ISSN:3026-0442

Proceedings of the 2nd International Conference on Education, Science Technology and Health (2nd ICONESTH 2024 Universitas Bina Bangsa Getsempena, Sept 10-12, 2024, Banda Aceh, Indonesia

Optimization of Self-Regulated Learning (SRL) Through Technology-Based Learning Environments

Bima Pambudi [1], Roemintoyo [2] , Deny Tri Ardianto [3]

[1] Department of Educational Technology, Sebelas Maret University, Indonesia
[2] Department of Educational Technology, Sebelas Maret University, Indonesia
[3] Department of Educational Technology, Sebelas Maret University, Indonesia

***** Corresponding email: *bimapambudi@student.uns.ac.id, roemintoyo@staff.uns.ac.id, denytri@staff.uns.ac.id,*

ABSTRACT

This study aims to optimize Self-Regulated Learning (SRL) through technology-based learning environments using the Systematic Literature Review (SLR) method. Out of 58 selected articles, only 17 Q1-indexed articles from 2020-2024 were relevant, spanning fields of Social Sciences (68%), Computer Science (20%), Mathematics (8%), and Arts and Humanities (4%). The application of technology-based SRL has so far only been implemented in a few developed countries, including Hong Kong, the United States, Australia, Switzerland, and Finland. The study results indicate that technologies such as AI-based chatbots, real-time scaffolding, Virtual Reality (VR), and learning analytics dashboards hold potential for supporting SRL development. However, there are challenges in effective implementation, including accessibility limitations, students' digital readiness, and the need for technology designs that foster sustainable autonomous learning. A holistic and adaptive approach, along with collaboration between developers and educational institutions, is needed to enhance students' learning experience and support independent skill development.

Keywords: *self-regulated learning, technology-based learning, systematic literature review.*

INTRODUCTION

The development of technology in education has driven the transformation of how students learn and access information. One aspect that is increasingly receiving attention is Self-Regulated Learning (SRL), where students actively plan, monitor, and evaluate their own learning process. Technology-based learning environments can provide various features and tools to support SRL, including access to a broader range of learning materials, progress monitoring tools, and flexibility in managing study time. Recent studies show that the use of technology in learning can

enhance students' SRL skills, such as time management and self-monitoring (Broadbent & Fuller-Tyszkiewicz, 2018; Panadero, 2017). However, challenges in the design of technology and the implementation of optimal learning environments to support SRL remain an unresolved issue.

One major gap in related research is the lack of attention to specific features or design elements that support SRL. While many educational apps and platforms offer various self-directed learning facilities, few are specifically designed to encourage students to develop their self-regulation skills optimally (Carter et al., 2020). Most educational technologies focus on providing content and information but do not specifically consider elements that allow students to set goals, monitor progress, or evaluate their learning outcomes. This creates a gap between the potential of technology to support SRL and its actual effectiveness in educational practice (Jansen et al., 2020).

Additionally, there are issues related to accessibility and students' digital readiness to use technology for SRL. Not all students have adequate access to digital devices or stable internet connections, and students' ability to use technology for SRL varies widely. These barriers can exacerbate academic achievement gaps between students who have full access to technology and those with limited access (Reinhold et al., 2021). Low digital literacy is also a hindering factor, where students may have adequate devices but lack the understanding of how to leverage the technology to support self-directed learning (Zimmerman & Schunk, 2020).

Therefore, a deeper study is needed to understand how technology-based learning environments can be optimized to effectively support SRL. This systematic literature review aims to identify the latest findings regarding the role of technology in supporting SRL, examine the challenges faced, and offer recommendations on design elements that can enhance the effectiveness of SRL in digital learning environments. Through this review, it is hoped that a clearer understanding will be gained about strategies that can be implemented in designing technology-based learning environments that effectively promote students' self-regulation skills.

RESEARCH METHOD

This study uses the systematic literature review method. Systematic Literature Review (SLR) is a research method aimed at identifying, interpreting, and evaluating findings on a research topic to answer pre-determined questions (Kitchenham & Charters, 2007). The article selection process is carried out through four main steps according to The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA), namely identification, screening, eligibility, and inclusion (Page et al., 2020).

