Mapping the Landscape of Self-regulated Learning with Interventions – A Bibliometric Guide for Academic Decision-Making

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***Abstract*—Research indicates that novice learners often struggle to plan, monitor and evaluate their cognitive processes during academic tasks, limiting their ability to engage meaningfully with the content. This challenging gap underscores the need for educational paradigms that cultivate learner autonomy and support lifelong learning. Self-regulated learning (SRL) offers a promising pathway to address this need by integrating metacognitive, behavioral, and motivational components to foster sustainable self-regulated skills.To trace the evolution of SRL research-particularly in relation to interventions, this study conducts a bibliometric analysis, to map its academic trajectory. Using Scopus and WoS databases, 1151 documents from 2000 to 2025 were analysed using VOS viewer and RStudio-Biblioshiny. The objective of this study is to guide researchers in understanding and analyzing scientific production, thematic co-occurrence patterns, evolving publication trends , influential authors, countries and affiliations in the domain .The analysis reveals a significant surge in scaffolded intervention driven SRL research with developed nations leading the way. This highlights the need to integrate such practices in a contemporary pedagogical approach. These insights provide a foundation for policymakers and academic decision makers to synthesize literature and adopt this emerging educational model. In turn, this would help foster a proactive learning culture aligned with emerging paradigms and will help support a seamless transition from academic environments to the workplace.**

***Keywords*—Bibliometric; decision-making; Intervention; learning strategies; R-studio; Self-regulated learning; Vosviewer,**

***ICTIEE Track*—Emerging Technology and future skills**
***ICTIEE Sub-Track*—Learning Analytics in academic success and behavioural modelling**

I. INTRODUCTION

In an ever-evolving world, it is imperative to inculcate lifelong learning and reflective decision making for success. The "Organization for Economic Co-operation and Development" - OECD Learning indicators mention that students need to acquire skills like "metacognitive skills, critical thinking and and self-regulation" along with social, emotional and practical skills. (Education Today 2009 | OECD). UNESCO's Education 2030 Framework (SDG 4) also focuses on the Promotion of lifelong learning incorporating self-regulation (Bayly-Castaneda et al., 2024). Self-regulated learning (SRL) is a learner oriented process where a learner utilizes his cognitive, motivational and affective strategies to achieve personal goals (Ng et al., 2024). Students who have better autonomy can effectively apply self-regulated learning and have a likelihood of better learning outcomes, while those who face deficits in SRL are prone to learning challenges (Patel et al., 2015). Problem-solving skills have been a perennial challenge in engineering studies. These skills require the execution of cognitive and metacognitive strategies. SRL based interventions are known to enhance learning performance,problem-solving, reduce test anxiety (Putwain et al,2020), strengthen mastery-oriented goals, improve at-risk learner performance (Espinoza, P. & Genna, G. M. (2021) and bolster self-efficacy (Samuel & Warner, 2021). These developments underscore the growing recognition of SRL interventions as effective drivers of deep learning. Although Bibliometric studies exist, few integrate intervention characteristics and the effectiveness of SRL in academia for policymakers and decision-making. Hence this classic study addresses that gap. The aim of this study is to analyse academic publications and gain understanding of the scientific output evolving rapidly from SRL literature in terms of publications in the past 25 years. Prior research on SRL has seen systematic reviews to assess the effectiveness of SRL with respect to empirical outcomes, domain specific effects and various learning environments. In contrast, the present bibliometric analysis offers a mapping of SRL interventions across diverse educational settings, revealing how the field has evolved.

Additionally, it tries to understand the trend topics and co-citations unraveling the collaborative work between authors and countries.The rising body of literature demonstrates that well-designed SRL interventions can significantly enhance academic performance across diverse domains and learning environments, online and blended settings (Zhao et al., 2025).Consequently, this creates individuals with a growth mindset and transforms them into lifelong learners as they transition into the workforce. This study holds immense practical significance in improving instructional strategies in

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SRL and understanding learner outcomes, while enhancing the overall learning process. Most of the recent AI-driven academic work has focused on the deployment of tools such as chatbots, Intelligent tutoring systems and several generative AI tools with a focus on empirical outcomes , instructional implications and practices within limited contexts (Rad, H.,2025). In contrast,the present Bibliometric analysis systematically analyses the broad spectrum of research trends and a macro-level mapping of the SRL landscape. Thus, it complements the existing AI-focused research within the academic landscape providing actionable directions for academic decision makers. As learners evolve into tomorrow's workforce, SRL strategies become essential for employer-regulated continuous workplace education (Hemmler & Ifenthaler, 2024). Employees equipped with SRL skills demonstrate improved problem-solving, adaptability, and continuous self-improvement, thereby contributing to organisational growth and innovation.

Therefore, academicians, curriculum developers, policymakers, corporate leaders, and decision-makers can leverage these insights to align academic learning with industry needs, ensuring a future-ready workforce.

RQ1: What is the annual scientific production in the domain of SRL intervention research seen globally from 2000 to 2025?

RQ2: Who are the most prolific and influential authors, and countries in SRL intervention research, and how has their influence changed over time?

RQ3: Which publications and affiliations have most significantly shaped SRL intervention research, and what is their relative influence??

RQ4: What are the trend topics and dominant conceptual themes and emerging topics in SRL intervention research, as revealed through keyword co-occurrence networks?

RQ5: What patterns of collaboration exist among authors and countries in SRL intervention research, and which networks demonstrate the strongest partnerships?

II. BACKGROUND OF THE STUDY

Literature reviews are an integral part of academia, helping to synthesise existing knowledge while evaluating the current landscape within the field of study (Kunisch et al., 2018).Systematic reviewing helps a methodical gathering of academic literature and selectively reviewing studies appropriate to the researcher (Tranfield, D et al,2003).

