* = 4); C2 (*N* = 2); C3 (*N* = 7); C4 (*N* = 3).

ENA: coding framework

- Community of inquiry (CoI): Students and AI may form a learning community where the social, cognitive, and teaching presences students perceive in interacting with AI can forge meaningful learning experiences and facilitate L2 acquisition (Jeon, 2022; Wang et al., 2022).

- Student approach to learning (SAL):
    - Substantial research (e.g., Ellis & Bliuc, 2019; Lindblom-Ylänne et al., 2019) has shown that the ways in which students approach online or offline learning play a crucial role in determining their learning experiences and performance.
    - SAL framework has been found to effectively explain why some students are more successful than others in school (Ellis & Bliuc, 2019).
    - Deep, surface, organized approaches to learning

- CoI + SAL

ENA: coding framework

Table 1. Finalized coding framework.

Components	Sub-components	Explanations and examples
Social presence	Emotional expression	Students clearly express their positive feelings toward the AI coach. e.g., "It (the AI coach) is an excellent learning platform." "… I deeply appreciate the help of the AI coach."
	Affinity	Students perceive the affinity with the AI coach. e.g., "It (the AI coach) is like an authentic British person." "It (the AI coach) always encourages us…"
Teaching presence	Instructional design	Students perceive that the AI learning platform has a systematic instructional design supporting their English learning. e.g., "It (the AI coach) has multiple functions, supporting pronunciation, vocabulary learning, …, giving you authentic learning experience, …., encouraging you in different ways…"
	Guidance & Facilitation	Students perceive the guidance and facilitation provided by the AI coach which increase their learning engagement. e.g., "…. what surprises me is that it (the AI coach) automatically categorizes my dubbing of movie clips for me to retrieve and review them easily." "It (the AI coach) facilitates us to challenge other learners…."
	Feedback	Students perceive that the AI coach provides timely and clear feedback for them so that they can know their achievements and problems. e.g., "It (the AI coach) will give you very specific feedback on your English speaking right after you read a sentence." "I will get a score for each practice so that I will know the difference between me and other learners who are doing the same practice."
Cognitive presence	Agentic exploration	During the students-AI interaction, students constantly reflect on their progress and take agentic actions to engage with the AI coach. e.g., "Ever since I have the AI coach, I rarely need my parents or teacher to remind me to learn English." "I often reflect on my progress aided by the AI coach."
	Problem-solving	During the infinite students-AI interaction, students can solve problems arising in the learning process by themselves. E.g., "I am making progress every day by tackling problems related to grammar and intonation."
Approaches to learning	Deep approach	Students use higher-order thinking skills in English learning. e.g., "I practice English with a clear goal." "…I consciously compare my pronunciation with the AI coach who also uses different colors to highlight the differences in pronunciation between my English and the more authentic one."
	Surface approach	Students emphasize memorization and reproduction in English learning. e.g., "…I often mimic movie clips or memorize words and sentences with the help of the AI coach."
	Organized approach	Students have an organized schedule in the use of the AI coach. e.g., "… I use it (the AI coach) every day and make progress every day."
L2 Learning enjoyment		Learning English with the AI coach is a pleasant experience for the students. e.g., "I am enjoying the learning process with the AI coach." "I cannot help but express my joy when I finally overcome the problems of pronunciation and intonation"
Intrinsic motivation		Students like the mode of learning English with the AI coach and have a strong interest in this mode. e.g., "I like to learn English with it (the AI coach) as it helps improve my English competence"
Extrinsic motivation		Students are extrinsically motivated to learn English. e.g., "You can get (virtual) flowers and awards if you practice English with the AI coach every day and achieve good performance."

