Zhou & Zhou (2025). A meta-analysis on mobile-assisted vocabulary learning: Do mobile applications help? *ReCALL*

Supplementary Materials A

Key terms used in literature search

Mobile-related keywords	Language-learning-related keywords	Vocabulary-learning-related keywords
(English keywords) mobile; portable; wireless digital; electronic; ubiquitous handheld; smartphone; PDA tablet PC; pad; laptop; iPad pocket e-dictionary; e-book SMS/MMS; messaging classroom response system mobile game; mobile flashcards applications (APP); texting	teaching learning development retention instruction training acquisition	vocabulary word
(Chinese keywords) 移动; 便携; 数字; 电子 无线; 彩信; 应用程序; 手机 手机游戏; 电子抽认卡 电子书; 电子词典; 短信 平板电脑; 笔记本电脑	教学; 发展; 培训 习得; 学习	词汇; 单词

∗Search terms: title: (“mobile” OR “portable” OR “digital” OR “electronic” OR “wireless” OR “ubiquitous” OR “handheld” OR “smartphone” OR “PDA” OR “tablet PC” OR “pad” OR “laptop” OR “iPad” OR “e-book” OR “e-dictionary” OR “classroom response system” OR “SMS” OR “MMS” OR “application” OR “APP” OR “mobile game” OR “mobile games” OR “mobile flashcards” OR “mobile flashcard” OR “messaging” OR “texting”) AND (“vocabulary” OR “word”) AND (“teaching” OR “learning” OR “development” OR “retention” OR “instruction” OR “training” OR “acquisition”) pubyearmin: 2008

Supplementary Materials C
Technical terms in this review

1. Prior distribution
A prior distribution is a probability distribution representing our beliefs about a parameter before observing the actual data. It represents our initial belief about the parameters of interest before observing any data.
Priors can be:

- Informative, reflecting previous studies or expert knowledge (e.g., Normal(0, 5));
- Weakly informative, providing mild regularization without strongly influencing the result (e.g., half-Cauchy(0, 0.5)); or
- Non-informative, aiming to have minimal impact (e.g., a uniform prior).

2. Posterior probability
The posterior probability is the updated probability after accounting for new data. It is a revised probability that takes into account newly available information. For example, researchers' initial belief about the chance that mobile-assisted learning is more effective than traditional learning could be changed after the experiment.

3. Posterior distribution
The posterior distribution reflects our updated belief about the parameters after observing the data. It combines the prior distribution with the likelihood of the observed data. It is a way to summarize what we know about uncertain quantities in Bayesian statistics.

4. Posterior mean
Posterior mean denotes the average value of the posterior distribution.

5. Credible interval
Credible intervals are intervals whose values have a posterior probability density, representing the plausibility that the parameter has those values. For example, a 95% credible interval indicates a 95% probability that the true parameter value falls within that interval, given the data and the prior.

6. Random-effects model

- $d_k \sim N(\delta_k, v_k)$: The observed effect size from study k (denoted as d_k) is assumed to be normally distributed around that study's true effect δ_k, with known sampling variance v_k. In other words, each study's published effect size bounces around its own true effect, with "noise" given by the study's precision (for example, how large the sample is or how reliable the measurements are).
- $\delta_k \sim N(\mu, \tau^2)$: The true effects δ_k vary from study to study and are assumed to be drawn from a normal distribution with overall mean effect size across studies (μ) and between-study variance τ^2. That is, we assume the true effects themselves are not identical, but cluster in a normal "cloud" of width τ scattered around one central value (μ).
- Each observed effect size d_k from the k-th study was modeled as normally distributed around a true study-specific effect size δ_k, with a variance v_k computed from each study's reported standard deviations and sample sizes. The true effect sizes δ_k across all studies were assumed to be normally distributed around a single overall mean effect size μ, with variance τ^2 representing between-study heterogeneity.