According to Bandura in 1986, the Social cognitive theory asserts that self-regulation comprises of three processes: self-observation, self-judgment, and self-reaction. Classic theories of SRL have sought to conceptualize the cognitive, motivational, and contextual factors that influence the learning process. Zimmerman (2002) and Pintrich (2000) are known for their classic frameworks of self-regulated learning, integrating motivational and metacognitive aspects as key components. Studies indicate that SRL scaffolds -both domain general and domain specific are considered as an optimal way to improve students' academic achievement.(Zheng, 2016). SRL interventions need to be implemented at the right time to produce effective results. According to Rienties et al.(2016) ,the challenging part of Learning Analytics is designing a well-established intervention to support learning (Sedrakyan et al., 2020). Scaffolds like 'Prompts' play an important role in guiding students to understand their beliefs and strategies towards their goal (Wang et al., 2023). The most frequently used intervention types used by the researchers that support SRL were prompts, digital diaries and integrated support systems. Learning Analytics interventions have also been seen to increase retention (Heikkinen et al., 2023). Self-regulated learning training in the classroom enhances the learning strategy, academic performance, and motivation of university students.(Theobald,2021). AI technologies and Chatbots in the digital learning environment are also very proactive in aiding the Self-regulated learning process.(Ng et al., 2024).SRL strategies, which comprise cognitive, metacognitive, motivational, and resource management, have a significant influence on academic achievement and show parallels with many other similar studies (Dignath & Büttner, 2008; Ergen & Kanadli, 2017) Metacognitive interventions help individuals choose an appropriate cognitive strategy during learning and strengthen executive functions, such as inhibitory control, cognitive flexibility, and updating of working memory.(Eberhart et al., 2025). Students, especially those in engineering, often lack the reflective skills and strategies required for solving complex problems (Litzinger et al., 2011). Circuit problem-solving requires efficient metacognitive regulation and self-regulated learning for identifying, analysing, and systematically troubleshooting components. Some of the strongest learning indicators, which were highly correlated with SRL, included goal level, persistence, effort, and self-efficacy.SRL is seen to have a positive effect on academic achievements in online and blended environments (Xu et al., 2023). Capturing the dynamic nature of self-regulated learning is crucial for understanding the regulation and transfer of SRL (Sitzmann,2011). The bibliometric review of studies aims to identify a vast body of literature and carefully select a subset of studies that meet the inclusion criteria, thereby contributing to the development of research goals. The literature indicates that SRL, with various interventions, play a significant role in regulating learning outcomes and achievements by honing SRL skills among learners, preparing them for the workforce of tomorrow. Much of an individual's learning methodology is reflected in their workplace performance. The transferring of these educational learnings to the workplace becomes increasingly important. This helps professionals in self-regulating professional learning at work (SRpL). SRpL focuses on how one can master their own learning curve(Cuyvers et al., 2020). Peer support can also help manage deficiencies such as poor time management, procrastination, and low motivation levels online (Liu & Ye, 2025). Deeper learning has come to the forefront of educational policies worldwide and has drawn attention from various stakeholders in academia (instructional designers, educators, policymakers). This is a result of core competencies such as problem-solving, metacognition, critical thinking, and

self-regulated learning, which are considered essential to navigating global challenges (Sergis & Sampson, 2019).

III. METHODOLOGY

Bibliometric Analysis is an integral part of evaluating literature. In this study, the comprehensive database of 'Scopus' and 'Web of Science'(WoS) has been used. The two databases encompass a vast amount of scholarly, peer-reviewed literature and are renowned for their high-quality indexing and search capabilities. Hence, they have been chosen for the study. The search Query used in the literature search analysis was (TITLE-ABS-KEY ("self-regulated learn*") AND TITLE-ABS-KEY ("interven*" OR "scaffold*" OR "training" OR "instructional support") AND TITLE-ABS-KEY("effect*" OR"affect* "OR "impact" OR "performance" OR "outcome*")). The inclusion criteria for our study required selecting only 'Articles' and the language chosen was 'English'. The two files were downloaded in BibTeX (.bib) file format from the Scopus and WoS databases. The data was collected from January 2000 to January 2025.This period was chosen because the year 2000 marked the beginning of the evolution of SRL research, and focused studies in SRL truly began. The search retrieved 1,008 publications from the Scopus database and 677 publications from the WoS database. The Bibliometric analysis was conducted using Biblioshiny and Vosviewer tools. Both tools provided a visual analysis of the scientific literature. In Biblioshiny, the execution was performed using the commands: install.packages("bibliometrix") followed by library(bibliometrix). This was followed by executing the' biblioshiny() command in RStudio, which directed the user to the Biblioshiny interface.Here, both the databases were imported and the duplicates were merged using the 'mergeDbSources(S, W, remove.duplicated = TRUE)' command. The merging of duplicates was followed by manual screening for missing values which resulted in a final dataset of 1,151 documents. Here, S and W stand for Scopus and WoS, respectively. This combined set of 1,151 publications were downloaded in .csv format for further use. Biblioshiny was used to visualise several bibliometric indicators, including annual publication trends, most productive authors, sources, and citation patterns. To enhance the accuracy of thematic clustering in VOSviewer, conceptually similar keywords (e.g: "self-regulated learning," and "self-regulated)were normalized using a 'replacement word' file. This merged synonymous terms into a single representative keyword and improved cluster coherence. The VOSviewer software analysis also generated Bibliometric distance-based maps, identifying clusters and helped to visualise the data.(Jan van Eck & Waltman, 2009). The procedure enhanced the reliability and standardised the terminology for analysis. The systematic workflow of Bibliometric Analysis can be best represented through stages in a methodological process (Zupic&Cater, 2015) as shown in Fig. 1. This study analysed publicly available secondary data without accessing any confidential information thereby complying with research ethics standards.

