Science Education and Application Journal (SEAJ)
Program Studi Pendidikan IPA
Universitas Islam Lamongan
http://jurnalpendidikan.unisla.ac.id/index.php/SEAJ

September, 2025. Vol. 7, No. 2,
p-ISSN: 2656-6672
e-ISSN: 2656-8365
pp. 200-209

Exploring Self-Regulated Learning and ICT Integration in Chemistry Education: A Study in the Digital Era

[1]Munawwarah, [2*]Sumiati Side
[1,2]Jurusan Kimia, FMIPA, Universitas Negeri Makassar, Indonesia
Email Correspondence: sumiati_kim@gmail.com

Article Info
Article History
Received: August 25th, 2025
Revised: September 18th, 2025
Accepted: September 19th, 2025
Published: September 25th, 2025
Keywords
Self-Regulated Learning, ICT utilization, chemistry education, digital learning, student profile

Abstract

Profiling Self-Regulated Learning and ICT Utilization among Chemistry Education Students in the Digital Era. *In the digital era, chemistry education faces dual challenges: fostering students' self-regulated learning (SRL) while optimizing the use of information and communication technology (ICT). This study aims to profile the levels of SRL and the extent of ICT utilization among chemistry education students, providing insights into how both aspects intersect in supporting academic success. A descriptive quantitative design was employed, involving 26 third-year chemistry education students at Universitas Negeri Makassar. Data were collected through two instruments: an SRL questionnaire covering dimensions of goal setting, planning, time management, learning strategies, self-monitoring, motivation, and self-reflection, and an ICT utilization questionnaire addressing access to digital resources, use of learning applications, participation in online discussions, digital collaboration, and creativity in ICT-supported chemistry learning. Responses were analyzed using descriptive statistics and thematic analysis of open-ended items. The results revealed that students' SRL abilities ranged from moderate to high, with notable strengths in goal setting, planning, and reflection, but persistent challenges in time management and independent study. In contrast, ICT utilization was consistently high across all dimensions, showing strong reliance on digital resources and collaborative tools. A comparative analysis indicated that students rely more on external ICT support than on internal self-regulatory strategies. The study concludes that while ICT integration in learning is robust, strengthening SRL remains essential to balance technology use with sustainable learning autonomy. These findings suggest the need for instructional designs that deliberately embed SRL-enhancing components into ICT-based learning, aligning with the demands of the digital era and the pursuit of quality education.*

Citations: Munawwarah, & Side, S. (2025). Exploring self-regulated learning and ICT integration in chemistry education: A study in the digital era. Science Education and Application Journal (SEAJ), 7(2), 200–209.

INTRODUCTION

In the digital era, characterized by the profound integration of advanced technologies into various sectors, particularly education, there has been a significant shift in pedagogical approaches aimed at fostering digital literacy among both students and educators. Yopi (2024) notes that the emergence of Industry 4.0 requires teachers to adapt their strategies to effectively utilize digital tools, making digital competence essential for modern educators. This viewpoint is further supported by Halimi et al. (2022), who suggest that the shift to online learning necessitates innovative teaching methods in civic education, thereby enhancing civic competence in an increasingly digital context. Habibillah & Hadjri (2024) also highlight the essential role of technology in improving educational experiences, affirming that the delivery of educational content relies heavily on digital means to engage learners and meet current educational demands. Additionally, the challenges posed by the COVID-19 pandemic have

accelerated the adoption of digital learning, resulting in educators needing to continuously update their methods to remain relevant and effective (Temiz & Salelkar, 2020). Thus, the integration of digital technologies in education is not merely an enhancement but is crucial for nurturing engaged and competent learners in the 21st century.