Supplementary Materials D
References of studies included in the review

Al-Ahdal, A. A. M. H., & Alharbi, M. A. (2021). MALL in collaborative learning as a vocabulary-enhancing tool for EFL learners: A study across two universities in Saudi Arabia. *SAGE Open, 11*(1), 1–9. https://doi.org/10.1177/2158244021999062

Alakrash, H. M., Razak, N. A., & Bustan, E. S. (2020). The effectiveness of employing Telegram application in teaching vocabulary: A quasi-experimental study. *Multicultural Education, 6*(1), 151–159. https://doi.org/10.5281/zenodo.3905099

Alavinia, P., & Qoitassi, K. (2013). On the viability of vocabulary learning enhancement through the implementation of MALL: The case of Iranian EFL learners. *Journal of Language Teaching and Research, 4*(2), 412–426. https://doi.org/10.4304/jltr.4.2.412-426

Alemi, M., & Lari, Z. (2012). SMS vocabulary learning: A tool to promote reading comprehension in L2. *International Journal of Linguistics, 4*(4), 1948–5425. http://dx.doi.org/10.5296/ijl.v4i4.2318

Alemi, M., Sarab, M. R. A., & Lari, Z. (2012). Successful learning of academic word list via MALL: Mobile-assisted language learning. *International Education Studies, 5*(6), 99–109. http://dx.doi.org/10.5539/ies.v5n6p99

Alkhezzi, F., & Al-Dousari, W. (2016). The impact of mobile learning on ESP learners' performance. *Journal of Educators Online, 13*(2), 73–101.

Al Shra'ah, A., & Hussein, M. (2021). The effect of Kahoot! on developing EFL Saudi students' vocabulary acquisition, reading comprehension, and their attitudes towards such a strategy. *IUG Journal of Educational & Psychological Studies, 29*(1), 604–619. https://doi.org/10.33976/IUGJEPS.29.1/2021/27

Arifani, Y., & Jumadi, J. (2021). Enhancing EAP learners' academic vocabulary learning: An investigation of WhatsApp-based reporting and receiving activities. *Teaching English with Technology, 21*(4), 51–75.

Aslan, M., & Tütüniş, B. (2024). The impact of blended mobile learning on EFL students' vocabulary development. *Journal of Theoretical Educational Science, 17*(4), 897–917. http://doi.org/10.30831/akukeg.1483178

Barjesteh, H., Movafaghardestani, E., & Modaberi, A. (2022). COVID-19's impact on digitalization of education: Incorporating visual vocabulary learning application to foster vocabulary knowledge. *Asian Education and Development Studies, 11*(1), 172–187. https://doi.org/10.1108/AEDS-05-2020-0111

Benlaghrissi, H., & Ouahidi, L. M. (2023). The impact of mobile-assisted language learning on developing EFL learners' vocabulary knowledge. *International Journal of Interactive Mobile Technologies, 17*(22), 38–51. https://doi.org/10.3991/ijim.v17i22.41665

Boroughani, T., Behshad, N., & Xodabande, I. (2023). Mobile-assisted academic vocabulary learning with digital flashcards: Exploring the impacts on university students' self-regulatory capacity. *Frontiers in Psychology*, *14*, Article 1112429. https://doi.org/10.3389/fpsyg.2023.1112429

Cetinkaya, L., & Sütçü, S. S. (2018). The effects of Facebook and WhatsApp on success in English vocabulary instruction. *Journal of Computer Assisted Learning, 34*(5), 504–514. https://doi.org/10.1111/jcal.12255

Chau, N. P. B., & Hương, V. T. L. (2021). Efficiency of the 'Memrise' mobile application in vocabulary learning of EFL students. *E-Journal of Inquiry into Languages and Cultures, 5*(1), 1–9.

Chen, Y., & Sitthiworachart, J. (2023, March). Mobile micro-learning in English vocabulary learning. In *Proceedings of the 11th International Conference on Information and*