IV. RESULTS AND DISCUSSION

The analysis of the Bibliometric data and their visualisations from the search process in 'Web of Science' and 'Scopus' are summarised below. Bibliometric studies have 2 subsections of study: (1)Performance Analysis: Performance Analysis evaluates the contribution of scholarly work primarily based on publication, author, country, affiliations and citation data (Sharma et al.,2023) (2) Science Mapping Analysis focuses on the research connections and the way they evolve. It emphasises visualising the structure of relationships and collaborations to understand the flow of knowledge. It explores aspects such as co-authorship networks and co-citation patterns to reveal how

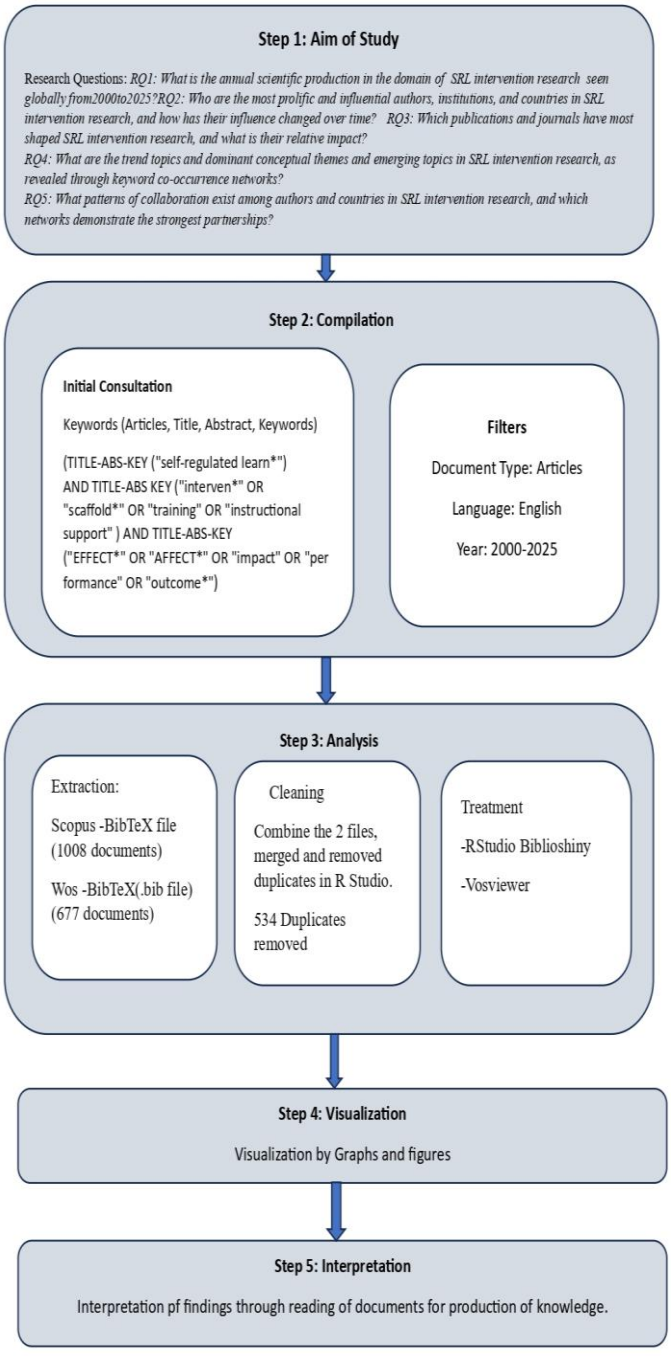

Fig. 1. Methodology steps

research communities interact. The cluster themes were triangulated and verified with established theoretical SRL intervention-based research trends reported in prior literature(Panadero, 2017) (Dignath & Büttner, 2018).

RQ1: What is the annual scientific production in the domain of SRL intervention research seen globally from 2000 to 2025?

The annual scientific production of articles from 2000 to 2025 is shown in Fig. 2. The graph exhibits a steady upward trend in publications, which underscores the importance of studying the effectiveness of self-regulated learning with interventions. The initial years saw minimal work in the domain and the year 2000 was not very encouraging. But the surge quickly began, and the year of significance with the highest number of publications was 2024. It is clearly evident that an increasing quantum of publications meant an increased line of interest in studying the domain. Post-COVID, there was a surge in independent learning and a significant shift toward digital learning and learning analytics. Hence, global policy frameworks changed, and this was one of the main reasons for the bibliometric momentum. The last decade saw a mighty shift in bridging the teaching-learning gap where the role of a learner is highly impacted by learning interventions in SRL.The nature of SRL in continuous education plays an important role in forming a strong foundation for designing effective interventions. Table I gives a good statistical summary of the production from 2000 to 2025 where the number of documents published were 1151 and the average citations per document was 23.58. Each paper was co-authored by four authors (4.05 approximately). The 10.07% annual growth per year is significant as it shows a sustained interest in rising pedagogy studies. The predominance of multi-authored works also reflects the need for expertise in education, science, engineering, psychology, and the integration of data analytics.

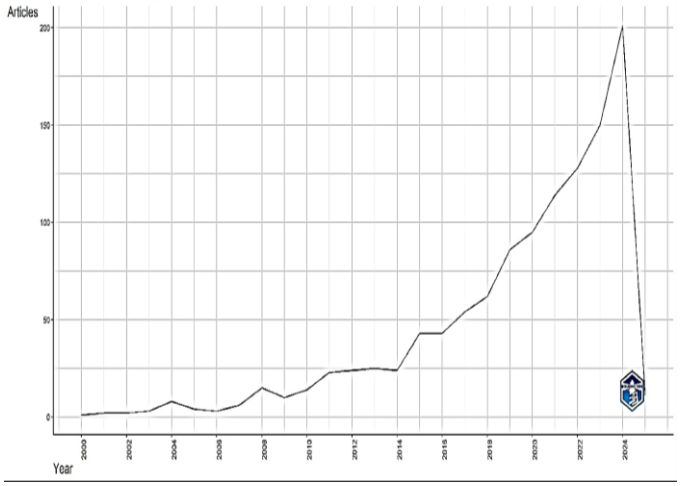

Fig. 2. Annual scientific publication

TABLE I
MAIN INFORMATION

Description	Results
Main Information about Data	
Timespan	2000:2025
Sources (Journals, Books, etc)	521
Documents	1151
Annual Growth Rate %	10.07
Document Average Age	5.59
Average citations per doc	23.58
Keywords Plus (ID)	1888
Author's Keywords (DE)	2791
Authors	3345
Authors of single-authored docs	113
Single-authored docs	127
Co-Authors per Doc	4.05
International co-authorships %	17.2
Article	1056

RQ2: Who are the most prolific and influential authors, and countries in SRL intervention research and how has their influence changed over time?