In higher education, particularly within chemistry education programs, the challenges of mastering complex and abstract concepts are significant. Effective learning strategies are imperative for students to grasp the intricacies of chemistry, as these courses necessitate not only practical skills but also robust analytical abilities. Faulconer et al. (2018). The integration of information and communication technology (ICT) in chemistry instruction can significantly enhance learning outcomes. For instance, virtual laboratories and interactive simulations allow students to engage in hands-on learning in a safe digital environment, thus bridging the gap created by physical limitations. (Mary Guruloo & Osman, 2023; Samosa, 2021). Samosa Samosa (2021) Demonstrated that mobile virtual laboratories result in improved student achievement and more favorable attitudes toward chemistry. Moreover, research by Mary Guruloo & Osman, 2023 Highlighted that chemistry educators must be adequately trained in utilizing virtual reality laboratories (VRLs) effectively to facilitate meaningful learning experiences. In a similar vein, Peechapol (2021) Emphasized that virtual laboratory simulations can engage students more effectively, allowing them to interact with lab equipment and visualize chemical processes, ultimately leading to increased self-efficacy and enhanced learning experiences. Therefore, the implementation of ICT in chemistry education serves not only as an innovative pedagogical strategy but also as a crucial element in preparing students to succeed in their academic and professional pursuits in a rapidly evolving educational landscape. The integration of ICT in learning environments not only provides access to diverse digital resources but also fosters essential components of self-regulated learning (SRL), such as goal setting, self-monitoring, and reflection, thereby enabling students to take greater control of their learning processes in complex subjects like chemistry.

Chemistry as a discipline requires a high level of self-regulated learning (SRL) because students must master abstract theories, connect multiple representational levels, and engage in complex problem-solving. The integration of ICT, through tools such as virtual laboratories and interactive simulations, can support these processes by providing visualizations and flexible learning environments that enhance students' conceptual understanding.

The integration of Information and Communication Technology (ICT) in educational practices offers significant opportunities for students to engage in both independent and collaborative learning, which can foster the development of self-regulated learning (SRL) skills. Flexible access to digital resources, such as online discussion forums, can enhance students' autonomy in their educational processes; however, specific effects on SRL were not directly addressed in the studies reviewed. Nwafor et al. (2022) Discuss challenges of ICT use in chemistry education rather than directly promoting self-directed learning strategies. Additionally, Qazi et al. (2021) Focus on gender differences in ICT use and skills, thus not directly supporting claims about leveraging digital tools for self-regulated learning across all students. The importance of SRL is noted in other contexts, but Mynaříková & Novotný (2021) Specifically address challenges in ICT education in the Czech Republic rather than SRL in a general sense. Therefore, while the necessity of effective ICT use is acknowledged, the claims around SRL may not be adequately supported by the references listed.

In chemistry education, self-regulated learning (SRL) plays a crucial role as the subject requires students to grasp abstract theories, master experimental procedures, and connect theory with practice. Without the ability to regulate their learning strategies independently, students may struggle with the complexity of the material. Thus, SRL serves as a fundamental foundation for chemistry education students in developing both academic and professional

competencies. The work of Russell et al. (2020) emphasizes that making educators' self-regulation visible promotes student SRL, which is particularly essential in a discipline as intricate as chemistry. Additionally, Wiyarsi et al. (2019) support the notion that effective learning strategies contribute to enhanced academic outcomes, noting that self-regulated learners generally achieve better learning results compared to their peers. Furthermore, the findings by Ekici and Ekici & Atasoy (2023) indicate that implementing strategies to enhance SRL among pre-service chemistry teachers can significantly improve their learning capabilities. Moreover, Wong et al. Wong et al. (2018) highlight the importance of creating supportive online learning environments that foster SRL, especially as educational landscapes increasingly shift toward digital platforms. Therefore, promoting SRL within chemistry education is critical for effective learning and future professional success.

The integration of Information and Communication Technology (ICT) can strengthen students' self-regulated learning (SRL) abilities. For instance, the use of learning management systems (LMS) enables students to plan their study schedules and monitor academic progress. Chemistry simulation applications assist in the adoption of effective cognitive strategies, while video-based learning facilitates reflection and self-evaluation. However, variations in students' SRL and the utilization of ICT are evident. While some students maximize ICT to support their learning, others face challenges in employing technology productively. These differences may be influenced by factors such as motivation, digital literacy, prior learning experiences, and the learning environment. Research indicates that effective ICT use can create a learner-centered atmosphere, enhancing motivation and self-efficacy among students - & - (2024). Additionally, Nnoli emphasizes that students' need for updating ICT skills is critical for adapting to digital learning environments, particularly highlighted during the COVID-19 pandemic (Nnoli, 2021). Furthermore, the study by Hori and Fujii demonstrates that using ICT fosters self-determination and intrinsic motivation, which are essential components of SRL. (Hori & Fujii, 2021). This multifaceted interaction of factors underscores the importance of addressing students' diverse backgrounds and support systems to facilitate effective ICT utilization for enhanced learning outcomes.