LITERATURE SEARCH

The literature search process was conducted by accessing the Scopus database. The search was carried out using the keywords self-regulation learning and technology-based learning. Filters applied included: years 2020-2024, article type, open access, and keywords self-regulation learning and technology.

INCLUSION CRITERIA

The inclusion and exclusion criteria are applied to assess the eligibility of the literature to be included in the SLR search (Fitriani & Prahmana, 2021). Articles that meet the inclusion criteria in the Scopus search will be included in this study, as explained in Table 1 below.

Table 1. Inclusion Criteria and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
The intervention focused on self-regulation learning with an emphasis on optimizing technology-based learning environments.	Interventions other than self-regulation learning, with a focus on optimizing technology-based learning environments.
Publications in journals from 2020-2024.	Publications in journals from before 2020 to 2024.
Index quartile Q1	*Index quartile* Q2, Q3 dan Q4

The articles collected from Scopus amounted to 58 articles that matched the keywords self-regulation learning and technology-based learning. These 58 journals were then filtered according to the inclusion criteria. The article extraction process is shown in Figure 1. Based on Figure 1, from the original 58 articles, 41 were excluded for not meeting the criteria. However, 17 selected articles were deemed suitable for the literature study related to self-regulation learning and technology-based learning.

ISSN:3026-0442
Proceedings of the 2nd International Conference on Education, Science Technology and Health (2nd ICONESTH 2024 Universitas Bina Bangsa Getsempena, Sept 10-12, 2024, Banda Aceh, Indonesia

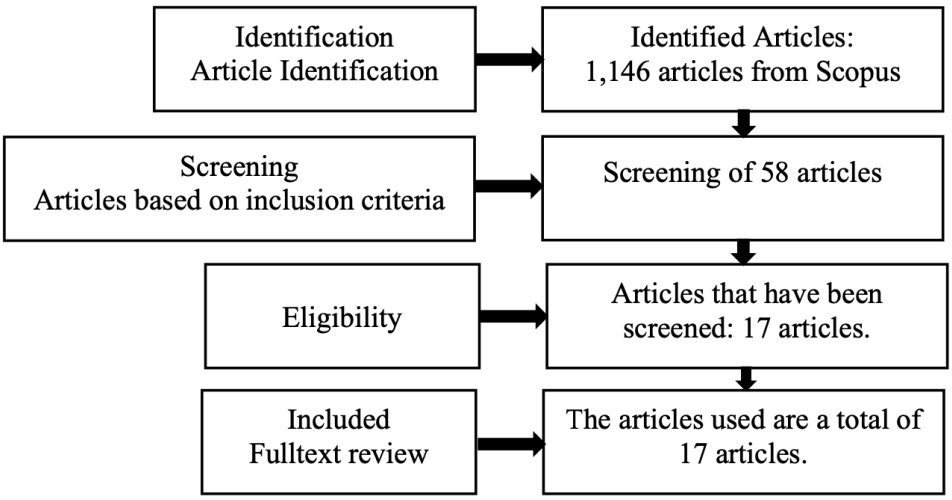

Figure 1. Stages of Article Extraction for Self-Regulation Learning Based on Technology

RESULTS AND DISCUSSION

This study uses a Systematic Literature Review (SLR) approach to analyze the optimization of self-regulation learning through technology-based learning environments, as published in international journals indexed from Q1 to Q4. The journals that met the inclusion criteria were analyzed using a systematic review and the PRISMA analysis framework. A total of 58 articles were collected from Scopus, which matched the keywords self-regulation learning and technology-based learning. These 58 journals were then filtered according to the inclusion criteria.

The first stage involved downloading the selected articles and analyzing them according to the publication years between 2020 and 2024. The second stage consisted of filtering articles based on abstracts and research outcomes with the assistance of Microsoft Excel. The next step was to review which articles aligned with the research objectives. In the final stage, 41 articles were excluded because they did not meet the criteria, leaving 17 articles that were deemed suitable for the literature review on self-regulation learning and technology-based learning.