Major Contributions : Authors

This section helps to know about the most influential authors in the field which helps serve as a reference for future researchers to identify seminal studies and domain experts. Azevedo R, Lajoie S, Perels F were the most active authors in their production as shown in Fig.3 . Azevedo entered the domain early, starting in 2004, followed by Perels F, who began contributing in 2009, and Lajoie S, who initiated her work in 2012. Azevedo primarily studied the interplay of Metacognition, cognition and affective domain of Self regulated learning in technology within open-ended learning environments (Duffy & Azevedo, 2015). Lajoie worked on computer-based environments as cognitive tools and optimizing the process of learning in technology-rich environments while managing metacognitive skills of self-monitoring(Lajoie, 2008). Perels F discusses primarily about interventions in SRL and the interplay of achievement, personality, cognition, metacognition and problem solving (Barz et al., 2024; Dörrenbächer & Perels, 2016). All three researchers have maintained a consistent interest and have been actively publishing their work through 2024. As observed in Fig. 3 ,the most prolific authors in the last 4 years were Azevedo, Lajoie, Brydges R, Li, Deb S,Molenaar and Perels. The local impact of authors also indicate that 'Azevedo' had the highest h-index of 12, implying that the author has 12 papers with at least 12 citations . The authors Lajoie S and Perles F followed closely with h-index of 11 and 10 respectively.

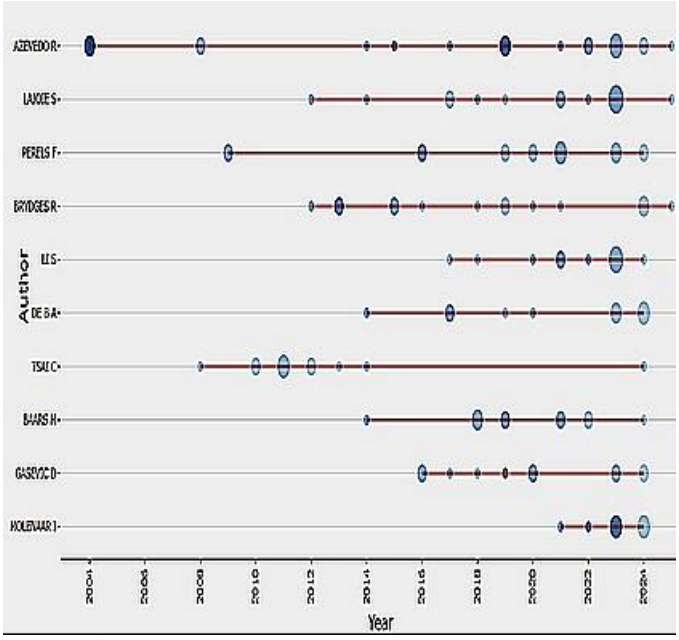

Fig. 3. Authors output over time

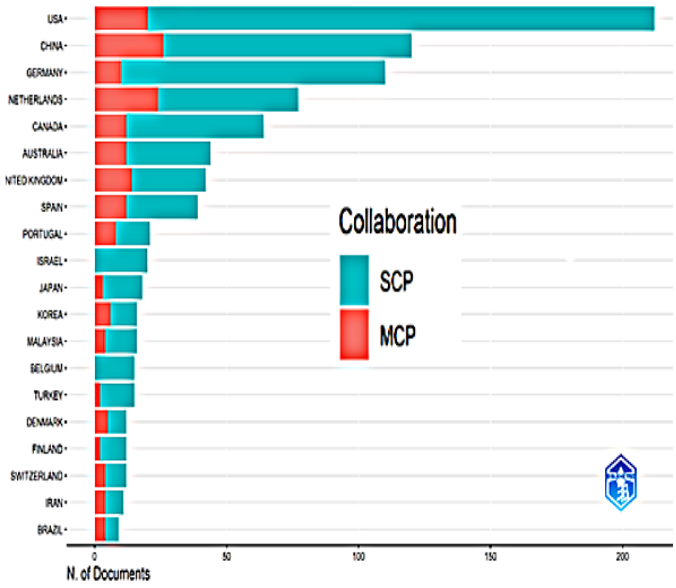

Fig. 4. Major Contributions : Author Countries

Major Contributions : Countries

Table II shows the top 8 countries that produced the maximum citations . Collaboration among nations is crucial for gaining insights to the scientific progress (El Khatib & Al Falasi, 2021).Developed nations have allowed the proliferation of newer learning patterns, while growing economies require a larger focus. USA being the top country having 8299 total citations followed by Germany and Netherlands having 4043 and 2984 citations respectively .

However, as shown in Fig.4, in terms of publication collaboration, the leading countries were the USA, China, Germany, followed by the Netherlands. Fig. 4 also shows that USA leads in single country publications(SCP) while China leads in multiple country publications(MCP). While SCPs reflect the strength in research, MCPs are an indicator for innovation and information exchange, especially for countries seeking to boost their scientific impact.

TABLE II
COUNTRY: CITATIONS

Country	TC (Total citations)
USA	8299
Germany	4043
Netherlands	2984
Canada	1669
China	1487
Spain	1017
Australia	978
United Kingdom	833

RQ3: Which publications and affiliations have most significantly shaped SRL intervention research, and what is their relative influence?