Research on the profile of self-regulated learning (SRL) and ICT utilization among chemistry education students is highly relevant. Such profiling can provide insights into students' learning behaviors, the extent of their self-regulation skills, and how they employ ICT in academic contexts. Moreover, mapping SRL and ICT utilization profiles is significantly important in supporting the achievement of the Sustainable Development Goals (SDGs), particularly Goal 4 on quality education. Higher education in the digital era must prepare graduates who not only master academic content but are also competent in managing self-directed learning and adapting to technological advancements. This aligns with the demands of the workforce, which increasingly requires individuals who are autonomous, creative, and committed to lifelong learning. Recent studies indicate that integrating SRL into educational practices can foster better academic outcomes and enhance student engagement (Kaiser et al., 2020). Additionally, it has been shown that positive psychology frameworks can significantly bolster self-regulated learning among students, thereby improving their academic performance in higher education settings (Kaiser et al., 2020). Furthermore, research emphasizes the importance of ensuring that educators and students possess adequate ICT skills to effectively utilize technology for learning, which directly impacts student success and adaptability in today's technological landscape (Khampirat, 2021). Lastly, fostering self-regulated learning is critical not just for academic success but also for lifelong learning, as students equipped with these skills are better prepared to navigate their future careers (Khampirat, 2021).

Based on these considerations, research on *Profiling Self-Regulated Learning and ICT Utilization among Chemistry Education Students in the Digital Era* is of great importance. Such a study is expected to provide a comprehensive picture of chemistry education students'

abilities to regulate their learning and the extent to which they utilize ICT in their academic pursuits. The findings may serve as a foundation for developing innovative instructional strategies that are relevant to the characteristics of the digital generation.

METHODS

This study employed a descriptive quantitative research design, which was considered appropriate for the exploratory aim of profiling self-regulated learning (SRL) and information and communication technology (ICT) utilization among chemistry education students. A descriptive approach was selected over experimental or correlational methods because it provides a comprehensive snapshot of students' learning behaviors without manipulating variables. Such a design is particularly suitable for identifying tendencies and usage patterns that can serve as a baseline for future experimental investigations. Similar studies in chemistry education and digital learning have also applied descriptive profiling methods to map SRL and ICT patterns (e.g., Wiyarsi et al., 2019; Fuchs et al., 2022).

The participants consisted of 26 third-year students enrolled in the Chemistry Education program at Universitas Negeri Makassar during the academic year 2025. A purposive sampling technique was applied, as third-year students were deemed the most relevant group due to their substantial exposure to ICT-supported courses and tasks requiring independent learning strategies. Although the sample size is relatively small, it was adequate for the exploratory scope of the study. Nevertheless, the limited number of participants may restrict the generalizability of the findings, and the possibility of sampling bias should be acknowledged.

Two instruments were used in this study. The first was a Self-Regulated Learning (SRL) questionnaire adapted from established SRL frameworks, consisting of items covering goal setting, planning, time management, learning strategies, self-monitoring, motivation, and self-reflection. The second was an ICT utilization questionnaire, developed to measure access to digital resources, use of learning applications, participation in online discussions, digital collaboration, and creativity in ICT-supported chemistry learning. Both instruments employed a 5-point Likert scale. To ensure credibility, the instruments underwent expert validation, and reliability testing indicated Cronbach's alpha coefficients above 0.70 for all dimensions, demonstrating acceptable internal consistency.

The data collection was carried out over two weeks using both online and paper-based formats to maximize accessibility for participants. Respondents were informed about the objectives of the study and assured that their participation was voluntary and confidential. Data were analyzed through descriptive statistical techniques, including mean, standard deviation, and percentage distributions, to profile students' SRL and ICT utilization across dimensions. Comparative interpretations were drawn by contrasting the average scores of SRL with those of ICT utilization to identify discrepancies in reliance on technology versus internal learning strategies. In addition, qualitative responses to open-ended items were examined using thematic analysis, following a structured process of open coding, axial coding, and categorization. This combination of quantitative and qualitative analysis provided a more comprehensive picture of students' learning profiles in the digital era.