Education Technology (pp. 187–192). IEEE. https://doi.org/10.1109/ICIET56899.2023.10111328
Demirel, E. T., Kul, M., Zibande, S., & Dilek, O. (2013). Effects of mobile phone compatible activities on vocabulary learning in English. *HUMANITAS-Uluslararası Sosyal Bilimler Dergisi, 1*(1), 71–84.
Dizon, G., & Tang, D. (2017). Comparing the efficacy of digital flashcards versus paper flashcards to improve receptive and productive L2 vocabulary. *The EuroCALL Review, 25*(1), 3–15. https://doi.org/10.4995/eurocall.2017.6964
Fageeh, A. A. I. (2013). Effects of MALL applications on vocabulary acquisition and motivation. *Arab World English Journal, 4*(4), 420–447.
Fathi, J., Alipour, F., & Saeedian, A. (2018). Enhancing vocabulary learning and self-regulation via a mobile application: An investigation of the Memrise App. *Journal of Modern Research in English Language Studies, 5*(1), 27–46.
Han, X. (2019). 移动学习模式在大学英语词汇学习中的应用研究 [A study on the application of mobile learning mode in college English vocabulary learning]. *Journal of Henan Institute of Education (Philosophy and social sciences edition), 38*(4), 114–119.
Javadi, Y., & Shehni, M. C. (2020). The role of auditory input enhancement through WhatsApp in EFL learners' vocabulary learning and retention. *Theory and Practice in Language Studies, 10*(12), 1576–1586. http://dx.doi.org/10.17507/tpls.1012.10
Jia, J. & Chen, Z. (2016). Blending smart phones into regular classroom learning. *Blended Learning: Aligning Theory with Practices. Proceedings of International Conference on Blending Learning* (pp.337-347). Lecture Notes in Computer Science, 9757.
Jin, S. (2018). 스마트폰 어플리케이션을 사용한 플래시카드 어휘 학습 및 SNS 기반 모바일 협력학습이 영어 학습자의 어휘 발달에 미치는 영향 [The effects of using smartphone applications for vocabulary flashcards and SNS-based mobile collaborative learning on English vocabulary knowledge]. *Multimedia-Assisted Language Learning, 2*1(4), 298–322.
Katemba, C. V. (2021). Enhancing vocabulary performance through mobile assisted language learning at a rural school in Indonesia. *Acuity: Journal of English Language Pedagogy, Literature and Culture, 6*(1), 1–11. https://doi.org/10.35974/acuity.v6i1.2457
Kazemi, M., & Mohammadi, Z. (2023). The impact of interactive content-embedded application on vocabulary learning and attitude change: a case study of Kahoot! in Iranian context. *SN Social Sciences, 3*(6), Article 87. https://doi.org/10.1007/s43545-023-00669-9
Khansarian-Dehkordi, F., & Ameri-Golestan, A. (2016). Effects of mobile learning on acquisition and retention of vocabulary among Persian-speaking EFL learners. *CALL_EJ, 17*, 43–56.
Khazaei, D., & Dastjerdi, H. V. (2011). An investigation into the impact of traditional vs. blended teaching on EFL learners' vocabulary acquisition: M-Learning in focus. *International Journal of Humanities and Social Science, 1*(15), 202–207.
Khodashenas, M., & Amouzegar, E. (2013). The effect of using MALL on Iranian EFL learners' vocabulary learning. *International Journal of Language Learning and Applied Linguistics World (IJLLALW), 4*(2), 43–47.
Koleini, N., Boroughani, T., Eslami, Z. R., & Xodabande, I. (2024). Exploring the impacts of mobile-assisted learning on university students' technical vocabulary knowledge. *International Journal of Educational Research Open, 7*, Article 100344. https://doi.org/10.1016/j.ijedro.2024.100344
Lai, A. (2016). Mobile immersion: An experiment using mobile instant messenger to support second-language learning. *Interactive Learning Environments, 24*(2), 277–290. https://doi.org/10.1080/10494820.2015.1113706

Lewis III, D. R., & Datzman, B. (2020). The effects of a mobile-based multisensory approach to vocabulary learning in a Japanese EFL context. *TESOL International Journal, 15*(6), 4–32.

Liu, C. (2017). *Application of Mobile Phones Apps in College English Vocabulary Learning-A case of Bai Cizhan* [MA thesis]. Northwest Normal University, China.

Ma, X., & Yodkamlue, B. (2019). The effects of using a self-developed mobile app on vocabulary learning and retention among EFL learners. *PASAA: Journal of Language Teaching and Learning in Thailand, 58*, 166–205. https://doi.org/10.58837/CHULA.PASAA.58.1.7

Malmir, P., & Rajabi, P. (2016). The effect of teaching vocabulary through text messaging by social networks on vocabulary comprehension of Iranian upper-intermediate EFL learners. *International Journal of Educational Investigations, 3*(7), 139–152.