Major Contributions: Publications

As depicted in Table III , the authors of the most highly cited journals are Boekaerts M, Paris S, Dignath C . Fig.5 illustrates that the "University of Toronto" is seen to be the most productive affiliation while Maastricht University and Beijing Normal University take the second and third position respectively. The journals which lead the list in terms of productivity are '*Frontiers in Psychology', 'Metacognition and Learning' and 'Frontiers in Education'* respectively (TABLE IV). Boekaerts M whose paper titled "Self-regulation in the classroom: A perspective on assessment and intervention" drew the highest citations. The paper delves into the conceptualization of SRL and domain specific self-regulatory skills for well-being goals in the classroom (Boekaerts & Corno, 2005) . This was followed by the publication "Classroom applications of research on self-regulated learning" (Paris & Paris, 2001) which emphasises the components of fostering self-regulated learning, creating a positive impact among learners. The 3rd highest citation was for the publication titled "A meta-analysis on intervention studies at primary and secondary school level " by Dignath & Buttner, which describes how SRL has translated into classroom practices with reading and writing strategies, cognitive engagement and SRL practices (Dignath & Büttner, 2008).

TABLE III
HIGHLY CITED ARTICLES

Paper	Total Citations	TC per Year	Impact Factor
Boekarts M, 2005,Applied Psychology	911	43.38	7.2
Paris s, 2001, Educational Psychologist	834	33.36	8.209
Dignath C, 2008, Educational Psychologist	662	36.78	8.209
Azevedo R, 2004, Educational Psychologist	574	26.09	8.209

Sitzmann T, 2011, Psychological Bulletin	506	33.73	17.3
Dunlosky J, 2012, Learning and Instruction	456	32.57	4.7
Cleary T, 2004, · Psychology in the Schools	360	16.36	2.14
Azevedo R, 2004, Contemporary Educational Psychology	347	15.77	3.9

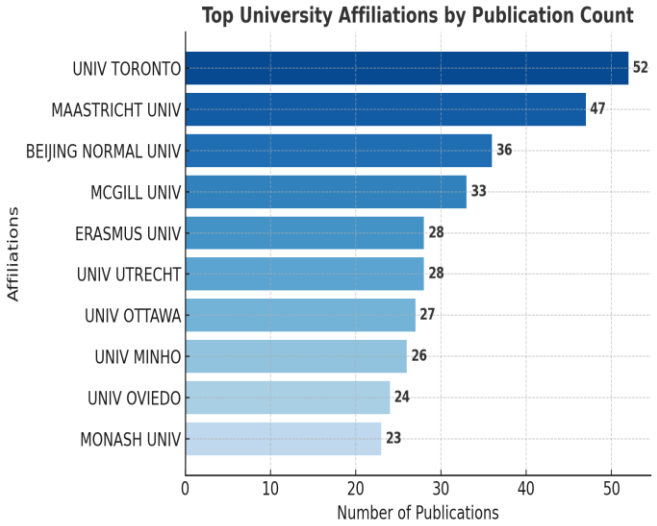

Fig. 5. Highest Affiliations

TABLE IV
TOP JOURNALS AND THEIR PRODUCTIVITY

Sources	Articles
Frontiers in Psychology	45
Metacognition and learning	35
Frontiers in education	28
Computers in human behavior	21
Journal of computer assisted learning	21
Learning and individual differences	19
BMC medical education	18
British journal of educational technology	18

RQ4: What are the trend topics and dominant conceptual themes and emerging topics in SRL intervention research, as revealed through keyword co-occurrence networks?

Trend topics

Fig. 6 illustrates the research trends on the effects of self-regulated learning outcomes, providing insights towards this evolving field. The years from 2005 to 2015 predominantly focused on the 'Psychological impact' and 'adolescence' domains, as the field has its origin in psychological studies. Over time, pedagogy experts began examining the effects related to "Self-regulated learning" and the research emphasis shifted towards topics such as 'cognition, 'educational measurement, and 'teaching. Following the Covid pandemic(2021), the world witnessed a mighty revolution in academia where it saw a lot of virtual learning and the focus moved to words like 'intervention', 'framework', 'knowledge', 'online'. In recent years, student-centred technologies have been shaping the future of education, aligning with the buzzword 'Education 4.0', which transforms educational practices to 'Industry 4.0' (Tikhonova & Raitskaya, 2023).This trend is reflected in the growing emphasis on research domains such as 'design', outcome', and 'engagement', which are the new buzzwords of research in recent years.

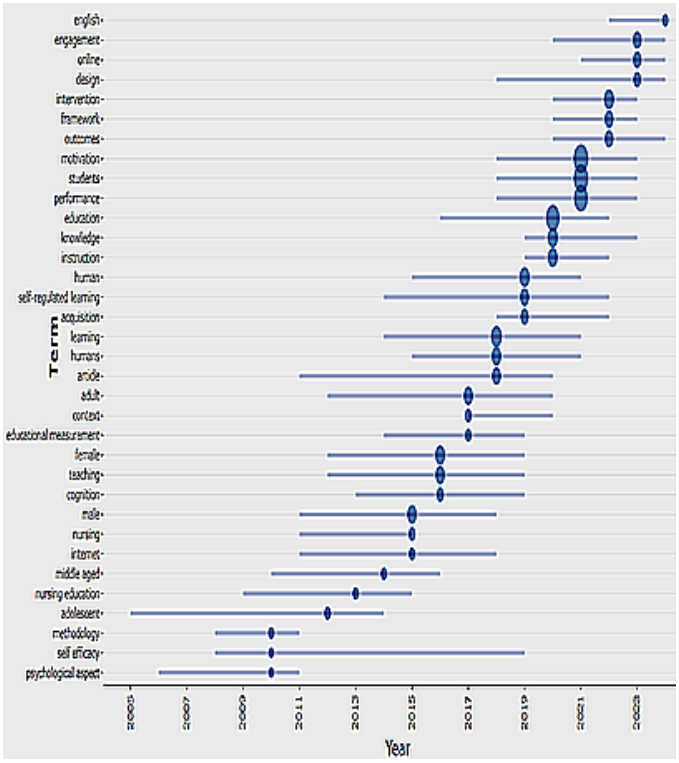

Fig. 6. Trend topics

The traditional teaching pedagogy which is still dominant worldwide, will be combined with innovative approaches, e-learning, flipped classroom and blended learning approach. Newer themes with SRL are gaining prominence highlighting the need for more effective interventions, AI enabled workplace learning (Deshmukh, S. C., & Mehta, M.,2025)and enhancing the impact of personalised learning.