RESULTS AND DISCUSSION

To provide a clearer picture of students' profiles in terms of *Self-Regulated Learning (SRL)* and the utilization of Information and Communication Technology (ICT) in chemistry learning, a descriptive analysis was conducted based on the questionnaire data. This analysis aims to identify the tendencies of students' self-regulated learning behaviors as well as the extent to which they employ ICT to support their learning processes. The findings are presented

in tables and graphical illustrations to enhance clarity, followed by a comprehensive discussion that connects the results with relevant theories and the actual learning context.

Table 1. Descriptive Statistics of Self-Regulated Learning (SRL) Based on Core Dimensions

Dimension	Mean	Std.Dev	Category
Goal Setting & Planning	3.63	0.54	High
Time Management	3.88	0.59	High
Learning Strategies	4.0	0.55	High
Self-Monitoring	3.87	0.46	High
Motivation	3.88	0.67	High
Self-Reflection	3.81	0.57	High

The results of the descriptive analysis indicate that students' Self-Regulated Learning (SRL) abilities fall within the moderate to high category across most dimensions. The relatively high mean score in the *goal setting and planning* dimension suggests that students are accustomed to setting clear learning objectives and planning academic activities, including preparing learning materials prior to lectures. This reflects students' awareness of the importance of planning in achieving academic success, particularly in courses that require deep conceptual understanding, such as chemistry. In the dimensions of *time management* and *learning strategies*, students also demonstrated satisfactory performance. They were able to allocate study time according to the difficulty of the material and adapt their strategies when encountering comprehension challenges. This indicates that time management skills and flexibility in learning strategies are key aspects that support autonomous learning. Nevertheless, the variation in scores among individuals suggests that some students still experience difficulties in managing their schedules consistently. Effective time control and flexibility in learning strategies have been proven to enhance academic performance, underscoring the importance of focusing on the development of these skills (Himawan & Widjaja, 2023). Furthermore, the literature indicates that a good learning organization can reduce academic stress and improve students' psychological well-being, which in turn contributes to their academic success (Biwer et al., 2022).

The dimensions of *self-monitoring*, *motivation*, and *self-reflection* fall within the high category, indicating that students are active in monitoring their understanding, comparing outcomes with targets, and reflecting on their learning to improve future strategies. These findings highlight that students are not only outcome-oriented but also engaged in the learning process itself. Consequently, it can be concluded that students' SRL has developed well, although continued support is needed to encourage deeper reflection and the consistent use of independent learning strategies. Research also demonstrates that intrinsic motivation plays a crucial role in the development of SRL; motivated students tend to be more proactive in monitoring and adjusting their learning processes (Bowles, 2024). Moreover, Hori and Fujii emphasize that students' engagement in reflective practices not only enhances academic achievement but also strengthens overall learning processes (Wilby, 2020). Constructive feedback has also been shown to enhance students' reflective abilities, helping them to formulate more effective learning strategies in the future (Villegas & D. Panoy, 2023).

Overall, SRL is essential in chemistry education to ensure that students not only acquire knowledge but also effectively manage their learning processes. This is supported by research indicating that the development of SRL contributes directly to academic success and students' readiness for the job market (Nofriyandi & Andrian, 2022). By emphasizing the deeper development of SRL competencies, educational institutions can better prepare students to face academic and professional challenges in the digital era. Furthermore, instructor support plays

a critical role in guiding students throughout the development of their SRL, as well as in creating a supportive learning environment (Fuchs et al., 2022). As a result, educational institutions should consider integrating SRL training and supportive learning strategies into the curriculum to promote improved outcomes for students (Nuankaew et al., 2019).

Table 2. Descriptive Statistics of ICT Utilization Based on Core Dimensions

Dimension	Mean	Std Dev	Category
Access to Digital Resources	3.96	0.74	High
Use of Learning Applications	3.74	0.43	High
Participation in Online Discussions	3.81	0.94	High
Digital Collaboration	4.17	0.52	High
Creativity in ICT for Chemistry Learning	4.23	0.71	High

The descriptive analysis of ICT utilization indicates that all dimensions fall within the high category. The dimension of access to digital resources shows that students already have adequate access to devices, internet connectivity, and various digital learning resources. This serves as an essential prerequisite for the effective implementation of technology-based learning, as equitable access is fundamental for ensuring that ICT integration in education can function optimally. Research indicates that access to reliable digital tools and resources significantly correlates with improved academic performance and engagement among students (Hidayah, 2019). Moreover, fostering equitable access not only enhances learning outcomes but also promotes digital literacy, which is critical in a technology-driven world (Mena-Guacas et al., 2023). Consequently, institutions must prioritize providing robust ICT infrastructure to facilitate effective learning environments.