Marzban, A., & Nafarzadehnafari, F. (2018). The effect of interventionist classroom vs. MALL dynamic assessment on EFL learners' vocabulary learning. *Applied Linguistics Research Journal, 2*(3), 58–66. https://doi.org/10.14744/alrj.2018.36844

Polakova, P., & Klimova, B. (2022). Vocabulary mobile learning application in blended English language learning. *Frontiers in Psychology*, *13*, Article 869055. https://doi.org/10.3389/fpsyg.2022.869055

Rachels, J. R., & Rockinson-Szapkiw, A. J. (2018). The effects of a mobile gamification app on elementary students' Spanish achievement and self-efficacy. *Computer Assisted Language Learning*, *31*(1–2), 72–89. https://doi.org/10.1080/09588221.2017.1382536

Rahimi, M., & Miri, S. S. (2014). The impact of mobile dictionary use on language learning. *Procedia-Social and Behavioral Sciences, 98*, 1469–1474. https://doi.org/10.1016/j.sbspro.2014.03.567

Rahmani, A., Asadi, V., & Xodabande, I. (2022). Using mobile devices for vocabulary learning outside the classroom: Improving the English as foreign language learners' knowledge of high-frequency words. *Frontiers in Psychology, 13*, Article 899885. https://doi.org/10.3389/fpsyg.2022.899885

Rajayi, S., & Poorahmadi, M. (2017). The impact of teaching vocabulary through "Kik" application on improving intermediate EFL learner's vocabulary learning. *International Journal of English Language Teaching, 5*(1), 22–28. http://dx.doi.org/10.5430/ijelt.v5n1p22

Rastegar, B. (2019). The effect of real-life online discussions on content-based vocabulary learning of Iranian IELTS test takers: With a focus on Telegram application. *Sapiens Journal of Modern Education, 2*(1), 5–17.

Reynolds, E. D., Fuchs, R. W., & Johnson, P. (2021). Game on with Kahoot!: Effects on vocabulary learning and motivation. *International Journal of Computer-Assisted Language Learning and Teaching (IJCALLT), 11*(4), 40–53. https://doi.org/10.4018/IJCALLT.2021100103

Saran, M., & Seferoglu, G. (2010). Yabancı dil sözcük öğreniminin çoklu ortam cep telefonu iletileri ile desteklenmesi [Supporting foreign language vocabulary learning through multimedia messages via mobile phones]. *Hacettepe University Journal of Education, 38*(3), 252–266.

Seyyedrezaeia, S. H., Kazemib, Y., & Shahhoseinic, F. (2016). Mobile Assisted Language Learning (MALL): An accelerator to Iranian language learners' vocabulary learning improvement. *International Journal of Research in Linguistics, Language Teaching and Testing, 1*, 7–13.

Valizadeh, M. (2022). Investigating the impacts of mobile assisted reading on EFL learners' vocabulary knowledge development. *Sakarya University Journal of Education, 12*(3), 573-590. https://doi.org/10.19126/suje.1105559