Co-occurrence Analysis

Citation networks reveal how documents reference one another. In Bibliometric analysis the network representations can be viewed using Co-citation or Bibliographic coupling networks. The number of shared references determine the strength of coupling. If an independent third document cites both documents A and B from the same dataset, then the two documents are said to be co-cited. Co-occurrence networks are mappings used to gain a deep understanding of conceptual structures. A Conceptual structure shows the hidden patterns in relevant publications and is evaluated using co-occurrence mappings. Co-occurrence refers to keywords, authors, or concepts that appear together in the same document. The Clustering techniques used here play a major role in Bibliometric research. Collaborative networks refer to research

partnerships, including co-authorship, where authors, countries, or institutions collaborate to produce publications.

Co-occurrence of author keywords

Table V shows the occurrence of the most frequently used 'Author keywords' in literature. The strong influence of co-occurrence creates a network of keywords, authors, countries , affiliations aiding academic growth (Acedo et al., 2006).

TABLE V
AUTHOR KEYWORDS

Author keywords	Total Occurences(TO)	Total link strength(TLS)
self-regulated learning	736	1207
learning strategies	120	289
motivation	85	201
metacognition	91	197
higher education	66	163
e-learning	62	135
self-efficacy	47	116
intervention	40	88

Fig. 7 shows a network visualisation of the co-occurrence analysis of "Author keywords," which represent the core content and scope. It displays the results based on 2,770 keywords where 120 met the threshold by selecting keywords having a minimum of 5 occurrences related to author keyword frequency.There are 11 clusters of keywords in the VOS viewer analysis which are formed using a clustering algorithm which identifies groups of keywords that are strongly connected based on their co-occurrence relationships. Each cluster has a different color. VOSviewer provides a Network Visualisation map in Fig.7.

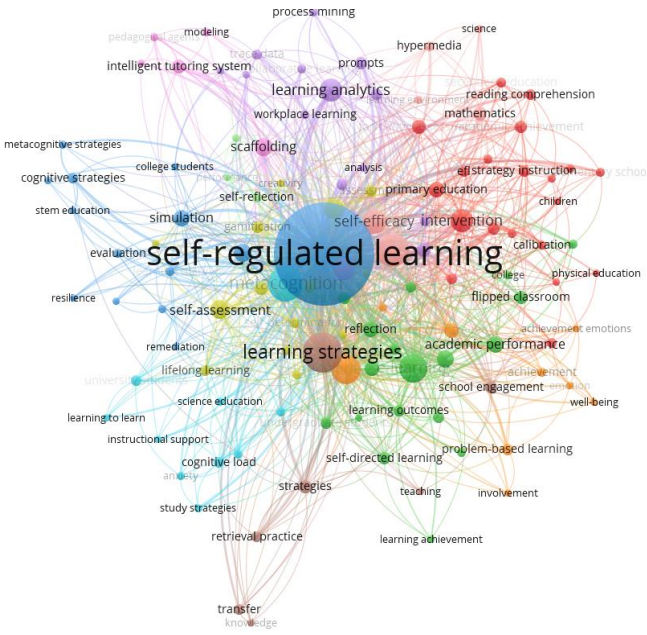

Fig. 7. Network Visualization : Co-occurrence Analysis of Author Keywords

The 'Network visualization' ,also known as 'Label view' displays labels representing 'author keywords' as circles called 'Nodes'.The size of the circle represents the frequency at which the keyword appears. A line between nodes represent a link between the 2 keywords. The map is constructed with the journal co-citation data. The key focus revolves around the largest circle(blue) which is the strongest keyword. 'Self-regulated learning' has its associated cluster keywords like 'self-reflection','self-determination,'reflection','instructional support','workplace learning'. For each keyword the total strength of its co-occurrence links with other keywords are calculated .As per Table V, keywords with the highest Occurrence are Self-regulated Learning, learning strategies, motivation, and metacognition, which focus on student-centred SRL goals.

Below are the themes emerging from the keywords:

Cluster 1: Self-Regulated Learning (20 items in the cluster)

This cluster forms the Central theme of the domain, anchoring the various interventions around it. This theme plays a significant role in various learning domains. Computer-based scaffoldings benefit learners in problem-solving by assisting students in developing and regulating their learning in an effective way (Azevedo & Cromley, 2004).Scaffolded Interventions can take a variety of forms like expert modeling, prompts, expert advice, learner guides, concept maps and tools. Prompts are in the form of heuristic questions , incomplete sentences, explicit execution instructions or visual support tailored for specific learning situations (Bannert, 2009).

Cluster 2: Learning Strategies(18 items)

Closely linked to SRL, this cluster highlights the significance of strategic regulation in learning to optimize performance. Training in cognitive and metacognitive learning strategies drives improvement in academic achievement (Perels et al., 2009).Strategy prompting has also seen higher learning outcomes during complex tasks in technology-based environments (Azevedo & Hadwin, 2005).