The dimensions of the use of learning applications and participation in online discussions also obtained high scores, indicating that students actively engage with simulation applications, digital modules, and online videos to enhance their understanding. Furthermore, they participate in online discussions, albeit with varied levels of involvement. This finding highlights that ICT not only serves as a learning resource but also acts as a medium for academic communication, strengthening interaction among students and between students and instructors. Mena-Guacas et al. emphasize that the development of digital skills is essential for effective collaboration and engagement in educational environments, reinforcing the interplay between technological use and collaborative learning (Mena-Guacas et al., 2023). Additionally, Sobko et al. note that leveraging online platforms for communication fosters deeper connections among peers, ultimately enhancing the quality of collaborative academic work (Sobko et al., 2019). Thus, the integration of ICT facilitates both individual learning and cooperative knowledge construction.

The results directly address the research questions by showing that students' SRL abilities were generally in the moderate to high range, with notable strengths in goal setting, planning, and reflection, but persistent challenges in time management and independent study. At the same time, the consistently high scores across all ICT utilization dimensions confirm that students are highly engaged with digital resources, learning applications, and collaborative platforms. These findings answer the central inquiry of the study, which was to profile the extent of SRL and ICT use among chemistry education students, and they highlight a clear discrepancy between the strong reliance on technology and the comparatively weaker development of internal self-regulatory strategies.

The dimensions of digital collaboration and creativity in ICT for chemistry learning scored the highest, suggesting that students frequently combine various platforms and digital resources to comprehend chemistry concepts and recognize ICT as a tool that enriches learning in contextual and engaging ways. This demonstrates that students are not merely passive users of technology but employ it actively to foster creativity and collaboration. These findings align with previous studies emphasizing that ICT integration encourages higher-order thinking and promotes learner autonomy in the digital era (i Sastre et al., 2022). Moreover, the capacity for digital collaboration in educational settings has been shown to enhance student participation and engagement, which are critical for developing essential skills in the 21st century (Maryani et al., 2023). Therefore, the active use of ICT in chemistry learning not only supports academic success but also prepares students for future challenges in a rapidly evolving digital landscape.