Alignment of the cluster analysis with epistemic network analysis

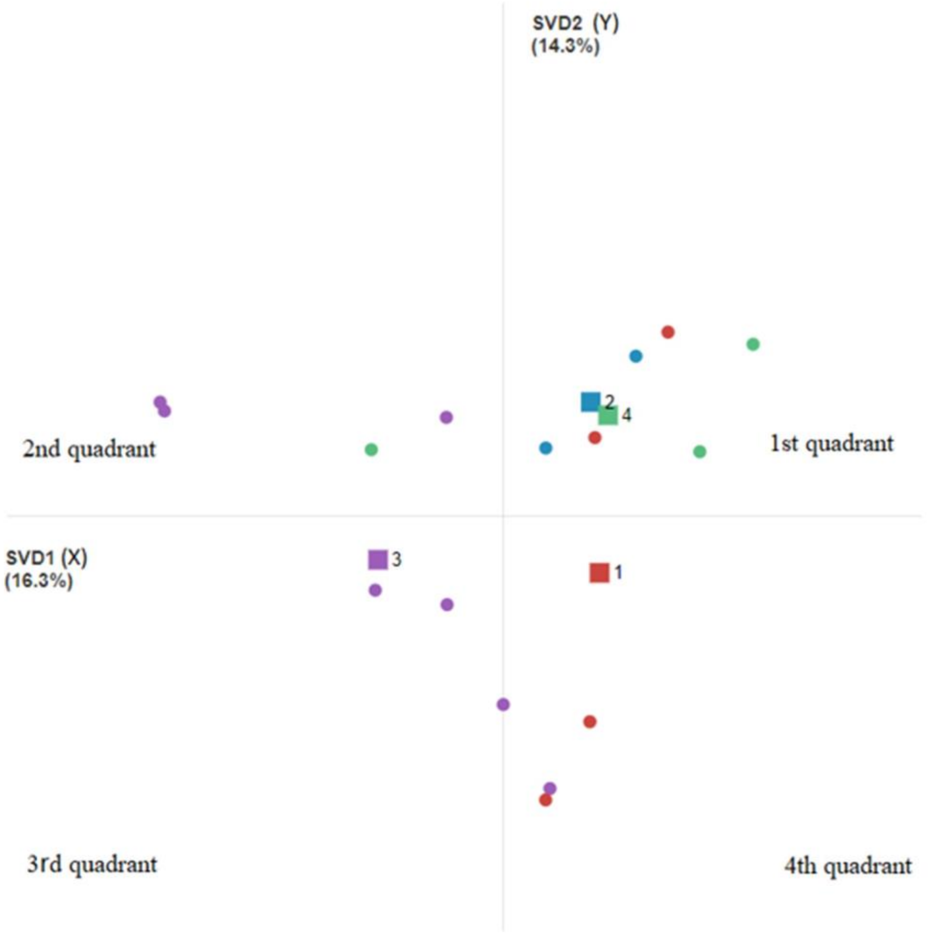


Figure 3. Distribution of the four clusters' centroids.

Note. The rectangle represents the centroid of each cluster, which is randomly assigned a color; The dot represents the participant in each cluster with the cluster's color; SVD = Singular Value Decomposition; ENA chooses two dimensions based on SVD as the X and Y axes that best account for the variance in the data.