Table 2. List of Articles Results

No	Publisher	Year	Author(s)	Title
1	British Journal Of Educational Technology	2024	Lyn Lim, et al	How do students learn with real-time personalized scaffolds?
2	British Journal Of Educational Technology	2024	Davy Tsz Kit Ng, Chee Wei Tan, Jac Ka Lok Leung	Empowering student self-- regulated learning and science education through ChatGPT: A pioneering pilot study
3	British Journal Of Educational Technology	2023	Marta Sobocinski, et al	Capturing self-- regulated learning processes in virtual reality: Causal sequencing of multimodal data
4	British Journal Of Educational Technology	2023	Jodie Torrington, Matt Bower, Emma C. Burns	Elementary students' self-- regulation in computer-- based learning environments: How do self-- report measures, observations and teacher rating relate to task performance?
5	British Journal Of Educational Technology	2023	Qi Xia, et al	The mediating effects of needs satisfaction on the relationships between prior knowledge and self-regulated learning through artificial intelligence chatbot
6	Education and Information Technologies	2024	Jiangping Chen, Chin-Hsi Lin, Gaowei Chen	Extramural ICT factors impact adolescents' academic performance and well-being differently: Types of self-regulated learners also matter
7	Education and Information Technologies	2024	Rui Guan, et al	How educational chatbots support self-regulated learning?
8	Education and Information Technologies	2024	Chi-Jung Sui, Miao-Hsuan Yen, Chun-Yen Chang	Teachers' perceptions of teaching science with technology- enhanced self-regulated learning strategies through the DECODE model
9	Education And Information Technologies	2024	Mathias Mejeh, Livia Sarbach, Tina Hascher	Effects of adaptive feedback through a digital tool – a mixed-methods study on the course of self-regulated learning

10	Technology Knowledge And Learning	2024	Doreen Prasse, et al	Challenges in Promoting Self-Regulated Learning in Technology Supported Learning Environments
11	Technology Knowledge And Learning	2024	Mathias Mejeh, Livia Sarbach	Co-design: From Understanding to Prototyping an Adaptive Learning Technology to Enhance Self-regulated Learning
12	Educational Technology Research And Development	2024	Thomas K. F. Chiu	A classification tool to foster self-regulated learning with generative artificial intelligence by applying self-determination theory: a case of ChatGPT
13	Educational Technology Research And Development	2021	Roy B. Clariana, Eunsung Park	Item-level monitoring, response style stability, and the hard-easy effect
14	International Journal of Educational Technology in Higher Education	2024	Hsin-Yu Lee, et al	Empowering ChatGPT with guidance mechanism in blended learning: effect of self-regulated learning, higher-order thinking skills, and knowledge construction
15	Journal Of Learning Analytics	2024	Ignacio Villagrán, et al	Enhancing Feedback Uptake and Self-Regulated Learning in Procedural Skills Training: Design and Evaluation of a Learning Analytics Dashboard
16	Research Studies In Music Education	2024	Dora Utermohl de Queiroz, Guadalupe López-Íñiguez, Clarissa Foletto	Investigating if and how string teachers instruct and support the self-regulation of students' practice in online lessons
17	Journal Of Computer Assisted Learning	2023	Carolien A. N. Knoop-van Campen, et al	Enacting control with student dashboards: The role of motivation

Based on the review of 17 articles, Figure 2 shows that a hot topic in the field of education is the use of AI-based chatbots, such as ChatGPT, which are designed to support self-regulated learning (SRL) (Thomas K. F. Chiu, 2024). Studies across various contexts, ranging from elementary to higher education, indicate that this technology can provide adaptive feedback, personalized learning support, and enhance students' higher-order thinking skills. ChatGPT, as an AI application, is

being tested to facilitate SRL through various methods, including analytical tools, VR-based learning environments, and real-time scaffolding techniques. Additionally, AI chatbots also leverage basic needs theories such as self-determination theory to promote the satisfaction of students' needs, which plays an important role in enhancing their academic performance and well-being in technology-based learning processes.

The presentation on the relevance of technology in supporting self-regulated learning (SRL) shows that, while the percentages presented reflect the contribution of various technologies, there is a risk of oversimplification that could overlook the nuances and complexities of the interactions between technology and the learning process. For example, while AI-based chatbots like ChatGPT occupy the largest portion of the discussion, their effectiveness highly depends on the context of use, user skills, and the quality of the system's design. Additionally, over-reliance on one type of technology can create problems, such as the lack of students' ability to learn independently without technological assistance. Meanwhile, technologies like VR and learning analytics dashboards offer exciting innovations, but challenges in accessibility and effective implementation in real-world educational environments need to be considered. Therefore, it is important not only to look at the percentage contribution of each technology but also to understand how their integration holistically can impact learning, as well as to consider factors that support or hinder the adoption of these technologies in educational contexts.