Wang, B. T., Teng, C. W., & Chen, H. T. (2015). Using iPad to facilitate English vocabulary learning. *International Journal of Information and Education Technology, 5*(2), 100–104.
Wang, F., & Suwanthep, J. (2017). Constructivism-based mobile application for EFL vocabulary learning. *International Journal of Learning, 3*(2), 106–112. https://doi.org/10.18178/ijlt.3.2.106-112
Wang, J. & Fu, Y. (2019). 基于手机应用程序的大学英语词汇学习[College English vocabulary learning based on mobile APP]. *Journal of Hainan Tropical Ocean University, 26*(4), 122–128.
Wang, W., & Liu, L. (2019). “互联网+” 背景下大学英语词汇的移动自主学习实证研究 [An empirical study on mobile autonomous learning of college English vocabulary in the background of “Internet +”]. *Education Teaching Forum, 10*, 196–198.
Wang, Y. H., & Shih, S. K. H. (2015). Mobile-assisted language learning: Effects on EFL vocabulary learning. *International Journal of Mobile Communications, 13*(4), 358–375. https://doi.org/10.1504/IJMC.2015.070060
Wiboolyasarin, W., & Jinowat, N. (2024). Revolutionising dual language learning for young learners with the RILCA app: A mobile-assisted approach. *Journal of Computers in Education, 11*(2), 575–593. https://doi.org/10.1007/s40692-023-00271-1
Wu, Q. (2015). Pulling mobile assisted language learning (MALL) into the mainstream: MALL in broad practice. *PloS One, 10*(5), e0128762. https://doi.org/10.1371/journal.pone.0128762
Wu, Z. & Zhang, R. (2019). 单词 APP 应用于初中英语教学的实证研究 [An empirical study on the application of vocabulary learning app in English teaching in junior middle schools]. *Research on Modern Basic Education, 35*, 205–213.
Xiao, J., & Wang, J. (2019, January). Effectiveness of mobile learning in college English vocabulary teaching under multimodal environment. In *Proceedings of the 10th international conference on e-education, e-business, e-management and e-learning* (pp. 93–97). Association for Computing Machinery. https://doi.org/10.1145/3306500.3306558
Xodabande, I., & Atai, M. R. (2022). Using mobile applications for self-directed learning of academic vocabulary among university students. *Open Learning: The Journal of Open, Distance and E-Learning, 37*(4), 330–347. https://doi.org/10.1080/02680513.2020.1847061
Xodabande, I., Atai, M. R., & Hashemi, M. R. (2024). Exploring the effectiveness of mobile assisted learning with digital flashcards in enhancing long-term retention of technical vocabulary among university students. *Journal of Computers in Education, 1*(1), 1–26. https://doi.org/10.1007/s40692-024-00347-6
Xodabande, I., Asadi, V., & Valizadeh, M. (2022a). Teaching vocabulary items in corpus-based wordlists to university students: Comparing the effectiveness of digital and paper-based flashcards. *Journal of China Computer-Assisted Language Learning, 2*(2), 257–280. https://doi.org/10.1515/jccall-2022-0016
Xodabande, I., & Boroughani, T. (2023). Mobile-assisted focus on forms in English for academic purposes instruction: Investigating the impacts on learning academic words. *Frontiers in Psychology*, *14*, Article 1071555. https://doi.org/10.3389/fpsyg.2023.1071555
Xodabande, I., & Hashemi, M. R. (2023). Learning English with electronic textbooks on mobile devices: Impacts on university students’ vocabulary development. *Education and Information Technologies, 28*(2), 1587–1611. https://doi.org/10.1007/s10639-022-11230-1
Xodabande, I., Iravi, Y., Mansouri, B., & Matinparsa, H. (2022b). Teaching academic words with digital flashcards: Investigating the effectiveness of mobile-assisted vocabulary learning for university students. *Frontiers in Psychology, 13*, Article 893821. https://doi.org/10.3389/fpsyg.2022.893821

Xodabande, I., Pourhassan, A., & Valizadeh, M. (2022c). Self-directed learning of core vocabulary in English by EFL learners: Comparing the outcomes from paper and mobile application flashcards. *Journal of Computers in Education, 9*(1), 93–111. https://doi.org/10.1007/s40692-021-00197-6

Yarahmadzehi, N., & Goodarzi, M. (2020). Investigating the role of formative mobile based assessment in vocabulary learning of pre-intermediate EFL learners in comparison with paper-based assessment. *Turkish Online Journal of Distance Education, 21*(1), 181–196.

Yu, Z. (2014). The impact of clickers use on vocabulary knowledge and satisfaction in an EFL class in China. *International Journal of Information and Communication Technology Education (IJICTE), 10*(3), 47–59. https://doi.org/10.4018/ijicte.2014070104

Yusoff, Z. S., Gurmani, M. T. A., Sanif, S., & Noor, S. N. F. M. (2022). The effect of mobile-assisted CEFR English vocabulary profile word lists on L2 students' vocabulary knowledge. *Asian Journal of University Education, 18*(2), 526–543. https://doi.org/10.24191/ajue.v18i2.18159

Zakian, M., Xodabande, I., Valizadeh, M., & Yousefvand, M. (2022). Out-of-the-classroom learning of English vocabulary by EFL learners: investigating the effectiveness of mobile assisted learning with digital flashcards. *Asian-Pacific Journal of Second and Foreign Language Education, 7*(1), 1–16.