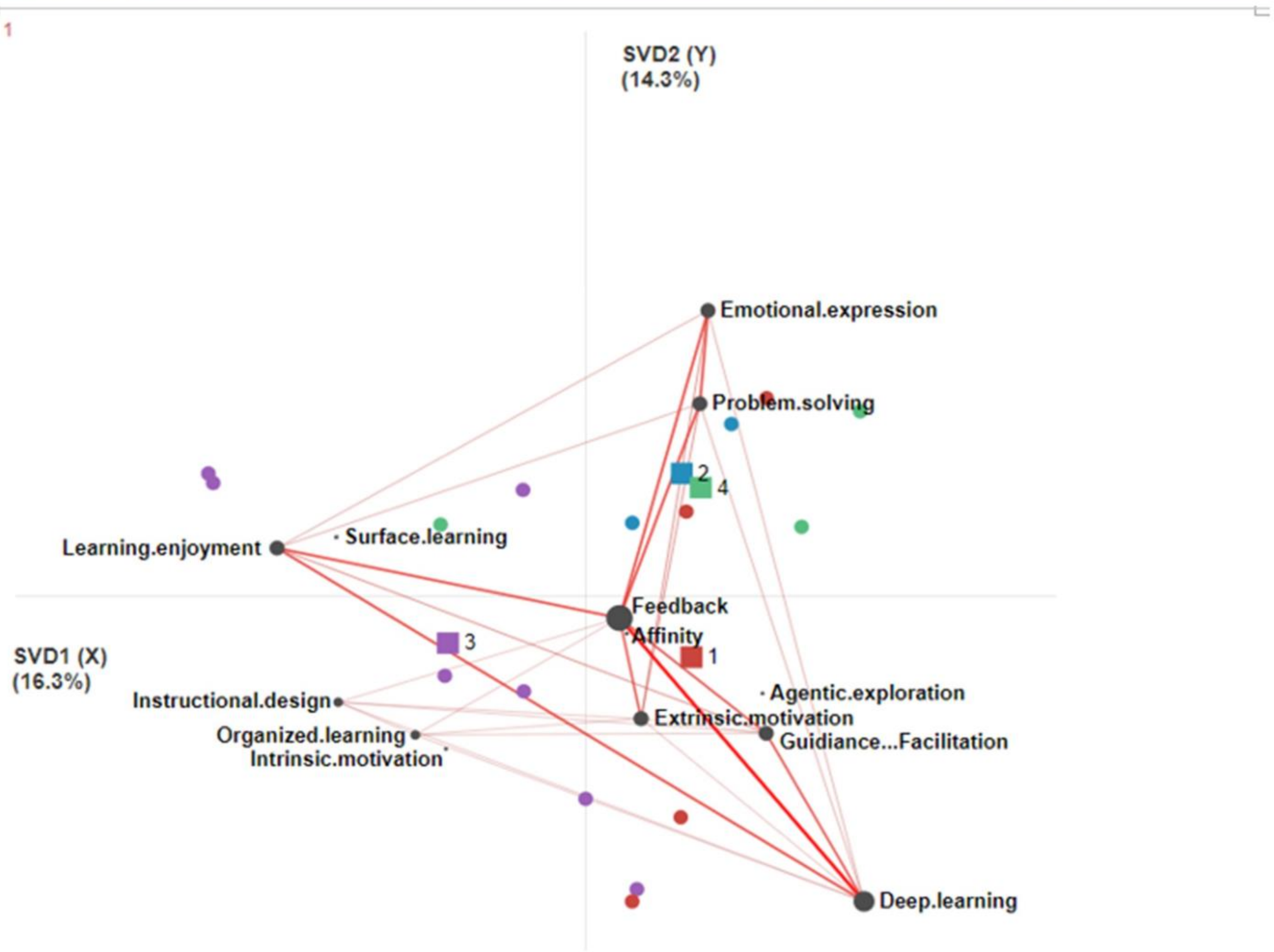
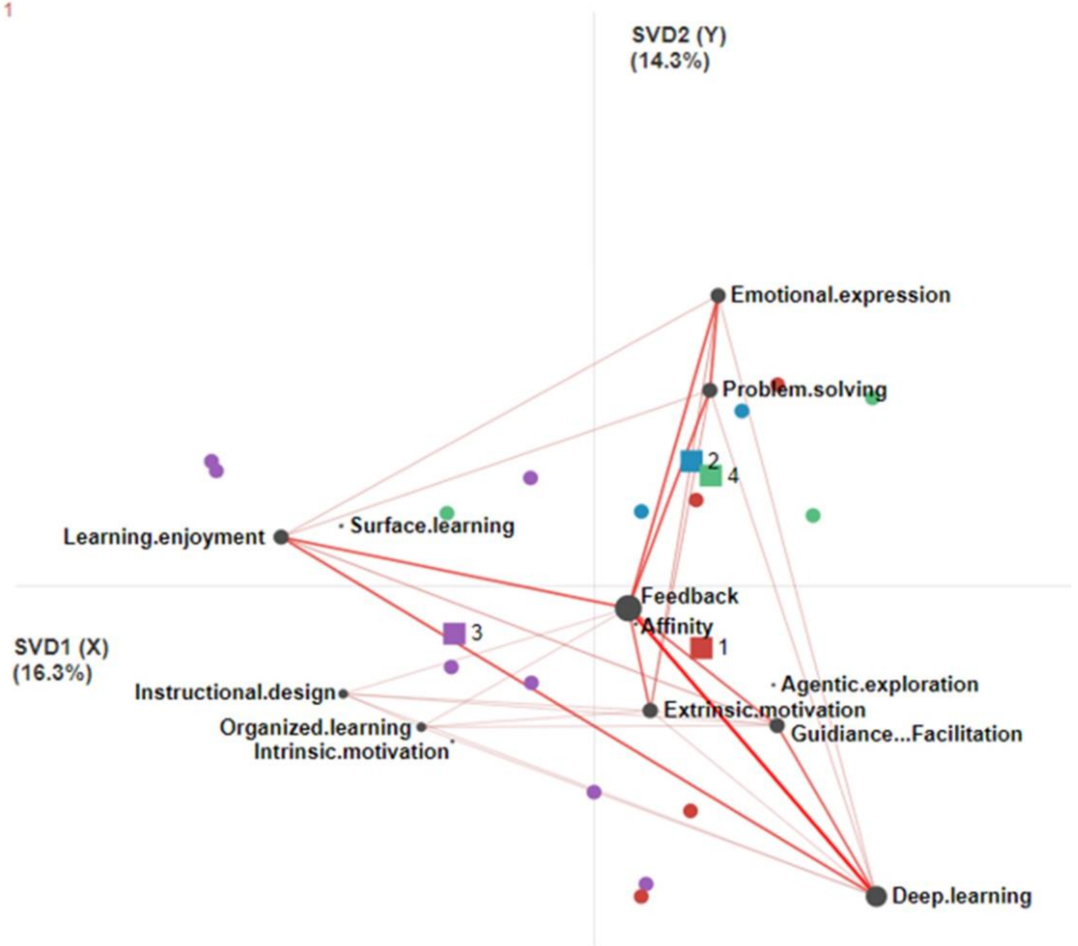