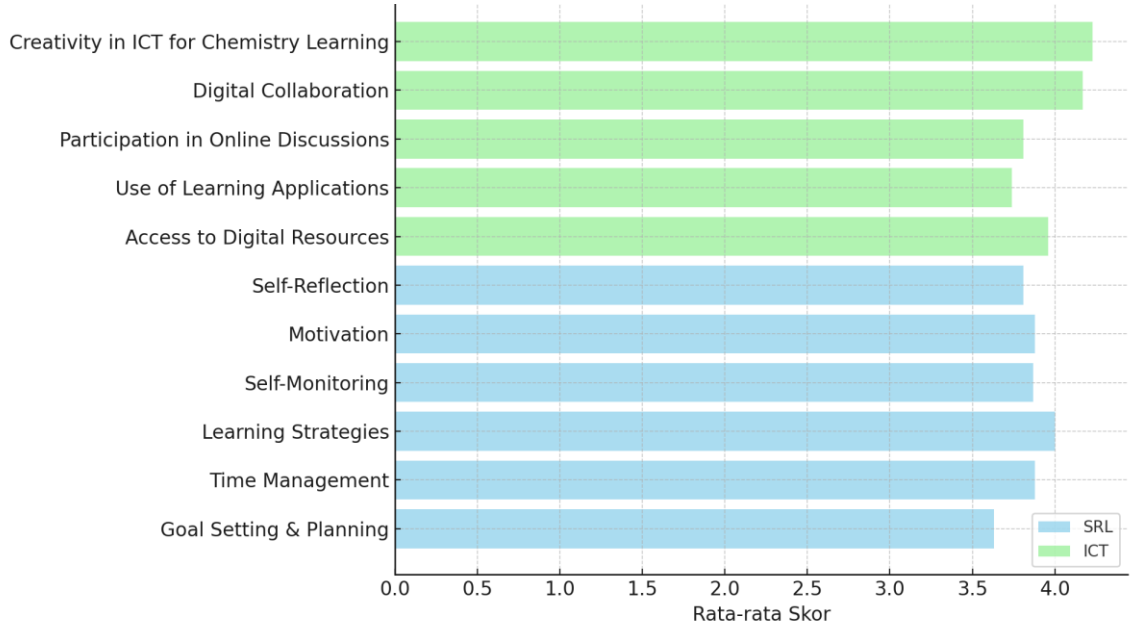

Figure 1. Comparison of Mean Scores of SRL and ICT Utilization Across Core Dimensions

The comparative graph illustrates that the average scores for ICT utilization dimensions are generally higher than those for SRL. This implies that students are more adept at leveraging technology for learning purposes compared to regulating, monitoring, and reflecting on their own learning processes. Such a tendency suggests that while technology adoption is highly prevalent, the development of internal self-regulatory skills may still require further attention and reinforcement. This discrepancy also suggests a reliance on external technological tools rather than on internal strategies for managing learning. For instance, while students actively use applications and digital platforms, some still encounter challenges in maintaining consistent time management and planning. In other words, the successful use of ICT does not automatically translate into enhanced SRL unless the integration of technology is deliberately designed to foster self-regulation.

These findings carry important practical implications for chemistry education. Instructors can integrate reflective journals into learning management systems, design goal-setting exercises within virtual laboratory simulations, and employ peer-feedback tasks in online discussions to foster both ICT engagement and SRL development. Such strategies not only make technology use more meaningful but also encourage students to monitor and regulate their own learning processes in complex subjects like chemistry. However, the results

should be interpreted with caution, as the relatively small sample size and the cross-sectional design limit the generalizability and prevent causal conclusions. In the long term, embedding SRL-enhancing activities into ICT-based learning environments can contribute to improved academic performance, stronger professional readiness, and lifelong learning competencies. Future research should involve larger and more diverse samples, as well as experimental or longitudinal designs, to examine how integrating ICT and SRL-focused strategies impacts students' motivation, persistence, and achievement over time, thereby providing more robust evidence to guide curriculum innovation and teacher training.

CONCLUSION

This study found that chemistry education students demonstrated moderate to high levels of Self-Regulated Learning (SRL), particularly in goal setting, planning, and reflection, while still facing challenges in consistent time management and independent study. At the same time, ICT utilization was consistently high across all dimensions, showing that students actively engaged with digital resources, applications, and collaborative tools. These findings indicate that while ICT has become an integral part of students' academic practices, reinforcing SRL skills is essential to ensure a balanced approach to learning in the digital era. In practical terms, educators are encouraged to design learning activities that integrate SRL-focused strategies into ICT platforms, such as reflective journals in learning management systems, goal-setting exercises in digital simulations, and peer-feedback tasks in online discussions.

However, the study's limitations must be acknowledged. The relatively small sample size and cross-sectional design restrict the generalizability of the findings and limit causal interpretation. Despite this, the study contributes to the broader field of chemistry education by profiling the intersection of SRL and ICT, providing insights into students' learning behaviors in the digital era. Future research should involve larger and more diverse samples and adopt longitudinal or experimental designs to test the long-term effects of integrating SRL strategies within ICT-based learning. Such efforts will not only strengthen academic performance but also cultivate lifelong learning competencies necessary for the demands of the 21st century.

SUGGESTION

Future research should expand the scope of this study by involving larger and more diverse student populations, as well as exploring disciplinary contexts beyond chemistry education to examine whether the findings are consistent across different fields of study. In addition to broadening the sample, employing experimental and longitudinal designs would allow researchers to test causal relationships between ICT integration and the development of SRL, particularly by implementing specific interventions such as goal-setting tasks within digital platforms, reflective journaling in learning management systems, or peer-collaboration activities through virtual laboratory simulations. Further investigations should also evaluate the effectiveness of particular technological tools, such as mobile learning applications, adaptive learning systems, or virtual reality simulations, in fostering SRL and enhancing academic outcomes. Finally, future studies should consider the role of teacher training in integrating ICT with SRL-enhancing strategies, as instructors' pedagogical readiness is a critical factor in ensuring that these approaches are successfully implemented and sustained in educational practice.