To optimize the use of technology in supporting self-regulated learning (SRL), a holistic and balanced approach is essential. First, educational institutions need to ensure that the implementation of technologies such as AI-based chatbots and VR is carried out with consideration for students' needs and abilities, while also providing adequate training for both educators and students. Furthermore, the integration of technology should be done gradually, with continuous evaluation to identify positive impacts and emerging challenges. The development of tools that enhance independent learning skills without over-relying on technology is also important. Therefore, collaboration between technology developers, educators, and researchers will be invaluable in creating solutions that can improve the overall student learning experience, while ensuring that technology is used as a tool for empowerment, not a replacement for deep and meaningful learning processes.

ISSN:3026-0442
Proceedings of the 2nd International Conference on Education, Science Technology and Health (2nd ICONESTH 2024 Universitas Bina Bangsa Getsempena, Sept 10-12, 2024, Banda Aceh, Indonesia

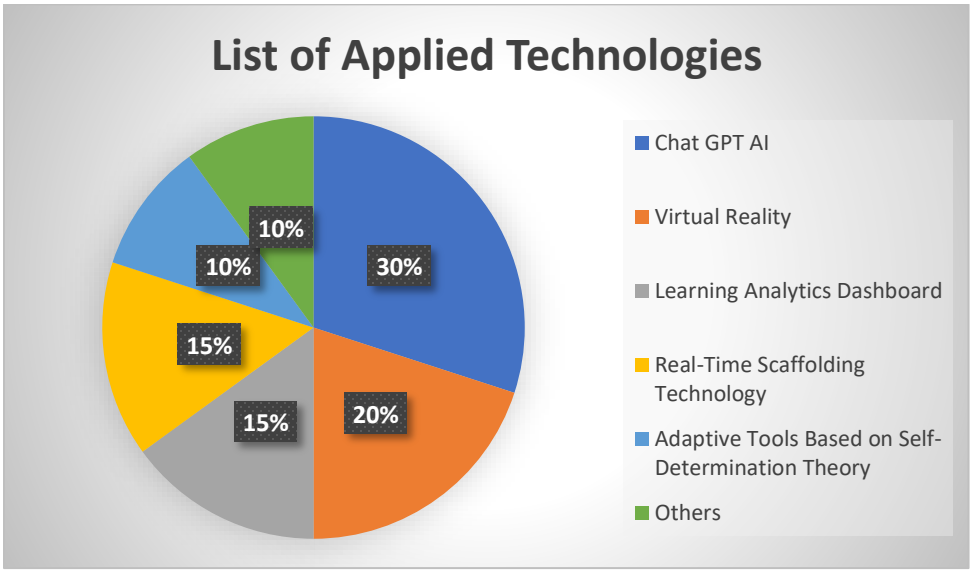

Figure 2. List of Applied Technologies

The optimization of self-regulated learning through technology-based learning environments over the past five years (2020–2024), as presented in Figure 2, reveals that the highest number of articles were published in 2024, totaling 15 articles. This indicates that the ability to learn independently, think critically, and manage time are key 21st-century skills essential for the workplace and daily life. Technology-based self-regulated learning enables students to develop these skills, driving increased research in this field to understand and strengthen students' abilities to meet these demands. Research on self-regulated learning through technology-based learning environments has the potential to yield more personalized and adaptive approaches tailored to individual needs. Researchers are increasingly interested in developing more inclusive learning models that adapt to students' learning pace. This growing relevance has led to a surge in studies in this area.

Many countries are beginning to focus on the digitalization of education as part of national education reform. Governments and educational institutions are providing financial and policy support for the development of technology-based education, which has, in turn, increased the volume of research on this topic.