Figure 4. C1 students' network.

Note. C1's centroid and network are in red. The edge width represents the frequency of co-occurrences between two codes.

Analyses of the networks of the four clusters of students

C1: Effective learners



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Summary of the four-cluster solution

Clusters		Frequency of ES		Frequency of LP		Frequency of VL		Scores of ES	
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Note. ES = English shadowing; LP = Listening practice; VL = Vocabulary learning.
*Comparisons were calculated based on summed values of the three engagement variables.

Analyses of the networks of the four clusters of students

C2: Passive learners

Figure 5. C2 students' network.

Note. C2's centroid and network are in blue. The edge width represents the frequency of co-occurrences between two codes.

Summary of the four-cluster solution

Clusters		Frequency of ES		Frequency of LP		Frequency of VL		Scores of ES	
	N (%)	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
C1	4 (25%)	51.75	1.26	22.50	3.11	16.00	7.44	92.30	1.023
C2	2 (12.50%)	51.50	6.37	27.50	6.36	6.00	0.00	83.05	1.48
C3	7 (43.80%)	50.571	3.46	31.86	2.27	10.43	6.13	90.53	1.30
C4	3 (18.80%)	55.67	4.04	24.67	5.13	57.00	9.54	88.73	3.02
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Note. ES = English shadowing; LP = Listening practice; VL = Vocabulary learning.
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Analyses of the networks of the four clusters of students