REFERENCES

Biwer, F., H. Bruin, A. B., & Persky, A. M. (2022). Study Smart – Impact of a Learning Strategy Training on Students' Study Behavior and Academic Performance. *Advances in Health Sciences Education*. https://doi.org/10.1007/s10459-022-10149-z

Bowles, M. (2024). Digital, Self-Regulated Vocabulary Learning and Device Control in Out-of-Class, Higher Education Settings. *The Electronic Journal of E-Learning*. https://doi.org/10.34190/ejel.22.1.3261

Ekici, F., & Atasoy, B. (2023). Implementation of Strategy Instruction to Promote Pre-Service Chemistry Teachers' Self-Regulated Learning Skills. *Shanlax International Journal of Education*. https://doi.org/10.34293/education.v11is1-jan.5863

Faulconer, E., Griffith, J. C., Wood, B. L., Acharyya, S., & Roberts, D. (2018). A Comparison of Online and Traditional Chemistry Lecture and Lab. *Chemistry Education Research and Practice*. https://doi.org/10.1039/c7rp00173h

Fuchs, K., Pösse, L., Bedenlier, S., Gläser-Zikuda, M., Kammerl, R., Kopp, B., Ziegler, A., & Händel, M. (2022). Preservice Teachers' Online Self-Regulated Learning: Does Digital Readiness Matter? *Education Sciences*. https://doi.org/10.3390/educsci12040272

Habibillah, R., & Hadjri, M. I. (2024). Literature Review: The Relationship Between Technology Development, the Digital Era, and HRD in Indonesia's Underdeveloped Regions. *Kne Social Sciences*. https://doi.org/10.18502/kss.v9i14.16124

Halimi, M., Rahmat, R., Nugraha, R. A., & Pratiwi, E. D. (2022). Young Digital Citizen Answers: Can Online Learning Improve the Quality of Civic Education Learning? *Jurnal Civics Media Kajian Kewarganegaraan*. https://doi.org/10.21831/jc.v19i1.40140

Hidayah, S. N. (2019). Hybrid Model-Based Learning Learning in Welcome Era Industrial Revolution 4.0. *The Innovation of Social Studies Journal*. https://doi.org/10.20527/iis.v1i1.1262

Himawan, A. G., & Widjaja, Y. (2023). Self-Regulated Learning and Academic Stress in Medical School: Are They Related? *Indonesian Journal of Health Sciences Research and Development (Ijhsrd)*. https://doi.org/10.36566/ijhsrd/vol5.iss2/161

Hori, R., & Fujii, M. (2021). Impact of Using ICT for Learning Purposes on Self-Efficacy and Persistence: Evidence From Pisa 2018. *Sustainability*. https://doi.org/10.3390/su13116463

i Sastre, M. S., Pifarré, M., Cujba, A., Cutillas, L., & Falguera, E. (2022). The Role of Digital Technologies to Promote Collaborative Creativity in Language Education. *Frontiers in Psychology*. https://doi.org/10.3389/fpsyg.2022.828981

Kaiser, V., Reppold, C. T., Hutz, C. S., & Almeida, L. S. (2020). Contributions of Positive Psychology in Self-Regulated Learning: A Study With Brazilian Undergraduate Students. *Frontiers in Psychology*. https://doi.org/10.3389/fpsyg.2019.02980

Khampirat, B. (2021). Relationships Between ICT Competencies Related to Work, Self-Esteem, and Self-Regulated Learning With Engineering Competencies. *Plos One*. https://doi.org/10.1371/journal.pone.0260659

Mary Guruloo, T. N., & Osman, K. (2023). Integrating Virtual Reality Laboratories (VRLs) in Chemistry Education: A Systematic Literature Review. *International Journal of Education*. https://doi.org/10.5296/ije.v15i4.21372

Maryani, L., Nur, J., Utami, S., Nurnaifah, I. I., & Farida, F. (2023). Strengthening School Management With Digital Education Technology to Improve the Quality of Educational Output. *Indonesian Journal of Educational Research and Review*. https://doi.org/10.23887/ijerr.v6i2.66039