ISSN:3026-0442
Proceedings of the 2nd International Conference on Education, Science Technology and Health (2nd ICONESTH 2024 Universitas Bina Bangsa Getsempena, Sept 10-12, 2024, Banda Aceh, Indonesia

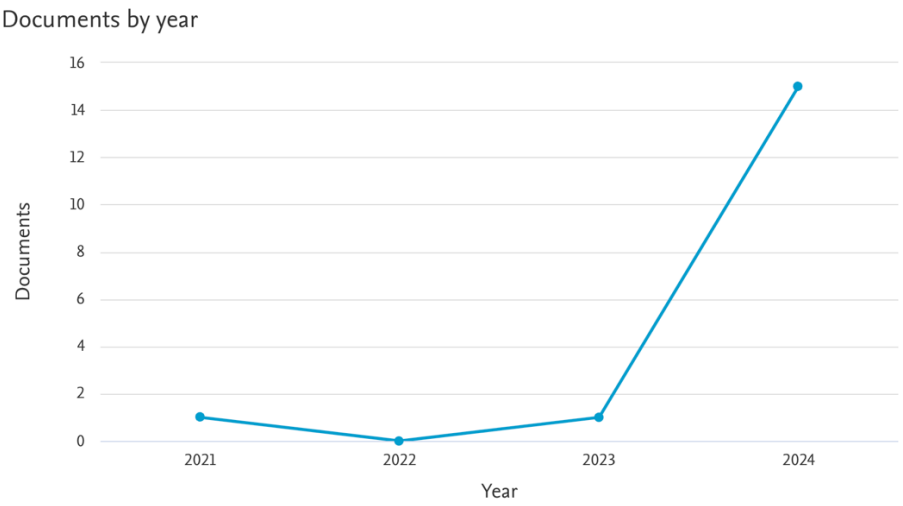

Figure 2. Number of Articles Based on Year of Publication

In the diagram presented as Figure 3, it is evident that the majority of research on optimizing self-regulation learning through technology-based learning environments is concentrated in the field of Social Sciences (68%), followed by Computer Science (20%), Mathematics (8%), and Arts and Humanities (4%). A critical analysis of this distribution provides several insights. The primary focus on Social Sciences suggests that technology-supported self-regulation learning is predominantly examined from the perspectives of behavior, education, and social interaction. This is logical, as the development of self-regulation skills is closely linked to pedagogy, educational psychology, and effective learning methods—all of which are central topics in the social sciences.

Computer Science accounts for 20% of this research, indicating that the technological support for self-regulation learning is explored not only from the educational implementation standpoint but also from technical aspects. Studies in Computer Science likely cover software development, learning applications, and algorithms that enable adaptive learning environments to support self-regulated learning.The 8% of research in Mathematics may relate to the application of self-regulated learning in enhancing critical thinking and problem-solving skills in mathematical contexts. Mathematics often demands independent and structured learning approaches, making the optimization of self-regulation through technology particularly relevant in assisting students to improve their performance in this subject. The 4% presence of research in Arts and Humanities suggests that self-regulated learning also garners attention outside the realms of exact sciences and social studies. Such research might explore how technology can support independent learning in artistic disciplines, such as developing creative skills, interpretation, and appreciation of the arts.

ISSN:3026-0442

Proceedings of the 2nd International Conference on Education, Science Technology and Health (2nd ICONESTH 2024 Universitas Bina Bangsa Getsempena, Sept 10-12, 2024, Banda Aceh, Indonesia

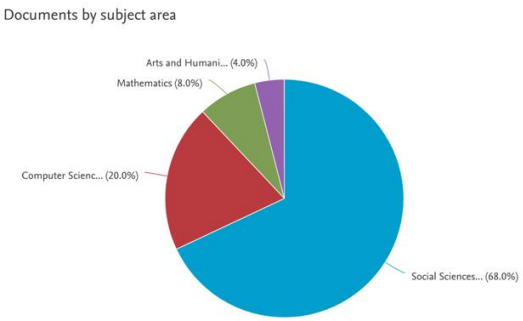

Figure 3. Number of Articles by Field of Study

In Figure 4 below, the number of articles related to optimizing self-regulation learning (SRL) through technology-based learning environments is shown across several developed countries. Countries with stronger educational and technological resources dominate research in this field. This disparity reflects that countries with limited access may lag behind in developing technology-based SRL strategies, potentially widening the global education gap.