C3: Well-balanced learners

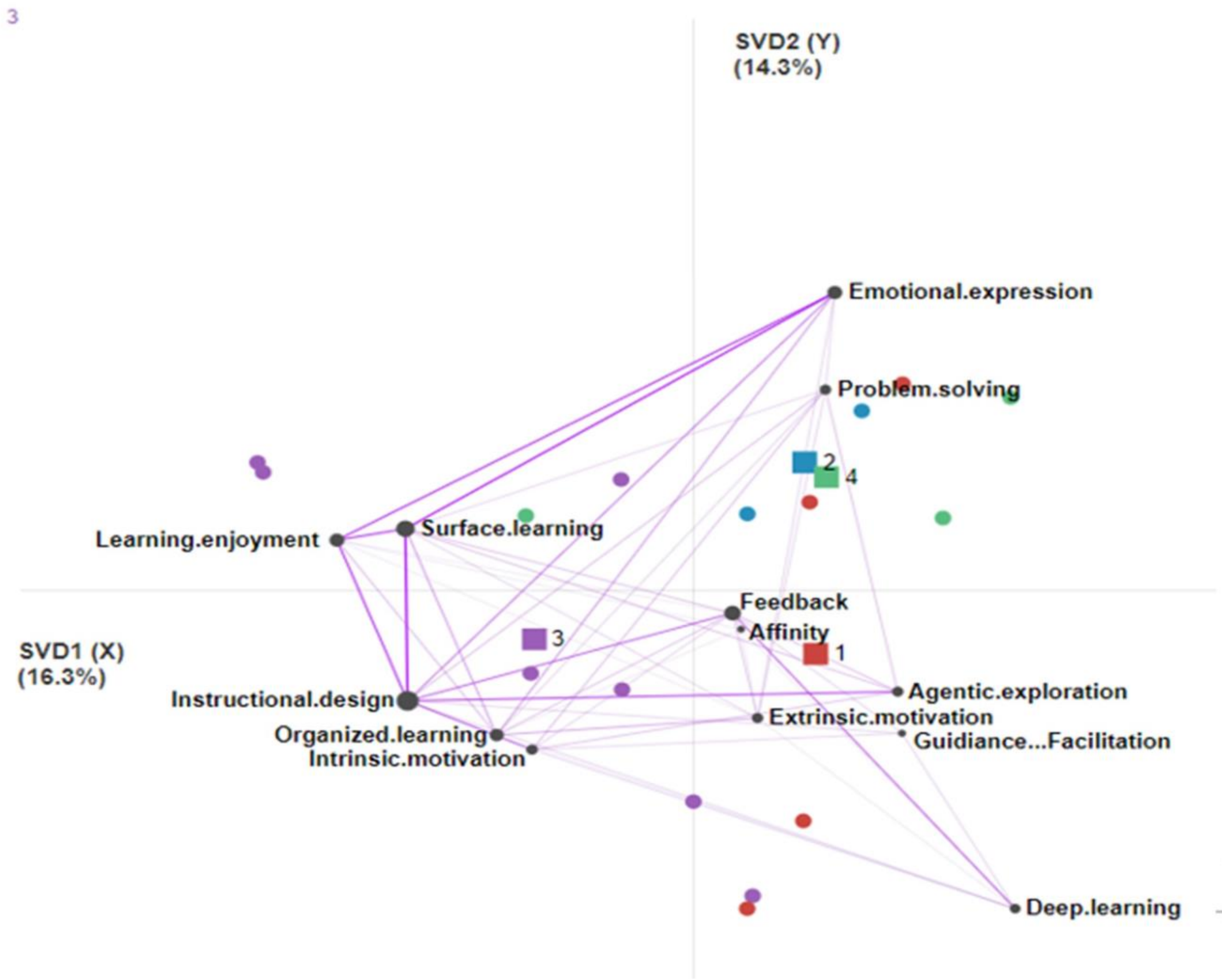

Figure 6. C3 students' network.

Note. C3's centroid and network are in purple. The edge width represents the frequency of co-occurrences between two codes.

Summary of the four-cluster solution

Clusters		Frequency of ES		Frequency of LP		Frequency of VL		Scores of ES	
	N (%)	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
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C4	3 (18.80%)	55.67	4.04	24.67	5.13	57.00	9.54	88.73	3.02
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Note. ES = English shadowing; LP = Listening practice; VL = Vocabulary learning.
*Comparisons were calculated based on summed values of the three engagement variables.