Cluster 3: Motivation (14 items)

This cluster is a link between SRL with motivation and self-perceptions.Self-regulated learning requires students to be metacognitively and behaviorally active participants in their acquisition of skill and knowledge.(Stoeger, H., & Ziegler, A,2011). Motivational orientation is said to be a key to cognitive engagement. Motivational support interventions can sustain significant learner engagement(Perels et al., 2009)

Cluster 4: Metacognition (14 items)

This cluster emphasises the highly important need for metacognitive monitoring and control in learning . Engineering environments see a lot of problem-solving where these studies are significant. Azevedo pioneered metacognitive regulation seen in assessments and also in technology-rich learning environments(Azevedo & Cromley, 2004).Studies show that metacognitive scaffolding facilitates improved problem-solving processes. Students exposed to metacognitive question prompts demonstrated significantly better performance than their peers who did not receive prompts (Ge & Land, 2003) .

Cluster 5:Higher education (13 items).

The use of SRL in higher education has seen a significant rise over the past few years, especially in the post-COVID era,

where several digital learning tools have been explored. Interventions like ChatGPT-assisted Learning Aids used saw a significant leap to enhance Higher order thinking skills and SRL.Learning journals,prompt cards,reflection logs,digital dashboards, Intelligent tutoring systems like Metatutor were used to aid theSRL intervened process to enhance learning in higher education (Bannert & Reimann, 2012)(Taub et al., 2018) This cluster focused on the design and evaluation of various types of enhancing interventions to achieve measurable academic gains.(Perels et al., 2009). In engineering education, students lack SRL skills and this is a sound knowledge gap towards developing complex problem-solving skills (Biwer et al., 2025).

Cluster 6: E-learning and Learning Analytics (10 items)

This cluster captures the data-driven dimensions and digital learning insights of SRL.Azevedo applied SRL frameworks in hypermedia and e-learning environments with adaptive scaffolds (Azevedo & Hadwin, 2005).MOOC and online coursed also saw usage of learning analytics to support SRL (Gašević et al., 2015) Technology integration in web-mediated pedagogy enhanced metacognitive regulation in science classrooms.(Tsai, 2014).Simulation-based studies have also been seen adapting SRL cycles (Brydges et al., 2016). This aligns with the literature, which highlights the merits of both motivational beliefs (e.g., interest and self-efficacy) and learning strategies within the self-regulated learning model.

RQ5: *What patterns of collaboration exist among authors and countries in SRL intervention research, and which networks demonstrate the strongest partnerships?*

Co-authorship of countries and Author collaboration :

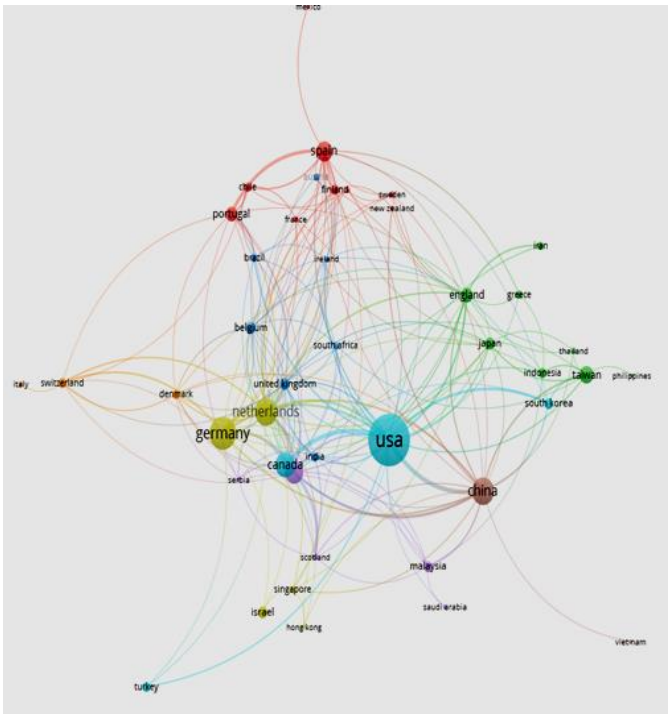

Fig. 8. Co-authorship : Countries

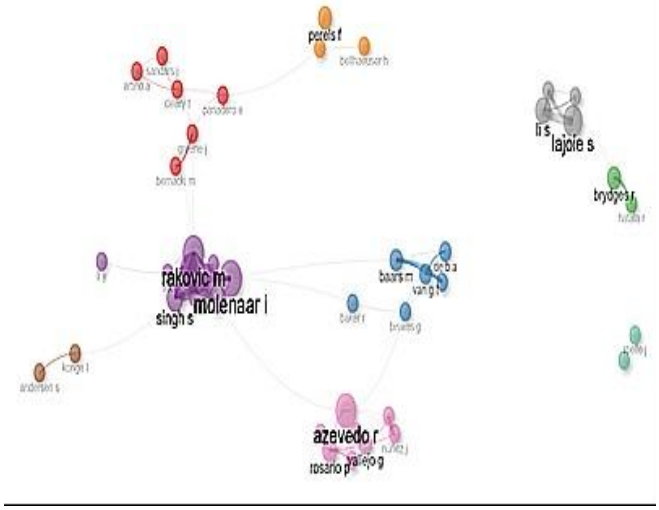

Fig. 9. Collaboration network : Authors

The visualization in Fig.8 represents the co-authorship of countries. Every node represents a country with the node size representing the quantum of publication in the domain. It has 8 clusters shown with USA having a Total link strength of 155 followed by Netherland , Germany, China and Australia having a TLS of 127 and 95,92 and 91 respectively. Thus USA with the largest node size leads in country co-authorship. It is evident that developed countries show large hubs while developing nations are making efforts to advance the research. The map shown in Fig. 9 provides a clearer understanding of the collaborative relationship between authors. Authors within the same cluster color exhibit strong collaboration links. Azevedo and Molenaar were identified as forming strong clusters. Molenaar, whose work on Multimodal data has immense significance today advancing SRL research with AI (Molenaar et al., 2023). Azevedo, on the other hand, focuses on metacognition and the scaffolding effects of 'Intelligent tutoring systems' (Azevedo et al., 2022).The authorship networks are seen shifting to more technology-enabled interventions in learning.