Mena-Guacas, A. F., Meza-Morales, J. A., Fernández, E., & Menéses, E. L. (2023). Digital Collaboration in Higher Education: A Study of Digital Skills and Collaborative Attitudes in Students From Diverse Universities. *Education Sciences*. https://doi.org/10.3390/educsci14010036

Mynaříková, L., & Novotný, L. (2021). The Current Challenges of Further Education in ICT With the Example of the Czech Republic. *Sustainability*. https://doi.org/10.3390/su13084106

Nnoli, J. N. (2021). Harnessing the Challenges of Covid-19 Ethics on Students Learning in Chemistry. *Sumerianz Journal of Scientific Research*. https://doi.org/10.47752/sjsr.43.70.75

Nofriyandi, N., & Andrian, D. (2022). Factors That Affect Students' Mathematics Performance at Higher Education in Riau Province During the Covid-19 Pandemic. *Infinity Journal*. https://doi.org/10.22460/infinity.v11i2.p367-380

Nuankaew, W., Nuankaew, P., Teeraputon, D., Phanniphong, K., & Bussaman, S. (2019). Perception and Attitude Toward Self-Regulated Learning of Thailand's Students in Educational Data Mining Perspective. *International Journal of Emerging Technologies in Learning (Ijet)*. https://doi.org/10.3991/ijet.v14i09.10048

Nwafor, S. C., Ibe, F. N., & Muoneke, N. M. (2022). Optimizing information and communication technology applications in chemistry learning. *Journal of Research in Instructional*, *2*(2), 151–162. https://doi.org/10.30862/jri.v2i2.92

Peechapol, C. (2021). Investigating the Effect of Virtual Laboratory Simulation in Chemistry on Learning Achievement, Self-Efficacy, and Learning Experience. *International Journal of Emerging Technologies in Learning (IJET)*, *16*(20), 196. https://doi.org/10.3991/ijet.v16i20.23561

Qazi, A., Hasan, N., Abayomi-Alli, O., Hardaker, G., Scherer, R., Sarker, Y., Paul, S. K., & Maitama, J. Z. (2021). Gender Differences in Information and Communication Technology Use &Amp; Skills: A Systematic Review and Meta-Analysis. *Education and Information Technologies*. https://doi.org/10.1007/s10639-021-10775-x

Russell, J. M., Baik, C., Ryan, A., & Molloy, E. (2020). Fostering Self-Regulated Learning in Higher Education: Making Self-Regulation Visible. *Active Learning in Higher Education*. https://doi.org/10.1177/1469787420982378

Samosa, R. C. (2021). Mobile Virtual Laboratory as Innovative Strategy to Improve Learners' Achievement, Attitudes, and Learning Environment in Teaching Chemistry. *International Journal of Multidisciplinary Applied Business and Education Research*. https://doi.org/10.11594/ijmaber.02.05.04

Sobko, S., Unadkat, D., Adams, J., & Hull, G. (2019). Learning Through Collaboration: A Networked Approach to Online Pedagogy. *E-Learning and Digital Media*. https://doi.org/10.1177/2042753019882562

Temiz, S., & Salelkar, L. P. (2020). Innovation During Crisis: Exploring Reaction of Swedish University Libraries to COVID-19. *Digital Library Perspectives*. https://doi.org/10.1108/dlp-05-2020-0029

Villegas, L., & D. Panoy, J. F. (2023). Development of Self-Regulated Learning Material (SLM) for Enhancing Students' Basic Science Process Skills. *International Journal of Research Publications*. https://doi.org/10.47119/ijrp1001331920235491

Wilby, J. (2020). Motivation, Self-Regulation, and Writing Achievement on a University Foundation Programme: A Programme Evaluation Study. *Language Teaching Research*. https://doi.org/10.1177/1362168820917323

Wiyarsi, A., Fitriyana, N., & Ikhsan, J. (2019). Using Technology in Hydrocarbon Topics: A Profile on Students' Self-Regulated Learning. *Journal for the Education of Gifted Young Scientists*. https://doi.org/10.17478/jegys.616947

Yopi, F. (2024). Tpack and Teachers' Digital Competence in the Era of Industry 4.0. *Ijmi*. https://doi.org/10.61796/ijmi.v1i1.32