Analyses of the networks of the four clusters of students

C4: Inefficient learners

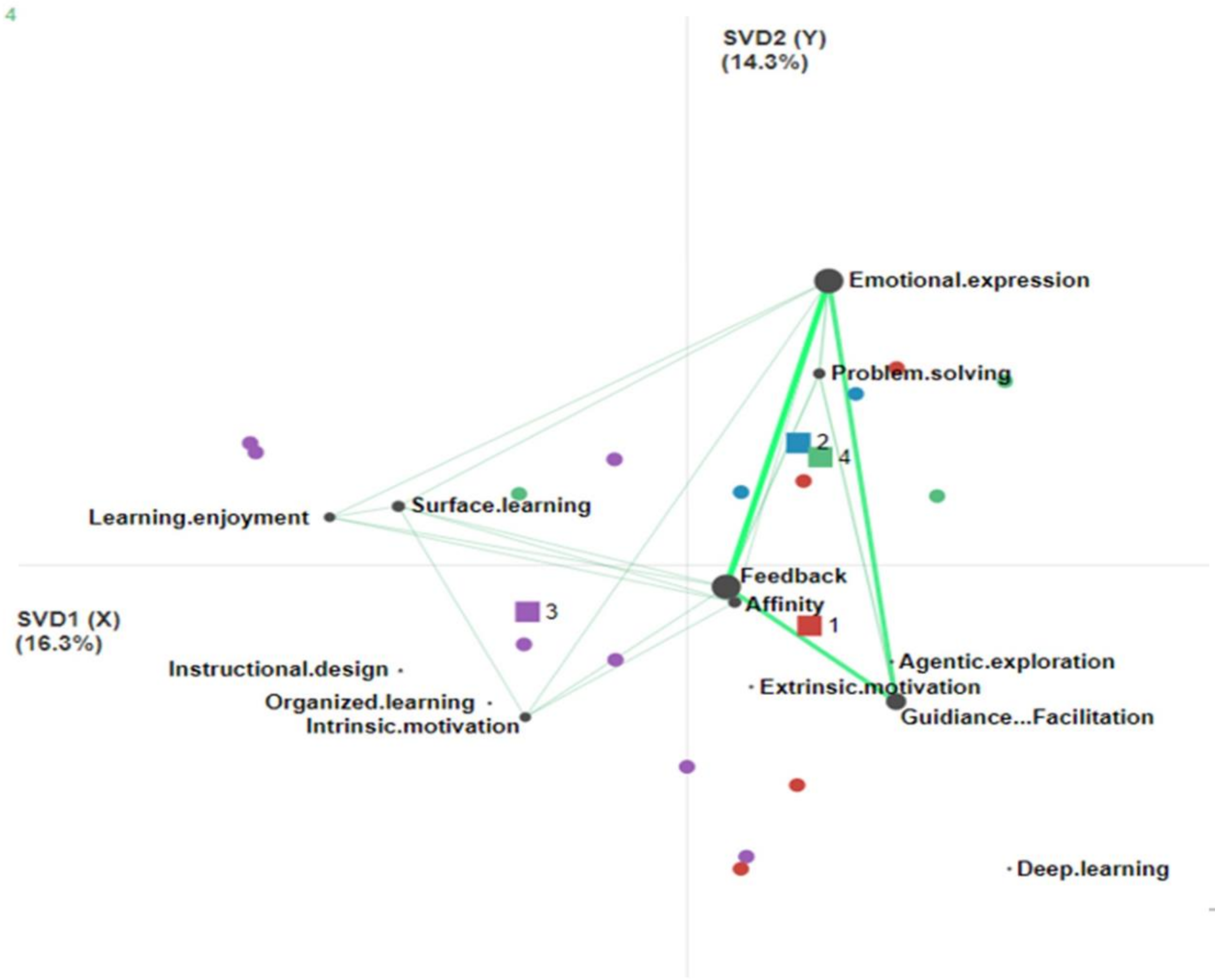

Figure 7. C4 students' network.

Note. C4's centroid and network are in green. The edge width represents the frequency of co-occurrences between two codes.

Summary of the four-cluster solution

Clusters		Frequency of ES		Frequency of LP		Frequency of VL		Scores of ES	
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Note. ES = English shadowing; LP = Listening practice; VL = Vocabulary learning.
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Summary of research findings

1) Not everyone can benefit from the potential promised by AI.