The data shows that countries such as Hong Kong and the United States have the highest number of publications, followed by Australia, Switzerland, and Finland. These findings highlight that research related to technology-driven SRL is predominantly conducted in developed countries. This may indicate higher availability of research funding and access to advanced technology in these nations. Countries with high levels of technology adoption tend to produce more research on SRL. For instance, Hong Kong and the United States, which rank highest in publication numbers, benefit from highly supportive educational and technological ecosystems. However, many other developed countries are not represented in this diagram. This could suggest that, despite rapid technological advancement, the adoption or focus on SRL remains uneven. Such disparities might signal that research in this area is still concentrated in specific countries.

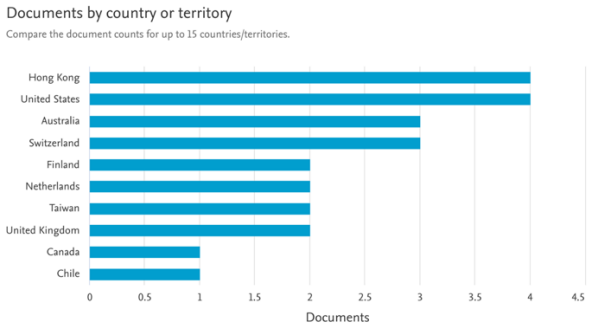

Figure 4. Number of Countries Based on Research on Technology-Based SRL Strategies

CONCLUSION

The conclusion from the discussion on optimizing self-regulated learning through technology-based learning environments shows that technology-based learning environments have great potential in supporting and developing SRL skills in students. Technologies such as AI-based chatbots, Virtual Reality, and learning analytics dashboards can help improve students' autonomy, time management skills, and critical thinking abilities. However, challenges related to accessibility and the design of sustainable self-directed learning still need to be addressed. Effective implementation of technology requires an integrated approach and collaboration between educational institutions, technology developers, and educators to create adaptive and inclusive learning environments, ensuring that technology serves as an empowering tool rather than a replacement for deep learning processes.

BIBLIOGRAPHY

Azevedo, R., Moos, D. C., Johnson, A. M., & Chauncey, A. D. (2012). *Measuring cognitive and metacognitive regulatory processes during hypermedia learning: Issues and challenges. Educational Psychologist*, 47(3), 224-238.

Broadbent, J., & Poon, W. L. (2015). *Self-regulated learning strategies & academic achievement in online higher education learning environments: A systematic review. The Internet and Higher Education*, 27, 1-13.

Chen. Jiangping., Lin. Chin-Hsi., Chen. Gaowei. (2024). *Extramural ICT factors impact adolescents'academic performance and well-being differently: Types of self-regulated learners also matter. Education and Information Technologies* . https://doi.org/10.1007/s10639-024-12642-x

Chiu, Thomas K. F. A. (2024). *classification tool to foster self-regulated learning with generative artificial intelligence by applying self-determination theory: a case of ChatGPT. Educational Technology Research And Development*. DOI https://doi.org/10.1007/s11423-024-10366-w

Clariana. Roy B., Park. Eunsung. (2021). *Item-level monitoring, response style stability, and the hard-easy effect. Educational Technology Research And Development.*https://doi.org/10.1007/s11423-021-09981-8

Dabbagh, N., & Kitsantas, A. (2012). *Personal Learning Environments, social media, and self-regulated learning: A natural formula for connecting formal and informal learning. The Internet and Higher Education*, 15(1), 3-8.

Fitriani, R., & Prahmana, R. C. I. (2021). Penelitian Implementasi Pembelajaran Matematika Bagi Anak Berkebutuhan Khusus di Indonesia. AKSIOMA: Jurnal Program Studi Pendidikan Matematika,10(3), 1293–1307.

Guan Rui., et al. (2024). *How educational chatbots support self-regulated learning? A systematic review of the literature. Education and Information Technologies*. https://doi.org/10.1007/s10639-024 12881-y

Hamid, S., Waycott, J., Kurnia, S., & Chang, S. (2015). *Understanding students' perceptions of the benefits of online social networking use for teaching and learning. The Internet and Higher Education*, 26, 1-9.