Country Collaboration

Countries with the highest occurrence indicate the cumulative strength of connections between co-authored papers of countries, as shown in Fig. 10. The thicker lines indicate higher co-authored papers and stronger collaborations.The top 10 countries are: Netherland(Total Link strength (TLS)=127), USA (TLS =112) and Germany (TLS =95),Australia (TLS =91) ,Peoples Republic of China(TLS =78) ,Canada (TLS =64) , Spain((TLS =53) ,United States (TLS =43), England(TLS =39) ,Portugal (TLS =39). Thus the countries with higher TLS have rich global research, highlighting the quantity of connections.

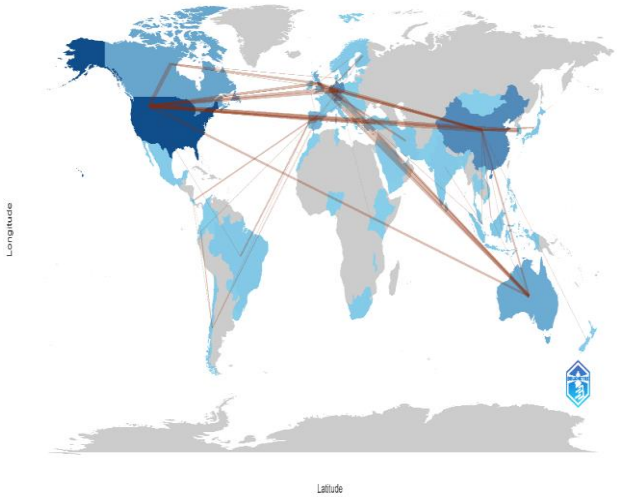

Fig. 10. Country Collaboration

CONCLUSION

The Bibliometric analysis provides an extensive overview of the evolving landscape of the rapidly emerging field of self-regulated learning, including interventions.The trending topics reveal that, post-COVID, academia has made remarkable strides in embracing and integrating technology, as well as utilising interventions in various contexts. Hence, the steep rise in scientific publications has been seen over the years. The USA emerged as the leader in publications, while "Frontiers in Psychology" was the leading journal. Boekaert M had the highest citation for his seminal studies. China emerged as the leader in multiple-country citation (MCP). Azevedo R stood out as the author with the highest production and the highest h-index in the domain. There has been a compelling need for new paradigms in education- one that empowers students to inculcate autonomy and lifelong learning. This study provides a glimpse into the rich tapestry of literature that spans learning strategies, metacognition, and higher education. These works attempt to fill existing lacunae by emphasising the role of self-regulated learning interventions in contemporary education.

Many students face significant challenges in Metacognitive regulation, leading to ineffective learning. Lack of metacognitive abilities and SRL causes students to struggle to reach the right answers despite having knowledge of the content (Niebler, 2023) .Hence, SRL needs to be a central focus in educational research and practice.

The role of scaffolds or interventions, such as prompts, serves to explicitly activate metacognitive regulation, especially in students who might not spontaneously engage in such strategies**.** SRL abilities are the need of the hour for a multi-tasking, fast-paced learning generation today. The seeds of SRL education sown in students today will cultivate a generation of empowered, self-driven leaders tomorrow, ready to navigate future challenges with resilience and adaptability. Hence, understanding the development of SRL and equipping learners for lifelong learning beyond the college years plays a pivotal role in higher education and this need fosters independent and self-regulated learners(Gonzalez-DeHass,2016).The growing volume of research suggests richer collaboration networks and transferability of intervention designs from academia to workplace learning.

Analogous to SRL educational settings, SRL reflections can lead to new learning from a professional learning perspective. Today, Managers typically focus on learning strategies, regulatory behaviour, and motivations at the workplace, which are the driving cornerstones of SRL. Metacognitive reflection during tasks and workplace challenges is essential and facilitates the effective application of SRL. When employees recognise obstacles or barriers in their tasks, they are likely to address and regulate them naturally as part of their workflow, especially when SRL patterns of workflow shape their approach.

IMPLICATIONS AND DIRECTIONS FOR FUTURE WORK

The limitations of the study include the possibility that bibliographical data could have been extracted from other scholarly databases, such as PubMed, ERIC, and Google Scholar, which could have added greater credibility to the study. Furthermore, scaling the study across diverse educational contexts by applying domain-specific interventions at various levels of instruction will provide nuanced insights and patterns. The study offers valuable insights for decision-makers in academia and industry. Evidence from various studies indicate that metacognitive skills are not adequately embedded in instructional practices. (Mutambuki et al., 2020).Taking ownership of learning, setting goals, and upskilling are desired facets of academia as well as the workplace today. Learners equipped with SRL skills are an asset as they drive continuous improvement and foster a Growth mindset. Leaders who practice SRL, model lifelong learning and self-efficacy.

As a direction for future work, educational policymakers should focus on cultivating an SRL-driven culture that encourages motivation and continuous growth. Outcomes such as self-awareness, goal setting, time management, emotional intelligence, and behavioural regulation, while managing setbacks, should be incorporated as part of value-added SRL interventions. Decisions to include scaffolded Self-regulated learning should be introduced so that Generative AI tools can be harnessed to create Metacognitive support. These will help create evaluation systems and better learning spaces. Problems like the drop-out rate can be managed by SRL learning programmes, which can be incorporated by educators and policymakers (Martín-Arbós et al., 2024). Adaptive learning platforms can deliver tailored content, while predictive analytics help anticipate learners' emerging skill requirements based on organisational trends (Deshmukh, S. C., & Mehta, M.,2025). Industry Policy makers can support an SRL culture that enables individuals to proactively upskill, stay relevant in a rapidly evolving job market, and contribute effectively to their fields. Also, HR professionals can use these insights to

implement SRL-based feedback systems. Thus, from academia to the workplace, these insights can be of immense significance in creating well-equipped, self-regulated learners.

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