2) The deep approach to learning may amplify the potential benefits of AI's personalized guidance and strengthen the sense of the human-AI learning community.

3) Passively or mechanically following AI's instruction, albeit with high levels of participation, may decrease the sense of the human-AI learning community and cause low performance.

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Preparing for AI-enhanced education: Conceptualizing and empirically examining teachers' AI readiness

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A R T I C L E I N F O

Handling Editor: Prof. Nicolae Nistor

Keywords:
AI readiness
Teachers
AI-Enhanced education
Innovation
Job satisfaction

A B S T R A C T

Teachers are at the front lines of implementing artificial intelligence (AI) in education. They are expected to develop an adequate understanding of AI and become educated users as well as educators. Their readiness for the use of AI is critical for the success of AI-enhanced education. The present study conceptualized AI readiness from four components: cognition, ability, vision, and ethics in the educational use of AI, and investigated their interrelationships and their implications for teachers' work. The data from 3164 primary school teachers were collected and analyzed by partial least square structural equation modelling and cluster analysis. This study found that cognition, ability, and vision in the educational use of AI were positively associated with ethical considerations. The four components of AI readiness all positively predicted, whereas perceived threats from AI negatively predicted, AI-enhanced innovation, which in turn positively predicted teachers' job satisfaction. This study identified three clusters of teachers based on their AI readiness levels. Teachers with high levels of AI readiness tended to perceive low threats from AI and demonstrate high AI-enhanced innovation as well as high job satisfaction. However, teachers from different socio-economic regions and of different genders showed no significant differences regarding AI readiness and its impact on their jobs. This study empirically validated the importance of AI readiness for teachers' work and has important implications for the development of strategies and policies facilitating successful AI-enhanced education.

1. Introduction

Artificial intelligence (AI) has been increasingly used in a variety of fields (e.g., industry, finance, and education) to promote innovation and increase work efficiency (Ng et al., 2021). In education, AI is touted as a seemingly almighty tool, supporting or even replacing teachers' work by automatically tracking students' progress, assessing their performance, and providing personalized help (Albacete et al., 2019; Chounta et al., 2022; Tarus et al., 2018). Teachers can rely on AI to make informed decisions on orchestrating teaching practice so as to better support student learning (Van Leeuwen & Rummel, 2020).

Nonetheless, in reality, intelligent tools for education are rarely used consistently in K-12 classrooms (Ferguson et al., 2016). Schiff (2021) found that much practice and research related to the educational use of AI did not deliver promised changes and benefits. Among the multiple reasons leading to this controversy, for instance, the quality of AI and users' preferences (Luckin et al., 2022) and ethical concerns (Holmes et al., 2022), an essential culprit could be the techno-centric approach vehemently promoted by some in the educational field, which stresses the role of AI but ignores the agency of teachers who can decide whether, what, when, and how AI technologies are used in the first place (Luckin et al., 2022). Teachers are on the front lines of AI deployment, bridging schools' AI policies and students' needs, thereby the critical role in the successful implementation of AI in schools (Felix, 2020). However, many teachers may not be actually ready for AI-enhanced education, though they are mostly aware of the potential benefits that

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You are very welcome, Xinghua. Now, the reviewer who recommended major revisions has just accepted my invitation to review the revised version, too, so I am expecting a timely decision. (The other reviewer had recommended minor revisions, so I have not invited them, I will check that myself.)

Personally, I am very interested in AI readiness. (And this is probably the main reason why I handle these papers at CHB, among all associate editors.) Even more so, as the summer term in Munich has just begun and I am giving two new seminars on media literacy including AI concerns. If your paper is published online in a few weeks (I hope so, although I actually cannot know), then I will be able to include it in the seminar.

Recently, I had the first seminar paper with a (small) part (one page from over 20) of it generated by ChatGPT. This was quite naive of the students, and we noticed right away, nevertheless it was very exciting to deal with the case. This is quite a topic for media education...