Kitchenham, B., & Charters, S. (2007). *Guidelines for performing Systematic literature reviews in Software Engineering. In Keele University and Durham University Joint Report.*

Knoop-van Campen, C. A. N., van der Graaf, J., Horvers, A., Kooi, R., Dijkstra, R., & Molenaar, I. (2024). *Enacting control with student dashboards: The role of motivation. Journal of Computer Assisted Learning*, 40(3),1137–1153. https://doi.org/10.1111/jcal.12936

Lee. Hsin-Yu , et al. (2024). *Empowering ChatGPT with guidance mechanism in blended learning: effect of self-regulated learning, higher-order thinking skills, and knowledge construction. International Journal of Educational Technology in Higher Education*. https://doi.org/10.1186/s41239-024-00447-4

Lim, L., Bannert, M., van der Graaf, J., Fan, Y., Rakovic, M., Singh, S., Molenaar, I., & Gašević, D. (2024). *How do students learn with real-time personalized scaffolds? British Journal of Educational Technology, 55*, 1309–1327. https://doi.org/10.1111/bjet.13414

Lust, G., Juarez Collazo, N. A., Elen, J., & Clarebout, G. (2012). *Content management systems: Enriched learning opportunities for all? Computers in Human Behavior,* 28(3), 795-808.

Mejeh. Mathias., Sarbach. Livia. (2024). *Co-design: From Understanding to Prototyping an Adaptive Learning Technology to Enhance Self-regulated Learning. Technology, Knowledge and Learning.* https://doi.org/10.1007/s10758-024-09788-5

Mejeh. Mathias., Sarbach. Livia., Hascher. Tina. (2024). *Effects of adaptive feedback through a digital tool-a mixed-methods study on the course of self-regulated*

learning. Education And Information Technologies. https://doi.org/10.1007/s10639-024-12510-8

Ng, D. T. K., Tan, C. W., & Leung, J. K. L. (2024). *Empowering student self--regulated learning and science education through ChatGPT: A pioneering pilot study. British Journal of Educational Technology*, 55, 1328 1353. https://doi.org/10.1111/bjet.13454

Page, M. J et al. (2020). *The PRISMA 2002 Statement: an updated guideline for reporting systematic reviews. Research Methods and Reporting*.

Prasse Doreen. et al (2024). *Challenges in Promoting Self-Regulated Learning in Technology Supported Learning Environments: An Umbrella Review of Systematic Reviews and Meta-Analyses. Technology, Knowledge and Learning*. https://doi.org/10.1007/s10758-024-09772-z

Queiroz. Dora Utermohl de., Íñiguez. Guadalupe López., Foletto. Clarissa. (2024). *Investigating if and how string teachers instruct and support the self regulation of students' practice in onlinelessons. Research Studies in Music Education*. https://doi.org/10.1177/1321103X241264943

Schunk, D. H., & Greene, J. A. (2018). *Handbook of Self-Regulation of Learning and Performance. Routledge.*

Sobocinski, M., Dever, D., Wiedbusch, M., Mubarak, F., Azevedo, R., & Järvelä, S. (2024*). Capturing self-- regulated learning processes in virtual reality: Causal sequencing of multimodal data. British Journal of Educational Technology*, 55, 1486–1506. https://doi.org/10.1111/bjet.13393

Sui Chi-Jung., Yen Miao-Hsuan., Chang Chun-Yen. (2024) *Teachers' perceptions of teaching science with technology- enhanced self-regulated learning strategies through the DECODE model. Education and Information Technologies.* https://doi.org/10.1007/s10639-024-12715-x

Torrington, J., Bower, M., & Burns, E. C. (2024). *Elementary students' self--regulation in computer-based learning environments: How do self--reportmeasures, observations and teacher ratingrelate to task performance?. British Journal of Educational Technology*, 55, 231–258. https://doi.org/10.1111/bjet.13338

Xia, Q., Chiu, T. K. F., Chai, C. S., & Xie, K. (2023). *The mediating effects of needs satisfaction on the relationships between prior knowledge and self regulated learning through artificial intelligence chatbot. British Journal of Educational Technology*, 54, 967–986. https://doi.org/10.1111/bjet.13305

Villagrán Ignacio, et al. (2024). *Enhancing Feedback Uptake and Self-Regulated Learning in Procedural Skills Training: Design and Evaluation of a Learning Analytics Dashboard. Journal Of Learning Analytics.* https://doi.org/10.18608/jla.2024.8195