Greetings,

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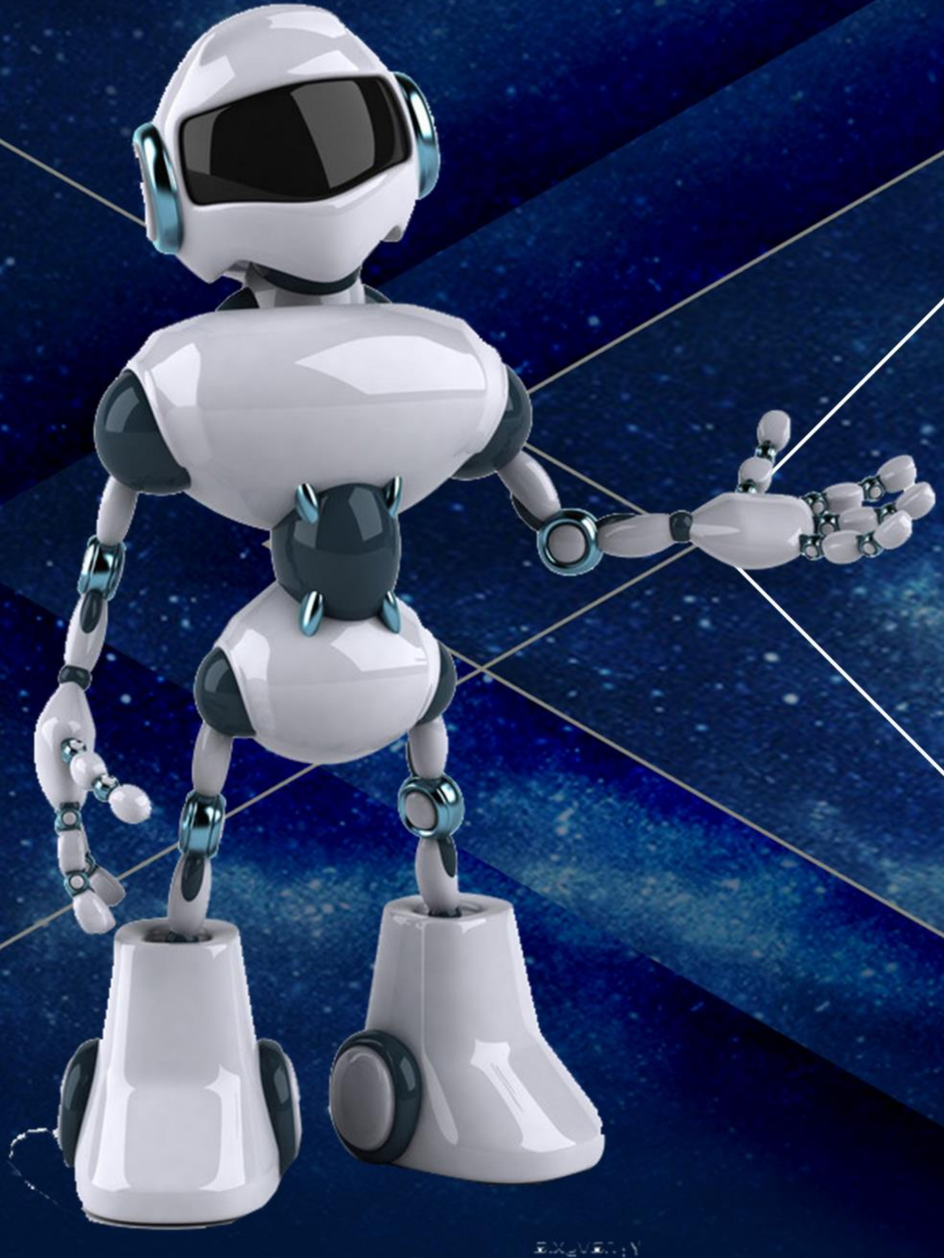

Waiting for ubiquitous robots

APA: Wang, X., Liu, Q., Pang, H., Tan, S. C., Lei, J., Wallace, M. P., & Li, L. (2023). What matters in AI-supported learning: A study of human-AI interactions in language learning using cluster analysis and epistemic network analysis. *Computers & Education*, *194*, 104703.

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